A NEW TECHNOLOGY FORESIGHT MODEL AND ITS APPLICATION IN TURKISH DEFENSE INDUSTRY FOR AEROSPACE COMMUNICATION TECHNOLOGIES OF 2040

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Approval of the Graduate School of Social Sciences

Prof. Dr. Tülin Gençöz
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

Prof. Dr. Teoman Pamukçu
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Assoc. Prof. Dr. Serhat Çakır
Supervisor

Examining Committee Members

Prof. Dr. Çiğdem Erçelebi	(METU, PHYS)	
Assoc. Prof. Dr. Serhat Çakır	(METU, PHYS)	
Prof. Dr. Türksel Kaya Bensghir	(Ankara Hacı Bayram Veli Üni., ISLE)	
Prof. Dr. Feza Arıkan	(Hacettepe Üni., ELE)	
Prof. Dr. Erkan Erdil	(METU, ECON)	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Nurdan YÜKSEL

Signature :

ABSTRACT

A NEW TECHNOLOGY FORESIGHT MODEL AND ITS APPLICATION IN TURKISH DEFENSE INDUSTRY FOR AEROSPACE COMMUNICATION TECHNOLOGIES OF 2040

YÜKSEL, Nurdan
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Supervisor: Assoc. Prof. Dr. Serhat Çakır

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A new technology foresight model -Foresight Periscope Model (FPM)- and Foresight Functional Framework (FFF) with its catchy acronym FORESIGHT of which each letter corresponds to the functions of foresight developed by the researcher are used as a base with the integration of Foresight Method Selection Algorithm (FMSA) developed within this dissertation. The application of integrated model is implemented for aerospace communication technologies' foresight in Turkish Defense Industry for 2040. Three segments of FPM -resources, methodology and futures' strategies- are evaluated by FMSA which is coherent with the functions in FFF. All suggested core and supportive methods given as the outputs of FMSA are conducted and analyzed for the stated technical subject within this dissertation. Suggested participative methods like expert panels with their sub-methods and Delphi technique are realized to build different future scenarios. The outcomes of methods' analysis are set forth with charts and graphs in technical details with the comments of the researcher. The scenario is determined by the methots' results for the preferred future. The strategy including the policy recommendations is established for the preferred scenario and of which actions are shown on the roadmap prepared for 2040 for the aerospace communication technologies in Turkish Defense Industry.

Keywords: Foresight Periscope Model (FPM), Foresight Functional Framework (FFF), Foresight Method Selection Algorithm (FMSA), Aerospace Communication Technologies, Turkish Defense Industry

ÖZ

YENİ BİR TEKNOLOJİ ÖNGÖRÜ MODELİ VE TÜRK SAVUNMA SANAYİİ'NDE 2040 YILI HAVA VE UZAY HABERLEŞME TEKNOLOJİLERİ İÇİN UYGULAMASI

YÜKSEL, Nurdan
Doktora, Bilim ve Teknoloji Politikası Çalışmaları
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Araştırmacı tarafından geliştirilmiş olan, yeni bir teknoloji öngörü modeli –Öngörü Periskop Modeli (ÖPM)- ve her harfi bir işleve denk gelen, kolay hatırlanan FORESIGHT akronimi ile ifade edilen Öngörü İşlevsel Çerçevesi (ÖİÇ) bu araştırma kapsamında geliştirilen Öngörü Metot Seçme Algoritması (ÖMSA) ile birleştirilmiştir. Modelin birleştirilmiş şekli temel alınmış, Türk Savunma Sanayii'nde uzay ve hava haberleşme teknolojilerinin 2040 yılı öngörüsü için uygulaması gerçeklenmiştir. ÖPM'nin üç katmanı –özkaynaklar, metodoloji, gelecekler stratejileri- ÖİÇ'deki işlevler ile tutarlı çalışan ÖMSA ile değerlendirilmektedir. Bu tezde ÖMSA'nın çıktıları olarak verilen tüm öz ve destekleyici metotlar, belirtilen teknolojik alan için uygulanmış ve analiz edilmiştir. ÖMSA ile önerilen uzman panelleri ve Delphi tekniği gibi katılımcı metotlar alt metotları ile birlikte farklı geleceklerin senoryolarını oluşturmak için gerçeklenmiştir. Metot analizlerinin çıktıları teknik detayda ve karşılaştırmalı şekilde çizelge ve grafikler ile araştırmacının yorumları ile verilmektedir. Metotların sonuçları tarafından tercih edilen geleceğe uygun senaryo belirlenmektedir. Tercih edilen senaryo için politika önerilerini içeren strateji oluşturularak, stratejinin eylemleri Türk Savunma Sanayii'nde 2040 yılı hava ve uzay haberleşme teknolojileri için hazırlanan yol haritasında gösterilmektedir.

Anahtar Kelimeler: Öngörü Periskop Modeli (ÖPM), Öngörü İşlevsel Çerçevesi (ÖİÇ), Öngörü Metot Seçme Algoritması (ÖMSA), Hava-Uzay Haberleşme Teknolojileri, Türk Savunma Sanayii

To

My Mother (Azime)

My Husband (Onur)

My Best Friend (Pınar)

My Brother (Nurkan)

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LIST OF ABBREVIATIONS

5G	The Fifth Generation of Cellular Mobile Communications
AHP	Analytical Hierarchical Process
AI	Artificial Intelligence
AIN	Aluminium Nitride
BMF	Below Microwave Frequency
BV	Knowledged (Bilgim Var)
C4ISR	Command-Control-Computer-Communication-Intelligence and Surveillance and Reconnaissance
CAGR	Compound Annual Growth Rate
CI	Consistency Index
CLA	Casual Layered Analysis
CR	Consistency Ratio
CYBORG	Cybernetic Organism
DoD	US Department of Defense
EDA	European Defense Agency
EFMN	European Foresight Monitoring Network
FFF	Foresight Functional Framework
FMSA	Foresight Method Selection Algorithm
FPM	Foresight Periscope Model
GaN	Gallium Nitride
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit
GERD	Gross Domestic Expenditure on R&D
GNSS	Global Navigation Satellite Systems
GÖKTÜRK-3	Earth Observation Satellite
GPS	Global Positioning System
HEO	High Earth Orbit
HF	High Frequency

HÜRKUŞ-B	New Generation Fundamental Training Aircraft
III-V materials	Chemical compounds with at least one group III (IUAC group 13) element and at least one group V element (IUPAC group 15)
IONOLAB	Ionosphere Research Laboratory
IoT	Internet of Things
Ka	K Band Above
KU	Field Expert (Konu Uzmanı)
Ku	K Band Under
LEO	Low Earth Orbits
M2M	Machine-to-Machine
MEMS	Micro Electro Mechanical Sensor
MEO	Medium Earth Orbit
MilSatCom	Military Satellite Communication
MMW	Millimeter Wave
NATO	The North Atlantic Treaty Organization
NGO	Non Governmental Organization
OECD	Organization for Economic Co-operation and Development
OSSA	OSTİM Defense and Aviation Cluster
PEO	Polar Earth Orbit
QCA	Qualitative Case Study Analysis
QDE	Qualitative Differential Equations
R&D	Research and Development
RAND	RAND Corporation
RI	Random Index
SAHA	Aviation and Space Cluster Association
SASAD	Defense and Aerospace Industry Manufacturers Association
SDT	Space&Defence Technologies
SEEPL	Social-Economical-Environmental-Political-Legal
SHF	Super High Frequency
SiGe	Silicon-Germanium
SIPRI	Stockholm International Peace Research Institute
SME	Small or Medium Enterprise
SOAR	Strengths-Opportunities-Aspirations-Results

SSB	Savunma Sanayi Başkanlığı (Presidency Of The Republic Of Turkey Undersecretariat for Defense Industries)
SSI	Defense and Aerospace Industry Exporters' Association
STEEPL	Social-Technological-Economical-Environmental-Political-Legal
STEM	Science-Technology-Engineering and Math
STK	Sivil Toplum Kuruluşu
SWOT	Strengths-Weaknesses-Opportunities-Threats
TAF	Turkish Armed Forces
TAFFO	Turkish Armed Forces Foundation Organizations
TF	Technology Foresight
TFA	Technology Futures Analysis
TFAMWG	Futures Analysis Methods Working Group
TF-X	National Combat Aircraft
TRL	Technology Readiness Level
TSA	Time Series Analysis
TÜBİTAK	Türkiye Bilimsel ve Teknolojik Araştırma Kurumu
TÜRKSAT-5A	Turkish Communications Satellite operated by TURKSAT
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
UNIDO	United Nations Industrial Development Organization
VHF	Very High Frequency
WC	Wild Card
WS	Weak Signal
XNAV	X-Ray Navigation

CHAPTER 1

INTRODUCTION

1.1 Importance of Aerospace Communication in Defense Sector

Aerospace is the "space comprising the earth's atmosphere and the space beyond"(“Aerospace,” n.d.). The aerospace industry focuses on the research, development, manufacture, operation and maintenance of main systems as flight platforms (balloon, zeppelin, airplane, missile, unmanned aerial vehicle, spacecraft, satellites, space launch vehicles etc.) (Amir & Stanley, n.d.). All these main systems are comprised of some subsystems. Traditionally, there have been four subsystems like aerodynamics, propulsion, structures, and dynamics/control (Long, 2004). But with the rapid developments of information and electronic technologies, Command-Control-Computer-Communication-Intelligence and Surveillance and Reconnaissance (C4ISR) have become the key subsystem. Computing through on board smart microprocessors is responsible in making parallel and fast calculations for controlling, identifying, analyzing, decision-making and commanding. Communication, which carries the information by providing the synchronization and networking between these subsystems on the board and also inter-boards like ground, naval platforms and other aerospace platforms is crucial. The platforms such as "F/A-22 Raptor has 2 million lines of software onboard and some Blackhawk helicopters have almost 2000 lb. of wire connecting all the computers and sensors" (Long, 2004). So, there are lots of examples can be given to show the importance of C4ISR. In today's knowledge based competitive world, technological progress is fundamental for also aerospace industry. There is reciprocity between the science-technological advancements and the aerospace industry, because the industry also paves the way of advancing science and technology as the world leading industry. Since it is also main determinant of the economic and political power among the countries in every area, it is inevitable that governments and political institutions of countries play an important role to shape the aerospace industry. They enforce the military sectors to increase the deterrence of their countries and stimulate the dual use of its technological products and services also for civilian use to increase the economical benefits. While countries of which research and development capacity have been investing in their technology infrastructure and providing export benefits economically for themselves; the others mostly pay for importing technology or its products and services. In both cases, the military expenditure[1] still occupies a significant share in overall budgets. In 2017, the World percentage of military expenditure of Gross Domestic Product (GDP) is 2.166 (World Bank, 2017a). Rising the terrorism and the polarization in world wide, defense expenses start to increase globally especially in United Arab Emirates, Saudi Arabia, India, South Korea, Japan, China. Because of these increasing global security threads, Global Aerospace & Defense sector revenue also will grow with %2 according to 2017 Deloitte forecast (Captain & Hussain, 2017). When Turkey is taken into consideration, its defense expenditure is % 2.112 of GDP in 2017 (World Bank, 2017b) as fifteenth military spending country in the world.

In the military applications, C4ISR is one of the main branches of this expenditure because of its mentioned necessity and cruciality. According to statistics, the global market size of C4ISR in 2016 was 90.67 billion US. Dollars, it is expected to be 110.6 billion dollars in 2021 (Statista, 2018). Since those systems are interconnected to each other through communication, the operability and strength of the army depends on communication effectiveness, dynamism, security and safety. Due to increasing trend in defense expenses as global and the emerging of new technologies and innovations in military communication, the market is expected to grow with the

[1] Military expenditures data from SIPRI are derived from the NATO definition, which includes all current and capital expenditures on the armed forces, including peacekeeping forces defense ministries and other government agencies engaged in defense projects; paramilitary forces, if these are judged to be trained and equipped for military operations; and military space activities (Stockholm International Peace Research Institute (SIPRI), n.d.).

%7-9 Compound Annual Growth Rate[2] (CAGR) for the period between 2015 and 2025 (Future Market Insights, 2017).

For the last decades the communication control over aerospace through satellites have been used extensively because of its effectiveness for the long-range applications. Also with the extensive use of Unmanned Aerial Vehicles (UAVs) and connections of forces over network for network centric operations, the aerospace communication systems have been becoming more central. The aerospace units are also controllers also for naval and territorial areas since they have long range and fast movement capability. The more advanced techniques for safer, faster, more secure and interoperable air and space communication that use bandwidth as efficiently bring success and deterrence; so, many countries invest in aerospace military communication market. According to forecast report of Global Military Communications Market Forecast: 2014-2024, satellite communication systems which includes space-based satellites and ground-based satellite terminals will be dominant in spending as systems although land-based communication continue to be the largest market (Anwar, 2015). For the next 10 years, globally 242 satellites in defense sector will be launched and number of countries investing in military satellite communication (MilSatCom) will increase (Stone, 2015).

The new developing communication infrastructure called fifth generation of cellular mobile communications (5G) and proliferation of Industry 4.0 based on the technologies of Internet of Things (IoT), Big Data and Artificial Intelligence (AI) bring the new networking standards, new frequency bands and sharing of them with new techniques in communication with hardware and software changes together. The automation of the systems will need automatic and adaptive control through smart communication networks. When all the things, which are communicated to each other, are taken into account; the bandwidth capacity and spectrum efficiency appear as problems. So, within this dense environment, investments' amount, type and allocation become more crucial.

[2] The compound annual growth rate (CAGR) is the mean annual growth rate of an investment over a specified period of time longer than one year (Investopedia, n.d.).

1.2 Need of Futures Studies on Aerospace Communication in Defense Sector

In the aspect of output products and labor force in terms of monetary value, the aerospace industry is comprised of few outstanding companies and based on international partnerships (Amir & Stanley, n.d.). So, it is inevitable in such an expensive and joint industry to do foreseeing and planning the future of technical communication environments of aerospace elements, especially when it comes to the defense of the states. When it is thought that most of technological innovations in communication area like Internet and Global Navigation Satellite Systems (GNSS) which require huge resources and effective planning have been invented with the triggering studies for special military purposes (GPS World Staff, 2010; Naughton, 2016), it is apparent that new innovations also require foreseeing and planning. In the communication of military forces and units on the stage of information exchange as fast, reliable and secure, there should be advanced technological infrastructure in the industry. To provide such structure, there is need of pre-defined strategies controlling and shaping technologies for the different futures scenarios. For that reason; governments support defense sector which needs mostly huge capitals, high labor and quality standards, of which products and services should be high technology-based and unique, confidential and reliable. In defense sector, development and production periods are longer so the changes and updates are difficult to adapt. It is also affected from internal and external dynamics like political, economic, social and ecological. These distinct differences of defense sector from civil necessitate more consistent and future-oriented steps. So, for the countries there is a need to be aware of the capabilities obtained in the past, determine the current situation and be ready for the future especially in their defense industries. At this point the discipline called Future Studies is the key to perform such goals. Futures studies are not just “looking ahead” (Sardar, 2010a), also include “looking back” (Slaughter, 1995) and looking present. By taking past and present conditions into account, Martin (1995) defines Technology Foresight (TF), which is one of the futures studies, as 'A process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits'.

Consequently, the new technological developments, trends and allocated budgets illustrate that military aerospace systems continue to be dominant in defense sector. When the communication is thought as the heart of interfacing all military systems in addition to distinct features of defense sector, it is apparent to foresee the future of aerospace communication systems with methods suitable to defense sector become very important to manage and allocate resources efficiently to determine futures strategies, roadmaps and integrating them to the policies.

1.3 Statement of Problem

There is increasing central role of aerospace systems in today's network-centric combat environment and it is apparent that the communication between and through these systems should be evaluated in all aspects. When it is looked at Turkish Defense Sector's on-going and planned projects, most of them in order to prepare the Turkish Armed Forces to future's war fighting environment are related with aerospace systems like ATAK Helicopter, Unique Helicopter, General Purpose Helicopter, New Generation Fundamental Training Aircraft (HÜRKUŞ-B), National Combat Aircraft (TF-X) and Earth Observation Satellite (GÖKTÜRK-3), TÜRKSAT-5A and national missile etc. according to 2017 Activity Report of Undersecretariat of Defense Industries of Turkey (Savunma Sanayi Müsteşarlığı, 2017b). In defense and aerospace sector of Turkey, the income of exports reached 1.655 billion USD in 2016 from 247 million USD in 2002 and R&D spending increased to 905 million USD from 49 million USD (Savunma Sanayi Müsteşarlığı, 2017a). In addition to these projects and income related to aerospace communication systems, the global trends and market share given above show that the exploring alternative mid and long term futures with extensive and systematic studies are getting more important instead of short-term, superficial development plans created by limited number of stakeholders.

When all of them are taken into account in addition that there is no TF specific to aerospace military communication systems in the literature, it is evaluated as crucial to set forth the TF study on this area, which is very prone to be developing with the new and on-going projects in shaping the future of Turkey's Defense Sector.

1.4 Research Question

The research question and sub-questions were presented in Table 1. For the answer of the research question, the *Foresight Periscope Model (FPM)* and *Foresight Functional Framework (FFF)* developed in the study of *A New Model for Technology Foresight: Foresight Periscope Model (FPM)* (Yüksel & Çifci, 2017) will be used as bases. Additionally, *Foresight Method Selection Algorithm (FMSA)* developed in this research will select the suitable foresight methods coherence with the FPM. Application and analysis of all used methods were explained coordinated with the research question and its sub-questions in the following chapter.

Table 1 Research Question and Sub-questions

Research Question	What is the roadmap of preferred strategy for foresighted aerospace communication technologies about futures until 2040 in Turkish Defense Sector?	
Sub-questions	Sub-question 1	What is the methodology which uses the optimum methods to conduct foresight of aerospace communication technologies about futures until 2040 in Turkish Defense Sector?
	Sub-question 2	What is the present condition of aerospace communication technologies in Turkish Defense Sector?
	Sub-question 3	Which aerospace communication technologies are foresighted to affect the futures until 2040 in Turkish Defense Sector?
	Sub-question 4	What are the different futures' scenarios for aerospace communication technologies until 2040 in Turkish Defense Sector?
	Sub-question 5	What is the strategy for aerospace communication technologies of preferred future scenario until 2040 in Turkish Defense Sector?

1.5 Motivation

TF studies have some impacts in short, medium and long periods at organizational, regional and national levels. With TF in Japan where the most participatory and successive foresight studies were done since 1971, 'precious knowledge assets, with

60-70% of topics identified having been successfully realized in one way or the other' (Harper, 2013). As it is seen from Japan, TF studies have more benefits like efficient resources allocation and prioritization, knowledge management, providing social learning process and networking between stakeholders, creating awareness and readiness for innovation and stimulating effective policy making.

The main motivation is the enthusiasm to exploring the unknown futures, predicting the some of future because of partiality feature of future studies[3].
Supportive motivations are,

- Wondering about the implementation of FPM
- Desire to improve the researcher's profession which is related with Air Communication Systems at work with the knowledge gained in this research
- Wish to see whether TF in this research is beneficiary for the further studies of individuals and institutions.

1.6 Goals

To be benefited from TF as much as possible it should be planned and conducted on the base of well-defined and applicable model. Foresight studies are meaningful when they are integrated with recommendations into policies and adopted by policy makers and all stakeholders.

Within this point of view, the goals are,

- Adapting FPM to Turkish Defense Sector for aerospace communication systems and using FMSA' outputs for methods according to given set of resources and features of the sector.
- Applying the catchy and generic FFF which defines the steps of carrying out foresight studies and adapting it to aerospace communication systems in Turkish Defense Sector.

[3] The impossibility of the future model which has holistic set covering the whole future (Loveridge, 1996).

- Applying the FPM and FFF to aerospace communication systems in defense sector for 2040 by providing the participation of large number of stakeholders from universities, public and private organizations, Turkish Armed Forces (TAF) and civil society organizations to create common sense, networking, knowledge and learning.
- Outlining the current condition of Turkey and the World on the aerospace communication systems, researching the on-going and possible new technologies and forcing the imagination of futures' technologies until 2040.
- Setting the strategies and roadmaps for futures of aerospace communication systems in defense sector forth together with the policy recommendations.

1.7 Originality/Value

There are some specific national TF studies on military and defense industry in the literature. Starting with the USA foresight activities especially shaped by RAND Corporation after the World War II, foresight studies in military and defense sector continued in France, Italy, the United Kingdom, Germany, Russia, China, Canada, Norway etc. (Dreyer & Stang, 2013). The government agencies like US Department of Defense (DoD), Singapore Centre for Strategic Futures (Douglas, 2016) conduct TF regularly. There are also Defense and Aerospace Market Reports and Forecasts of Deloitte (2017), PricewaterhouseCoopers' PWC (2016), KPMG International Cooperative (2015). RAND Corporation has a study prepared for the US Army specific to military communication bandwidth challenge of today and future (Leland & Porche III, 2004).

Turkey performed the first national technology foresight in 2003 by Vision 2023 which also includes Defense, Aeronautics and Space Industries (TÜBİTAK, 2017). In 2009, the study about the roadmaps of Space and Aviation until 2023 was set forth (TÜSİAD-Sabancı Üniversitesi Rekabet Forumu, 2009). There is another foresight study in 2013 for Aviation and Space Technologies sector based on working group of experts from public, private organizations and universities (Ulaştırma-Denizcilik ve Haberleşme Bakanlığı, 2013). Additionally, there are annual strategic plans of

Undersecretariat for Defense Industries covering aerospace inline with the development plans prepared by Ministry of Development. The foresight study on space vision of Turkey (Dede& Akçay, 2014) is another one as dissertation. Although these mentioned studies are suggestive, they are not about the specific subject of this research; they are not supported by any predefined model and not conducted according to any framework.

The FFF with its acronym (FORESIGHT) (Yüksel&Çifci, 2017) and generic FPM with its descriptive analogy (PERISCOPE) (Yüksel&Çifci, 2017) developed by the researcher are remarkable and easily memorable when compared to the ones in the literature. Additionally, in the extended literature review, it has not been run into any analogical model covering all elements of foresight although there are a few only about methods such as Popper's famous diamond model (Popper, 2008c). Furthermore, in Turkish literature "The Suggestion of TF Study Model for Turkey (Durgut, Göker, & Üçer, 2001)" which is not generic in the literature covering all steps for conducting a study by stating just limited methods and related specific organizations. The TF application on the basis of adaptation of the generic model and the framework developed by the researcher in addition to FMSA, which was developed for this research on the aerospace communication technologies of Turkish Defense Sector, is the first study in Turkey and the World according to literature review. Besides, FMSA implemented in Visual C# in the computer environment is the first software application for foresight in the literature.

This research study is evaluated as a valuable guide for the next foresight applications especially in Turkish Defense Sector and a reference for methods selection, their applications, methods analyzing, different futures' scenario building, strategy making and roadmapping for preferred future with its policy recommendations. Additionally, Wild Cards' (WC) application and its analysis are interpreted as unique especially in creating awareness among stakeholders by taking the remarkable events into account especially for Turkey and also the World.

CHAPTER 2

CONCEPT AND MODEL OF FORESIGHT

2.1 Futures and Futures Studies Concept

Future is very complex to predict since there are numerous variables to affect it. Nevertheless, people have always been trying to estimate the phenomenon and events of future beforehand. The reason is their desire to be prepared to future. The fear and wonder instincts of human being are the triggers of anticipating future. Bar (2007) states "the human brain is continuously busy generating predictions that approximate the relevant future." There are lots of futures, which called as alternative futures to be predicted, but only one of them comes true. Since, that future doesn't exist at that time, it is uncertain which provides itself plasticity of being shaped (Hancock & Bezold, 1994). So, 'futures studies' which is a plural term commonly and preferably used for systematically anticipating activities for different futures. The term 'futures studies' gives a information about there are more than one future which might be realized and there are studies can be made today to estimate them compared to other complex terms used such as futurology, futuristic, futurism. Additionally, this pluralism encourages imagining and creating the alternative futures by concentrating to bring desired results forth in advance (World Futures Studies Federation, 2018). Futures Studies is the research area involving many disciplines, so it is the combination of the descriptions of multi-disciplinary, interdisciplinary and supra disciplinary[4] (Sardar, 2010b). For such a huge research area there are also some indexes as State of Future Index (SOFI) which indicate 10-year view of future by looking at the previous data of chosen variables for the past 20 years or longer

[4] It consciously rejects the status and state of a discipline while being a fully-fledged systematic mode of critical inquiry (Yüksel & Çifci, 2017).

and by evaluating the each variable for the best and worst plausible 10 year outcomes (Gordon, 2015).

Futures Studies are performed in every subject. Among them, technology is the most effective and deterministic subject for futures studies. For the futures studies about technology, named as Technology Futures Analysis (TFA), has definitional categorization done by Futures Analysis Methods Working Group (TFAMWG) in 2004 (Firat, Woon, & Madnick, 2008). According to this categorization, technology monitoring, watch and alerts analysis are related with the collecting and evaluating the information. Technological and competitive intelligence analysis focus on acquiring beneficial and usable intelligence by transforming information collected. Technology forecasting does prediction of the changes and its effects. Technology roadmapping is used to establish plans which link technological changes to products. Technology assessment, impact assessment and strategic environmental assessment anticipate the mid and long term influences of changes in technology. Technological, national and regional foresight affects the strategies and plans with the participation of extended stakeholders.

When the evolution of futures studies is taken into account through time, the forecast and foresight studies are prominent studies. The differences between two are that while forecast tries to predict one future with less participants as taking passive manner, foresight targets to reach different futures with the aim of broad participation to invoke awareness between stakeholders as taking active manner (Steed & Tiffin, 1986).

2.2 Definition of Foresight

Foresight was first used as a term with the name Mr. Foresight, a character of Restoration Comedy in 1695. Then it was used in radio broadcasting in 1932 and in 1937 US National Committee used it meaningfully in their reports. The foresight technique was used in Japan forecast studies in 70s and became prevalent in TFA studies at the beginning of 90s. Since it was mostly used in technology anticipation, the form of technology foresight came forward. Emerging of foresight and its evolution through time as a term is shown in Figure 1.

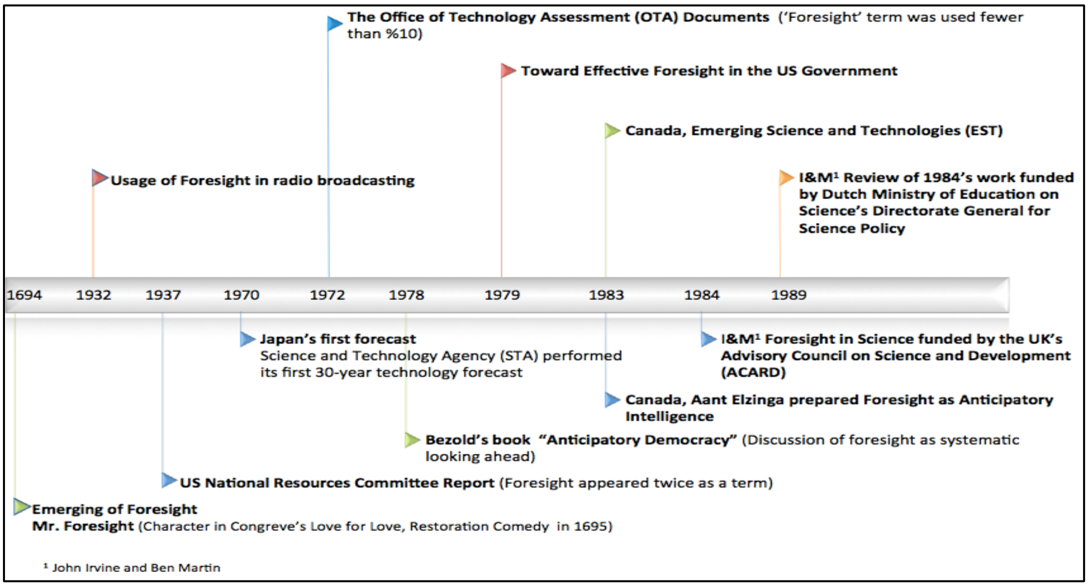

Figure 1 Emerging of Foresight and Its Evolution (Çifci & Yüksel, 2018)

Foresight based on the "uncomfortable marriage of well-structured and tested information to its counterpart subjective opinion" (Loveridge, 1996). In the European Commission context, foresight is medium-to-long vision building and intelligence collecting by the decisions taken from today in participatory and systematic way (FOREN, 2001). Yüksel & Çifci (2017) defines foresight as "a systematic and multidisciplinary process with proper methodology combinations for identifying technological, economic and social areas to prioritize investments and research in order to determine medium or long term future strategies by using all level of resources from organizational to international. They also state the key elements of foresight by researching numerous foresight definitions in the literature in Table 2.

Table 2 Key Elements for the Foresight in the Literature (Yüksel & Çifci, 2017)

Key Elements for the Foresight in the Literature	**Martin (1995)**	**Martin & Johnston (1999)**	**Slaughter (1995)**	**Georghiou (1996)**	**Georghiou et al. (2008)**	**Barre' (2001)**	**Miles & Keenan (2002)**	**Miles (2010)**	**Harper (2003)**	**Voros (2005)**	**European Commission & Keenan & Popoer (2007)**	**Popper (2008)**	**Popper (2011)**	**Schmidt (2015)**	**Conway (2015)**	**Yüksel & Çifci (2017)**
Systematic studies/process	X			X		X	X						X		X	X
Looking at medium and long term future	X				X	X		X				X				X
Participatory, collective, networking process					X	X	X		X		X		X			
Building visions						X	X		X		X					
Gathering intelligence						X	X									
Learning process											X	X				
Mobilized actions						X	X									
Joining key agents of change and knowledge sources						X						X				
Assessing scientific and technological developments				X												
Looking into science, technology, economy and society	X															
Identifying technologies which have impact to create economic and social benefits, industrial competitiveness, wealth creation and quality of life	X															
Identifying critical technologies to the success of the country or industry								X								
Cognitive capacity															X	
Setting Priorities					X											X
Changing research system and administrative culture					X											
Identifying and examining weak signals														X		
Activities **a**nticipating, **r**ecommending and **t**ransforming (ART) **t**echnological, **e**conomic, **e**nvironmental, **p**olitical, **s**ocial and **e**thical (TEEPSE) futures.													X			
Actively engaging key stakeholders													X			
Prospective and policy-oriented process													X			
Context for predictive analysis and planning														X		
Promoting trans-disciplinarily research												X				
Underpinning areas of strategic research	X															
Universal human capacity			X													
Wiring up the national/regional system of innovation		X														
Strategic thinking										X						
Common ownership of strategies									X							
Incubation of strategic approaches									X							
Using organizational, regional, national and international resources																X
Proper methodology combinations																X
Identifying technological, economic and social areas to prioritize investments and research																X

2.3 Generations of Foresight

Foresight has changed its concentration dimensions, participants and economic rationales and evolved through this time with the influences of society, globalization, certain eras and the actions taken (Yüksel & Çifci, 2017). In Figure 2, the main approaches of foresight generations in the literature are determined and grouped based on different criteria shown.

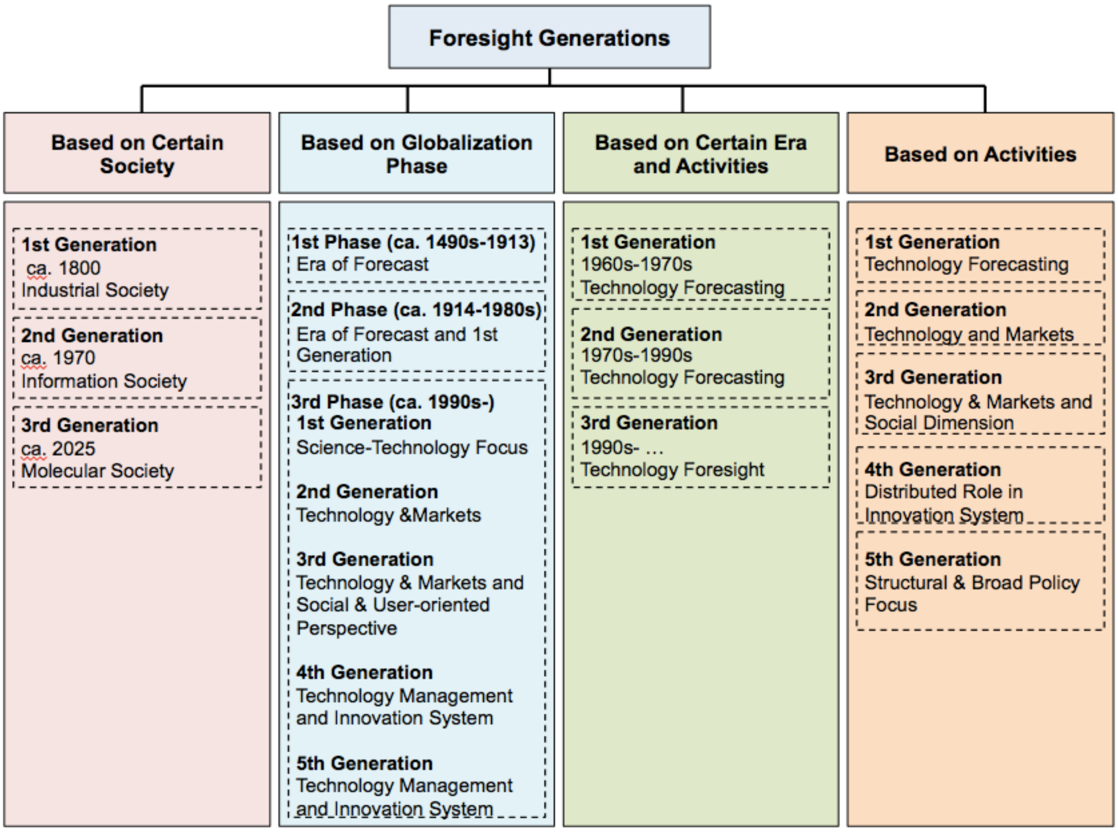

Figure 2 The Main Foresight Generations' Approaches in the Literature Based on Different Criteria (Yüksel & Çifci, 2017)

Linstone (2011) categorizes its generations into according to certain society. In his first generation (ca. 1800-Industrial Society), which starts with Taylor's scientific management, foresight activities were technology forecasting to anticipate the technological changes with some quantitative, semi quantitative and qualitative methods. In the second generation (ca. 1970-Information Society), with the increasing use of computers, computer-based foresight activities have become dominant and large amount of data has stored in databases to be used in fast processing in computers. In the third generation (ca. 2025 - Molecular Society), it is expected that Nano-Bio-Micro technology direct the foresight activities with the incredible speed of data processing with intelligence.

Jemala (2010) uses globalization phases as a classifying criterion and defines 5 foresight generations within them. In the first globalization phase between Christopher Columbus in 1490s and “Laissez Faire” approach, which came to end up to 1913, there was no systematical forecasting, there were only individual activities to predict the future inherently. In the second globalization phase which starts in 1914 and lasts in 1980s mainly dominated by world wars, the first generation of foresight emerged with the activities of China forecast, which carries most features of foresight although it was named as forecast. In 1970s, Japanese participatory activities with suitable methods in systematic format took place in the first generation of foresight. In the third globalization phase formed by unevenness coming from finance and global trade there were five foresight generations performed. In addition to first foresight generation, second foresight generation aroused from the dynamics of markets and industry were carried out with different range of participants within the triangle of social, economical and science-technology areas. In the third foresight generation performed in 2000s, the main focus was to create the foresight culture with the extended stakeholders and it started to contain vast areas from ethics to environment. In the fourth and fifth generation, innovation relation with technology became more dominant with the system point of view.

Reger (2001) defines three generations according to both specific eras Boutellier, Deplazes, & Loffler (2007) and actions taken in his mixed approach. First generation extended from 1960s to 1970s, forecasting for technology took place with prediction activities whereas foresight was just the part of project planning. In the second generation from 1970s to beginning of 1990s, foresight for technology started to be carried by foresight branches of organizations. Third generation from 1990s, the strategic management came into prominence, so in addition to technological foresight activities the social, environmental, economic and legal factors were included.

Georghiou differentiates the foresight generations as five groups by thinking stakeholders and activities (Georghiou & Keenan, 2006). The characteristics of these foresight generations were defined in the study of (Popper, Keenan, Miles, Butter, & Sainz, 2007a). For the first generation, there was just expert forecasting of technology, whereas in the second-generation science and market experts did foresight activities to create science networks between them. Third generation added the social point of view and factors by including the stakeholders from government and civil society as well. Fourth generation focused on the different actors also from innovation system whereas fifth generation handled with the more global issues for composite and complex policies. The foresight study may cover the characteristics of one to all generations, which they are "concurrent, overlapping and reflexive" (Gieseke, 2012). The changes in social, economic, technological, legal, ecological and ethics have influenced the foresight activities and cause emerging of the new ones. In the current literature, there has been just five generations for foresight reflecting these changes. Çifci & Yüksel, (2018) defines the new one, the sixth generation of foresight named *Foresight 6.0*, according to upcoming changes. Emerging and spreading the concepts of Industry 4.0, biotechnology, cyberspace, netocracy, ethics and the ambiguous roles in economy brings the need for the sixth foresight generation naturally. Industry 4.0 and its underlying concepts of cybernetics, biotechnology and Internet of Things (IoT) will cause the issues of ethics, employment and income distribution since there will be robots or cyborgs[5] in the society especially for labor force. New legislation, ethics and economy models will e inevitable in new netocratic system which affects the foresight generation. The proliferation of using Internet almost in every social area caused establishing networks in society. Networking through internet is the new form of "social interaction, taking action and decision-making" (Castells, 2006). This new form created its own social group, Netocrats, who rule, control and interconnect the

[5] Which is the abbreviation of "cybernetic organism" first used by Clynes and Kline in 1960 (Clynes & Kline, 1960).

networks through their technological knowledge and resources are new political elites (Ampuja & Koivisto, 2014) in the new system called Netocracy. The actors and their interactions with each other and the environment in *Foresight 6.0* are shown in the Figure 3.

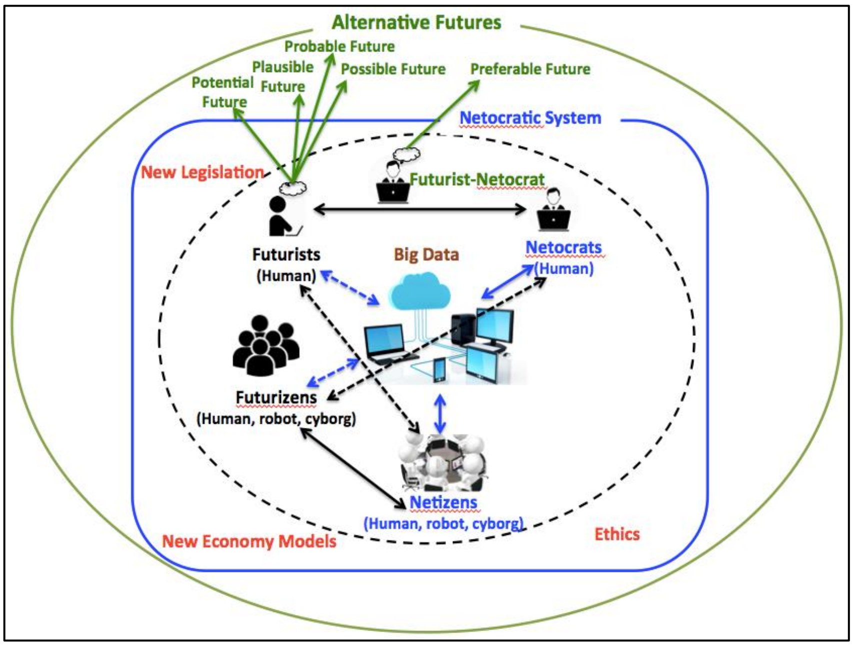

Figure 3 The Actors, Interactions and the Environment of *Foresight 6.0* (Çifci & Yüksel, 2018)

Netocracy, a term emerged in at the beginning of 1990s, stands for the coalition of Internet and aristocracy (V. Gupta, 2015) and is "post capitalist concept" in which netocrats are the new elite rulers (Bard & Söderqvist, 2012). In such an netocratic system, foresight actors are anticipated to be netocrats, netizens, futurizens, futurists and netocrat-futurists some of which are human, not human or both. Netizens, the lower class of netocracy and ruled by netocrats, are the users of network by promoting its development to keep it vibrant cooperatively (DeLoach, 1996). The environment of netocracy is the cyberspace defined as "the online world of computer networks and especially the Internet" ("Cyberspace," n.d.) where big data is hosted. Futurist anticipates the futures and conducts futures studies with the combination of suitable methods and use of their insights within netocratic environment (Çifci & Yüksel, 2018). Futurizen, the term which is first used in Digital Futures Study (European Commission, 2016) are the contributors of the futures studies with their field knowledge and expertise interrogatively (Çifci & Yüksel, 2018). Futurist-netocrat owns both netocrat's and futurist's competencies for whom it is very high possibility to anticipate and shape the preferred future.

2.4 Foresight Functional Framework (FFF) Supporting the Research

Evolution of the foresight generations is the main deterministic factor of establishing the foresight frameworks. Many academics have been trying to be coherent with these changes of generations by defining foresight activities. In this way, to be in common terminology they have created ontology which provides the formulation of shared concepts in formal way (Studer, Benjamins, & Fensel, 1998) and elucidation of knowledge (Abdollahi, Fasanghari, Mohammedpour, Soltani, & Nili, 2008). In Table 3 the most prominent frameworks for foresight in the literature are shown by being matched of which phases.

Table 3 Matching the Phases of the Most Prominent Foresight Frameworks in the Literature with the FFF (Yüksel & Çifci, 2017)

	Yüksel&Çifci (2017)	Martin (1995)	Miles (2002)	Voros (2003)	Bishop&Hines (2006)	Schultz (2006)	Sarıtaş (2011)
	Foresight Functions	Foresight Process	The Foresight Cycle	A Generic Foresight	Framework Foresight	Key Activities of Integrated Foresight	Systemic Foresight
F	Framing	Pre-Foresight (Decision, Preparation)	Pre-Foresight	Inputs	Framing		
O	Obtaining		Recruitment		Scanning	Identify and monitor change	Intelligence
R	Reviewing	Foresight (Process Design, Strategic Analysis, Agreeing, Disseminating)	Generation	Analysis Interpretation		Asses and Critique Impacts	Imagination
E	Establishing			Prospection	Forecasting	Envision Preferred Futures	Integration Interpretation
S	Sythesizing						
I	Illustrating			Outputs	Visioning Planning		
G	Guiding			Strategy		Plan and Implement Change	Intervention
H	Handling	Post-Foresight (Implemantation, Allocation)	Action		Action		
T	Tracking		Renewal				Impact

Among these frameworks, Functional Foresight Framework (FFF) by Yüksel & Çifci, (2017) defines foresight functions with easily memorable acronym as FORESIGHT.

FFF will be used as base framework in application of technology foresight in this research. Each function of FFF is explained with the related actions in the Table 4.

The functions of FFF are sequential and each successive function is related to and dependent on each other in some aspects.

Table 4 Explanations of the Functions in FFF

FFF	Functions	Actions
F	**Framing**	Defining foresight purpose, time horizon, context and content.
O	**Obtaining**	Determining and gathering participants from stakeholders, collecting data and information
R	**Reviewing**	Sharing opinions and ideas on collected data and information, grouping and analyzing them to be evaluated.
E	**Establishing**	Imagining the future without any knowledge and thinking about the future with the knowledge created by combining data, information, ideas and opinions in the minds.
S	**Synthesizing**	Putting alternative future thoughts together, linking them to the present conditions and resources in interpretive manner with negotiation, conflict resolution, facilitation.
I	**Illustrating**	Demonstrating the possible future, broadcasting it with multimedia and social media, generating reports to create awareness and contribute learning process.
G	**Guiding**	Planning about actions and changes those will be carried out, developing strategy and roadmaps.
H	**Handling**	Conducting actions, dealing with changes and solving the problems of application.
T	**Tracking**	Tracing outcomes and assessing the results of handling, performing short term evaluation analysis and mid-long term impact analysis to take lessons and contribute to the learning process.

2.5 Foresight Periscope Model (FPM) Supporting the Research

The periscope used as an instrument to search any object on the surface of the water was selected as an analogical tool to model the foresight since both have very similar features. In FPM developed in (Yüksel & Çifci, 2017) and given in Figure 4 how periscope has its sight range, angle and resolution; foresight has also time-horizon, scope and capacity in effective determining the alternative futures respectively. Periscope needs trained and capable users; foresight requires experts and capable conductors to direct the participants in the same way. Periscope houses its main parts making it operate under the water to see the unknown surface; the foresight has its main elements such as resources and methodology, which are related to present also coming from accumulations of past providing it to generate futures strategies with respect anticipated uncertain and unknown futures likewise. The more efficient and effective parts under the water the periscope has, the more correct detection of the object on the surface occurs. So, well-defined and properly selected resources and methodology causes more successful strategies for the futures.

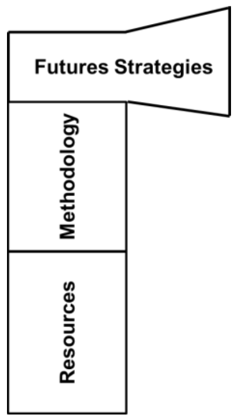

Figure 4 Foresight Periscope Model in the Periscope Tool (Yüksel & Çifci, 2017)

The resources of the periscope are comprised of hardware, software and users, whereas its methodology does needed adjustments by proper control units through some knobs and electronics. With the use of its resources and methodology, the aim of using the periscope is to detect the unknown object. Since resources are restrictive for methodology it is the base which determines the methodology of foresight at the second layer in the FPM. Methodology is chosen with respect to the resources as well as the objective and scope of foresight. Methodology enables anticipating the futures and generating strategies.

2.5.1 Resources of FPM

Resources are comprised of time, money, team, political support, infrastructure and culture (Popper, 2010). In the FPM, resources are grouped as tangible and intangible mainly. Tangible ones are infrastructural, financial and human resources whereas intangible resources are time; structure, processes and culture; information and knowledge; science, technology and innovation capabilities. These grouped of resources are generic in organizational, sectoral, national and international level as shown in Figure 5.

Infrastructural resources are the physical environment which might be comprised of industrial organizations, research institutions, universities etc. Archives, databases, networks and libraries are very powerful tangible instruments to make foresight conducted easily (Popper et al., 2007a).

Financial resources are the money funded by organizing institution, sponsors or voluntary groups. This amount corresponds to "participator's expenses, meetings and events' charges, travel, production and dissemination of publicity material, extensive consultation processes such as questionnaire surveys and other routine activities" (UNIDO, 2005b).

Time is the period of fulfilling foresight studies. The financial resources, the scope of the study and some national, sectoral, regional and organizational external and internal forces like politics or amount of stakeholders put restriction on it. For the national level it is extended to 1-2 years whereas it is shorter in organizational level since it is focused more specific fields (UNIDO, 2005a).

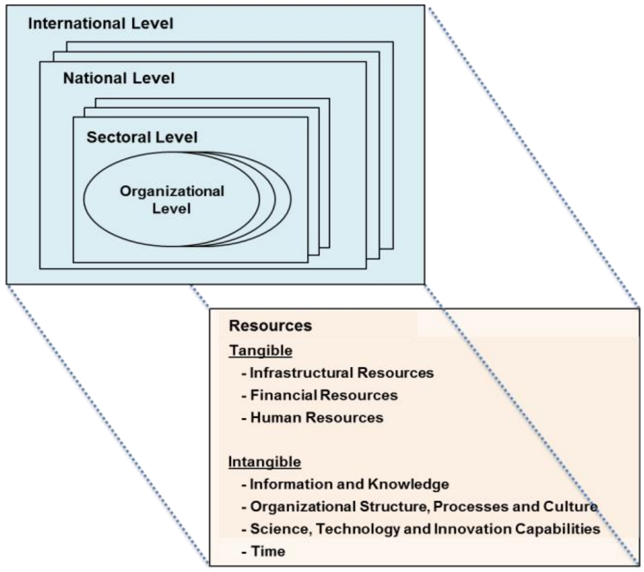

Figure 5 Resources of FPM (Yüksel & Çifci, 2017)

The structure of an organization or sector determines how the activities are conducted for the aims of the organization and sector in which flow. If the structure allows the knowledge creation and sharing in an easy and effective way, it contributes to organizational culture and provides more learning. Organizational culture is comprised of the values, meanings, beliefs and sharing of the people in the organization (Lupşa, 2016). According to Zali (1999) this organizational culture forms the behavior of the people and learning takes place because of the change in the behaviors. Since foresight studies create the foresight culture between all stakeholders and needs commitment; learning also occurs within this process. Effective foresight require flexible structure leading to knowledge management, proper culture provides learning to take risks and establish commitment between industry, academia and competitors are also inside these resources (Miles & Keenan, 2003).

Information and knowledge, which is not undiminishing even how much it is used, is the heart of foresight studies. According to Cooper (2010) "information is data together with a context, so that it gains meaning for the recipient. ... Knowledge is information that is structured and organized as a result of cognitive processing and validation". In the literature, knowledge is defined as explicit and implicit. Explicit knowledge can be expressed with words and numbers in open manuals, specifications or mathematic expressions (Smith, 2001) It is easy to gain, reach and reveal. Implicit or tacit knowledge, which is very hard to gain, reach and reveal, come from the experiences, intuitions, skills and mental models (Nonaka & von Krogh, 2009). Data, information and the knowledge are required in doing things right for past and present; wisdom, ability to increase effectiveness, is required in doing right things and it is related with the future (Vaes, n.d.).

The data, information, knowledge and wisdom a renewable, reusable and accumulating resource of organizations when applied in the organizational activities (Aktharsha, 2010). Within the foresight studies all kinds of them are needed in different steps, so there are very crucial resources for the success of the foresight.

Science is defined as "the careful study of the structure and behavior of the physical world, especially by watching, measuring, and doing experiments, and the development of theories to describe the results of these activities". Technology is the application of science. Having the infrastructure of science and technology being able to use it are very competitive for the nations (Xu, 2012). Innovation is the creation of new products, services, processes or structure having the characteristic of monetary value in the markets. Changing the environments of science, technology and markets and increasing competitiveness necessitate innovation (Goffin & Mitchell, 2010). The capability of science, technology and innovation is the indicator of knowledge and changes, which are the key elements of foresight studies.

2.5.2 Methodology of FPM

Method is the setup defining the way of doing something (Dictionary.com, 2017). The set of methods in logical and systematic form for special goals constitutes methodologies. In foresight studies, establishing the methodology by combining required methods in the proper order is very crucial for the success. Without effective methodology, the resources of foresight are not benefited efficiently. In the same way, if there is no active involvement of participant and commitment between stakeholders, methodology is useless. Slaughter (1997) states the importance of these factors, as “without this immersion there are likely to be many personal, cultural and organizational factors that go unnoticed and thus affect subsequent work in hidden ways”. At the beginning of foresight studies, it had been using forecast methods (Loveridge, 1996). Scapolo & Miles (2006) points out that simplification is the need for the methods by questioning “how they are used and on what subject”, “who apply them for what purpose”. So, also with the improvement and proliferation of foresight studies, academics have studied about the classification of the foresight methods with respect to some criteria to understand and select them well. But most of the scholars have not stated the criteria or the reason for the classification of methods in the literature (Yüksel & Çifci, 2017). In Table 5, the methods with their author's terminology used for their own grouping such as taxonomy, classification and typology are shown with their criteria in different colors. It has not been given any terminology to some groupings by the corresponding author, so they are named as simply grouping by (Yüksel & Çifci, 2017).

Table 5 Foresight Methods in the Literature According to Criteria Set by the Scholars (Yüksel & Çifci, 2017)

Author	Criterion	Grouping/Classification/Typology/Taxonomy
(Glenn, 1994)[6]	By Technique	Quantitative
		Qualitative
	By Purpose	Normative
		Exploratory
(Popper, 2008b)	By Nature	Quantitative
		Qualitative
		Semi Quantitative
	By Capacity	Creativity
		Evidence
		Expertise
		Interaction
	By Frequency	Widely used
		Commonly used
		Less frequently used

[6] Glenn didn’t define what the meanings of qualitative and quantitative in foresight are and give difference between them.

Table 5 (cont'd) Foresight Methods in the Literature According to Criteria Set by the Scholars (Yüksel & Çifci, 2017)

Author	Criterion	Grouping/Classification /Typology/Taxonomy
(Moll, 1996)	By Aspects	Extrapolative
		Normative
		Pragmatic
(A. L. Porter, 2010)	Not specified	Creativity Approaches
		Monitoring & Intelligence
		Descriptive
		Matrices
		Statistical Analyses
		Trend Analyses
		Expert Opinion
		Modeling & Simulation
		Logical/Causal Analyses
		Roadmapping
		Scenarios
		Values/Decision-aiding/Economic Analyses
		Combinations
	Not specified	Hard
		Soft
	Not specified	Exploratory
		Normative
(Inayatullah, 2001)	Not Specified	Predictive
		Interpretive
		Critical
		Participatory
(Loveridge, 1996)	By Activity	Creativity
		Expertise
		Interaction Alignment
	By Aspects of Future Models	Intentional-Formal
		Intentional-Informal
		Accidental-Formal
		Accidental-Informal
(Saritas, 2013)	By Spectrum	Divergent
		Convergent
(Slaughter, 1997)	By Functions	Input
		Analytic
		Paradigmatic
		Iterative& Exploratory
(Lüdeke, 2013)	Not Specied	Quantitative
		Qualitative
		Interface
(Miles & Keenan, 2003)	By Characteristics	Exploratory/Normative
		Quantitative/Qualitative
		Expert based/Assumption based
	Not specified	Identifying Issues
		Extrapolative Approaches
		Creative Approaches
		Prioritization

Table 5 (cont'd) Foresight Methods in the Literature According to Criteria Set by the Scholars (Yüksel & Çifci, 2017)

Author	Criterion	Grouping/Classification/Typology/Taxonomy
(Aaltonen & Sanders, 2006)	By Perspective	Mathematical
		Social
		Engineering
		System
(Voros, 2006)[7]	By Modes of Thinking	Evolutionary
		Revolutionary
	By Level of Depth	Event
		Trend
		System
		Worldview
		Historical
(Magruk, 2013)[8]	By Classes	Consultative
		Creative
		Prescriptive
		Multi-criteria
		Radar
		Simulation
		Diagnostic
		Analytical
		Survey
		Strategic

Glenn (1994) classified 19 methods according to their techniques -qualitative or quantitative- and their purposes -normative or exploratory-. Normative methods are defined as trying to search the answers of *what desirable future is* whereas exploratory ones are looking for the answer of *what the possible futures are* and *whether they are desirable or not.* In Glen's classification, one technique can be interpreted as both normative and exploratory whereas it can also be both qualitative and quantitative like environmental scanning, cross impact analysis, gaming and simulation, scenarios.

Popper (2008) characterized the methods according to their nature as qualitative, quantitative and semi-quantitative by evaluating the outputs of European Foresight

[7] "The classification is just for Voros' prospective methods of foresight (Yüksel & Çifci, 2017)".

[8] "Classes of methods were evaluated by contexts which are technological, social and cognitive and foresight stages which are preliminary, scanning, recruitment, main, planning, acting, evaluative and resuming (Yüksel & Çifci, 2017)".

Monitoring Network (EFMN) study, which covers 886 cases. He defines qualitative methods as having subjective interpretations and creativity; quantitative methods, as methods principles of which are variable measurement and statistics dependent and semi-quantitative methods, as methods that quantify subjectiveness. 15 qualitative, 3 quantitative and 6 semi-quantitative methods and also *exercise-applied methods* named 'other methods' are included in his study. Methods were also separated with regard to capabilities collecting and processing information as evidence, expertise, interaction and creativity, which are called as "genetic components of methods" by Popper. The grouping of foresight methods was shown as the corners of the diamond and Popper placed 23 methods in the foresight diamond. Evidence uses credible sources as documents, statistics and different measurement indicators to capture the reality. Expertise requires accumulated tacit knowledge on special subjects; interaction includes participation of different parties, like experts and non-experts to make foresight process legitimate and effective. He also differentiated the methods according to its usage frequencies as widely used, commonly used and less frequently used by analyzing the case studies. Literature review, expert panels and scenarios were appeared as the most used methods, extrapolation/megatrends, workshops, brainstorming, Delphi were recognized as common methods whereas roadmapping, modeling/simulation and back casting were analyzed as the least frequently used methods.

Moll (1996) classified the methodologies of future studies in three main aspects, which are extrapolative, normative and pragmatic. Extrapolative methodologies, which are mostly developed in the US, use previous information for estimation and planning; they are based on existing approaches and policy conformity. Normative methodologies, which are mainly from European origin, target preferred futures in utopic and radical way; pragmatic ones, which are based on the idea of human action is the most deterministic factor in future shaping, provide active participation and commitment for *economic, social, political realization*.

Porter (2010) presented 13 families of Future Oriented Technology Methods as indicated in Table 5 and assigned 48 methods into these families although some of them could be included in two or more families. Creative approaches force thinking in different ways, monitoring and intelligence methods are used to reveal and capture available information while descriptive methods and matrices prepare that information for interpretation. Trend Analysis looks at the time series of past data and try to find out their future reflections although the use of statistical methods is restricted in foresight. Expert opinion can be mixed with empirical analysis while modeling and simulation can be qualitative or quantified. Logical/Causal Analysis evaluates the implications with if/then statements; roadmapping conditions for the future to provide input to Science and Technology planning. Scenarios generate the alternative futures whereas valuing/decision-aiding/economic is used to evaluate the policy and actions. Lastly, combinations mix the available methods for better foresight. Porter also named quantitative methods as hard methods, which are based on numbers and experiments; whereas qualitative methods as soft methods.

Inayatullah (2001) differentiated future studies' methods by the classification of predictive, interpretive, critical and participatory. Predictive methods use empiric techniques in social studies and they are like extrapolative methods of Moll while interpretive methods' aim is to understand the future beyond forecasting it. Critical methods look for the answers of the questions that for whom realization of particular futures provide benefit and which methods are privileged for those futures. Participatory methods are collective future building process of stakeholders contingent upon their own assumptions.

Loveridge (1996) mentioned about the impossibility of modeling the future entirely but he put forward a triangle of methods based on foresight activities, which has edges called creativity, expertise and interaction alignment for the perceived future model building. Creativity and expertise depend on the knowledge flow coming from monitoring and become meaningful when interaction is provided between them. He also presented taxonomy formed with the nature of the model (formal and informal) and how future models are generated (intentional and accidental). The future methods are grouped according to taxonomy as intentional-formal, intentional-informal, accidental-formal and accidental-informal. Intentional-formal methods are target oriented, computable and quantitatively manipulated like real-time simulation, virtual realities, visualization, tactile sensation, cross impact, econometrics and system dynamics. Intentional-informal ones are the scenarios generated by the groups or individuals needed at that time for that subject like *books, pamphlets*. Accidental-formal methods are the ones used for unsponsored models developed with unstructured manner like multiple scenarios. Accidental-informal methods are for the models developed mostly conceptually and based on observation; they are like *fiction, plays, dreams and utopian writings.*

Saritas's (2013) spectrum of methods extends from convergent to divergent methods. Convergent methods are more quantitative methods while divergent methods require more creativity. In foresight, divergent and convergent methods can be used in both exploratory approach and normative approach. Exploratory approach searches the evidences and emerging developments' signals while normative one focuses on accomplishing specific future (Miles, Saritas, & Sokolov, 2016). There is also no restriction in using divergent or convergent methods together according to approach.

Slaughter (1997) grouped future methodologies into four main headings as input methods, analytic methods, paradigmatic methods, and iterative and exploratory methods according to their different functions in his strategic foresight study. He specifies input methods as the ways of collecting material by asking high quality questions in capable manner whereas he identifies analytic methods as connected methods to previous steps which should be determined, like in cross impact analysis that requires the exploration of the factors and their relations in the environment before it is applied. Delphi technique and environmental scanning are the examples of input methods; trend analysis and back casting are some techniques used as analytic methods. Paradigmatic methods are used to comprehend the phenomena effectively -which are not superficially capture the process- and enable foresight to do deep analysis with the disciplinary paradigms on personal, cultural, religious and social concerns (Slaughter, 1997). They complement the empirical methods and provide social construction for future studies. Casual layered analysis, critical future studies and system thinking are the examples of pragmatic methods. Fuller and Loogma (2009) state that foresight is social construction itself but also the mechanism for social construction. In this view, they define foresight as the selection of symbols representing ideas, actions, models etc. by making them meaningful with negotiation and an approach produced and assimilated by society called social construction. Iterative[9] and exploratory methods like scenario building discover the future states and options also by examining the current internal and external conditions (Slaughter, 1997).

Lüdeke (2013) grouped the foresight methods as quantitative, qualitative and interface methods, which are bridging of first two. He emphasized the importance of the variable definition in quantitative techniques, transparency and explicitness of underlying assumptions in modeling for quantitative techniques though they are favorable in generalization of large case numbers in the expense of missing outliers. Qualitative methods provide comprehensive data and focus on each case including extreme ones more profoundly in a closed loop with feedback mechanisms when it is compared to linear approach in quantitative methods. Interface methods are used to combine the use of qualitative and quantitative methods unlike just merging the results of each. They are such as being contingent on variables but at the same time covering outliers or qualitative understanding of quantitative variables' development in time. Qualitative Case Study Analysis (QCA), which is used to apply rules for many cases and Qualitative Differential Equations (QDE), which is the equation form of qualitative interpretation of system variables and their change in time series are some interface methods to combine quantitative and qualitative techniques.

Miles and Keenan (2003) grouped foresight methods as exploratory/normative, quantitative/qualitative and expert/assumption based on their characteristics. Exploratory methods such as trend, cross-impact analysis and Delphi start with 'present' and determine the critical points and actions through time for desired future where normative methods like relevance trees, morphological analysis and success scenarios start with desirable future or futures and go back to the present by evaluating how they can be realized with the available resources. Quantitative techniques are handled as numeric representations whereas qualitative techniques are used when numeric indicators or data related with key trends and developments are absent. Expert-based techniques depend on the expert opinions and inferences by sampling of the general public. Assumption based techniques are the ones those use

[9] Slaughter didn't explain the iterative feature of the methods.

explicit knowledge to detail visions and priorities. Delphi, cross-impact analysis and scenario workshops are some of expert based methods; simulation, modeling and scenario building are the assumption-based methods. Miles and Keenan (2003) also presented the typology of foresight methods. Although there is no information about how and on which criteria this typology was done, 13 methods are assigned to groups for identifying issues (environmental scanning, SWOT [Strengths, Weaknesses, Opportunities and Threats) analysis, issue surveys], extrapolative approaches (trend extrapolation, simulation modeling, genius forecasting), creative approaches (brainstorming, expert panels, cross-impact analysis, scenarios) and prioritization (critical technologies, technology roadmapping).

Aaltonen & Irene Sanders (2006) put forward a landscape from which it is understood that how the use of methods and theories affect the perception of the *environment and the outcomes of the strategic process*. In the landscape while mathematical complexity and social complexity try to find the answers about emerging futures, engineering approaches and system thinking look at the strategic management. Engineering approaches and mathematical complexity are based on the rules reducing ambiguity; social complexity and system thinking include more uncertainty in heuristic approach. Rules and heuristic are used to command the systems; design and emergence are the nature of possible understanding of systems as contrasting elements. Designing of a system can be accomplished by the ability of manager but the emergence of the system is provided by the interaction between the actors. Aaltonen & Irene Sanders (2006) classified methods according to these four distinct perspectives and placed 41 methods onto the landscape by concluding that most methods are used to decrease the ambiguity with more knowledge whereas the least number of methods allowing uncertainty concentrate on social complexity. Roadmapping, text mining, and environmental scanning are some methods within engineering approach; Delphi, wild cards, prediction markets and simulation/games are the methods of system thinking. Morphological analysis, relevance trees, substitution analysis are some methods included in mathematical complexity; participatory methods, casual layered analysis and visioning take place within social complexity.

Voros (2006) accepts foresight as a separate discipline because of its systematic structure and prospective thinking characteristic and classifies prospective methods according to future thinking modes and different depth levels of prospection under the name of *mode level analysis*. Evolutionary future thinking method starts from determined point –mostly present- and tries to find out answers about future through continuous and accumulative time, while revolutionary method leaps to different future states in discrete manner without being dependent on the previous states (Voros, 2005a). Contingent upon divergent layers of reality, different levels of interpretive depth named as event, trend, system, worldview and historical were presented by Voros (2006). The depth levels of interpretation were determined from the Voros' Generalized Layer Methodology (GLM) consisting of strata, which are constructs, contents, capacities and conditions beneath the visible events (Voros, 2005a). Trend is the observing level of emerging forms and trends corresponding to Slaughter's pop level[10] and Inayatullah's litany level[11] in Casual Layered Analysis (CLA), system is the level of interpretation of system drivers and structures corresponding to Slaughter's problem-oriented level[12] and Inayatullah's social causes level[13]. Beneath the system level, consciousness and comprehension are the fundamental pillars of mental models and worldviews, which constitute worldview level of interpretive depth matching with the Slaughter's critical level[14], Inayatullah's worldview/discourse[15] and myth/metaphor level[16]. The deepest level is called

[10] Slaughter's shallowest level (first level) of futures thinking, level of reading trends.

[11] Inayatullah's first level of casual layered analysis of future, level of perceiving quantitative trends, issues especially imposed by media and politicians.

[12] Slaughter's second level of futures thinking, level of dealing with the reactions of society and organizations in the face of challenges for short term future.

[13] Inayatullah's second level of casual layered analysis of future, level of quantitative interpretation of social causes like *economic, political, cultural and historical factors*.

[14] Slaughter's third level of futures thinking, level of going deeper the social reasons by questioning assumptions.

[15] Inayatullah's third level of casual layered analysis of future, level of finding profound *social, linguistic and cultural structures.*

historical which includes both time and space dimensions on society, history and macro-historical changes.

Magruk (2015) puts forward 10 classes of foresight research methods as shown in Table 4, related them according to their strengths on technological, social and cognitive contexts and also foresight steps. Classes complement each other and use the common information resources. Magruk (2017) explains the properties of each class and reveals the connection of them with uncertainty. Consultative methods are based on expert judgments while creative ones include discovery of relations and generation of new ideas. Prescriptive methods identify the current and future conditions; multi-criteria methods are used to choose among alternatives, prioritization and decision-making and radar methods concentrates on monitoring, detection and estimation of emerging signals about innovations by evaluating past and present. Simulation methods use mathematics to revive thoughts in real environment and form codified outputs. Diagnostic methods are related with understanding and evaluating the present system together with its potential boundaries, issues and ambiguities where analytical methods focus on longer period assessments, strength and level of developments. Survey methods evaluate the knowledge of present state and use secondary data, like publications, statistics, databases etc. Strategic methods are used in formulation of the results in *planning, decision-making, scenario building and change management*.

2.5.3 Futures Strategies of FPM

The final step of the Foresight Periscope Model titled as Futures Strategies serves to establish alternative futures and perspective to create future strategies based on resources and methodology. Strategy is defined in dictionary as "A plan of action designed to achieve a long-term or overall aim" (Oxford Dictionary, 2017). One of the main scholars of strategic management Michael Porter points out the difference between strategy and operational effectiveness underlining that "The essence of strategy is choosing a unique and valuable position rooted in systems of activities

[16] Inayatullah’s fourth level of casual layered analysis of future, level of unconscious and emotional dimension of worldview.

that are much more difficult to match" (M. E. Porter, 1996). A similar theory named Blue Ocean Strategy by Kim & Mauborgne (2004) suggests creating new markets or expanding the existing Red Ocean markets, where the competition is high. The desired aim of organizations and people from these strategies is to be prepared for the potential and get to the desired future with desired benefits for the organizations, society and environment.

The terms for alternative futures can be defined as clusters that are sometimes in relation with each other. The broadest one, beyond current knowledge and imagination is potential future; plausible future is the one obtainable with current knowledge; current trends leads to probable future and finally preferable future which can intersect with all these counted futures is the desired one (Voros, 2005b). Due to the unknown nature of the futures', the challenge of strategic vision is to reach the preferred future. In foresight there are countless potential futures "depending on action or non-action at present", yet the one obtained will be just one of them (Grupp & Linstone, 1999).

Dator's first law of future suggests "The future cannot be 'predicted' but alternative futures can be 'forecasted' and preferred futures can be 'envisioned' and 'invented'- continuously" (Sardar, 2010b). Slaughter (1995) enhances this law about foresight stating that it is not the ability to predict the future, it is a human attribute that allows us to weigh up pros and cons, to evaluate different courses of action and to invest possible futures allowing prevention from undesirable futures. Since there are various futures, there are also many different ways to get to them combination of which brings about the scenario (Godet & Roubelat, 1996). Although scenarios reflect the projections of change (Ringland, 2010), they are different from strategies in the sense that "scenarios depend on the type of vision adopted (exploratory, normative or retro projective[17]) and on probability, strategies depend on attitudes adopted in the face of possible futures" (Godet & Roubelat, 1996). In short, scenarios show states while strategies show stances.

[17] In retro projective, there are no scenario objectives but only strategies (Godet & Roubelat, 1996)

Scenarios can determine strategies, for instance, probable futures can be established with similar scenarios with some certainty and a risky or a reliable strategy can be chosen whereas in case of more uncertainty flexible strategies are required. In all cases there is always a risk in strategies, therefore apart from the negative issues analyses in risk assessments, foresight and risk assessments have a lot in common (Durance & Godet, 2010). In literature, scenarios are built in consecutive steps of definition of the subject, stating the drive, constraints, trends and stakeholders, then concluded with an evaluation taking account of ambiguities and significances brought by the former steps (Amer, Daim, & Jetter, 2013). Different from foresight, scenarios are endless and used for decision-making to make foresight (Durance & Godet, 2010). Since scenario building needs contemplating and takes time, the number of hypotheses should be limited to four to six (Durance & Godet, 2010).

Unlike strategic vision, strategic foresight enhances the perception of possibilities for alternative futures (Slaughter, 1995). Strategic foresight is about the key figures affecting the desired outcome in a positive or a negative manner (Hammett, 2005). From this point of view, in organizations as a strategically thinking foresight takes part in strategy development and planning (Voros, 2005b). The meaning of strategy development is interfering the present while strategic foresight easily incorporates drastic changes (Amer et al., 2013). (Conway, 2015) states that to get integrated with strategies foresight should take part in strategy development, and this approach is called Foresight Infused Strategy Development. Strategies are constructed by means of strategic thinking, development and planning. Strategic thinking results in different alternatives; strategy development is about making decisions and setting the goal and strategic planning is determining the actions to be taken (Voros, 2005b). It should be noted that in the literature there is confusion between strategic thinking and planning. According to Mintzberg strategic thinking and planning are both modes of thinking used in different stages of management, and Porter claims that unlike strategic thinking, analytical strategy planning is a creative action. Some scholars think that strategic planning is used for strategic thinking and where some others find it useless (Heracleous, 1998). "Strategy development is revealing the insights whereas strategic planning is converting them to the actions" (Yüksel & Çifci, 2017). Roadmapping is one of the used methods to plan the actions in the strategy. In technology roadmapping, the changing technologies, products and the markets are linked together visually and sequentially in general according to some of their aspects throughout time (Phaal, Farrukh, & Probert, 2004). With such methods, the strategy speeds up the processes clearing the uncertainty by increasing the awareness about possible futures and its outcomes (Luhmann, 2006). Therefore approaches for future studies are changing drastically, becoming more exploratory than predictive making iterations of foresight. In addition, this process is performed not only by executives but also by other participants including the process users, which allows an easier and systematic policymaking (Miles & Keenan, 2003).

Foresight study can allow predicting the developments to be made in future by means analyzing the present. The main indicator of success of a foresight study is increase level of awareness of the contributors about plausible futures (Schatzmann, Schäfer, & Eichelbaum, 2013). Hammoud & Nash (2014) have observed interviewees from a group of participants and pointed out the most important benefit of the foresight study as "shaping the future" which means to have a look at alternatives of future, be able to guide management to shape the future, provide means to determine a strategy to obtain preferred future and change the mindset of employees to contribute the strategic process. In case of ambiguity, instead of "the best strategy" the main concern should be "the best strategy process" (Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005). This approach will bring proactivity changing questions from "what will happen to us?" to "what would we do if this or that should happen?" by means of using foresight process (Rialland & Wold, 2009).

Foresight Periscope Model doesn’t imply a specific way to determine futures strategies, however FFF (FORESIGHT) provides methods sequentially to be able to develop future strategies (Yüksel & Çifci, 2017).

2.6 Constructing the Foresight Methodology

Selecting the methods and integrating them together properly are two main stages of establishing the methodology. Miles & Keenan (2003) states that establishing the methodology with the right methods depends on the resources, objectives, scope and time horizon. In the first stage determining the criteria to chose the methods is crucial whereas the interface setting in the second section to combine them is needed to complete the meaningful constitution of foresight methodology. The foresight methods differ from each other in some aspects as can be seen from the Table 5. Some are useful in collecting data and information; some are effective in analyzing and synthesizing them with their own advantages and disadvantages.

2.6.1 Foresight Methods Selection in the Literature

Providing coherence between the foresight purposes with the methods means a lot since foresight quality does not just contingent on the methods themselves (Ciarli, Coad, & Rafols, 2013a). Organization strategy is another factor in methods selection therefore organization's capabilities and requirements should be taken into account for that (Schwarz, 2008). Slaughter (1997) points out that, the decision makers' precedence, organization type and environment in which it operates, the needs of organization, individual experiences coming from previous foresight studies and the kind of problem subjected are the determinants of methods selection. The tradition of the organization for practitioners in such activities and context of organization affects the methods selection (Conway, 2006). Firat et al. (2008) adds to them the industry where the organization operates by analyzing the results of the study covering the Europe and North America's big institutions named as ‘Technology Intelligence Process in Leading European and North American Multinationals’ by E. Lichtenthaler, According to analysis, publication citation analysis is dominant in science driven industries such as pharmaceutical industry whereas it is not so meaningful in market driven industries such as telecommunication and automotive. According to Keenan (2007) time, money, the kind of participation, learning from previous practices, the desired outputs of foresight, the self-competency of the method, the conformity with the other methods, the required data type -quantitative/qualitative- and the objective of foresight study are the criteria of methods selection. Popper (2008a) set forth the criteria based on theoretical background and on the practical works. According to theoretical background, "project budget, availability of expertise, political support, technological and physical infrastructure and time" are the method selection factors. For the criteria from practical works in which foresight cases are investigated by European Foresight Monitoring Network (EFMN) and "it determines 11 factors as nature of methods, capabilities of methods, geo-R&D context[18] domain coverage, territorial scale, time horizon, sponsorship, target groups, participation scale, codified outputs and methods mix which influence the foresight method selection" (Yüksel & Çifci, 2017). Impossibility of covering the whole future which is the most important limitation of foresight (Loveridge, 1996) and the risk are the factors affecting the selection of methods (A. L. Porter, 2010). The risks in the foresight are going with linear models, blurriness of the assumptions, having not sufficient expert ideas in addition to the difficulties of creating flexible nonlinear models and searching of the big databases (A. L. Porter et al., 2004). Porter et al. (2004) emphasizes the importance of making explicit assumptions to establish common understanding between the stakeholders and having the data availability.

Levary & Han (1995) underlines that "extent of data availability, degree of data validity and degree of similarity between proposed technology and existing technologies" (Yüksel & Çifci, 2017). According to them when there are similarities between the existing technologies and proposed ones in the case of having the big amount of data that has medium to high validity, correlation analysis or similar methods are suitable. If data have high validity, trend analysis is proposed. When the data is not enough and there is not correspondence between the suggested technology and the available technology, focus groups of experts, interviews or Delphi method are used. The expert-based methods are very logical if there is possibility of quick changes, sudden qualitative breaks and social and technological innovations (Miles and Keenan, 2002). In their study of foresight in BRIC (Brazil, Russia, India, China) countries which are weak about turbulences and social changes and are influenced by macro level conditions very easily, Chan and Daim (2012) suggest scenario analysis for such conditions. In the innovative and competitive environment, catching the emerging technologies is one of the most important determinants in methods

[18] Taking into account the country's geographic location and its gross expenditure on R&D (GERD) as a percentage of GDP (Popper, 2008).

selection. (Miles & Keenan, 2002) points out that bibliometrics and patent analysis are the needed methods to catch emerging patterns since there is no available and sufficient data for trend analysis. According to A. L. Porter (2010), science-based foresight which doesn't have enough data requires creative and monitoring/intelligence methods such as genius forecasting, environmental scanning and issue surveys instead of trend analysis or similar methods. He also adds the time horizon as important factor in methods selection by stating that scenario analysis is proper for long terms whereas extrapolative analysis is better for short terms. For the extrapolative analysis like simulations and trends, Miles & Keenan (2002) emphasizes the clearness of assumptions should be the base.

In this research; with the light of the suggestions presented in the literature, the FMSA output the selected methods with respect to the resources of FPM. The resources were determined by the researcher according to subject of the foresight study and the features of industry which cover the subject.

2.6.2 Foresight Methods Integration in the Literature

Combining the methods according to their inherent nature and the flow of foresight study is crucial for effectiveness. Popper (2008a) shows that qualitative methods are used more often although they are more prone to be open to errors compared to quantitative methods as a result of the EFMN study by researching 866 foresight cases. However, with the increasing number of stakeholders and the amount of data, the usage of quantitative data analysis also comes into prominence. According to A. L. Porter & Cunningham (2005), spreading the electronic data will bring the cyber world to the futures studies more. Within the same context, increasing importance of big data and rising methods such as webometrics and prediction market accelerate the usage of quantitative method (Ciarli, Coad, & Rafols, 2013b). The common insight among the foresight practitioners is that mixing the quantitative and the qualitative one will be the best solution by looking at the trends, but the process about mixing is at low rates (Haegeman, Marinelli, Scapolo, Ricci, & Sokolov, 2013). Haegeman, et al. (2013) sets three ways to integrate the qualitative and quantitative methods together. In the first one, qualitative and quantitative methods are conducted separately in parallel form or input-output relation in sequential form is established. In the second one, web-based interfaces are suggested to create static learning[19]. The third one provides the full integration of qualitative and quantitative such as quantification of the process and modeling the condition created by qualitative methods by providing dynamic learning[20]. Additionally, the foresight approaches determines the flow between the methods and their integration. If there is already a shared goal or desired future between the stakeholders the normative approach come into prominence (Miles & Keenan, 2002), otherwise exploratory approach is applied.

2.7 The Integration of FPM-FFF-FMSA

The FFF is also used as interface to integrate the methods together. FFF is the explanation for the methods according to their functions for FMSA but its methods can be expandable. The outputs of FMSA are in the integrated form by supplying sequential order of FFF. The methods in framing function are determined by the researchers, handling and tracing function might be kept outside of the study since there is no conductor and sponsoring institution. For the rest of the functions, FMSA output the methods and their sequential integration to establish the methodology. FFF was designed according to exploratory modifications. In FPM, the methods are selected according to the resources in FPM, the ranking of the methods are selected from FFF shown in Table 6.

Resources are given as inputs explained in section 2.8.1 addition with the answers of framing function in FFF by the researcher (since there is no sponsorship or commitment from any source) to FMSA and FMSA outputs the foresight methodology as stated in section 2.8.2.

[19] Static learning is limited in FTA studies since integration of quantitative and qualitative methods are stationary through predetermined structured process, which is not evolving during the process (Yüksel & Çifci, 2017).

[20] Dynamic learning includes different domains of knowledge and there is continuous flow of ideas so process provides evolution (Yüksel & Çifci, 2017).

The methods in Table 6 coherent with FFF were the choices for the FMSA and the outputs of FMSA were established by supplying sequential order of FFF. For the clarification of the models integration was given in Figure 8.

Table 6 Suitable Foresight Methods Coherent with FFF (Yüksel & Çifci, 2017)

Functions	Suitable Methods
Framing	Horizon Scanning, Literature Review, Visioning
Obtaining	Data Mining, Bibliometric Analysis, Literature and Statistics Review, Patent Analysis, Conferences/Workshops, Citizen Panels, Voting/Polling, Brainstorming, Interviews, Surveys, Benchmarking
Reviewing	Trend Analysis, STEEPL Analysis, Agent-based Modeling, System Dynamics, SWOT Analysis, SOAR Analysis, Horizon Scanning, Stakeholder Analysis, Cross-impact/Structural Analysis, Indicators/Time Series Analysis (TSA), Extrapolation
Establishing	Delphi, Simulation/Gaming, Expert Panel, Wild Cards, Science Fictioning, Backcasting, Genius Forecast, Multi-criteria
Synthesizing	Scenario Building, Visioning, Key/Critical Technologies, Quantitative Scenarios/ Cross Impact Systems and Matrices (SMIC)
Illustrating	Roadmapping, Essays/Scenarios
Guiding	Strategy Planning, Policy Recommendations, Critical/Key Technologies
Handling	Strategies, Policies
Tracking	Assessment, Survey, Bibliometric Analysis, Impact Indicator Development, Post Mortem Project, Policy Impact

2.8 Foresight Method Selection Algorithm (FMSA) Supporting the Research

In the literature there are some recommendations and evaluations regarding the method selection according to certain criteria. Hence, in the first subsection of this section some scholar's studies about the methods' selection and integration are mentioned. In the second subsection, the software algorithm developed within this research is explained in detail.

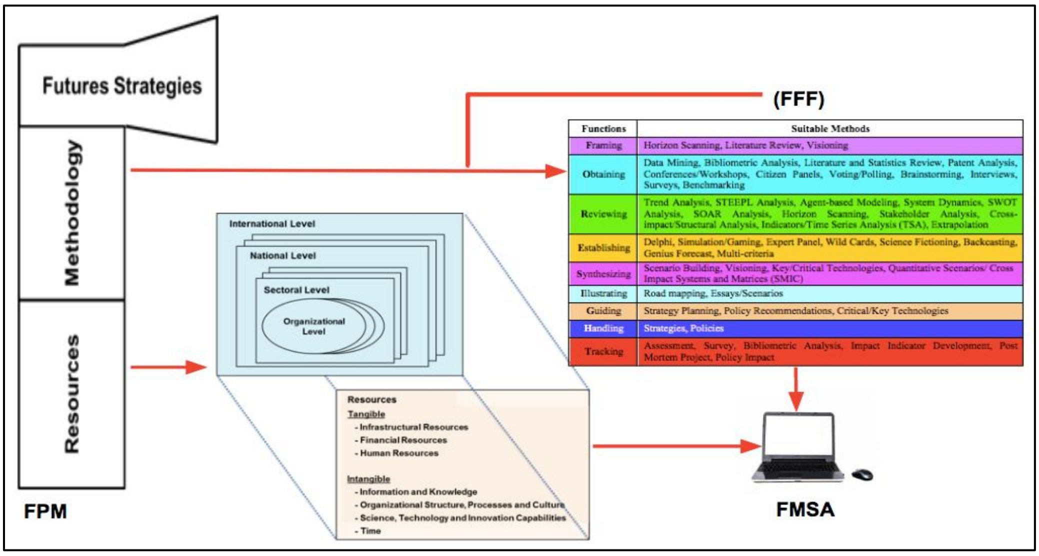

Figure 6 The Integration of FPM-FFF-FMSA

The FMSA algorithm was implemented in Visual C# program. In the interface, there are some sections to be stated by the users. These sections are; level of foresight, the sector in which foresight is operated and the resources. All the levels and resources of FPM, which were explained in section 2.5.1, are shown in Figure 5. The level and sector type are selectable from the list as inputs in the interface. In the resources section, there are questions about each tangible and intangible ones. The answers given to them are the inputs of the FMSA. The questions about Information and Knowledge become active when clicking on the related button. There are step-by-step pop-up yes/no questions about it. After all questions are asked about the Information and Knowledge, then the next one Organizational Structure, Process and Culture button becomes active to ask questions and accept the answers. Likewise the rest of the questions are answered in the same way for all resources. At the end the program evaluates the answers with its embedded algorithm; it outputs foresight approaches, suggested methods, core methods and supportive methods respectively. (Popper, 2008c) determined that six methods have been used as average in the EFMN study by examining the 866 cases. Being kept the number of methods at a certain level in the aspects of time, complexity and cost have been accepted as logical, so the suggested methods reduced to core methods and supportive methods by setting some criteria and eleven methods were set forth with the FMSA for this research. In the FMSA, four core methods were suggested by setting certain criteria which was established by the researcher's evaluations. To conduct these core methods, seven supportive methods were determined again by setting another criteria. Foresight approach was determined with respect to another criteria likewise as seen in Table 8.

2.8.1 Inputs of FMSA

Although all levels and some of the sectors are defined within the program but just sectorial level and defense sector subjected to this dissertation was implemented. The questions used are given in Table 7 as grouped with respect to resources' types.

The researcher gave the answers of these questions as inputs according to literature review and her work experience in defense sector as follows and stated them as No (Green colored) or Yes (Red colored) seen in the figures of The Interface Of FMSA section.

- The costs of the systems are quite high since they are very complex and sophisticated using high technology in addition to having long life cycle and being operable in heavy conditions are requirements (Ercan, n.d.).
- The life-cycle time[21] of defense sector's products is minimum 30 years in USA, and the systems acquisition costs are between 20% and 40% of the total costs as in seen in Figure 9 (Jones et al., 2014).
- Defense sector is controlled by governments to provide security and deterrence for the global and peripheral threads and to keep the peace (Ercan, n.d.). Therefore it is open to experience turbulences especially for the developing countries of which geo-politic importance.
- According to statistics of Defense and Aviation Sector (SASAD, 2017) there are 44.740 employments. The engineer percentage is about 31%, (13.703) so it is evaluated that there is intensity in design and development activities in addition to increase in the tendency to the employment of the personnel with academic

[21] "The product life cycle describes the period of time over which an item is developed, brought to market and eventually removed from the market. The cycle is broken into four stages: introduction, growth, maturity and decline" (INVESTOPEDIA, 2018).

career. 62% of the total engineers have bachelor degrees, 34% have master degrees and 4% of them have Ph.D. degrees.

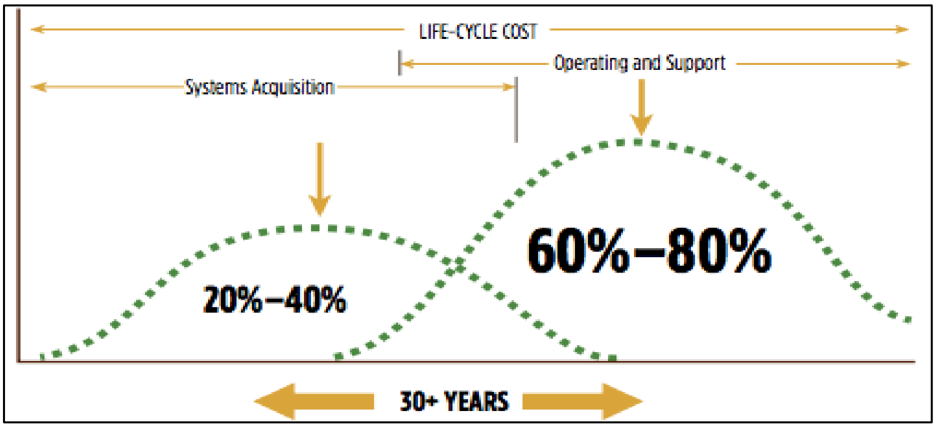

Figure 7 Life-Cycle Time of Defense Sector Products (Jones et al., 2014)

- There are some public and private institutions operating in defense sector. TAI Inc. (Turkish Aerospace Industry) and TUBİTAK-Space are the most prominent organizations directly operating in aerospace field. ASELSAN Inc., HAVELSAN Inc., Space&Defence Technologies (SDT), METEKSAN DEFENCE product support and services. There are also lots of techno parks, clusters and nongovernmental organizations like, Defense and Aerospace Industry Manufacturers Association (SASAD), OSTİM Defense and Aviation Cluster (OSSA), Defense, Aviation and Space Cluster Association (SAHA) İzmir Space and Aviation Cluster, Eskişehir Aviation Cluster, Bursa Aerospace Defense Cluster. All these are assessed as there exist enough public and private organizations and networks in the area of aerospace in defense sector.
- Responsibility of Presidency of the Republic of Turkey Undersecretariat for Defense Industries for the networking, organizing and conducting the projects facilitates to have common platform and database for the institutions.

- According to OECD (Organization for Economic Co-operation and Development) statistics Turkey's triadic patent[22] indicator was 49.68 for 2015 while it was 2703 for Korea, 4454 for Germany, 67.33 for Brazil and 38.54 for Saudi Arabia. From these indicators it is clearly seen that there are fewer patents.
- Turkey's GERD (Gross domestic spending on R&D) was 0.945 in 2016, while OECD average was 2.337 (OECD, 2018a).
- These indicators also show that defense sector is not science or innovation driven. The products and systems in the global defense market are trying to be caught.
- The data for defense industry is very difficult to reach because of confidentiality. The export and import data is kept and shared by mainly SSB, SASAD, SSI (Defense and Aerospace Industry Exporters' Association) etc. In the world, SIPRI and World Bank databases are the fundamental sources of data. Since these data is market related data so, any data availability about technological researches about current and emerging technologies, taxonomies of certain technology areas and technology readiness levels are lack of Turkish Defense Industry. Absence of independent technology management companies focusing on defense sector to do research and establish databases is evaluated as the problem of data availability, validity and extensity.

Additional inputs of FMSA are the answers of framing functions given by the researcher in Table 7.

[22] "Triadic patent families are a set of patents filed at three of these major patent offices: the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO) (OECD, 2018b)".

Table 7 FPM Resources' Types and Related Questions for FMSA

Intangible Resources	Information and Knowledge	1-Are there available accurate historical data? 2-Ara data valid? 3-Is extend of data availability large? 4-Is foresight time horizon is 10 years or longer? 5-Is there correspondence between the existing and the most advanced technology? 6-Are there well-defined and clear assumptions?
	Sectorial Structure, Process and Culture	1-Is there already shared goal or common preferred future? 2-Are there rapid changes, qualitative breaks and social/technological innovations? 3-Are there satisfying objectives for technological competitiveness? 4-Is it largely affected by macro level conditions or open to experience turbulence? 5-Are there situations with distinct levels of complexity? 6-Are systems' costs huge? 7-Is it market driven? 8-Is it science driven? 9-Is it innovation driven? 10-Are there lots of stakeholders and audience? 11-Does R&D take long time? 12-Is Life-Cycle-Period of systems more than 10 years?
	Science, Technology and Innovation Capacity	1-Is GERD 2% or higher? 2-Is there a capability to catch or create emerging patterns? 3-Are there effective networks between stakeholders? 4-Is there triadic patent families' number more than 500 (priority year)? 5-Does it depend on multi variables of which interactions are not linear? 6-Is doctoral graduation rate at typical graduation age (as percentage of cohort) in science and engineering bigger than 0.4?
	Time	1-Is foresight implementation time 1 year or longer?
Tangible Resources	Infrastructural Resources	1-Are there enough public and private institutions performing in the area? 2-Are there enough scientific community infrastructures such as research organizations, common data base and communication networks?
	Financial Resources	1-Are financial resources large?
	Human Resources	1-Are there required domain experts and technical sophistication?

2.8.2 Outputs of FMSA

The FMSA outputs were given according to the determined different criteria respectively again in Table 8. For the outputs, the inputs were evaluated by the FMSA according to the criteria set by the researcher through the literature research and thinking about the aerospace communication technologies in Turkish Defense Sector.

As outputs,

- Foresight approaches as explorative and normative

- Suggested methods as the ones in Table 6 by differentiating them as core methods and supportive methods.

Table 8 Criteria for FMSA Outputs

CRITERIA	FORESIGHT APPROACH	CORE METHODS (4)	SUPPORTIVE METHODS (7)
Is there already shared goal or common preferred future? Are there satisfying objectives for technological competitiveness?	Normative /Explorative		
Are there available accurate historical data? Are data valid? Is extend of data availability large? Are there required domain experts and technical sophistication?		Literature Review Expert Panel Delphi Survey Road-Mapping	
Are systems' costs huge? Is Life-Cycle-Period of systems more than 10 years? Is GERD 2.5% or higher? Are there rapid changes, qualitative breaks and social/ technological innovations? Is it largely affected by macro level conditions or open to experience turbulence? Are there situations with distinct levels of complexity?			SOAR[23] Analysis STEEPL[24] Analysis Trends Analysis Weak Signal Analysis Wild Cards Analysis Visioning Scenario Building

2.8.3 The Interface of FMSA

The interfaces of FMSA are given level by level here with the figures just to establish the general overview of the program execution. Since it is ongoing project and having potential to implement different changes and possibility of being using commercially; sharing the interfaces of FMSA is thought as sufficient currently. But in the Appendix A some of the codes are shared.

[23] STEEPL stands for the Social-Technological-Economical-Environmental-Political-Legal Analysis.

[24] SOAR stands for the Strengths-Opportunities-Aspirations-Results Analysis

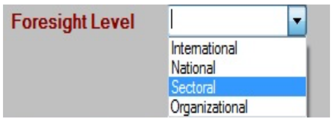

Figure 8 The 1st Step in the FMSA Interface

Figure 9 The 2nd Step in the FMSA Interface

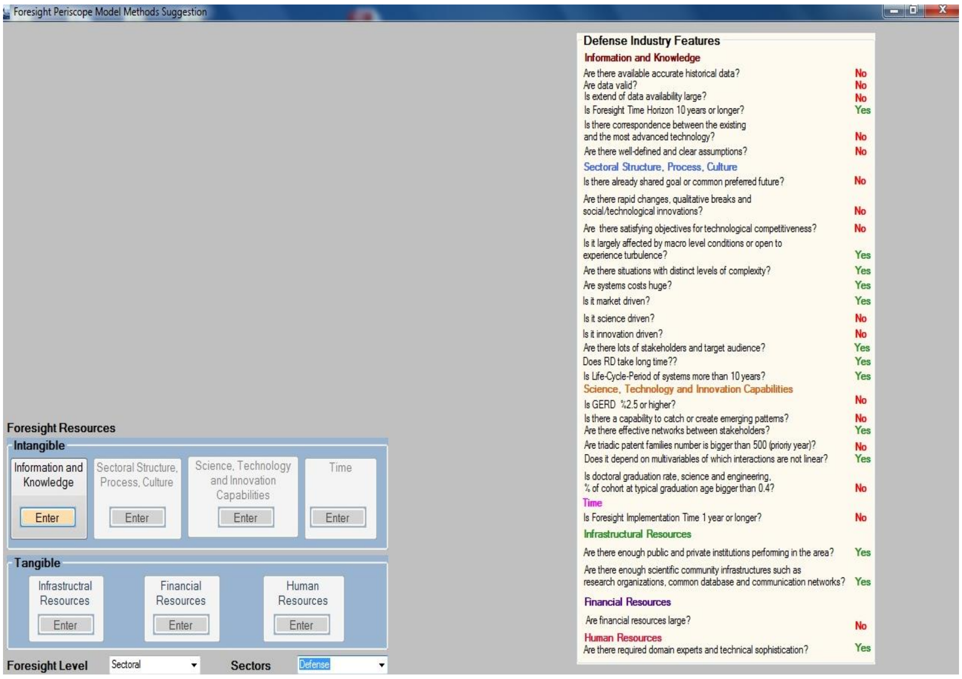

Figure 10 The 3rd Step in the FMSA Interface

Figure 11 The 4th Step in the FMSA Interface

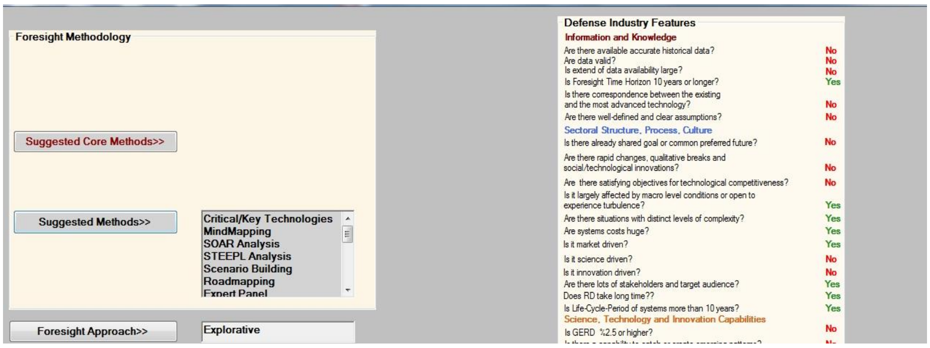

Figure 12 The 5th Step in the FMSA Interface

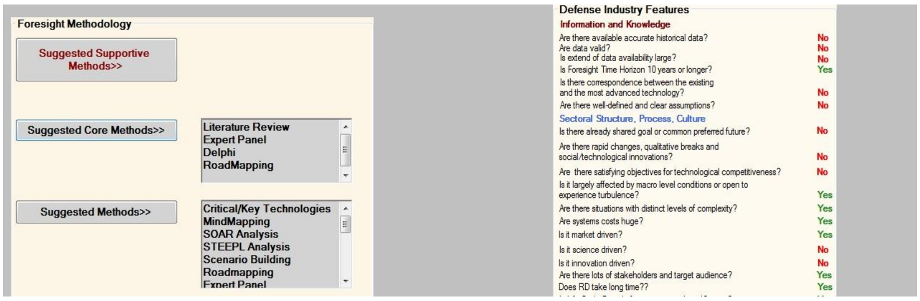

Figure 13 The 6th Step in the FMSA Interface

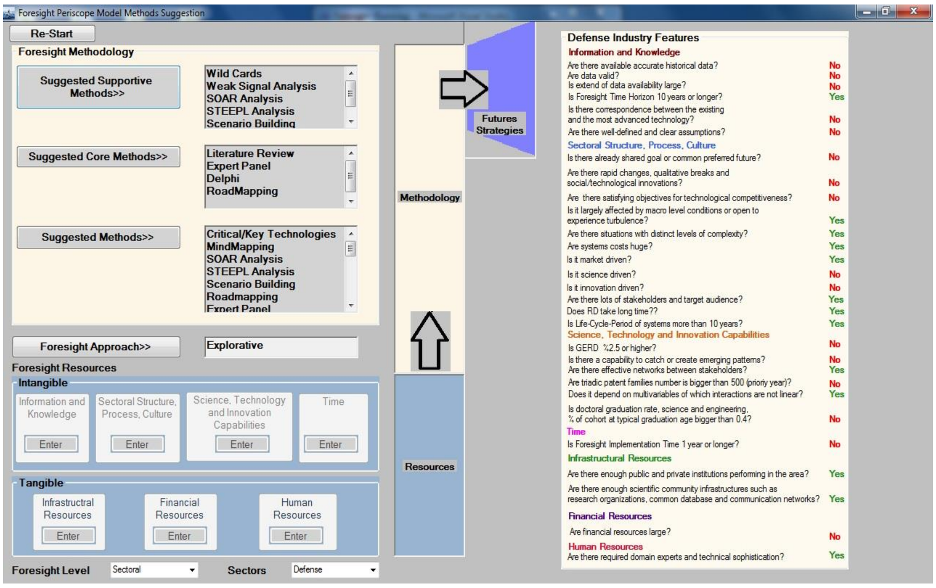

Figure 14 The Final Step in the FMSA Interface

2.8.4 The Flowchart of FMSA

The flowchart of FMSA was given in Figure 15 and part of the codes was shared in Appendix A.

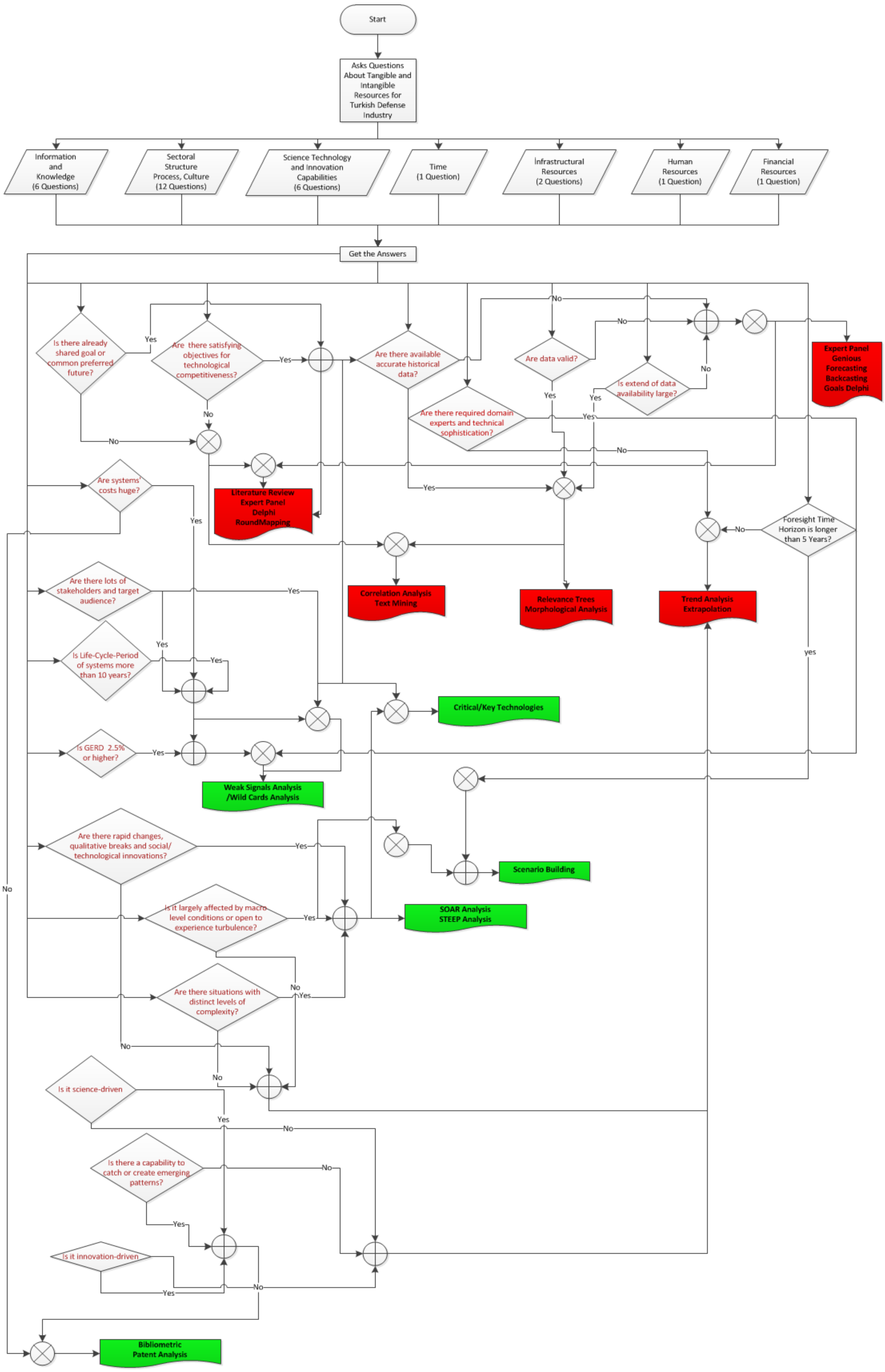

Figure 15 The Flowchart of FMSA

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Approach

In the literature, positivism and interpretivism are based on different approaches of ontological and epistemological doctrines. Ontology is the nature of reality (Hudson & Ozanne, 1988) and epistemology is the "study of nature and scope of knowledge and justified belief" (Mastin, 2008) and "relationship between the nature and researcher" (Carson, Gilmore, Perry, & Gronhaug, 2001). Knowledge is "a dynamic human process of justifying personal belief toward the truth" (Nonaka and Takeuchi, 1995). Knowledge means awareness and understanding of the reality and is acquired as a priori (non-empirical) and a posteriori (empirical) way (Mastin, 2008). Positivism is "an approach to science based on a belief in universal laws and insistence on objectivity and neutrality" (Thompson, 1995). It is mainly based on knowledge acquired as a posteriori mainly. Positivism claims that there is single objective reality independent of researcher's belief and point of view whereas interpretivism asserts that there are multiple realities which are relative (Hudson & Ozanne, 1988). Positivists use quantitative methods by discarding personal experiences and emotions, interpretivists use mostly qualitative methods and get base from experiences, feelings and perceptions.

For this research; the futures are the main complex subject of which uncertain and undetectable nature. So, the possible futures are multiple, relative and it is impossible to cover the whole features of the futures, because of its partiality nature (Yüksel & Çifci, 2017). Additionally, the statements of futures are not tested at the time which they are set (Kreibich, Oertel, & Wölk, 2011). So, future oriented studies like foresight have serious challenges to be performed. On the other hand, foresight is the systematic active attitudes of today to shape the futures. When all these mentioned properties of the futures and foresight are considered, it is apparent that approaching the subject with both positivist and interpretivist manner is the optimum one. Since the multiple futures are related with the perception and the subjectivity with knowledge feelings, imagination and interpretation is important; interpretivism is more dominant for the futures. However, foresight doesn't only deal with the futures; it is also related with the past and present to create the bridge for coherent and effective anticipations. Past and present conditions include some statistical data, objectively tested information and accumulated knowledge in addition to reality of presence of single past experienced and present being experienced respectively. In this way, positivist approach is dominant for the foresight study in evaluating the past and present.

Within this logic, research approach for the foresight study was given in Figure 16.

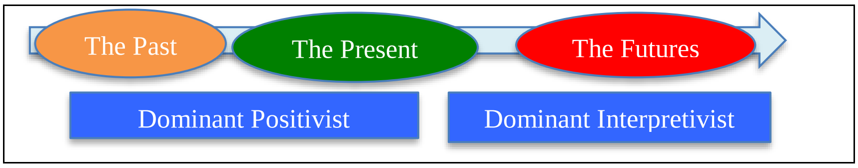

Figure 16 Research Approach

3.2 Research Methodology Design

Dewey (1933) assessed methodological approaches as inductive discovery (induction) and deductive proof (deduction) (Gray, 2013). Deductive reasoning begins with a theory, theory is narrowed to hypothesis and observations are collected to confirm it. Inductive reasoning, which is a bottom-up method, starts with the observations and they are generalized to the patterns and theory. Qualitative research tries to understand the nature of the things, their description and explanation by focusing on the quality of the things whereas quantitative research focuses on the quantity of the things (Lums Effective Learning, 2016). However quantitative research is more proper to do generalizations using expanded data sets and samples;

qualitative research is more detailed, rich and appropriate for situations where the detail understanding is required with the holistic view. Nevertheless, qualitative and quantitative approaches are sometimes used together according to the nature of the research; so it is rare to separate the two generally.

For this research; methodology was conducted mainly as qualitative with inductive reasoning. Qualitative data gathering methods with semi-structured and unstructured open-ended questions were used; but in some cases these data were quantified, prioritized, sorted for selection and survey applications. Since the nature of the future is complex and uncertain, it is very understandable to do qualitative research. But in such a multidisciplinary area, which also includes a very quantitative subject like technology, it is also inevitable to cover quantitative data. So, the models (FPM) and frameworks (FFF), which were developed previously by Yüksel & Çifci (2017) and the computer program (FMSA) developed in this study to suggest the required methodology explained in Chapter 2 formed the guide for systematic infrastructure of the research. This research started with literature review done by the researcher, continued with the opinions and ideas of the stakeholders and they were generalized according to expertise level. Stakeholders were expected to evaluate them and create the new ones based on their implicit and explicit knowledge. The knowledge collected qualitatively was quantified and sorted with respect to some criteria by using some semi-quantitative and quantitative methods.

Within this logic, basic research methodology design for the foresight study was given in Figure 17.

3.3 Research Methodology Application

Methodology application is the sequence and explanations of the methods performed. For this research; most of the methods and their applications were carried out in two main expert panels held in different dates at Presidency Of The Republic Of Turkey Undersecretariat for Defense Industries (SSB) as the first part. In the second part, expert panels' results were surveyed with online Delphi which was established by the researcher and it was expected from experts to evaluate it in two rounds. The results were analyzed and presented again before the third part of the application performed by the researcher which is setting futures strategies by constructing scenario building and road-mappings with political suggestions. Within this logic, research methodology application for the foresight study was given in Table 9.

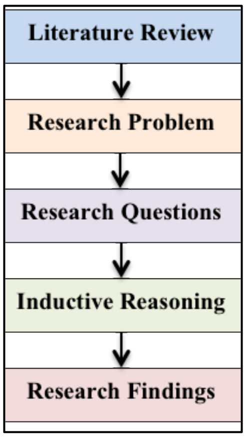

Figure 17 Basic Research Methodology Design of this Research

Table 9 Research Methodology Application

Methodology Application Parts	Applications	Activities in the Main Methods
Part-1	Expert Panels	The First Expert Panel Activity
		The Second Expert Panel Activity
Part-2	Delphi Survey	The First Round Delphi Survey Activity
		Sharing the Results of the First Round Application of Delphi Survey with the Participants
		The Second Round Delphi Survey Activity
Part-3	Futures' Strategies	Scenario Building Activity
		Roadmapping Activity
		Integration of Political Recommendations Activity

3.3.1 Application of Expert Panels

In research methodology field, the expert panel is one of the most common methods in foresight to obtain explicit expert knowledge in selected field (Laidlaw, 2014a). Expert panels are comprised of groups who are international, national, regional and local people dedicated with their knowledge and vision to the determined subject. Experts are expected to have the capabilities of creating statements, making imaginations and building visions especially in the studies related to the futures. Expert panels are mostly beneficiary especially in complex and knowledge required issues and resolving the conflicts, but it can be expensive (Laidlaw, 2014b).

Foresight as a futures study is a discursive process that ought to be based on the best available resources, evidence and judgment and the participants are not only expected to share their experience but also get into in-depth discussions and debate with other participants (European Commission-Joint Research Center-IPTS, 2005). Expert panels are also learning and networking platforms for foresight process on the specified subject. So, the panel format should be encouraging the participation and it needs highly skilled moderator who has done needed arrangements and template formats if they are written (Laidlaw, 2014b).

Popper, Keenan, Miles, Butter, & Sainz (2007) investigated 755 foresight cases all around the world and he determined that most widely used method is literature review in the first (437 times) while expert panel is at the second (324 times).

For this research; in the expert panel applications, opinions and ideas of experts were collected by requesting them making modifications on the pre-written statements on templates and writing their own statements. Panelists were allocated based on their institutions in the seating arrangement according to table especially for some specific methods' applications. There was an option for the panelists not to share their names but use their table number assigned to institutions instead. For the efficient use of the restricted time of the experts, all methods output from the FMSA based on the FPM explained in Chapter 2 were prepared in templates beforehand by the researcher. Within 2.5 hours for each panel, all needed information was tried to acquire from the participants. The methods of the expert panels were sequential and applications were explained under their titles in the following sections.

All templates were pre-prepared by the researcher's own efforts and illustrated in the following sections for better comprehension of the whole picture. Within this logic, the applications of the expert panels with detailed and explained sub-methods suggested from FMSA were explained.

3.3.1.1 The First Expert Panel Application

The first expert panel flow with all methods was given in Figure 18. The main aim of the first expert panel was to determine the current situation of the Aerospace Communication Technologies of Turkish Defense Sector by creating awareness between the stakeholders and catching the commitment and synergy.

The first expert panel was comprised of 44 panelists given in Appendix B, with only their institution names, and the panel was held in SSB with its sponsorship on 19th January 2018. The panelists were invited among academics from the universities, R&D specialists and managers of the public and private defense companies, non governmental organizations, SSB and Turkish Armed Forces (TAF) personnel in the aerospace communication sector selected by SSB and the researcher together. The contribution of the first expert panel was to create the awareness among stakeholders in evaluating the current situation with STEEPL, SOAR, Single Source, Trends Studies, Vision Study and Taxonomy Grading with respect to criteria for the Aerospace Communication Technologies in Turkish Defense Sector for the year of 2040.

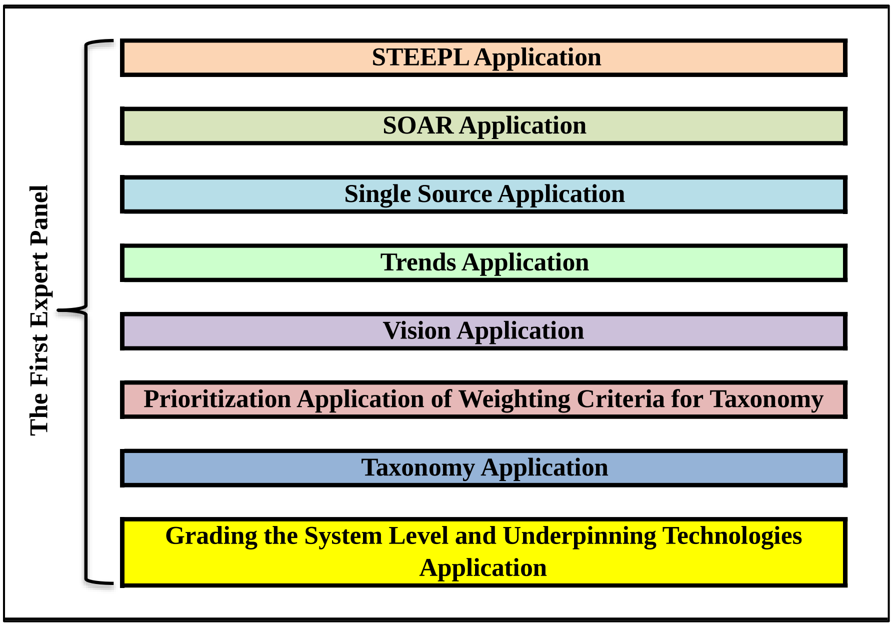

Figure 18 The First Expert Panel Application

3.3.1.1.1 STEEPL Application

It is the mostly common used evaluation of external business environment (A. Gupta, 2013). STEEPL is used generally for strategic planning in assessing the social, technological, economical, environmental, political and legal impacts and it is a strategic framework to comprehend the external effects on the subject (Rastogi & Trivedi, 2016). The study mostly starts with the brainstorming activity, it involves cross-sectional skills and expertise (Free Management EBooks, 2013), therefore it covers factors of high variety. The participation from all main areas of subject increases the effectiveness of STEEPL. It also ensures the possibility of capturing potential risks and issues (Rastogi & Trivedi, 2016).

In the STEEPL application, semi-structured STEEPL form created by the researcher with reviewing literature was presented to expert evaluation and modification. At the end of each factor group, there were also unstructured part for open-ended additions from the experts. After reading the all statements of each factor, modifications and additions from the experts were requested. Thus, experts created their own STEEPL forms and at the end the researcher asked them to prioritize the factors on the final list for each factor.

The presented template pre-prepared by the researcher for **STEEPL** is shown in Table 10.

Table 10 Template for STEEPL Pre-Prepared by the Researcher

No	Social Factors (Demographic Structure, Business Approaches, Consumer Views and Attitudes, Changes in Values and Attitudes, Brand Preferences, Lifestyle Changes, Education Conditions, Working Environment and Conditions, Health Situation ...)	Priority
1	Increased user dependency on aerospace platforms in Defense Industry	
2	Increasing aerospace cluster studies	
3	Increase in international consortium and dependencies in aerospace systems	
4	Establishment of academic units in institutions	
5	Increasing interdisciplinary programs at universities	
6	Workload in space colonization	
No	**Added By Expert**	**Priority**
No	**Technological Factors (Technological Development, Widespread of New Technologies, Technology Access, R&D Project Support, Patents and Innovation ...)**	**Priority**
1	Increased efficiency of network based operations management and data systems	
2	Widespread use of UVA systems	
3	Increasing jamming, blocking and listening activities of communication systems	
4	Increase in the development and deployment of global/regional navigation satellite systems in the world	
5	Widespread use of communication satellites	
6	Widespread use of intelligent communication systems that can sense the environment	
7	The widespread of wireless communication	
8	The widespread use of interoperability concept	
9	Advancement of advanced material technologies	
10	Widespread of the concept of Industry 4.0 (Big data, artificial intelligence, internet of things, cyber security, etc.)	
11	Increased speed of change in information-communication technologies	
12	Acceleration of 5G communication infrastructure development efforts	

No	Environmental Factors (Environmental Environment, Energy Production and Consumption, Global Climate Change, Wastes ...)	Priority
1	Increased use of renewable energy (solar cells, etc.)	
2	Increased electronic waste from systems (including space wastes etc.)	
3	Increased radiation effect of communication signals	
No	**Added By Expert**	**Priority**
No	**Economic Factors (GNP, Exchange Rates, Inflation, Public Finance, Economic Situation and Stability, Incentives and Access to Loans…)**	**Priority**
1	Increasing investments in civil and military communication satellites on a global scale	
2	Increasing defense expenditure on a global scale	
3	Increasing number of newly established companies and entrepreneurs in Defense Industry	
4	The cost of aerospace platforms and ground stations to operate communications and navigation systems	
5	Rapid changes in the semiconductor market that constitute the infrastructure of communication and navigation systems	
6	Reduction of taxes and financial burdens in the information-communication industry on a national scale	
No	**Added By Expert**	**Priority**
1	Political support for space and satellite applications	
2	Difficulties in procurement of semiconductor materials	
3	Increasing international lobbying in technological fields	
4	Political support for the transition to 5G infrastructure	
No	**Added By Expert**	**Priority**

Table 10 (cont'd) Template for STEEPL Pre-Prepared by the Researcher

13	Widespread of satellite-independent navigation systems	
14	Complexity of software infrastructure of systems	
15	Increasing technological activities for deep space	
16	The emergence of the concept of production in space	
No	**Added By Expert**	**Priority**

No	**Political Factors (Trade Policies, Global and National Political Developments, Foreign Pressures, Lobbyism, Tax Policies, Labor Policies, Political Stability ...)**	**Priority**
No	**Legal Factors (Laws, Regulations and Other Regulations ...)**	**Priority**
1	Legislation for establishment of National Space Agency	
2	Regulations on frequency spectrum distribution, management and control	
3	Challenges arising from international export control agreements (Wassenaar, FTKR ...)	
4	Regulations on the protection of intellectual property rights	
No	**Added By Expert**	**Priority**

3.3.1.1.2 SOAR Application

It is a strategic planning tool focusing on current strengths and future vision of the organization to develop strategic goals. Unlike Strengths-Weaknesses-Opportunities-Threats (SWOT), which is a general top-down analysis, all functional areas from all levels of an organization are considered in SOAR with more optimistically. In short, improving the current success is more important than current threats and weaknesses in SOAR analysis (Stavros & Hinrichs, 2009). Organization development studies generally relied on the SWOT results for strategic planning whereas SOAR analysis is relatively new which may serve as a better alternative to SWOT to perform a satisfying inquiry (McLean, 2006). SOAR focuses on more optimistic and creative processes. SOAR provides the environment for stakeholders to comprehend the potential of the organization and create a shared vision of the future ("SOAR analysis," n.d.). It is more action oriented than SWOT for the desired results since it concentrates on developing strengths with less effort instead of making more efforts for weaknesses. In the SOAR application, semi-structured SOAR form created by the researcher with reviewing literature was presented to expert evaluation and modification. At the end of each factor group, there were also unstructured part for open-ended additions from the experts. After reading the all the factors of each subject, modifications and additions of the experts were requested. Thus, experts created their own SOAR forms and at the end the researcher asked them to prioritize the factors on that list for each title.

The presented template pre-prepared by the researcher for **SOAR** is shown in Table 11.

Table 11 Template for SOAR Pre-Prepared by the Researcher

No	Strengths	Priority
1	Demand to meet the needs for communication domestically	
2	Young entrepreneur human resource	
3	Institutionalized and developing organizations in communication	
4	Original and nationally developed communication systems	
5	Financial resources and funds reserved for aerospace platforms	
6	System/test infrastructures designed for aerospace systems/subsystems	
7	Knowledge and experience in the communication satellites operation	
8	R&D support programs	
9	The existence of legal infrastructure protecting personal data, ideas and works (Law of Intellectual and Artistic Works and Protection of Personal Data etc.)	
No	**Added By Expert**	**Priority**

No	Opportunities	Priority
1	Making space technology one of the areas of priorities	
2	Decisions on the creation and updating political intellectual strategy and road maps in space technology	
3	Launching a number of new projects in the field of aerospace communications	
4	Increasing R&D Expenditures in Gross National Expenditure	
5	Academic interest in space and air communication departments	
6	To have a share of export market for the countries which are closely related and undeveloped infrastructure in communication industry	
7	Establishment of 5G Valley	
8	Public interest in aviation and space	
No	**Added By Expert**	**Priority**

No	Aspirations	Priority
1	Increasing the number and quality of R&D human power	
2	National construction of R&D	
3	Cooperation of relevant institutions and organizations	
4	Reduction of foreign dependency on basic materials constituting the substructure of aerospace communication systems	
5	Increasing support for universities and research centers	
6	Prevention of brain drain	
7	Increasing interest in basic sciences	
8	Increasing international R&D collaborations	
9	Taking reponsibility, control and follow-up of plans and projects	
10	Reliable and high speed communication	
11	Providing reverse brain drain	
12	Preventing the closure of academic units for basic sciences in universities	
No	**Added By Expert**	**Priority**

No	Results	Priority
1	No dependence on other countries	
2	Qualified human resource	
3	High technology exports	
4	Innovative product, patent and utility model	
5	Cost reduction	
No	**Added By Expert**	**Priority**

3.3.1.1.3 Single Source Application

It is based on the Technology Readiness Level (TRL)[25] assessment is at the center of determining the single resources. TRL assessment tries to detect the maturity, the risk and the critical technologies under development. "It is a systematic and metrics-based process with the efforts of required and qualified stakeholders to determine the amount of resources - time, funds, intellectual potential, facilities etc., - necessary to bring this technology to life" (Laidlaw, 2014b).

In the Single Source Study application, although there is no apparent list kept which shows TRL and its assessment methodology for Turkey[26], the researcher preferred to ask expert opinions for the information about the single sources of the aerospace communication technologies of Turkish Defense Sector as an encouraging starting point. It was also used for determining the technological areas where Turkey is strong.

The open-ended questions were asked to experts in written format so the presented template pre-prepared by the researcher for **The Single Source** is shown in Table 12.

Table 12 Template for Single Source Pre-Prepared by the Researcher

No	**What is the technology or product for aerospace communications where Turkey is the single source?**

[25] "Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest (Mai, 2017)".

[26] This information might be confidential and available, but the researcher couldn't access the TRL list.

3.3.1.1.4 Trends Application

It is a tool using techniques to predict future outcomes based on historical data (Project Management Institute, 2008). The study provides a sense of perspective showing a potential for change by extrapolating the data to make an estimation of future capabilities (OECD, 2006). Trends looks at the past and present and tries to estimate their direction, spread and power in the future. This process differs contingent upon the time span where the pattern is seen, and "unlike the most time-series forecasting techniques, the Trend Analysis does not assume the condition of equally spaced time series" (Arsham, 2015). Technologies based both on trends and drivers are generally empowering to give participants a sense of perspective and reminding them of the potential for change (OECD, 2006). Trend analysis is a statistical procedure performed to evaluate hypothesized linear and nonlinear relationships between quantitative variables (Lavrakas, 2008). Generally, trend researchers have a relatively short time horizon, 1-5 years, to look for emerging trends and opportunities. Popper, Keenan, Miles, Butter, & Sainz (2007) determined that "analysis of trends and drivers has been reported as an output most frequently (relatively speaking) in Latin America".

In the Trends Study Application, semi-structured trends form created by the researcher with reviewing literature and open-ended trends were asked as tables with respect to expertise level. Participants created their own trends forms and at the end the researcher asked them to prioritize the trends on that tables. Additionally, any suggestions for trend survey questions for the following studies were requested.

The presented template pre-prepared by the researcher for **The Trends Study** is shown in Table 13, 14 and 15.

Table 13 Template-1 for Trends

1	In the next 5 years which aerospace platforms (Manned Warfare Aircraft, Unmanned Warfare Aircraft, Logistic Support and Surveillance Aircraft, Helicopter, Unmanned Air Vehicle [UAV], Armed Unmanned Air Vehicle [Armed UAV], Lighter-than-air Platforms [Balloon, Zeppelin], Communication Satellites, Surveillance and Navigation Satellites, Space Station, Space Rocket ...) will be on the forefront? Please list up to 5 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Aerospace Platforms	**Priority**

2	In the next 5 years, which frequency bands (Below Microwaves [LF, MF, HF, VHF, UHF] Micro-Milimetric Wave [P, L, S, C, X, K, Ku, Ka, Q, V, W], Optic, X-Ray ...) will be in the forefront of communication? Please list up to 5 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Air Bands	**Priority**

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Space Bands	**Priority**

3	In the next 5 years, which different technologies (Artificial Intelligence, Material Technologies, Big Data, Deep Learning, Augmented Reality, Machine Learning, Internet of Things, Cloud Computing, Cognitive Computing, Quantum Computing, Military UAV, Machine-Machine Communication, Edge Computing) will affect aerospace communication? Please list up to 5 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Technologies that can affect aerospace communication	**Priority**

Table 14 Template-2 for Trends

4	In the next 5 years, which technologies (5G, MEMS, Artificial Intelligence, Big Data, Deep Learning, Augmented Reality, Machine Learning, Internet of Things, Cloud Computing, Material Technologies, Cognitive Computing, Quantum Computing, Military UAV, Machine-Machine Communication, Edge Computing ...) will affect space and air navigation? Please list up to 5 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Technologies that can affect aerospace navigation	**Priority**

5	In the next 5 years which navigation systems (Pre-information required, global positioning satellite system, satellite-based augmentation, ground-based augmentation, inertial / air data inertia …) will be the forefront? Please list up to 3 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Navigation systems	**Priority**

6	In the next 5 years, which material technologies (Silicon-based, III-V Composites [GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN], Carbon based, Superconductors, Optical, Laser [FIR, VNIR, mid-IR], Transparent ...) will come to the forefront? Please list up to 3 items in an order.

Please choose one:	…. I'm expert on the subject
	…. I have information on the subject

Material technologies	**Priority**

Table 15 Template-3 for Trends

7	In the next 5 years, which orbits (LEO, MEO, GEO, HEO, PEO, Deep Space ...) will come to the forefront? Please list up to 3 items in an order.	
	Please choose one:	…. I'm expert on the subject
		…. I have information on the subject
	Orbiting satellites	**Priority**
8	In the next 5 years, which technologies that would directly affect Space Communications (internet in the space [internetworking], communication between the orbiting satellites, inter-orbit telecommunication, high efficiency satellite, quantum satellite ...) will come to the forefront? Please list up to 3 items in an order.	
	Please choose one:	…. I'm expert on the subject
		…. I have information on the subject
	Technologies that would directly affect satellite communication	**Priority**
9	**Survey Question Suggestions** a. ……………………………………………………………………………… b. ……………………………………………………………………………… c. ……………………………………………………………………………… d. ……………………………………………………………………………… e. ………………………………………………………………………………	

3.3.1.1.5 Vision Application

Foresight provides the guiding in codified form of technological expectations with the participation of socio-technic actors and stakeholders (A. Smith, Stirling, & Berkhout, 2005). Visioning starts with the questioning where we are now and ends with where you expect to be in the future. Bishop & Hines (2012) states that "the vision is something tangible and concrete- something that people can get excited about". Vision is an indicator showing the interdependencies of the stakeholders. It has a mission to engage, inspire, and create awareness among the actors by establishing commitment. For foresight studies, visioning brings the stakeholders together which it is a participatory process. The main questions were "where we are now and where we want to be in the future (BusinessDictionary, n.d.)".

In the Vision Study Application of the Aerospace Communication Technologies in Turkish Defense Sector for the year of 2040, the participants of the study were grouped and seated according to their positions and institutions/organizations in the sector.

The participants were asked to write down the most important topics as a short sentence, a word, or a noun phrase on their post-it papers, stick them on their given A3 formatted paper and then pass through the paper to the next person on the table. After 4-5 loops, the post-its were read and each post-it was stuck on the board in different columns based on their certain topics (same and similar statements were stuck on one below the other). Each group member was given 4 ballots and asked to vote the statements given on the board and then the group members created their own vision statement out of the most preferred statements on the board. The vision statements were shared out load. With this method, each group (table) presented their own visions according to their institutions, so the researcher had a chance to compare them.

Since the presented template pre-prepared by the researcher for **The Vision Study** were blank A3 formats, post-its and voting stamps, they are not shown in any figure.

3.3.1.1.6 Prioritization Application of Weighting Criteria for Taxonomy

It is used in sorting the system and underpinning aerospace communication technologies.

In The Prioritization Study Application, the weighting criteria was defined and explained to the experts by the researcher in the Table 16. It was expected from the experts to compare them in pairs according to the comparing scale of the criteria. It was expected from participants to compare the criterion on the left with the one on the right and put 'X' to their selected importance level.

Table 16 Weighting Criteria Explained by the Researcher

CRITERIA	REMARKS
To create competitive advantage	**Innovation** (*Trending technologies*[1] in *developed countries*[2]) **Double Use** (Transferrable competencies developed by Defense Industry technologies to civil applications)
To create other technological research areas	**Qualified Human Resource** (Researchees, R&D personnel…) **Infrastructure** (Research centers, laboratories…) **Relation with Other Technologies** (Related researches)
To meet national security needs	**National Technology** (Technology obliged to be developed domestically for security reasons even if it is acquirable from other countries) **Critical Technology** (Technology necessary to be developed domestically due to the risk in operation for *certain reasons*[3] whether it is not acquirable from other countries or acquirable but not maintainable) **Technology Directly Contributing to National Technology** (Technologies to be used in tools, devices and systems for security reasons) **Indirectly Contributing to National Technology** (Technologies to be used in supporting systems of tools, devices and systems for security reasons)
[1] Technology Readiness Level(TRL) of TRL-3 (experimental demonstration of concept demonstration) [2] From OECD science and technology indicators, the percentage of R&D spending in Gross National Expenditure is minimum 2 (USA, Germany, G. Korea etc ...) [3]Subordination to international agreements is included.	

The presented template pre-prepared by the researcher for **The Prioritization of Weighting Criteria for Taxonomy** is shown in Figure 19.

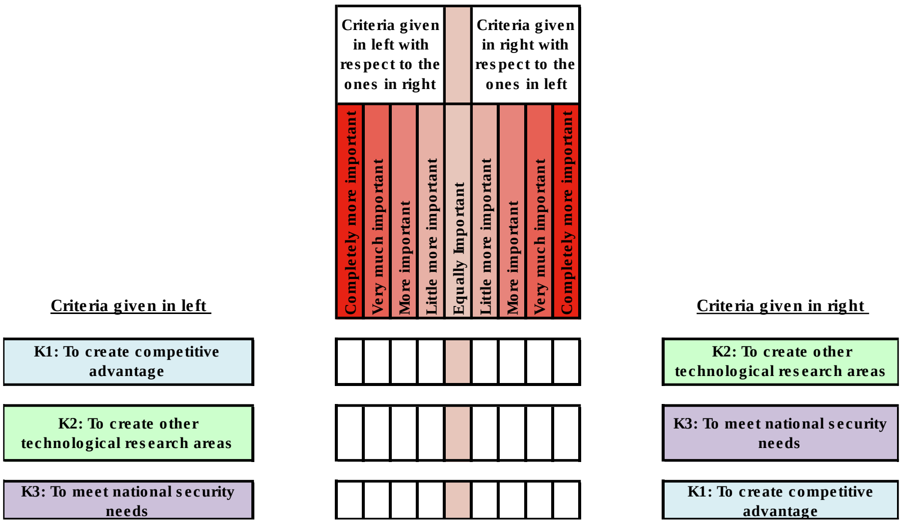

Figure 19 The Prioritization of Weighting Criteria for Taxonomy

3.3.1.1.7 Taxonomy Application

It is the knowledge management tool and special purpose framework which contains the point of view, providing classification in the levels and organizing the existing knowledge explicitly (Garcia et al., 2015). Taxonomy facilitates the accessibility to and usability of accumulated knowledge by easy searching between the levels in its hierarchical arrangement and allows users finding needed information in indexed and codified form inside the specific categories with their sideways or related topics (Walli, 2014). The drawbacks of the absence of taxonomies are summarized as "Knowledge workers spend 15 to 35 percent of their time searching for information, 40 percent cannot find the information they need on their corporate intranets, 15 percent of their time is spent duplicating information that exists but cannot be found (Feldman, 2014) ". The underpinning is defined as "the materials and constructions (such as a foundation) used for support of a structure (Merriam-Webster, 2018). Underpinning technologies enables the progress and processes especially for the system level variable domains, although even in a military or national security context, it is rare that research technologies are entirely classified for taxonomy studies (Militarily et al., 2014)**.** The system level technologies are defined as technical requirements used to describe the set of statements that identifies a system's functions, characteristics, or constraints (MITRE, 2018).

In The Taxonomy Study Application, since there is no taxonomy in the literature for the Aerospace Communication Technologies, European Defense Agency (EDA) Technology Taxonomy (European Defense Agency, 2006), SSM Taxonomy (SSM Teknoloji Yönetimi Daire Başkanlığı, 2017), NASA Technology Roadmapping (NASA, 2015) studies were studied and investigated by the researcher. The researcher's implicit and explicit knowledge was integrated with the mentioned taxonomies and a new taxonomy for the system and underpinning technology levels were established. The researcher requested from experts to give the grades according to their explicit and implicit knowledge for three criteria (K1, K2, K3) for both system and underpinning technology levels.

The presented template pre-prepared by researcher for **Grading** is shown in Table 17.

Table 17 Grading of Weighting Criteria for Taxonomy

GRADING	
9-10	Certainly Important
7-8	Very much important
5-6	Important
3-4	Less Important
2-1	Not Important
0	Not Related/Don't Know

3.3.1.1.8 Grading the System and Underpinning Level Technologies

The presented template pre-prepared by the researcher for **The Taxonomy of System and Underpinning Levels Aerospace Communication Technologies** for evaluation are shown in Table 18 and 19 respectively. For all the criteria, it was expected from experts to grade them according to the Table 17.

Table 18 Template for Grading System Related Aerospace Communication Technologies in Taxonomy

SYSTEM RELATED TECHNOLOGIES (1)	Grades K1	K2	K3
Communication Technologies			
Below Microwave Frequencies (BMF) Communication			
Micro and Millimetre Wave (MMW) Communication			
Optical Communication			
X-Ray Communication (XCOM)			
Quantum Communication			
Earth Launch and Re- Entry Communications			
Power and Spectrum Efficiency Related Technologies			
Coding			
Modulation			
Access			
Synchronization			
Networking			
Power Amplification			
Communication Electronic Warfare Technologies			
BMF Communication Electronic Counter Measures (ECM-COMMs)			
BMF Communication Electronic Support Measures (ESM-COMMs)			
BMF Communication Electronic Protection Measures (EPM-COMMs)			
MMW Communication Electronic Counter Measures (ECM-COMMs)			
MMW Communication Electronic Support Measures (ESM-COMMs			
MMW Communication Electronic Protection Measures (EPM-COMMs)			
Communication ElectroOptic Counter Measures (EOCM-COMMs)			
Communication ElectroOptic Protection Measures (EOPM-COMMs)			
Antenna Technologies			
Optical			
Plasma			
Microwave			
Terahertz			

SYSTEM RELATED TECHNOLOGIES (2)	Grades K1	K2	K3
Position, Navigation and Timing Technologies			
Timekeeping and Time Distribution			
A-Priori Data Based Navigation			
Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)			
Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)			
Optical Navigation			
Neutrino-Based Navigation			
X-Ray Navigation (XNAV)			
Microsensor Systems for Active Control of Structures			
Motion Sensor Systems			
Communication and Information Systems (CIS) Related Technologies			
CIS Security Systems			
Command & Information Systems Integration			
Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)			
Geographic Information Systems			
Environmental Monitoring Systems			
Optimisation, Planning & Decision Support Systems			
Infrastructure to Support Information Management & Dissemination			
Automated Intelligent Networked Systems			
Network Management Systems			
Air Traffic Control Systems			
Internet of Things (M2M)			
Integrated Systems Technologies			
Systems Engineering and Integrated Systems Design			
Radiation Hardening			
Electromagnetic Compatibility			
In-Service Data Capture			
Integrated System Testing and Evaluation			
Middleware systems			

Table 19 Template for Grading Underpinning Aerospace Communication Technologies in Taxonomy

UNDERPINNING TECHNOLOGIES (1)	Grades K1	K2	K3
Structural &Smart Metarials&Structural Mechanics			
Composite Technologies (Metals&Ceramics&Glass&Polymer)			
Structural Materials Processing, Joining and Surface Protection Technologies			
Non-Destructive Evaluation & Life Extension of Structural Materials			
Corrosion and Wear Control Technology			
Structural Mechanics			
Structural Materials -Forming and Materials Removal Technologies			
Smart/Functional Materials for Structural Uses			
Computing Technologies & Mathematical Techniques			
Protocol Technology (satellite/terrestrial communication systemsmanagement and control, LANs, WANs...)			
COTS Software Assessment (integration/maintenance technologies)			
Architectures			
High Integrity and Safety Critical Computing (safety critical software fault tolerance/detection...)			
Secure Computing Techniques			
Encryption / Crypto Technologies (quantum optical processing...)			
OA Tools and Techniques			
Mathematical Modeling Development (communication networks...)			
Mechanical, Thermal & Fluid-Related Technologies & Devices			
Mechanical/Hydraulic Technologies & Devices			
Lubrication Technology			
Thermal & Thermodynamic Technologies & Devices			
Fluid Mechanics - Phenomenological & Experimental			
Fluid Dynamics Techniques			

UNDERPINNING TECHNOLOGIES (2)	Grades K1	K2	K3
Electronic Materials Technology			
Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)			
III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)			
Other Semiconducting Materials			
Insulating & Dielectric Materials			
Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)			
Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)			
Electronic, Electrical & Electromechanical Device Technology			
Device Concepts and Fabrication			
Device Packaging			
Device Integration/Reliability			
Solar Cells			
RF Power Sources & Devices			
Inertial/Gravitational Devices			
Photonic/Optical Materials & Device Technology			
Optical Materials & Devices			
Non-Linear Optical Materials & Devices			
Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)			
Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)			
Non-Laser Devices (specific structures in III-V materials and in porous silicon...)			
Transparent Materials (diamond windows and coatings...)			
Information and Signal Processing Technology			
Data & Information Management Technology			
Optical Signal Processing Technology			
Speech & Natural Language Processing Technology			
Optimisation & Decision Support Technology			
Information & Data Fusion Technology			
Operating Environment Technology			
Terrain Science			
Meteorology (weather systems, ocean-atmosphere coupling, air movements...)			
Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)			
Electromagnetic Propagation in Air			

3.3.1.2 The Second Expert Panel Application

The second expert panel flow with all methods was given in Figure 20. The main aim of the second expert panel was to determine Technological Delphi Statements of the Aerospace Communication Technologies of Turkish Defense Sector for the year of 2040 with the field experts. The second expert panel was performed on 26th April 2018 in SSB with the participation of 19 panelists in Appendix B, with only their institution names, after the analysis of the first expert panel done by the researcher. This time, there was no sponsorship from SSB because of its organizational change. It just gave the meeting location support and the participants were determined by the self-effort of the researcher. The purpose of the second expert panel was to collect Technological and SEEPL Delphi Statements with wild cards reviews from the experts. For the application, the semi-structured Delphi Statements which were developed previously by the researcher with literature review were presented to expert evaluation and then open format Delphi Statements creation were expected from them by adding wild cards.

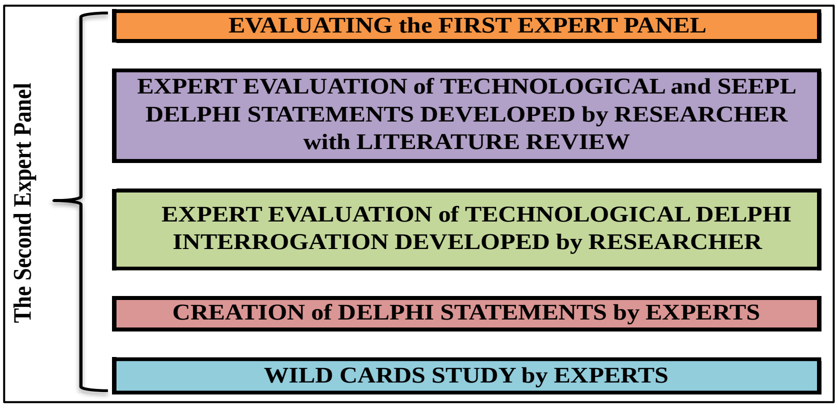

Figure 20 The Second Expert Panel Application

The Delphi Method was developed in RAND Corporation in 1950s on military defense project (Habibi, Sarafrazi, & Izadyar, 2014) by Dalkey and Helmer (1963) based on the convergence of the expert opinions through controlled feedbacks between the iterations of the questions about specific areas. The Delphi technique is applied as a tool and method for consensus building using a series of questionnaires for data collection from a panel of selected participants and it is expected from participants to review their opinions again and modify them if they feel needed. The Delphi method can be used when there is incomplete knowledge about a problem or phenomena (Adler & Ziglio, 1996; Delbeq et al., 1975). According to Popper (2008) it is a well-built technique which consists of repetitive polling of the same participants with the controlled feedback mechanism from the previous ones to eliminate following the leader tendency, bias and forceful effects to direct individuals in face to face participation. The most important features of the Delphi technique are its anonymity, iteration, controlled feedback, and statistical group response (Habibi et al., 2014). In the Delphi technique the anonymity of the experts clears away the dominance effects of participants to make the group-based process prominent in gathering and synthesizing information and in the feedback process, quantitative results are presented on qualitative data (Hsu & Ohio, 2007). The feedback mechanism is really important; it should be easily understandable, visual and clear. It is mainly a consensus building technique in establishing today's and future's scenarios for determined issues with the contribution of experts and stakeholders (Renzi & Freitas, 2015). Delphi process often continues up to three iterations which are often enough to gather the needed information and provide consensus in most cases.

3.3.1.2.1 Evaluating the First Expert Panel

It was the initial step of the second expert panel to create the environment to establish the technological Delphi statements by participants' evaluations. It was crucial to set the current condition of the aerospace technologies in Turkish Defense Sector first. In this way, the experts were directed to contemplate about the aerospace communication technologies of Turkish Defense Sector by taking the current conditions and stakeholders' opinions more.

In the Evaluating the First Expert Panel Application; the password-based website (http://www.foresightaerospacecomm.com/) established by the researcher for the first expert panel analysis was already shared with the participants before the second expert panel was held. Nevertheless, the results of the first expert panel were provided as inputs to the experts and explained briefly to the participants as presentation by the researcher.

3.3.1.2.2 Expert Evaluation of Technological and SEEPL Delphi Statements Developed by the Researcher

It was the second step to gather the modified and reviewed Delphi Statements from the field experts. In the Expert Evaluations of Delphi Statements Application; Technological (38 items) and SEEPL (19 items) Delphi Statements created by the researcher with literature review were presented to expert assessment as seen in Table 20 and Table 22 respectively. Experts had chances to change or rewrite them to the following lines of the given templates. The system and underpinning level technology list with the codes were given to the experts as seen in Table 21 The list had already been sorted and prioritized list analyzed by the researcher after the first expert panel. Some of the technologies in the list were bolded by the researcher to attract the attention of the participants to the analysis' results of the first expert panel. The researcher requested from experts to write down their free Delphi statements also by including the system and underpinning level technology codes from the list.

Table 20 Technological Delphi Statements Developed by the Researcher

KU: Field Expert **BV**: Knowledged

				Delphi Questions														
				Expertise		**Importance**				**Time of Realization**					**Initiation Capability**			
No	**Related System Technologies**	**Related Underpinning Technologies**	**Delphi Statements**	**KU**	**BV**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**	**Basic Research**	**Applied Industrial Research**	**Industrial Development Before Competititon**	**Industrial Development**
1			Digital Beam-Shaping Active Electronic Antenna technology has been used.															
2			Effective coding and decoding techniques have been developed for multiple terminals in heterogeneous networks.															
3			Quantum error correction codes have been developed.															
4			Adaptive channel coding techniques to provide a spectrum activity of at least 5 bits / s / Hz have been developed															
5			Compact Multi-Band MIMO Antenna Technologies have been used.															
6			Reconfigurable (frequency / polarization / pattern) MEMS antenna technologies have been developed.															
7			High Throughput Multi Spot Beam satellite has been developed.															
8			Multiplexing in multiple domains (frequency, time, code, spatial) has been used.															
9			Tactical (between vehicles) and satellite (satellite-vehicle) links that provides uninterrupted and safe mass communication of SWARM UAV / armed UAV and manned aerial vehicles are used.															
10			A Ka-band satellite with GEO orbiting satellite communication capability has been developed and used.															

Table 20 (cont'd) Technological Delphi Statements Developed by the Researcher

KU: Field Expert **BV**: Knowledged

				Delphi Questions														
				Expertise		**Importance**				**Time of Realization**					**Initiation Capability**			
No	**Related System Technologies**	**Related Underpinning Technologies**	**Delphi Statements**	**KU**	**BV**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**	**Basic Research**	**Applied Industrial Research**	**Industrial Development Before Competititon**	**Industrial Development**
11			Tracking and data relay satellites have been developed and used.															
12			Internet in space satellite technologies have been developed and used.															
13			Inter-satellites space-based optical mesh-networkshave been used.															
14			Avionics Full-Duplex Switched Ethernet (AFDX) technology has been adopted.															
15			Technologies using a large number of narrow-band signals with short data bursts have been used for communication jamming countermeasure.															
16			Air terminals composed of lighter-than-air platforms, UAV / armed UVA platforms have provided intelligent wide networks for communication of elements in air operation field.															
17			Virtualized network functions and low power software based networks have been used.															
18			High efficiency over 100W solid-state power amplifiers, low noise amplifiers and filters have been developed.															
19			National regional positioning system has been developed and in use.															

Table 20 (cont'd) Technological Delphi Statements Developed by the Researcher

KU: Field Expert **BV:**Knowledged

				Delphi Questions														
				Expertise		**Importance**				**Time of Realization**					**Initiation Capability**			
No	**Related System Technologies**	**Related Underpinning Technologies**	**Delphi Statements**	**KU**	**BV**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**	**Basic Research**	**Applied Industrial Research**	**Industrial Development Before Competition**	**Industrial Development**
20			Remote Controlled Optical Passive Devices (detectors, structures, reflectors) have been developed.															
21			Inter-orbital and orbiting satellite laser communication technologies have been used.															
22			Identification and key technologies of data transmission in quantum-based communication has been developed.															
23			Photonic signal generators and transponder systems have been developed.															
24			Effective detection, tracking and display (ATP) systems have been used to achieve optical reception from moving platforms to the receiver reliably.															
25			Ka band software based radio systems programmable in orbit have been available															
26			Optical vortex beam (angular momentum based multiplexing) technology that will increase communication bandwidth and provide spectrum efficiency have been available.															
27			Identification of Friend or Foe System (IFF) has been implemented via satellite communications.															

Table 20 (cont’d) Technological Delphi Statements Developed by the Researcher

KU: Field Expert **BV:**Knowledged				**Delphi Questions**														
				Expertise		**Importance**				**Time of Realization**					**Initiation Capability**			
No	**Related System Technologies**	**Related Underpinning Technologies**	**Delphi Statements**	**KU**	**BV**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**	**Basic Research**	**Applied Industrial Research**	**Industrial Development Before Competition**	**Industrial Development**
28			Ground Gateway Terminal, teleport or hub have been installed.															
29			Frequency reconfigurable graphene Terahertz Antenna technologies have been developed.															
30			Quantum satellite has been developed and in use.															
31			Outdoor optical wireless communication has been made between satellite and UAV / armed UAV / Airplane / Balloon / Zeppelin / Helicopter.															
32			On-board Space-Wire data link networks have been available.															
33			Hardware real-time encryption and decryption technologies have been developed.															
34			Faster and variable frequency hopping technologies using more frequency bands have been used.															
35			Cognitive network technologies and protocols have been available.															
36			Ionosphere / Atmosphere / Solar Activity Modeling technologies have been used.															
37			Intelligent multi-band plasma antennas that can direct the beam of radio waves have been developed.															
38			Atomic clocks have been developed and deployed in space and ground.															

Table 21 The System and Underpinning Level Technology List with the Codes

Code	System Level Technologies	Code	Underpinning Level Technologies
S1	**Coding**	**U1**	**Encryption / Crypto Technologies (quantum optical processing...)**
S2	**Microwave Antenna**	**U2**	**Composite Technologies (Metals&Ceramics&Glass&Polymer)**
S3	**Micro and Millimetre Wave (MMW) Communication**	**U3**	**Secure Computing Techniques**
S4	**Networking**	**U4**	**RF Power Sources & Devices**
S5	**Synchronization**	**U5**	**Information & Data Fusion Technology**
S6	**Power Amplification**	**U6**	**High Integrity and Safety Critical Computing (safety critical software,fault tolerance/detection...)**
S7	**Systems Engineering and Integrated Systems Design**	**U7**	**Inertial/Gravitational Devices**
S8	**Optical Communication**	**U8**	**Data & Information Management Technology**
S9	**Modulation**	**U9**	**Device Concepts and Fabrication**
S10	**CIS Security Systems**	**U10**	**Solar Cells**
S11	**Access**	**U11**	**Mathematical Modeling Development (communication networks...)**
S12	**MMW Communication Electronic Counter Measures (ECM-COMMs)**	**U12**	**Electromagnetic Propagation in Air**
S13	**Terahertz Antenna**	**U13**	**Structural Materials Processing, Joining and Surface Protection Technologies**
S14	**Communication ElectroOptic Counter Measures (EOCM-COMMs)**	**U14**	**III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)**
S15	**BMF Communication Electronic Counter Measures (ECM-COMMs)**	**U15**	**Optimisation & Decision Support Technology**
S16	**Command & Information Systems Integration**	**U16**	**Protocol Technology (satellite/terrestrial communication systems management and control, LANs, WANs...)**
S17	**Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)**	**U17**	**Device Integration/Reliability**
S18	**Optical Antenna**	**U18**	**Architectures**
S19	**MMW Communication Electronic Protection Measures (EPM-COMMs)**	**U19**	**Optical Signal Processing Technology**
S20	**Geographic Information Systems**	**U20**	**Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)**
S21	Communication ElectroOptic Protection Measures (EOPM-COMMs)	U21	Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)
S22	BMF Communication Electronic Protection Measures (EPM-COMMs)	U22	Device Packaging
S23	BMF Communication Electronic Support Measures (ESM-COMMs)	U23	Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)
S24	MMW Communication Electronic Support Measures (ESM-COMMs)	U24	Structural Mechanics
S25	Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)	U25	Optical Materials & Devices
S26	Electromagnetic Compatibility	U26	COTS Software Assessment (integration/maintenance technologies)
S27	**Automated Intelligent Networked Systems**	U27	Thermal & Thermodynamic Technologies & Devices
S28	Air Traffic Control Systems	U28	Smart/Functional Materials for Structural Uses
S29	Below Microwave Frequencies (BMF) Communication	U29	Insulating & Dielectric Materials
S30	Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)	U30	Corrosion and Wear Control Technology
S31	**Internet of Things (M2M)**	U31	Meteorology (weather systems, ocean-atmosphere coupling, air movements...)
S32	Network Management Systems	U32	Non-Destructive Evaluation & Life Extension of Structural Materials
S33	Environmental Monitoring Systems	U33	Terrain Science
S34	Timekeeping and Time Distribution	U34	OA Tools and Techniques
S35	Radiation Hardening	U35	Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)
S36	**Integrated System Testing and Evaluation**	U36	Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)
S37	**Quantum Communication**	U37	Speech & Natural Language Processing Technology
S38	**Earth Launch and Re- Entry Communications**	U38	Structural Materials -Forming and Materials RemovalTechnologies

Table 21 (cont'd) The System and Underpinning Level Technology List with the Codes

Code	System Level Technologies
S39	Motion Sensor Systems
S40	A-Priori Data Based Navigation
S41	In-Service Data Capture
S42	**Optical Navigation**
S43	Infrastructure to Support Information Management & Dissemination
S44	**Plasma Antenna**
S45	Microsensor Systems for Active Control of Structures
S46	Middleware systems
S47	**X-Ray Communication (XCOM)**
S48	Neutrino-Based Navigation
S49	X-Ray Navigation (XNAV)

Code	Underpinning Level Technologies
U39	Non-Linear Optical Materials & Devices
U40	Fluid Dynamics Techniques
U41	Other Semiconducting Materials
U42	Transparent Materials (diamond windows and coatings...)
U43	Mechanical/Hydraulic Technologies & Devices
U44	Fluid Mechanics - Phenomenological & Experimental
U45	Lubrication Technology
U46	Non-Laser Devices (specific structures in III-V materials and in porous silicon...)
U47	Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)

Table 22 SEEPL Delphi Statements Developed by the Researcher

		Delphi Questions								
		Importance for Turkey				Time of Realization				
No	**Delphi Statements for Political Aspect**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**
1	Turkey has become a full member of the European Space Agency (ESA) and with prior and continuing membership has been active in studies of the Asia-Pacific Space Cooperation Organization (APSCO).									
2	Technological Readiness Level-TRL 1-2-3has been mainly carried out by the university, 4-5-6 by SME, 7-8-9 by the integrator company.									
3	The National Space Agency has been founded as merit-based and has provided co-ordination among stakeholders.									
4	Economical income of leading scientists working in space communications have been at least doubled and incentives have been given to the families 3 times a year to bring them in Turkey.									
5	In order to increase interest in basic sciences, incentives at a rate of monthly minimum wage were provided for successful university and graduate students.									
6	The National Space Agency has been carried out aerospace communications R & D investments assessment analysis annually and impact analysis every 5 years.									
7	The comprehensive reform focusing on STEM (Science- Technology-Engineering-Mathematics) based team work for creative young population has been done starting from the elemantary education.									
No	**Delphi Statements for Economical Aspect**									
1	Turkey has been the leading country in the software-based radio export market in the Middle East, Africa, South America and the Balkans.									
2	Turkey has been the only source in the region as service provider of internet from space to the allied countries.									
3	The scope of the regional positioning system developed has been extended to the Middle East, the Balkans and the Turkic Republics providing an economical income.									

Table 22 (cont'd) SEEPL Delphi Statements Developed by the Researcher

		Delphi Questions								
		Importance for Turkey				Time of Realization				
No	**Delphi Statements for Legal Aspect**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**
1	Necessary restrictions for aerospace communication organizations have been determined by participation of stakeholders and a legal arrangement has been established to provide common use of infrastructure.									
2	The legal infrastructure to ensure the permanence of researchers has been developed to improve the personal rights of researchers in research centers established / to be established in universities.									
3	The legal infrastructure for the integration of technological intelligence and foresight studies into the TAF Plan / Program / Budgeting system has been established.									
No	**Delphi Statements for Social Aspect**									
1	Managers and project managers have been trained to have awareness to take responsibility, control and follow-up aerospace plans and projects.									
2	Competition programs, workshops and camps have been organized, including radio / small satellite / UAV, to guide young people to this area by providing awareness to first / middle / high school about aerospace communications.									
3	Representatives with national degrees from space law undergraduate / graduate programs have participated in international spacial law organizations.									
4	The human resource working in the field of Aerospace Communications has been increased in number and quality, being composed of specialists in the field, scientists and engineers with triadic patents.									
5	Conciliatory activities / trainings have been developed to establish trust between stakeholders operating in aerospace communications and progress has been made in confidence and confidence indices.									
No	**Delphi Statements for Environmental Aspect**									
1	Aerospace communication systems have been developed with subsystems providing power from renewable energy sources (solar, wind).									

3.3.1.2.3 Expert Evaluation of Technological Delphi Interrogation Developed by the Researcher

There were two types of Delphi interrogation. The first Delphi interrogation was used in second expert panel just to use in determining the Delphi Survey Statements. All Delphi Statements in the second expert panel was evaluated with the questions in the first Delphi Interrogation. The Delphi Survey Statements were determined with some analysis by taking the answers (the expertise and the importance level of Turkey) in the interrogation into account. They were grouped, reviewed and sorted by the researcher according to the results of the interrogation.

In the second Delphi Interrogation for the survey, the questions about the weighted criteria such as meeting national needs and economy took the place of the importance level of Delphi Statements for Turkey. The Second Delphi Interrogation was applied just to Technological Delphi Statements in two-round survey; therefore the questions were different from the first one. The answers of the second Delphi Interrogation were used to scenario building, the answers of the first and second Delphi Interrogation answers were used in policy recommendations and roadmaps.

- **The First Delphi Interrogation Questions**

  - **Expertise:** There were two choices for Tehnological Delphi Statements as *Field Expert (KU) and Knowledged (BV)*. The expertise level for SEEPL was not interrogated.
  - **Importance for Turkey:** There were four choices of the importance for Turkey for the statements as; *very much, normal, little, non.*
  - **Time of Realization:** There were five choices of Delphi Statements for the realization time as; *2019-2023, 2024-2029, 2030-2035, 2036-2040* and *Never.*
  - **Initiation Capability**: Initiation capability was interrogated just for technological Delphi Statements to get some sight about the Technology Readiness Levels of the Delphi Statements. There were four choices of Delphi Statements for the initiation capability as; *Basic Research, Applied*

Industrial Research, Industrial Development Before Competition and *Industrial Development.*

- **The Second Delphi Interrogation Questions in Delphi Survey**

  - **Expertise:** There were three choices for Tehnological Delphi Statements as *Not Knowledged*, *Field Expert and Knowledged*. In the Delphi Survey the ones selecting Not Knowledged skipped to answer the related Delphi Statements for the rest of the questions.
  - **Time of Realization:** There were five choices of Delphi Statements for the realization time as; *2019-2023, 2024-2029, 2030-2035, 2036-2040* and *Never.*
  - **Contribution to National Security:** It was Likert Scale from 1 to 5.
  - **Contribution to National Economy:** It was Likert Scale from 1 to 5.
  - **Initiation Capability**: Initiation capability was interrogated just for technological Delphi Statements to get some sight about the Technology Readiness Levels of the Delphi Statements. There were four choices of Delphi Statements for the initiation capability as; *Basic Research, Applied Industrial Research, Industrial Development Before Competition* and *Industrial Development.* Basic research is an experimental and a theoretical study in order to obtain new information from the basics of the facts and observable phenomenon. Applied industrial research aims to solve certain problems of created projects by using the basic's reseach's promising outputs in universities, research centers and R&D departments of industrial institutions mostly with the infrastuructural contribution of industry. Industrial development before competition includes the activities which need informational, financial and infrastructural cooperation for prototype and pilot productions between industrial institutions. Industrial development means to do mass production of the systems and sub-systems.

In the first Delphi Interrogation Questions Application; questions were asked to experts for their opinions and ideas by putting 'X' signs to the allocated cells for the Delphi statements created by the researcher and themselves.

The explanations of the first and second **Delphi Interrogation Questions** was shown and explained in Appendix C in Tables more clearly.

3.3.1.2.4 Creation of Delphi Statements by Experts

It was free session to collect Delphi Statements from the field experts. The system and underpinning level technology list with the codes were requested from experts to be used again. The researcher asked experts to write down their free Delphi statements including the system and underpinning level technology codes from this list.

In The Creation of Delphi Statement Application; the blank templates were requested from experts to be filled freely for SEEPL and Technological Delphi Statements in the Table 23 and Table 24 respectively.

3.3.1.2.5 Wild Cards Study by Experts

It represents the uncertainty which is in the center of the futures studies. In this perspective, it is inevitable not to take the surprises into account while anticipating the futures in this research. Ansoff (1975) came up with the strategic surprise which is a "sudden, urgent, unfamiliar changes in the firm's perspective which threaten either a major profit reversal or loss of a major opportunity". Wild Card (WC) is defined as the event with low occurrence probability but with high impact when it occurs (Rockfellow, 1994). This definition was accepted as wildcards in futures studies. Within this definition, 2001 attack to the World Trade Center on 9/11 is one of the wild card examples of a huge impact on economical, social and technological areas of the whole world. So, wildcards in foresight studies is a complementary technique so foresight practitioners use them to enlarge their visions and to investigate the future deeply (Mehrabanfar, 2014). According to iKNOW Project of European Commission the wild cards are classified as "nature-related surprises, unintentional surprises resulting from human action, intentional surprises resulting from human actions" (European Commission, 2018).

Table 23 Blank Template for SEEPL Delphi Statements

		Delphi Questions								
		Importance for Turkey				**Time of Realization**				
No	**Delphi Statements for Political Aspect**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**
No	**Delphi Statements for Economical Aspect**									
No	**Delphi Statements for Legal Aspect**									
No	**Delphi Statements for Social Aspect**									
No	**Delphi Statements for Environmental Aspect**									

Table 24 Blank Template for Technological Delphi Statements

KU: Field Expert **BV**: Knowledged

	Delphi Questions														
	Expertise		**Importance**				**Time of Realization**					**Initiation Capability**			
Delphi Statements	**KU**	**BV**	**Very much**	**Normal**	**Little**	**Non**	**2018-2023**	**2024-2029**	**2030-2035**	**2036-2040**	**Never**	**Basic Research**	**Applied Industrial Research**	**Industrial Development Before Competence**	**Industrial Development**

Although in the literature there is common opinion about WC are strongly linked with WS, there are also opposite ideas about it. Moijanen (2003) claims that WC is

WS which “last for a short time”. Caraca, Cardoso, & Mendonca (2012)contradict this linkage by stating that WC surprising occurrences even is there was no sign beforehand. Accordingly to Kaivo-oja (2012) the concepts of WS and WC have the following differences: probability of WC is lower but their impact is higher. WS have a lower level of uncertainty than WC.

Markley (2011) brought a new dimension by adding credibility to these definitions and classifications which was also adopted by the researcher especially in thinking the nature of the foresight. Hines (2014) comments this typology by exampling climate change as follow "Climate change started as a Type 1, then scientific consensus grew to it being high probability, but the public was largely unaware. I’d argue it’s now a Type 3, as society is debating/disputing it (but aware)". In the literature, collecting information for WC is done by environmental scanning (or horizon scanning) since it analyses “potential opportunities, challenges, and likely future developments (Jackson, 2013).”

In the Wild Cards Study Application, the researcher explained the types of wild cards based on the Markley's new wildcards typology to the experts and requested them to fill the imaginative events onto the form by differentiating them as political, technological, social, economical, environmental and legal within the horizon scanning.

The presented blank template pre-prepared by the researcher **Wild Cards Study by Experts** is shown in Table 25.

3.3.2 Application of the Delphi Survey

Delphi Survey is defined as a "structured group interaction process that is directed in rounds of opinion collection and feedback (Turoff & Hiltz, 1996)". The ideas of the survey participants are collected with the questionnaires. Between the rounds the controlled feedback are shared with the participants to catch the convergence and consortium. In the Delphi Survey Application; the steps were shown in Figure 21.

Table 25 Blank Template for Wild Cards Study by Experts

	P:Political **T:**Technological **S:**Social **E:**Economical **Ev:**Environmental **L:**Legal	
		P/T/S/E/Ev/L
Type 1 Wild Card **Low Probability-High Impact- High Credibility**		
Type 2 Wild Card **High Probability-High Impact- Low Credibility**		
Type 3 Wild Card **High Probability-High Impact-Disputable Credibility**		
Type 4 Wild Card **High Probability-High Impact- High Credibility**		

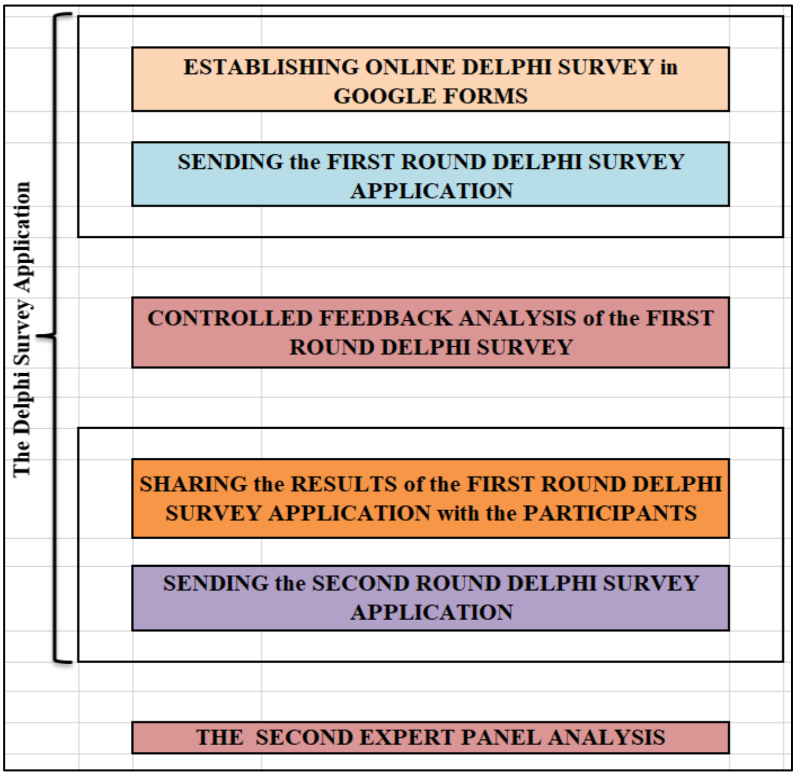

Figure 21 Application of the Delphi Survey

3.3.2.1 Establishing Online Delphi Survey in Google Forms

It was the built-in process performed by the researcher in the commercial program. Although Google Forms was not so proper for multi-matrix surveys which can be done in just one sheet, it was also effective and sufficient. Nevertheless it was realized as 27 sheets for each Delphi Statements[27].

3.3.2.2 Sending the First Round Application of Delphi Survey

It was performed as online through e-mails. 27 Technological Delphi Statements were selected with the analysis; they were integrated with the Delphi Questions in The Google Forms. The first round of the Technological Delphi Survey is presented in Appendix C. It was sent to the 44 participants in Appendix B of the first expert panel, 19 participants of the second expert panel in Appendix B, 1541 academics in Electrical and Electronics Engineering, Aeronautics and Astronautics Engineering and related departments of the universities listed in (Yükseköğretim Kurulu, 2018), 76 experts (given with institutions' names) of 11th Development Plan for Space Studies conducted by Ministry of Development in Appendix D, 440 experts in Communication and Information Technologies Sector of ASELSAN in which with institutions' names. The first round of the survey was sent online to 2120 experts in total. The results of the first Delphi round were collected from 123 participants (mostly from ASELSAN with 32 participants) within 4 weeks because of some restrictions and limitations mentioned in section 3.4.

Controlled feedback analysis of the first round Delphi Survey included the results of the first round. Since this section includes the analysis, it was explained in Data Analysis in Chapter 4.

[27] The reason of using Google Forms for the Delphi Survey was given in research limitations and restrictions in detail.

3.3.2.3 Sharing the Results of the First Round Application of Delphi Survey with the Participants

It was performed with the second round Delphi Survey. The purpose of sharing the first round analysis was to give information, encourage the experts contemplate on the technological Delphi statements again for a better review and to catch the convergence on the opinions. Since this section includes the analysis, it was explained in Data Analysis in Chapter 4.

3.3.2.4 Sending the Second Round Application of Delphi Survey

It was again online process in Google Forms and included 120 participants who responded to first round. Since this section includes the analysis, it was explained in Data Analysis in Chapter 4. No survey for the SEEPL Delphi statements was prepared since the main goal of the research is to determine the aerospace communication technologies futures strategies for the year of 2040. But, the collected SEEPL Delphi statements in the second expert panel of this research were used in political recommendations in the Results Section of Chapter 5.

3.3.3 Application of the Futures' Strategies

A scenario is a "story" illustration of the futures and determines the states. Since all analysis of the research was used to create different scenario buildings, the answers of Delphi Questions were the criteria to determine the illustrative scenarios for different futures. Since the scenario determines the strategies and roadmapping, they were constructed with the policy recommendations and the Futures' Strategies were presented in the Results Section of Chapter 5 as research findings by the researcher. The application of establishing the Futures’ strategies was given in Figure 22. The responsibility of performing the strategies is the related public and or private institutions of aerospace communication technologies.

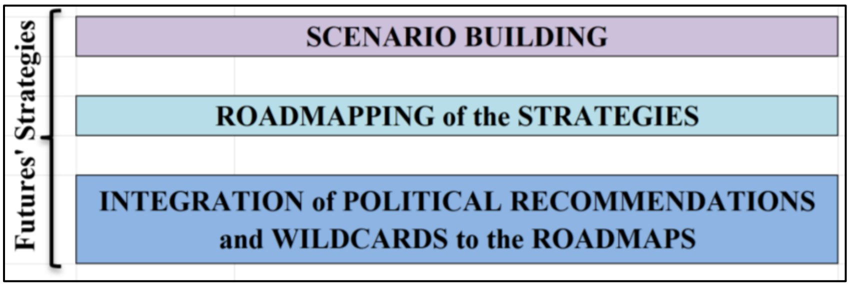

Figure 22 Application of the Futures' Strategies

3.4 Research Limitations and Restrictions

The main theme of this research is collecting the expert opinions and evaluations since there is not enough, valid and extended statistical data for the defense sector mostly affected by micro and macro factors.

Foresight studies require commitment, but there was only the researcher's commitment. Therefore, the difficulty to gather the experts together was the first limitation of the study. For the first expert panel, SSB gave its support for a formal gathering process but for the second one because of its organization change, it just gave a support for the meeting location. Nevertheless, without any sponsorship and any stimulation or motivation, the participation number and necessary expertise covering all the stakeholders was remarkable in the first expert panel. In this expert panel, the general outline of the aerospace communication technologies in Turkish Defense Sector were tried to be determined, so the participators from the most stakeholders were very valuable. Trying to arrange the meeting time and location according to every participant's availability was realized mostly by the efforts of the researcher. For the second expert panel, the technical competency was the main focus although the participation to the second one was less; there were enough technical experts for technological evaluation.

The time restriction of expert panels was another limitation. All templates created by the researcher were printed on paper and made available in front of the participants to prevent a loss of time. The researcher presented the timelines and explanations of the activities to be done briefly to the participators. In this limited time, most of the data and information were tried to be taken in a written format.

Additionally, in Delphi Survey application, there was no commercial survey program allowing matrix interrogation. There was no option in Google Forms and Survey Monkey for a more proper survey design just in a single window for this purpose. Likewise, in Lime Survey program, there was just a dual matrix form which is not sufficient for effectiveness. For the Delphi Survey of this research, it would be better to use multi-matrix form. The Excel Macro Programming was developed by the researcher for multi-matrix Delphi Survey, but because of the risk of the e-mails containing micro codes getting blocked by the related servers of he receiving parties, this macro couldn't be used as a form. Finally, Delphi Survey was prepared in Google Forms as 27 pages by the researcher.

The other restriction of the research was the confidentiality nature of Defense Sector. Participants couldn't share everything especially related with the confidential/secret and on-going projects.

The most important restriction of the study was the current conjecture of Turkey. The drawbacks of people to participate and response to any study were very discouraging.

For the similar studies in the future, finding the sponsorships and establishing the commitment among all the stakeholders would be the most important criteria for the success.

CHAPTER 4

DATA ANALYSIS AND COMMENTS OF THE RESEARCHER

4.1 General Explanations for Data Analysis

Data Analysis is the process of manipulating, ordering, structuring and giving the meaning to the collected data. It should be well planned and time-effective for creativity and easiness of the research (Marshall & Rossman, 1999). Data analysis enables the researchers and subject-interested people to give conclusions and ideas from the piece of the research. The quantity and quality of data collected in the research may be opaque and vague from being immediately obvious, therefore data analysis must provide proper means to get meaningful conclusions by finding a way to summarize the data. In the sequence of the data analysis, after defining the questions, defining what to measure and defining how to measure them are general steps (Chaturvedi, 2017). But as overall, in the data analysis, data reduction and data display are evaluated as the most important steps especially for the readers and users.

According to the time periods of the researches; longitudinal study is conducted by several observations for the same subjects over a period of time, whereas "cross-sectional study measures the outcome and the exposures in the study participants at the same time (Maninder Singh Setia, 2016)".

According to the purpose of the researches; exploratory research is used to get a better understanding of the problem although its results are typically not useful for decision-making alone. In the exploratory research, data collected for the analysis was usually in unstructured and informal. Exploratory research design is referred as gathering information in an informal and unstructured manner (Burns & Bush, 2005). But, exploratory research is not limited with just one type data analysis and may use either qualitative or quantitative data analysis. Descriptive research, also known as statistical research, is to describe situations and provide rich and important recommendations. Descriptive research deals with everything that can be measure or counted. Naming as observational methods, case-study methods and survey methods are the main types used in the descriptive researches.

According to data type of the researches, nominal data identifies the names of something whereas ordinal data assigning it to an order in relation to other numbered objects or pieces of data (Beacom, 2018).

According to data source, data may be primary and secondary data. Primary data is the first collected data from the original sources such as observations, experiments, expert panels, interviews and surveys whereas secondary data is the interpretation of the primary data by another researcher such as articles, books websites and etc. (ENotes, 2018). Primary data is collected real time; secondary data comes from the past.

4.2 Data Analysis of this Research

Red blocks seen in the some figures of Chapter 3 were not explained since they were related to the data analysis. For this research; the outline of data analysis including red blocks were shown and explained in Figure 23.

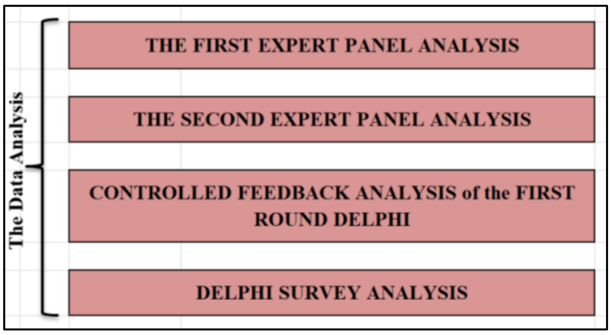

Figure 23 The Outline of Data Analysis

Conducting qualitative research design was performed through with quantitative and qualitative data analysis explained in this chapter briefly. Each detailed data analysis constructing the red blocks was differentiated from each other according to the performed research application and type. For the first expert panel, the purpose of the research was descriptive to explain the current condition of aerospace communication technologies of Turkish Defense Sector. For the second expert panel and Delphi Survey, the purpose was explorative to foresee aerospace communication technologies and conclude with the futures strategies. Data was from primary and secondary sources. Both nominal and ordinal data was obtained in the data analysis. The data was belonged to the single point in time, so it was cross-sectional study in time aspect. The data was not obtained by observing it within some time interval, so it is not longitudinal. The paper formatted evaluations of the experts were collected from all participants in the expert panels as semi-structured questions and open-ended blank templates pre-developed by the researcher (all required templates for the methodology applications were shown in the related figures of Chapter 3) The evaluations were transferred to excel format. For the first expert panel data analysis; grouping, prioritization sorting, weighting, establishing charts with respect to participants' expertise and tables were obtained especially for some specific analysis. Tables were allocated as Academics (Table-1), TAF and SSB Personnel (Table-2), Senior Executives of TAFFO (Table-3), Mid-level Managers and Engineers of TAFFO and Public Institutions (Table-4), Mid-level Managers and Engineers of Private Institutions (Table-5) and Engineers of Private Organizations and The Managers of NGOs (Table-6). The tables in the seating arrangement should be thought as groups differentiated to their institutions and duties. For the second expert panel, the Technological Delphi Statements were grouped, combined, prioritized and selected for expanded survey evaluation. All these analyses were done by the formulas developed by the researcher in the Excel format of the computer program and given in the following sections specifically.

4.2.1 The First Expert Panel Analysis

The first expert panel analysis given in Figure 24 were carried out sequentially and each one was explained in the following sections.

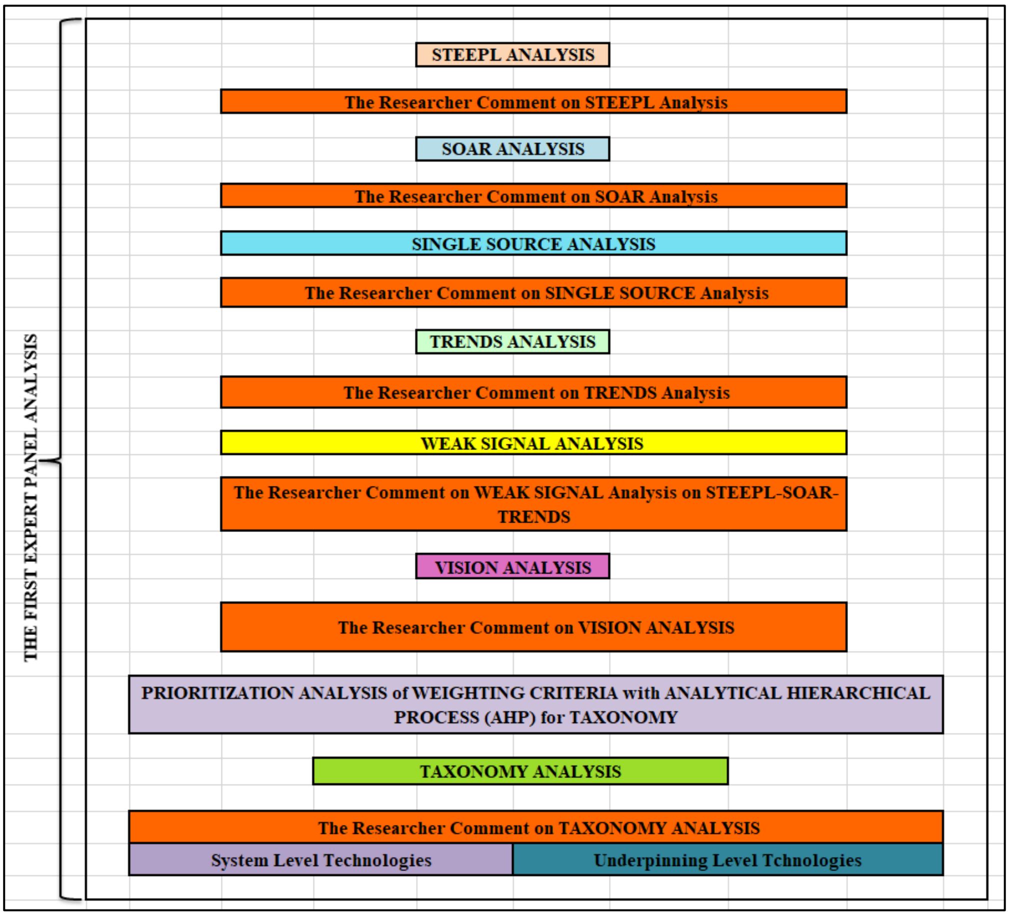

Figure 24 The Flow of the First Expert Panel Analysis

4.2.1.1 STEEPL Analysis

It included the experts' prioritization of the pre-developed STEEPL template constructed by the researcher. Voted and the freely added STEEPL by the experts were analyzed independently. But, the factors contributed by the participants were studied; revised, similar ones were combined and interpreted. Factors not explicitly related to the subject (such as if a social factor was added as a technological factor in

STEEPL study) were eliminated and added to the related heading and the factors not given prioritization were evaluated as the lowest priority level. The same factors added by the same participant were reduced to one with the higher priority given. These adjustments were minimal and recorded in the excel format. All participants were numbered in the columns and allocated according to institutions in the Excel. The factors took place in the rows the STEEPL. Histogram [28] diagrams and prioritized average graphics were established. For histogram diagrams, it was counted by COUNTIF function that how many experts voted the each prioritization numbers. For prioritized weighted averages, maximum weight was assigned to the first priority and all rest priorities were multiplexed by sorted weights and summed. This process was done for each factor in STEEPL by SUMPRODUCT function. For example, in STEEPL-Social Aspect, when all priorities assigned to "increase of user dependence on aerospace platforms in Defense Industry" are grouped; it was determined that 1st priority was given by 23 participants, 2nd priority by 9 participants, 3rd priority by 6 participants, 4th priority by 2 participants, 5th priority by 2 participants and 6th priority by 1 participant. The histogram was prepared grouping the priorities according to the number of participants.

All STEEPL histogram diagrams and prioritized average graphics with respect to participants and tables (groups-allocated according to institutions) were presented in Appendix E.

[28] A histogram is a display of statistical information that uses rectangles to show the frequency of data items in successive numerical intervals of equal size (Search Software Quality, n.d.).

4.2.1.2 The Researcher Comment on STEEPL

4.2.1.2.1 Social Aspect

4.2.1.2.1.1 Participants' Comparisons

From the voted factors, increased user dependency on aerospace platforms in the Defense Sector has emerged as the most important social factor. When the added factors were considered, proposals foregrounding the more efficient operation of the environment in the defense industry and the more use of technology in the population especially in the young generation were emphasized.

4.2.1.2.1.2 Groups’ Comparisons

From the voted factors, the priorities of senior executives of TAFFO, TAF and SSB personnel are the same in all social aspects. *While increased user dependency on aerospace platforms in Defense Sector* was given the highest priority in average by mid-level managers and engineers of TAFFO and public institutions, TAF and SSB personnel and academics; mid-level managers and engineers of private institutions gave the highest importance to the *increase in international consortium and dependencies in aerospace platforms* and engineers of private organizations and the managers of NGOs gave the most priority to the *increasing in aerospace cluster studies.*

4.2.1.2.2 Technological Aspect

4.2.1.2.2.1 Participants' Comparisons

From the voted factors, *increased the efficiency of network based operations management and data systems* has emerged as highly prioritized. But in overall, it was determined that there was no significant outstanding technological factor. The most obvious deviations were found as *complexity of the software infrastructure of systems*, *increasing of technological activities for deep space*, and *the emergence of the concept of production in space* evaluated much less effective when compared to the other factors. When the added factors were analyzed, it was evaluated that a variety of factors have emerged, while *software based radio applications*, *countermeasures for communication security and intelligence*, *national R&D studies of payloads on satellite platforms* are foreground, *unmanned aerial platforms*, *satellite systems*, *networking* and *testing*, *qualification*, *modeling*, *simulation* were interpreted as factors that participants generally discussed from different technological aspects.

4.2.1.2.2.2 Groups' Comparisons

The order of all tables was different from each other and the 1st factor in the average for academics was *widespread of the UAV systems* and *wide-use of the concept of Industry 4.0 (big data, artificial intelligence, internet of things, cyber security etc.)* For the senior executives of TAFFO it was appeared as *widespread use of communication satellites.* The 1st factor for TAF and SSB personnel and mid-level managers and engineers of TAFFO and public institutions was *increasing in jamming, blocking and listening communication system*, for the engineers of private organizations and the managers of NGOs and mid-level managers and engineers of private institutions it appeared as *increased efficiency of network based operations management and data systems*.

4.2.1.2.3 Economic Aspect

4.2.1.2.3.1 Participants' Comparisons

From the voted factors, *increasing investment in professional and military communication satellites on a global scale* has emerged as the first priority. When leading factors were examined, it was estimated that *global economical activities* appeared as the most important economic factor in the industry.

4.2.1.2.3.2 Groups’ Comparisons

The 1st priority factor of the academics and TAF and SSB personnel was *the increasing investments in defense on the global scale,* while for senior executives of TAFFO and mid-level managers and engineers of TAFFO and public institutions it appeared as the *increase of civil and military communication investments on the global scale,* for mid-level managers and engineers of private institutions it emerged as *high cost of communication and navigation systems aerospace platforms and ground stations,* and for engineers of private organizations and the managers of NGOs it was *increase in number of entrepreneurs and established companies in Defense Sector.*

4.2.1.2.4 Environmental Aspect

4.2.1.2.4.1 Participants' Comparisons

From the voted factors, *increase in the use of renewable energy (solar cells, etc.)* has emerged as the most significant environmental factor in both the average and priority order.

4.2.1.2.4.2 Groups’ Comparisons

The 1st priority factor of the participants from engineers of private organizations and the managers of NGOs appeared as *increase in the radiation effect of communication signals,* whereas for all other groups it was *increase in the use of renewable energy (solar cells, etc.).*

4.2.1.2.5 Political Aspect

4.2.1.2.5.1 Participants' Comparisons

From the voted factors, *political support for space and satellite applications* was the most prominent political factor in both average and priority order. When the added factors were examined, being added by 3 participants *political stability* was the most dominant factor, where the *external pressures and embargoes* and *the lack of coordination between institutions* were the foregrounded factors that were added by 2 participants.

4.2.1.2.5.2 Groups' Comparisons

The 1st priority factor in all groups was voted as *political support for space and satellite applications.*

4.2.1.2.6 Legal Aspect

4.2.1.2.6.1 Participants' Comparisons

From the voted factors, although adoption of the scheme for the establishment of the National Space Agency appeared as 1st in average and priority *difficulties arising from international export control agreements* was evaluated with the prominence voted as 1st (by 13 participants) and 2nd priority (by 12 participants). When first 3 added factors were evaluated, *to make legal arrangements for merit, qualified manpower and cooperation and clarity between institutions/organizations* was foregrounded.

4.2.1.2.6.2 Groups' Comparisons

The 1st priority factor for senior executives of TAFFO was the *regulation of frequency spectrum distribution, management and control,* whereas in all other groups it appeared as voted *legislation for the establishment of the National Space Agency.*

4.2.1.3 SOAR Analysis

It included the experts' prioritization of the pre-developed SOAR template constructed by the researcher. The freely added SOAR by the experts was analyzed independently. But, the factors contributed by the participants were studied; revised, similar ones were combined and interpreted. Factors not explicitly related to the subject (such as if a strength was added as a opportunity in SOAR study) were eliminated and added to the related heading and the factors not given prioritization were evaluated as the lowest priority level. The same factors added by the same participant were reduced to one with the higher priority given. These adjustments were minimal and recorded in the Excel format. All participants were numbered in the columns and allocated according to their belonged institutions in the Excel. In the rows, the SOAR factors took place. Histogram diagrams and prioritized average graphics were established. For histogram diagrams, it was counted by COUNTIF function that how many experts voted the each prioritization numbers. For prioritized weighted averages, maximum weight was assigned to the first priority and all rest priorities were multiplexed by sorted weights and summed. This process was done for each factor in SOAR by SUMPRODUCT function.

All SOAR histogram diagrams and prioritized average graphics with respect to participants and tables were presented in Appendix F.

4.2.1.4 The Researcher Comment on SOAR

4.2.1.4.1 Strengths

4.2.1.4.1.1 Participants' Comparisons

From the voted factors for the strengths, *to meet the communication needs with national sources* emerged as the strongest strength in the first place. When other strengths were taken into consideration, the distinctions was observed in t*he presence of a legal infrastructure that protects personal data, ideas and works being emerged as much less powerful*. When the added factors were analyzed, the 3 participants focused on the *experienced human resource in development processes for aerospace platforms*. In general, *human resource* was added as an emphasized strength and it was remarkable.

4.2.1.4.1.2 Groups' Comparisons

The 1st priority strength for the participants of TAF and SSB personnel, *originally and nationally developed communication systems* were chosen as the strongest feature in the average, while for participants from mid-level managers and engineers of private institutions it emerged as *young and entrepreneurial human resource* and for all other groups it was *to meet communication needs with national resources.*

4.2.1.4.2 Opportunities

4.2.1.4.2.1 Participants' Comparisons

From the voted factors for the opportunity, the first-tier was voted as *space technologies being in priority technology domains*, while *the interest of community in aviation and space emerged as considered the least significant opportunity*. When the added factors were analyzed, the most important opportunity was seen as *having young and entrepreneurial human power.*

4.2.1.4.2.2 Groups’ Comparisons

For academics, the primary opportunity was *the creation and updating strategy* and *roadmaps in space applications by political will*. For the engineers of private organizations and the managers of NGO, it appeared as *to initiate a number of new projects in the area of aerospace communications*. For all other groups the 1st priority emerged as *space technologies being priority in the technology domains*.

4.2.1.4.3 Aspirations

4.2.1.4.3.1 Participants' Comparisons

From the voted factors for the aspirations, *human resource* came to the forefront. When the added factors were analyzed, the underlined ones were *capability and advancing in the contemporary technology*, *becoming full-member of international space agencies*, *increase in support for space applications for small sized companies*, which in general indicates the demands were focused on support, education, entrepreneurship, cooperation, observation and analysis. It also emerged as *TRL*[29] *1-2-3 would be the most concrete request to be conducted by universities, 4-5-6 by small sized companies, 7-8-9 by the integrator.*

4.2.1.4.3.2 Groups’ Comparisons

For the academics, senior executives of TAFFO and mid-level managers and engineers of TAFFO and public institutions determined that the *nationalization of R&D* was the first request in average, the mid-level managers and engineers of

[29] "Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology (Mai, 2017) ".

TAFFO and public institutions also evaluated *the increase in the number and quality of R&D man power in the 1st order as aspiration.* While TAF and SSB personnel evaluated that *increase in the number and quality of R&D manpower* in the 1st order, the most important request of engineers of private organizations and the managers of NGOs emerged as *to co-operate with the relevant institutions and organizations.*

4.2.1.4.4 Results

4.2.1.4.4.1 Participants' Comparisons

From the voted factors for the results, the most outstanding one was *not having external dependence*. By taking a comment made by one participant into account of this result was rewritten as *to decrease the external dependency* by the researcher. In the results there was an emphasis *on increase in production and export by using experienced human resource in other technological areas*, but in general the main underlined result was *the participation and competition in the international arena.*

4.2.1.4.4.2 Groups’ Comparisons

For the senior executives of TAFFO and engineers of private organizations and the managers of NGOs, the highest priority for the results in the average was chosen the as *the experienced human resource*, while other groups selected first priority as *not to have external dependency*. Mid-level managers and engineers of TAFFO and public institutions and mid-level managers and engineers of private institutions evaluated both of these at the same priority level.

4.2.1.5 Single Source Analysis

In the single source application for Turkey, the blank form was expected from the experts to be filled. The added single sources were as follows:

- Polar coding developed by Prof. Dr. Erdal Arıkan, which is one of the standard codes of 5G and enables the fast and flexible telecommunication.
- IONOLAB group studies and mapping/analysis services on aerospace communication, navigational ionosphere modeling/observation.
- There is no fully integrated product similar to the Tactical Data Link Management Center (data sharing and peer to peer results by integrated single product between different products). NATO and other countries can do that with 5-6 item non-integrated products. However, since it is not integrated in NATO, data transfer between different products and end-to-end results cannot be obtained effectively.
- Airborne radios and data links.
- Having qualified and successful academics.
- Missile, ammunition and data links.
- Tactical communication systems' development/integration/test infrastructure of satellite sub-systems.
- Development of training and test criteria that primary, secondary and university education and R&D institutions can use for space education applications.

4.2.1.6 Researcher Comment on Single Source Analysis

The analysis of the single sources was done just by the efforts of the researcher with the literature reviews since there were confidentiality and classified information. According to such restricted analysis below single sources for Turkey were determined.

- In the literature review done by the researcher that *Polar Coding*[30] developed by Prof. Dr. Erdal Arıkan, which is one of the standard codes of 5G and enables the fast and flexible telecommunication was analyzed as the single source for Turkey.
- In the literature review done by the researcher that *IONOLAB*[31] group studies and mapping/analysis services on aerospace communication, navigational ionosphere modeling/observation were analyzed as the single source for Turkey.

[30] "Polar coding was originally designed to be a low-complexity recursive channel combining and splitting operation of this type, to be used as the inner code in a concatenated scheme with outer convolutional coding and sequential decoding (Arıkan, 2015) ".

- Although researcher have done the literature review and detailed research about whether there is no fully integrated product similar to the *Tactical Data Link Management Center*[32](data sharing and peer to peer results by integrated single product between different products) or not, it was not analyzed effectively since it is confidential and restricted information

4.2.1.7 Trend Analysis

It was performed using run charts and involves mathematical techniques to forecast future outcomes based on historical results and often used to monitor the technical performance by using linear and nonlinear regression with time.

In this research's trend analysis, the priorities of participants who were evaluated themselves as KU (Field Expert) and BV (Knowledged) were multiplied by the weighted scores, and then the average was taken using different coefficients. Line graphs were created by sorting the averages and histograms were constructed separately for KU and BV.

All Trends histogram diagrams and prioritized average graphics with respect to participants and tables were presented in H.

4.2.1.8 Researcher Comment on Trend Analysis

- For the aerospace platforms, the *Unmanned Aerial Vehicle (UAV)/Armed UAV* came to the forefront. When the added platforms were evaluated *intelligent navigation missiles* was in the front plan.

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[31] IONOLAB is a group of electrical engineers and scientists of various study areas, getting together to handle challenges of the earth's ionosphere (IONOLAB, 2011).

[32] Software that will gain TDL design, planning, management and analysis capabilities towards the use of Tactical Data Link (TDL) systems in the operation environment and check the conformity of the TDL R/F broadcasts to the Frequency Clearance Agreement (FCA) restrictions is developed (HAVELSAN, 2017).

- For the air communication bands, *UHF (300-3000MHz)* and *VHF (30-300MHz)* were at the forefront. *L (1-2 GHz)* was the communication band that stands out in *UHF*. *Ku (12-18 GHz)* was the interval that became apparent in the *SHF (3-30GHz)* band.
- For the space communication bands, while *Ka* became the first, *Ku* and *X* bands appeared as also important trends.
- For the technologies that affect aerospace communications, *material technologies* and *artificial intelligence* have emerged as the first two trends. When added trends were evaluated, *autonomy* and *unmanned systems* covered by *artificial intelligence* were also evident.
- For the technologies that impact aerospace navigation, *material technologies* and *MEMS* have come to the forefront as the first two trends. When looking at the trends added, *autonomy*, *quantum sensors*, *MEMS sensors* and *GPS jamming* became evident.
- For the navigation systems *inertial/aerodynamic data inertial systems* was the first trend. When looking at the added trends, it was noticed that experts commented that these systems should be *image-aided*. Added by 3 participants *satellite-based regional positioning system* emerged as a distinctive trend. *Mobile/ pedestrian/automobile navigation systems* were also significant trends added by the experts.
- For the material technologies, *mid-IR in laser* and *optical materials* was underlined, while *GaN in III-V materials* was selected as the 1st and *AIN* was selected as the 2nd important trend. *SiGe* material was evident in the added trends.
- For the orbiting satellites, *GEO* and *LEO* satellites were the prominent trends.
- For the technologies that directly affect satellite communications, *communication between the orbiting satellites* was clearly in the forefront.

4.2.1.9 Weak Signal Analysis

The mathematician and economist Igor Ansoff defined the Weak Signal (WS) term first in 1975 related to the strategic management in the literature by proposing three filters named as observation, mentality and power to analyze them shown in Table

26. In the Foresight, it is really big challenge to observe and catch the WSs in timely manner, linking them to the futures' changes and integrating the application of them to the scenario building and roadmappings to decrease the risks and negative events. For the observation filter, the researcher accepted that a weak signal is a sign of value that appears when information seemed random and disconnected is viewed from a different point of view and combined with other parts of information (Schoemaker & Day, 2009).

Table 26 Weak Signal Analysis Filters

Suggested Analyzing Filters of Weak Signals by Igor Ansoff	**Function of the Analyzing Filters**
Observation	Obtaining the information
Mentality	Indicating the relevance and significance of the signal based on existing experience
Power	Applying the acquired knowledge in the decision making process

With this point of view, in STEEPL, SOAR, Trend Analysis and Taxonomy studies, when factors and technologies in the middle or in the last in the ranking of the averages are over-rated in priority as 1st or 2nd priorities, they are considered as weak signals as observation filter and mentality filter in this chapter under the title of researcher comment on Weak Signal analysis. For example, a factor of 9th in the average order is considered as a weak signal if it is the 2nd in the 1st priority order especially by the field experts.

4.2.1.10 Researcher Comment on Weak Signal Analysis

4.2.1.10.1 STEEPL

- For the technological point of view; *spread of advanced material technologies* was regarded as the 9th factor in average, but it was prioritized as a very important technological factor in terms of weak signal analysis since it came to the 3rd in priority order. The majority of the 1st priority selections of *increase in technological activities for deep space* made this factor be regarded as a weak signal.
- For the economical point of view; although *rapid change in the semiconductor market*, which constitutes the infrastructure of communication and navigation systems was ranked 5th in the average, but it was given highest priority as the 1st by 8 participants and the 2nd by the 7 participants, it was regarded as a weak signal naturally as well.

4.2.1.10.2 SOAR

- For the voted aspirations; *increase in the number and quality of R&D manpower* was remarkably considered as a weak signal, *to prevent closing academic units for basic sciences in universities coming to the last rank on the average* was also evaluated as a weak signal since it was seen in the first three priority orders.

4.2.1.10.3 Trends

- For the aerospace platforms, *UAV/Armed UAV* have come forward. However, when the KU were taken into consideration, the 1st priority order was given to *Communication Satellites so it emerged* as a weak signal.
- For the air communication bands, *HF (3-30MHz)*, which ranks 8th in the average was regarded as a weak signal according to the prioritization of KU.

- For the space communication bands, *V (50-75 GHz)* and *Q (33-50 GHz)* were in the 4^{th} and 6^{th} order in average, they were considered as weak signals since they were important in prioritization of the experts. Likewise, *Optic Band (1 THz [10^{12}Hz] - 1EHz [10^{18}Hz])*, which includes laser, was interpreted as a weak signal because it was considered important in the priority order by the experts.
- For the technologies affecting aerospace communication; *Internet of Things (IoT)* was interpreted as a weak signal when the expert prioritization were taken into account.
- For the technologies affecting aerospace navigation *Big Data* was considered as a weak signal according to the evaluation of the priority order of the experts.
- For the technologies affecting the satellite communication directly; *Internet in space (internetworking)* was considered as a weak signal when the priority order of the experts was taken into consideration. Additionally, *Small Satellites* which came prominent in added trends and were observed in technological factors of STEEPL, so it was evaluated as a weak signal.

4.2.1.11 Vision Analysis

It included the vision statement defined in the dictionary as "an aspirational description of what an organization would like to achieve or accomplish in the mid-term or long-term future and intended to serves as a clear guide for choosing current and future courses of action (BusinessDictionary, n.d.) "The written, visualized and sometimes illustrative statements for the foresighted future are tried to be obtained (EFP, 2010).

The main purpose in the vision analysis was to determine the different point of views of the stakeholders. Although, there were some common points in the visioning such as national, own R&D, qualified human resources, unique terms like sustainability and own ecosystem emerged. The vision statements created by the Tables were given below. Tables should be thought as groups to which participants are allocated to according to their institutions and duties.

Table-1 (Group-1): To be a country that has sustainable, national and pioneering original technologies developed by highly qualified basic science and technological researchers working on space and communication.

Table-2 (Group-2): To be a country that can produce technologies and systems with qualified human resource locally and nationally, and have fast and secure aerospace communication technologies and systems from its own R&D and production infrastructure.

Table-3 (Group-3): To be a country that develops its own original technologies in Aerospace Communication Technologies nationally and securely, leading the international field with technologies shaping the future, training qualified human resources needed for increasing the competitiveness index and developing and carrying out the legal regulations for protection of intellectual property rights.

Table-4 (Group-4): To be a country that is technologically independent, has established its own ecosystem including basic sciences, including advanced applications such as space laboratory, and meets military and civil needs.

Table-5 (Group-5): To have an automated military data network and secure communication that does not depend externally, produces technology, has international competitive power.

Table-6 (Group-6): To have advanced national, original and competitive communication technologies with qualified human resource and academic cooperation.

4.2.1.12 Researcher Comment on Vision Analysis

All visions created by the tables were interpreted and combined by the researcher. The researcher tried to foreground some unique technical features of aerospace technologies and set some numerical goals for creating more clear future awareness in the minds for the year of 2040 in Turkish Defense Sector.

Vision of 2040 for the Aerospace Communication Technologies in Turkish Defense Sector[33]*:* To be among the first five innovative countries with sustainable technology that develops dynamic, reliable communication and navigation systems on aerospace platforms nationally with qualified human resource.

4.2.1.13 Prioritization Analysis of Weighting Criteria with Analytical Hierarchical Process (AHP) for Taxonomy

The data obtained from the pairwise comparisons of *To Create Competitive Advantage (K1), To Create Other Technological Research Fields (K2)* and *To Meet National Security Requirements (K3)* according to their significances were evaluated using Analytical Hierarchical Process (AHP), consistency indexes and ratios were calculated and sorted according to the criteria weight and column graphs were created in the Excel Format.

For the system and basic technologies assessment in taxonomy, the scores given by participants (between 0-10) were weighted using the scores given by each participant for each criterion, averaged and sorted. Sorted system level and underpinning technology lists and line graphs are created. System and basic technologies ranking according to the criteria differences were calculated and interpreted accordingly.

4.2.1.13.1 Explanation of AHP

In complex decision-making by setting priorities, The Analytic Hierarchy Process (AHP) is the efficient tool introduced by Saaty (1980). It allows the pairwise comparisons of the criteria and controlling the consistency of the participants' evaluations. AHP is analytical, because it converts the evaluations into numeric

[33] Stated vision is just the recommendation of the researcher according to the expert panel results explained in this chapter.

values. The following steps were executed in AHP while evaluating weighting criteria in this research.

4.2.1.13.1.1 Computing the Vector of Criteria Weights

Pairwise comparison matrix $\boldsymbol{A}$ with dimension mxm was established where m is the number of evaluation criteria considered. Each entry a_{jk} (for a matrix $\boldsymbol{A}$, a_{ij} denotes the entry in the i^{th} row and the j^{th} column of $\boldsymbol{A}$) For a vector v, v_i denotes the i^{th} element of the matrix $\boldsymbol{A}$ represents the importance of the j^{th} criterion relative to the k^{th} criterion.

For the elements of $\boldsymbol{A}$ matrix,

if $a_{jk} > 1$, then the j^{th} criterion is more important than the k^{th} criterion
if $a_{jk} < 1$, then the j^{th} criterion is less important than the k^{th} criterion
if two criteria have the same importance, then the entry a_{jk} is 1.

The entries a_{jk} and a_{kj} should satisfy that

$$a_{jk} . a_{kj} = 1 \tag{4.1}$$

So for all j,

$$a_{ji} = 1 \tag{4.2}$$

In this case the matrix $\boldsymbol{A}$**,** for three criteria is 3x3 matrix.

$$\boldsymbol{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \tag{4.3}$$

In this research, with respect to our criteria of,

K_1: To create competitive advantage

K_2: To create other technological areas

K_3: To meet national security need

$$\boldsymbol{A}_{\mathrm{K}} = \begin{bmatrix} K_{11} & K_{12} & K_{13} \\ K_{21} & K_{22} & K_{23} \\ K_{31} & K_{32} & K_{33} \end{bmatrix} \tag{4.4}$$

The values of the $\boldsymbol{A}_{\mathrm{K}}$ matrix were filled according to numeric values assigned to the experts' evaluations in the Table 27.

Table 27 The Numerical Values of the $\boldsymbol{A}_{\mathbf{K}}$ Matrix According to Evaluation

Numerical Value	**Evaluation**
1	j and k are equally important
3	j is little more important than k
5	j is more important than k
7	j is very much important than k
9	j is completely more important than k

$\boldsymbol{A}_{\mathrm{norm}}$ matrix was established by making equal to 1 the sum of the entries on each column as,

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \tag{4.5}$$

Finally, the criteria weight vector w (that is an m-dimensional column vector) is built by averaging the entries on each row of $\boldsymbol{A}_{\mathrm{norm}}$.

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m} \tag{4.6}$$

4.2.1.13.1.2 Constructing the Matrix of Option Scores

The score matrix was constructed as each entry s_{ij} indicates the score of the i^{th}option with respect to j^{th} criterion. Before score matrix, pairwise comparison matrix of $\boldsymbol{B}^{(j)}$ 3x3 matrix was established in this research according to our criteria. Each element $b_{ih}^{(j)}$ is the i^{th}option compared to the h^{th}option with respect to the j^{th} criterion.

If $b_{ih}^{(j)}$>1 then the i^{th}option is better than the h^{th}option

If $b_{ih}^{(j)}$<1, then the i^{th} option is worse than the h^{th} option

If two options are evaluated as equivalent with respect to the hj^{th} criterion, then the entry is 1.

The entries $b_{ih}^{(j)}$ and $b_{hi}^{(j)}$ should satisfy that,

$$b_{ih}^{(j)}.b_{hi}^{(j)} = 1 \tag{4.7}$$

So for all i,

$$b_{ii}^{(j)} = 1 \tag{4.8}$$

Afterwards, each entry of $\boldsymbol{B}^{j}$was divided by the sum of the entries in the same column, and then it was averaged the entries on each row and score vectors $s^{(j)}$ which contains the scores of the evaluated options with respect to the j^{th}criterion were obtained.

Score vector was the comprise of score vectors as,

$$\boldsymbol{S} = [s^{(1)}\dots s^{(m)}] \tag{4.9}$$

4.2.1.13.1.3 Ranking the Options

For the ranking of the options the weights and the scores were computed together as obtaining $\boldsymbol{v}$ matrix.

$$\boldsymbol{v} = \boldsymbol{S}.\boldsymbol{w} \tag{4.10}$$

The i^{th} entry of $\boldsymbol{v}_i$ represents the global score assigned by the AHP to the i^{th}option.

4.2.1.13.1.4 Checking the Consistency

While evaluating the criterions as pairwise, the evaluators might some mistakes, so AHP calculates the consistency to eliminate them. For instance, if a decision maker evaluates that K1 is more important than K2 and K2 is more important than K3, it is inconsistent that K3 is more important than K1. These examples might be increased with respect to importance levels.

To obtain Consistency Index (CI), matrix $\boldsymbol{A}$ is replaced by $\boldsymbol{B}^{(j)}$, $\boldsymbol{w}$ with $s^{(j)}$, m with n.

In that case,

$$CI = \frac{x - m}{m - 1} \tag{4.11}$$

where x are the averages of the elements in $\boldsymbol{A}.\boldsymbol{w}$ vector and m is criteria number.

While perfect consistency requires CI=0, some inconsistencies may be tolerated.

$$\frac{CI}{RI} < 0.1 \tag{4.12}$$

where RI is Random Index and for small number of criteria $m \leq 10$ it is shown in Table 28.

Table 28 Random Index according to Criteria Number

m	2	**3**	4	5	6	7	8	9	10
RI	0	**0.58**	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Since the criteria number in this research was 3, (that is m=3), the RI was taken as 0.58.

Consistency Ratio (CR) was defined as,

$$CR = \frac{CI}{0.58} \tag{4.13}$$

The values of $CR \leq 0.2$ were accepted as consistent according to (Pauer et al., 2016). So, in this research CR values smaller than or equal to 0.2 were accepted as consistent responses for the criteria.

4.2.1.14 Researcher Comment on Prioritization Analysis of Weighting Criteria with AHP

All the applications of AHP were shown in Appendix H. According to results there, the graphs are in Figure 25 (with respect to consistent and inconsistent results) and Figure 26 (with respect to just consistent results).

When looking at the figures, K3 (to meet national security needs) took the first priority; K1 (to create competitive advantage) was in second priority whereas K2 (to create other technological areas) was in the third for all responses. For the consistent responses, K2 and K3 shared the same priority. In the taxonomy sorting for the system and underpinning technologies, all criteria were taken into account but since K3 came first in the weighting, all evaluations of the researcher were done according to K3.

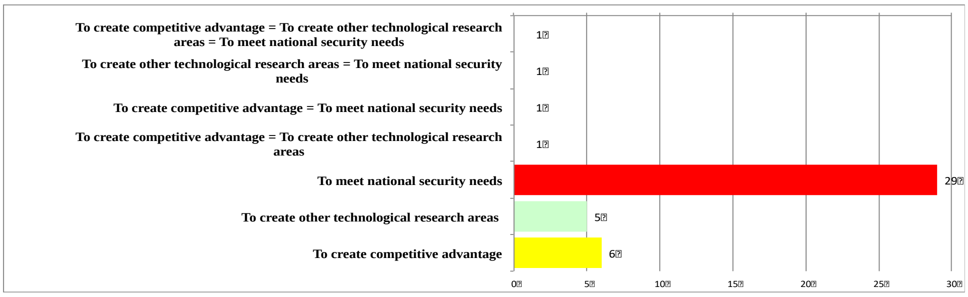

Figure 25 Prioritization of Criteria with Consistent (24) and Inconsistent (20) Responses in AHP

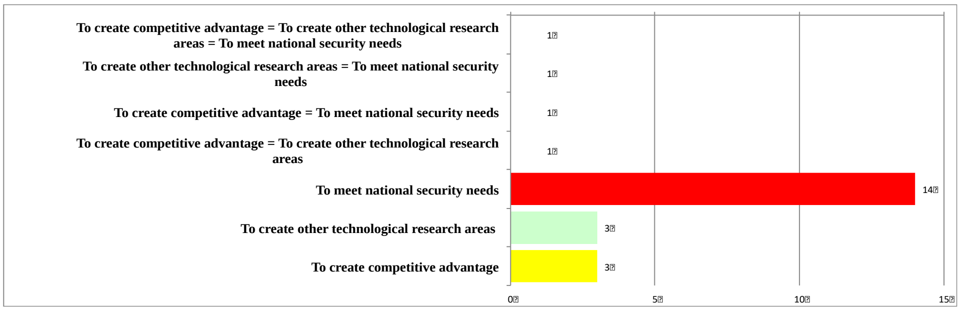

Figure 26 Priotization of Criteria with Consistent (24) Responses in AHP

4.2.1.15 Taxonomy Analysis

For the aerospace system and underpinning communication technologies, the grades (between 0-10) given by each participant were weighted by SUMPRODUCT in the Excel with the values obtained from AHP for each participant' criterion. They were summed and sorted for each criterion. With this analysis, sorted system and underpinning technology lists and line graphs were created and given in Appendix I.

System and underpinning technologies ranking differences according to the criteria were calculated in the lists with VLOOKUP function in the Excel, shown in Table 29 and Table 30 for K3 and other rank comparison tables in Appendix I. The researcher took these ranking differences into account for the interpretation. The distinct differences in the ranking between criterions were reviewed.

For instance, if the system or underpinning technology comes at first ranks in the most important criterion of K3 (to meet national security needs) but comes at last ranks in the criterion of K1 (to create competitive advantage); it means that although it was very urgent need for the national security but delayed. They have to be acquired at once and especially needed political preventions and decisions have to be taken.

In the following section, for the given rank differences resulting from the mentioned analysis of the system and underpinning level technologies, the researcher reviews and comments were shared. Since in the prioritization of weighted criteria analysis; K3 was the first one, the researcher's evaluations were made especially regarding the K3.

Nevertheless in the appendices, all the graphs and ranking differences' lists for each criterion were given and it is very encouraging for the future studies and articles.

4.2.1.16 Researcher Comment on Taxonomy Analysis

As a result of the dual comparisons from the three selected criteria, since K3 (to meet national security needs) is clearly identified as the most important criterion, the evaluation of the aerospace system level communication technologies was done based on the comparison table of K3 sequences with K1 and K2 Sequences[34].

4.2.1.16.1 Comments on System Level Aerospace Communication Technologies

In Table 29, the K3 rank differences of technologies with respect to K2 and K1 were shown. The big rank differences for the criteria were reviewed and interpreted by the researcher.

[34] Since there are other difference comparisons for the aerospace communication system level technologies for all criteria in the appendices, they may be evaluated for the encouraging future studies.

Table 29 Comparisons Aerospace Communication System Technologies According to Criteria

Aerospace Communication System Technologies	Rank in K3	Value in K3 Ranking	Rank in K1	Rank in K2	The rank difference between K3 and K1	The rank difference between K3 and K2
Coding	1	5,28	10	4	-9	-3
Microwave Antenna	2	5,15	1	7	1	-5
Micro and Millimetre Wave (MMW) Communication	3	4,97	5	2	-2	1
Networking	4	4,92	7	1	-3	3
Synchronization	5	4,79	14	8	-9	-3
Power Amplification	6	4,78	2	12	4	-6
Systems Engineering and Integrated Systems Design	7	4,70	6	11	1	-4
Optical Communication	8	4,67	11	6	-3	2
Modulation	9	4,59	12	3	-3	6
CIS Security Systems	10	4,53	4	13	6	-3
Access	11	4,39	19	9	-8	2
MMW Communication Electronic Counter Measures (ECM-COMMs)	12	4,27	24	19	-12	-7
Terahertz Antenna	13	4,17	3	5	10	8
Communication ElectroOptic Counter Measures (EOCM-COMMs)	14	4,13	38	28	-24	-14
BMF Communication Electronic Counter Measures (ECM-COMMs)	15	4,03	44	34	-29	-19
Command & Information Systems Integration	16	4,03	8	17	8	-1
Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)	17	4,01	29	33	-12	-16
Optical Antenna	18	3,99	17	16	1	2
MMW Communication Electronic Protection Measures (EPM-COMMs)	19	3,90	23	27	-4	-8
Geographic Information Systems	20	3,90	20	20	0	0
Communication ElectroOptic Protection Measures (EOPM-COMMs)	21	3,82	31	31	-10	-10
BMF Communication Electronic Protection Measures (EPM-COMMs)	22	3,74	34	37	-12	-15
BMF Communication Electronic Support Measures (ESM-COMMs)	23	3,70	42	35	-19	-12
MMW Communication Electronic Support Measures (ESM-COMMs)	24	3,62	39	29	-15	-5
Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)	25	3,46	36	36	-11	-11
Electromagnetic Compatibility	26	3,38	26	40	0	-14
Automated Intelligent Networked Systems	27	3,37	13	24	14	3
Air Traffic Control Systems	28	3,33	35	26	-7	2
Below Microwave Frequencies (BMF) Communication	29	3,22	32	18	-3	11
Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)	30	3,21	27	39	3	-9
Internet of Things (M2M)	31	3,20	9	10	22	21
Network Management Systems	32	3,16	21	30	11	2
Environmental Monitoring Systems	33	3,13	30	21	3	12
Timekeeping and Time Distribution	34	3,12	33	22	1	12
Radiation Hardening	35	3,11	22	44	13	-9
Integrated System Testing and Evaluation	36	3,11	15	38	21	-2
Quantum Communication	37	3,06	18	15	19	22
Earth Launch and Re- Entry Communications	38	2,96	37	14	1	24
Motion Sensor Systems	39	2,95	25	32	14	7
A-Priori Data Based Navigation	40	2,83	41	42	-1	-2
In-Service Data Capture	41	2,77	46	48	-5	-7
Optical Navigation	42	2,60	16	41	26	1
Infrastructure to Support Information Management & Dissemination	43	2,48	43	46	0	-3
Plasma Antenna	44	2,32	28	25	16	19
Microsensor Systems for Active Control of Structures	45	2,28	40	47	5	-2

Table 29 (cont'd) Comparisons Aerospace Communication System Technologies According to Criteria

Aerospace Communication System Technologies	Rank in K3	Value in K3 Ranking	Rank in K1	Rank in K2	The rank difference between K3 and K1	The rank difference between K3 and K2
Middleware systems	46	2,25	45	45	1	1
X-Ray Communication (XCOM)	47	2,10	47	23	0	24
Neutrino-Based Navigation	48	1,14	48	49	0	-1
X-Ray Navigation (XNAV)	49	0,89	49	43	0	6

- There are two major points seen in the scores given according to K3 as *Neutrino-Based Navigation* and *X-Ray Navigation (XNAV)* systems. This may be due to the fact that these technologies are still in the research phase or relatively few participants with expertise and knowledge in navigation have participated in the study.
- *Coding* and *Microwave Antenna* took place in the first two rows. Looking at the difference between the criteria of K3 (to meet national security needs) and K1 (to create competitive advantage), *Electro Optic Communication*, *MMW Communication*, *BMF Communication Electronic Counter Measures*, *BMF Communication Electronic Support Measures* systems are required even they are acquired immediately, it is now late to have these systems. *MMW Communication Electronic Support Measures* and *Counter Measures* systems appear to be ahead of other communication measures in terms of creating other technological research areas. This means that, there is already technological infrastructure, efforts and knowledge on this area in Turkey.
- *Communication protection measures, countermeasures, supporting measures* are more important in K3 (to meet national security needs), but they fall behind in other criteria. This situation is also in parallel with the STEEPL analysis resulting from the *TAF and SSB Personnel* (Table-2), stated as *increasing jamming, blocking and listening activities of communication systems* as the 1st technological factor. It means that, these are the most important aerospace communication systems which should be acquired immediately.
- It is thought that *Internet of Things (IoT)* system is not yet in need in K3 but it is important to create technology field and competitive edge, therefore it is necessary to act quickly to develop and acquire.

- Although *Network Management and Automated Intelligent Network Systems* are not seen so important in K3 (to meet national security needs) or in creating competitive advantage, they have been evaluated as important in create other technological areas since it is one of the key points to step into more important technological research fields.
- The fact that *Integrated Systems Testing and Evaluation* systems are at the forefront in creating competitive advantage, but it is behind in creating other technological areas. This condition is interpreted as these systems have a certain technological infrastructure and accumulation but not fully embodied.
- *Quantum Communication and Plasma Antennas* are not seen in K3 (to meet national security needs) at the moment but they are considered as systems that need to be taken quickly in the acquisition to create other technological fields for and competitive advantage.
- Although *Optical Navigation* systems don't seem appeared as important in K3 (to meet national security needs), it is seen as the system to create competitive advantage. However, these systems are behind in creating other technological research areas in the list. This case is interpreted as they have a certain technological efforts in academia and awareness between stakeholders for acquiring but it will take time to get the system.
- At present, *Earth-Launch and Re-Entry Communications* and *X-Ray Communications*, which are not considered in K3 (to meet national security needs), have clearly emerged as important criteria to create other technological research areas. This suggests that the technological infrastructure for the acquisition of these systems should also be developed.

4.2.1.16.2 Comments on Underpinning Level Aerospace Communication Technologies

In Table 30, the K3 rank differences of technologies with respect to K2 and K1 were shown. The big rank differences for the criteria are reviewed and interpreted by the researcher.

Table 30 Comparisons Aerospace Communication Underpinning Technologies According to Criteria

Aerospace Communication Underpinning Technologies	Rank in K3	Value in K3 Ranking	Rank in K1	Rank in K2	The rank difference between K3 and K1	The rank difference between K3 and K2
Encryption / Crypto Technologies (quantum optical processing...)	1	4,50	6	12	-5	-11
Composite Technologies (Metals&Ceramics&Glass&Polymer)	2	4,28	2	18	0	-16
Secure Computing Techniques	3	4,21	4	14	-1	-11
RF Power Sources & Devices	4	4,17	1	8	3	-4
Information & Data Fusion Technology	5	3,89	3	7	2	-2
High Integrity and Safety Critical Computing (safety critical software fault tolerance/detection...)	6	3,85	5	3	1	3
Inertial/Gravitational Devices	7	3,66	7	11	0	-4
Data & Information Management Technology	8	3,58	11	6	-3	2
Device Concepts and Fabrication	9	3,47	10	15	-1	-6
Solar Cells	10	3,46	8	2	2	8
Mathematical Modeling Development (communication networks...)	11	3,37	12	9	-1	2
Electromagnetic Propagation in Air	12	3,32	22	4	-10	8
Structural Materials Processing, Joining and Surface Protection Technologies	13	3,30	16	28	-3	-15
III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)	14	3,29	9	20	5	-6
Optimisation & Decision Support Technology	15	3,27	14	10	1	5
Protocol Technology (satellite/terrestrial communication systems management and control, LANs, WANs...)	16	3,21	13	1	3	15
Device Integration/Reliability	17	3,21	20	16	-3	1
Architectures	18	2,86	17	13	1	5
Optical Signal Processing Technology	19	2,71	15	26	4	-7
Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)	20	2,66	19	29	1	-9
Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)	21	2,63	26	17	-5	4
Device Packaging	22	2,52	21	30	1	-8
Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)	23	2,50	25	25	-2	-2
Structural Mechanics	24	2,43	32	19	-8	5
Optical Materials & Devices	25	2,43	24	34	1	-9
COTS Software Assessment (integration/maintenance technologies)	26	2,28	18	22	8	4
Thermal & Thermodynamic Technologies & Devices	27	2,24	33	35	-6	-8
Smart/Functional Materials for Structural Uses	28	2,12	23	27	5	1
Insulating & Dielectric Materials	29	2,10	42	38	-13	-9
Corrosion and Wear Control Technology	30	2,10	39	36	-9	-6
Meteorology (weather systems, ocean-atmosphere coupling, air movements...)	31	2,08	35	5	-4	26
Non-Destructive Evaluation & Life Extension of Structural Materials	32	2,01	29	44	3	-12
Terrain Science	33	1,99	30	24	3	9
OA Tools and Techniques	34	1,94	36	31	-2	3
Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)	35	1,87	37	37	-2	-2
Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)	36	1,85	28	32	8	4
Speech & Natural Language Processing Technology	37	1,81	27	23	10	14
Structural Materials -Forming and Materials RemovalTechnologies	38	1,74	40	21	-2	17
Non-Linear Optical Materials & Devices	39	1,74	31	45	8	-6
Fluid Dynamics Techniques	40	1,61	34	39	6	1
Other Semiconducting Materials	41	1,52	46	33	-5	8

Table 30 (cont'd) Comparisons Aerospace Communication Underpinning Technologies According to Criteria

Aerospace Communication Underpinning Technologies	Rank in K3	Value in K3 Ranking	Rank in K1	Rank in K2	The rank difference between K3 and K1	The rank difference between K3 and K2
Transparent Materials (diamond windows and coatings...)	42	1,39	38	41	4	1
Mechanical/Hydraulic Technologies & Devices	43	1,37	44	43	-1	0
Fluid Mechanics - Phenomenological & Experimental	44	1,37	41	40	3	4
Lubrication Technology	45	1,35	47	46	-2	-1
Non-Laser Devices (specific structures in III-V materials and in porous silicon...)	46	1,31	43	47	3	-1
Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)	47	1,24	45	42	2	5

- *Encryption/Crypto Technologies*, *Composite Technologies*, and *Secure Computing Techniques* are considered to be technologies that have a certain background but not yet been acquired, since they are evaluated behind in creating other technological research areas.
- *Protocol Technologies and Meteorology* have emerged in the first place to create other technological fields, however, they are far behind for other criteria. This situation also suggests that they have a certain infrastructure that is open to be developed in these technologies and acquisition is partly found.
- Although *Structural Materials-Forming* and *Materials Removal Technologies* are considered more important to create other technological research areas, it is interpreted as it is a technology that has a certain maturity of the infrastructure, but does not have a significant need and that will not bring competitive advantage.

When thinking about the underpinning technologies interpretation, it is clearly seen that multi-disciplinary technological areas and expertise have been becoming more important since the creation of other technological areas becomes prominent. This case strongly suggests that the studies between different disciplines should be encouraged.

4.2.2 The Second Expert Panel Analysis

For the expert sampling size and the quality, the resources of Delphi Study which was in the center of the second expert panel such as time, commitment and cost were considered. In the literature, there is no suggested certain number for the experts in Delphi Studies for that reason. For the Delphi Survey Analysis according to Hasson, Keeney, & McKenna, (2000) "the sample is purposively selected and it depends on the problem being investigated such as some studies have used 15 participants whilst others have used 60". In the range of 10 and 50 participants for the sample size are also suggested since smaller than 10 is not effective to create sufficient ideas and more than 50 means cost in time, product and process (Needham & de Loë, 1990). De Villiers, de Villiers, & Kent (2005) bring another point of view in defining sample size according to its homogeneity or heterogeneity as the same discipline (15–30) or from differing ones (5–10) per professional group. "Delphi survey studies do not call for a representativeness of the sample in terms of statistical purposes; therefore, sample size principles differ from those in other surveys" (Hasson et al., 2000).

For the content validity[35], Delphi Studies are very strong since the content is established by published literature, field experts' judgments and pretested-tools. Likewise, for the Delphi Survey Analysis, the iterative evaluations with the controlled feedbacks provide the validity of the content and concepts by giving more extended participants a chance to review these. This suggests that the final results are high in content validity (Bowlings, 2005).

The establishment of the Delphi Statements and Questions in the Delphi Survey was done with qualitative data collecting technique from the expert opinions with semi-structured and un-structured questions given in templates in the following sections.

[35] "Content validity refers to the extent to which the items on a test are fairly representative of the entire domain the test seeks to measure (Salkind, 2010) ".

For the reliability[36], Delphi Studies are consistent to have a ability to create the similar results when they are repeated (Bowlings, 2005; Delport, 2002; Sharkey & Sharples, 2001). The Delphi Survey increases the reliability since there is no bias and effect of dominating factor. The participants of the survey don't meet face to face and group thinking is prevented with its anonymity feature. The iterative rounds are also another factor in enhancing the reliability of the Delphi Survey.

For the face validity[37], Delphi Survey is accepted as the effective instrument if the relevance and the establishment of the questionnaire are well integrated. For high face validity, the Delphi Survey should be clear and unambiguous in content and language (LoBiondo & Wood, 1998).

All Delphi Statements' data analysis was performed by mixing quantitative and qualitative techniques by the researcher in the Excel.

4.2.2.1 Expert Evaluation of Technological Delphi Statements (38 Items) Developed by the Researcher

The pre-written technological Delphi Statements by the researcher about aerospace communication were interrogated by the experts. Experts gave the prioritization levels according to criterion K3. The values given were weighted and sorted by taking them as KU and BV into account. They were given in Table 20 in Chapter 3.

[36] "Reliability refers to whether or not you get the same answer by using an instrument to measure something more than once (Dudovskiy, 2018)".

[37] "Face validity refers to the extent to which a test appears to measure what it is intended to measure (Johnson, 2013)".

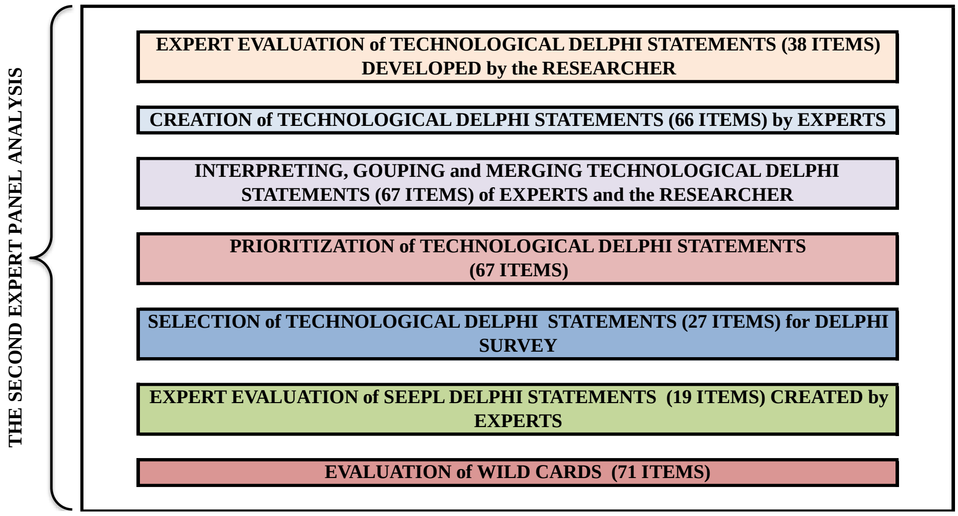

Figure 27 The Flow of the Second Expert Panel Analysis

4.2.2.2 Creation of Technological Delphi Statements (66 Items) by Experts

It was expected from experts to imagine future technologies by assessing the current condition of Turkey and The World to write Delphi Statements about aerospace communication technologies. Experts prioritized them by thinking the criteria K3. Additionally, the codes of related system and underpinning technologies of each added Delphi were requested from the experts to enter. The values given weighted and sorted by taking them into account as KU and BV. Created technological Delphi Statements were given in Table 31.

Table 31 Technological Delphi Statements Created by Experts

No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
1	S7, S14, S16	U17	Communication, radar and electronic warfare systems were realized as a single system.
2	S1, S9	U1, U3, U5, U11, U16	Common coding was realized for the communication, radar and electronic warfare systems in a single system.
3	S31	U9	The number of smart sevices became widespread.
4	S27, S31		Communication between smart devices became widespread.
5	S20, S27		Navigation independent of satellites was carried out.
6	S2, S4, S12, S15, S16, S22, S27	U1, U9, U11	A network-based communication system capable of interference management with directional access was developed.

Table 31 (cont'd) Technological Delphi Statements Created by Experts

No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
7	S2, S4, S12, S15, S16, S22, S27	U1, U9, U11	Satellite and airborne platforms have created a communication network and information systems in a mobile environment with a relative navigation system.
8	S2, S12		Low-cost digital beam forming smart antennas were developed as easily producible.
9			Quantum cryptography techniques have been used.
10			Stratospheric Balloons and regional communication and positioning systems in coordination with satellites and independent of satellites were developed.
11	S1, S3, S6	U4, U12	The warplanes were developed with a capacity of narrow-span AD-HOC (ECCM, LPI-enabled) networks interconnected to each other, providing mid-short range, two-way mass data communication.
12	S1, S12	U4, U14	High power/high efficiency (> 50%) in wideband was achieved with modules containing GaN-based power components.
13	S14	U2, U10, U13	Selective infrared emitter surfaces were made by synthesis of certain optical characteristics (Metallodielectric, photonic bandgap) of nano-particles buried in composite materials.
14			Using quantum radar and entanglement feature, any object in the air was detected.
15	S7, S10, S16, S20	U5, U8, U15, U17	SWARM UVA communication network systems were developed allowing intelligence from big data to be interpreted by IT technologies.
16	S1, S4, S10	U1	Safe and reliable military communication systems based on commercial and mobile communication technologies were developed and in use.
17	S28, S31	U10	A distributed airborne traffic control systems were developed using passive sensors, IoT technologies, infrastructures constructed for different purposes, and organic objects on earth.
18	S1,S10	U1, U3	Secure communication and information systems technologies integrating with the human brain as the key role were developed.
19	S1	U5, U8	Data security and transfer speed were increased with the polar coding which becomes standard between devices and systems.
20		U2, U14	Know-how on materials and especially composite production have been widely used in our country and improved according to the needs.
21		U5, U8, U21, U31	The regional positioning and timing system was in use working together with GPS and satellites monitoring ionosphere sytems.
22		U10	Significant progress was made in battery technologies by increasing the efficiency of solar panels.
23	S17, S39	U1, U5, U6, U8	Effective transmitter/receiver integration systems for IFF were in operation.
24	S27	U5, U8, U21	Air and space platforms able to communicate over an intelligent network, correct position codes despite the deterioration caused by the ionosphere and protect the network structure in a robust manner using narrow communication were developed.
25	S1	U5, U8, U11	Between aerospace platforms, encoding and decoding technologies were used to provide secure communication, high-speed communication (> = 100GB/s) and efficient communication (> 1pJ/bit).
26	S1, S9, S31	U1, U3, U5	New and original coding techniques for Internet of Things (IoT, M2M) communication were developed and widely used in our country.
27	S4, S13, S42, S16	U1, U5	Intelligent network systems and new technologies with different features of use were developed which can be used without user intervention (such as inter-vehicle communication, autonomous motion, etc.).
28			Atomic clocks with MEMS were developed and deployed in space and ground.
29			Communication and surveillance satellite technologies were developed.
30			Satellite launch centers were realized.
31			Satellite rocket technology was realized.
32			Space qualified components were developed.
33	S2		Multi-band (X-Ku-Ka) satellite communication technology were developed.
34			Inter-satellites communication technologies were developed.
35			Detecting the region from the images taken by surveillance satellites while passing over Turkey was made available.
36			Handheld terminals with minimum dimensions were developed in Q/V bands.
37	S34	U9	Low cost, high precision atomic clock modules were developed to be used in handheld transceiver terminals or GNSS receivers.

Table 31 (cont'd) Technological Delphi Statements Created by Experts

No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
38	S7	U40	With a low-cost launch system deployed on ground/air/naval platform, nano-satellite sets could be deployed in the orbit in a very short time after a decision is taken.
39	S37	U18	Receiver systems that can communicate and navigate under a heavy jamming condition were developed.
40	S44	U44	Communication plasma antennas have replaced the use of common antennas by 80%.
41	S13		THz communication and imaging systems have been widely used.
42		U10	A photovoltaic cell with more than 50% efficiency was developed for use on satellites for communication.
43		U9, U23	The infrastructure for developing silicon carbide or similar semiconductor technologies providing operability up to 150ºC was made available with domestically manufacturing.
44	S35		Radiation-resistant, programmable in the field for back-up FPGA development technology was made available.
45	S38		Rocket technology that can launch communication satellites up to 5 tons to orbitwas made available.
46	S42	U7, U19, U33	Strategic Inertial Navigation Systems which are supported by using earth images were made available.
47	S31	U5, U8, U15, U37	Systems that allows intelligence from big data to be interpreted through embedded features of Internet of Things devices which were started to be widely used for civil and military purposes on earth..
48	S3, S13	U5, U8, U14, U16	Very narrow bandwidth and short-range stealth communication and data transfer systems between airborne systems which cannot be detected by radar, satellites and other flying platforms were developed.
49	S37	U1	Quantum computers were developed and in use.
50	S30, S42	U7, U25	The fiber optic navigation system was developed for aerospace platforms.
51	S30, S35, S42	U7, U25	Space-compatible (radiation-resistant) fiber optic materials and devices were developed.
52	S2, S7	U2, U4, U9, U13, U27,U35	Antenna systems deployable in orbit were used for LEO satellites.
53	S6, S7	U4, U13, U23, U27, U36	High efficiency, small size, high power amplifier for LEO satellites were developed.
54	S30	U7	Inertial sensors (gyro, accelerometer) were developed and used for all purposes (strategic, navigation, tactical).
55	S42		Precise navigation systems using image-based techniques were developed.
56			Ground stations and necessary receiver systems for the national regional positioning system were developed and in use.
57	S40		The world-wide precision Digital Elevation Model (DEM) which uses the data from the earth for navigation was achieved with low memory requirements.
58	S7	U18	System model languages were started to be widely used.
59	S39	U9	Micro Electric Mechanical Systems (MEMS) providing robust-reliable-precise torque meter, accelerometer and detecting systems were developed and in use.
60	S45	U7	Precise, low-cost, reliable devices (micro-sensors) were developed for use in SWARM micro-satellites.
61			Coding Techniques accessible to channel capacity were being used.
62			Smart communication network which are self organizing and healing were made available.
63			Effective network structures are used for SWARM platforms.
64			Artificial Intelligence were developed for communication optimization.
65			Edge compting was made for the network load optimization.
66	S1, S3, S7, S8, S11, S13, S18, S29, S37, S38, S41, S44, S47	U1, U5, U8, U11, U16, U19, U20, U37	Any communication (satellite, satellite-ground, satellite-other vehicles) could be listened, recorded and decrypted and at least 10% of encrypted communication could be solved in maximum 1 week.

4.2.2.3 Interpreting, Grouping and Merging Technological Delphi Statements (67 Items)

These analyses were done and interpreted by the same methods. The similar and the different Delphi statements prewritten by the researcher (38 items) and experts freely (66 items) were detected and re-thought. The similar ones were grouped as rows in the same column whereas the different ones were added to rows of different column. Delphi statements were reduced to 67 items according to importance levels given by KU and BV. They were weighted with different coefficients assigned by the researcher and averaged.

The freely added Delphi Statements (66 Items) by the experts were given in Table 31. With researcher's statements (38) totally 104 statements were reduced 67 Delphi Statements.

4.2.2.4 Prioritization of Technological Delphi Statements (67 Items)

It included the listing of all similar and different Delphi Statements as rows in the same column. They were evaluated according to given importance level and related with especially for *aerospace communication technologies*. The given X signs were counted separately for all experts by allocating them with respect to their identification of themselves as KU and BV. COUNTA function was used for this purpose in the Excel. Then the weights were assigned to the importance levels by the researcher and the numbers calculated with COUNTA were multiplied with these weights. They were summed and normalized with SUMPRODUCT/SUM function and then they were sorted.

4.2.2.5 Selection of Technological Delphi Statements (27 Items) for Delphi Survey

It was done according to sorting. The first 27 Technological Delphi Items were selected and re-written by the researcher to establish the Delphi Survey. In this selection, the implicit and explicit knowledge of the researcher played the most important role. Another important factor was to find the saturation Delphi Statements' number at which the survey participants don't get bothered in the survey evaluation. Time was taken as criterion and 25 minute was calculated for the evaluation. It was accepted as logical by the researcher.

The selected Delphi Statements (27 Items) by the researcher were given in the Table 32.

Table 32 Technological Delphi Statements for Delphi Survey

Delphi No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
D1	S2, S4, S12, S15, S16, S27, S22	U1, U9, U11	A network-based communication system capable of Interference Management with Directional Medium Access-DMA has been developed.
D2			Regional communication and positioning systems which uses stratospheric balloons in coordination with satellites and independent of satellites have been developed.
D3	S7, S10, S16, S20	U5, U8, U15, U17	Information Technologies (IT) that intreprets the intelligence obtained from the big data in SWARM UAV/Armed UAV communication network have been developed.
D4	S1, S2, S3, S4, S8, S37	U1, U11	Quantum cryptology techniques have been used.
D5			Smart communication networks that have the ability to do self organizing-healing and optimizing the network load (with edge computing) have been used.
D6	S2, S4, S12, S15, S16, S22, S27	S1, S9, S11	Communication and information systems network in a mobile environment by constructing relative navigation infrastructure with the satellite and air platforms have been developed.
D7	S27	U5, U8, U21	Air and space platforms able to communicate over an intelligent network, correct position codes despite the deterioration caused by the ionosphere and protect the network structure in a robust manner using narrow communication have been developed.

Table 32 (cont'd) Technological Delphi Statements for Delphi Survey

Delphi No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
D8	S1	U5, U8, U11	Between aerospace platforms, encoding and decoding technologieshave been used to provide secure communication, high-speed communication (> = 100GB/s) and efficient communication (> 1pJ/bit).
D9	S1, S3, S6	U4, U12	Air-based network between the air platforms having the capacity of narrow-beam AD-HOC (ECCM, LPI-enabled) interconnected to each other, providing mid-short range, two-way mass data communication have been developed.
D10	S1, S3, S4, S7	U1, U11	Ka band software based radio systems programmable in orbit were developed.
D11	S1, S2, S3, S4, S7, S31	U1, U3, U4, U5, U8, U11, U12, U21	Tactical (between vehicles) and satellite (satellite-vehicle) links that provides uninterrupted and safe mass communication of SWARM UAV/Armed UAV/Manned AV have been used.
D12	S7, S36	U8, U15, U16	Tracking and data relay satellites heve been developed and in use.
D13	S2, S3, S6, S7, S12, S13, S31	U2, U3, U4, U9, U11, U12, U13, U14, U17	Low-cost easily-producible, electronically directive based, digital beam-forming antenna technologies have been used.
D14	S2, S4, S7, S13	U8, U11, U18	Cognitive network technologies and protocols have been made available.
D15			Frequency reconfigurable graphene-based Terahertz Antenna technologies have been developed.
D16	S1, S3, S4, S8, S31	U4, U8, U11, U12	Outdoor optical wireless communication has been used between satellite and UAV /Armed UAV/Airplan/Balloon/Zeppelin/Helicopter.
D17	S4	U11	Software based networks with virtualized network functions and low power consumption have been used commonly.
D18			Effective detection, tracking and display (ATP) systems have been used to reach optical beam from moving platforms to the receiver reliably.
D19	S17	U16	Identification of Friend or Foe System (IFF) has been implemented via satellite communications.
D20			Smart multi-band plasma antennas that can direct the beam of radio waves have been developed and have replaced the use of common antennas by more than 50%.
D21			Internet space satellite technologies in LEO orbithave been developed and in use.
D22	S4	U19, U20	Inter-satellites space-based optical mesh-networks have been used.
D23			The multi-band inter-satellites communication capability in GEO orbit has been developed and in use.
D24			High throughput multi spot beam satellite have been developed and in use.
D25	S30	U7	Inertial meters (gyro, accelerometer) have been developed and in use for all levels (strategic, navigation, tactical).
D26	S30, S42	U7, U25	The fiber optic navigation system has been developed for aerospace platforms.
D27	S1, S12	U4, U14	High power/high efficiency (> 50%) goals in wideband have been achieved with modules containing GaN-based power components.

4.2.2.6 Evaluation of SEEPL Delphi Statements (19 Items) Developed by the Researcher

The pre-written technological SEEPL Delphi Statements by the researcher in Table 22 given in Chapter 3 were interrogated by the experts. Experts evaluated the importance for Turkey and realization time according to criterion K3. The importance levels given were weighted and sorted. In Chapter 5, this section with the addition of expert's own SEEPL Delphi Statements filled in Table 23 was presented as Policy Recommendations.

4.2.2.7 Evaluation of Wild Cards (71 items)

Kussi (2000) claims that weak signals come before the wild cards and they are usually predicted by pioneers and special groups instead of acknowledged expert. Sometimes to catch the wild cards, there might be outside of the subject. Futures studies should not undervalue the wild cards. Especially, today's globalization world with the rapid changes and innovation-dominated environment, it is not sufficient to try to estimate the wild cards. Handling them and managing for the future applications is more important. Within this point of view the approach of Peterson (1999) is reasonable. He suggests 'answering three questions about if we know what wild cards are and if we can anticipate the time of their arrival and at last if there is anything we can do? In contrast to Kussi, Peterson cares about the experts' ideas more for wild cards and recommends Delphi method's to collect the wild cards.

For this research, Delphi Survey was not performed for the wild cards. Since they were not surveyed, the researcher presented all WCs created by the experts in the second expert panel. All types of wild cards were presented in Table 33, 34, 35 and 36 respectively.

Table 33 Type 1 Wild Card Statements

TYPES OF WILD CARDS	NO	WILD CARDS (33 ITEMS)	P/T/S/E/Env/L
Type 1 Wild Card Low probability-High affect-High credibility	1	Communication using neutrinos due to non-blocking nature as it is not affected like materials.	T
	2	No requirement of remote communication by using teleportation.	T
	3	Determination of the properties of dark matter and the emergence of new technologies.	T
	4	Realization of space colonization.	T/P/S
	5	Turkey to become the most powerful country in Europe after 2050.	P/E
	6	Turkey to become a global power with sustainable aviation / aerospace technologies.	P
	7	Realization of space colonization.	S
	8	Recording the undergrounding sources and archeological remains in Turkey by means of earth observation and probing satellites	P/T/S/E/Env/L
	9	The disruption of life and agriculture by shifting the poles of the earth's magnetic field	P/T/S/E/Env
	10	Providing a training in secondary school and high school education where maximum 6 courses are determined in depth according to the curiosity of the students	P/T
	11	Ensure that high school students are elected by research universities in high school-3 without entering the university entrance exam	P/T
	12	Turkey to reach economic and social level of the world's leading civilized countries and to become a leading country fully integrated with these countries	P/S/E
	13	Education in schools to be compatible with or even better than with the best systems in the world	P/S
	14	Travelling to planets by nuclear powered space vehicles carrying humans	T
	15	Construction of non-fuel driven propulsion engines	T
	16	The end of humanity by artificial intelligence	S/T
	17	Producing energy in space using radiation and X-ray emission from the sun	T
	18	Space mining	E
	19	The Third World War	P
	20	To take precautions against satellites falling out of orbit and creating danger in some regions on earth	T/P/E/Env
	21	To be able to listen and observe other planets using telescopic systems and increase the capabilities of these systems	T/P
	22	To become completely dependent on domestic resources due to an international embargo against the country	P/E
	23	Development of a single technological system involving all kinds of aerospace communication technologies	T
	24	Use of communication satellite with infinite operation life-time	T
	25	Achieving the ability to transfer images, data and audio with the least delay and the highest quality in the world	T
	26	Discovering that some neurons in the brain that communicate between the human brain and the soul and determining that the electrical activity measured in the human brain reflects only the perceived part of this communication	T/S
	27	Using low-cost ammunition-packed WWIs in battle as kamikaze	P/T
	28	Food discovery and initiation of agricultural activities for people in space	E
	29	Directing wars over space	P
	30	Reduction of losses and noises by exploration or production of superconducting materials working at room temperature	T
	31	Training new generations supporting them to use analytical thinking and questioning	P/S
	32	Realization of colonization on lunar surface	T
	33	Wide use of free, independent research infrastructures	L

Table 34 Type 2 Wild Card Statements

TYPES OF WILD CARDS	NO	WILD CARDS (8 ITEMS)	P/T/S/E/Env/L
Type 2 Wild Card High probability - High affect - Low credibility	1	Using codes developed and modified with artificial intelligence in communication	T
	2	The development of systems using big data applications that control all the behavior of people and result in disappearence of free will	ST
	3	An extremely powerful geomagnetic storm in space to hit the space and ground systems, breaking down transformers, satellites and to make them fall, resulting in shortages of internet, electric and all technological systems	P/T/S/E/Env
	4	Development of magnetic thrust technology	T
	5	The collapse of democracies, the widespread of authoritarian and protective policies in economy	P
	6	Monopoly of the USA in space and communication	P
	7	Satellite communication terminals to become low cost and obtainable by everyone	S
	8	The unipolar effect of the capitalist world to strengthen a formation similar to 'Internet of People' and this 'networked' living group to collapse the world and a new group to be formed that can reconstruct the destructed networks and to take the lead in the world	T/P/S/E/Env/L

Table 35 Type 3 Wild Card Statements

TYPES OF WILD CARDS	NO	WILD CARDS (13 ITEMS)	P/T/S/E/Env/L
Type 3 Wild Card High probability - High affect - Unclear credibility	1	Carrying out coordinated tasks for a specific purpose with a small number of autonomous UVAs	T
	2	All battles to be done with armed UVAs	T/P
	3	A nuclear war	P/S/E/Env
	4	Coastal flooding with the rise of sea level	P/S/E/Env/L
	5	The beginning of a social and economic crisis in the world as a result of an epidemic disease	T/S/E/Env
	6	Middle East countries to become the rising economy class	P/E
	7	Artificial intelligence and robots to dominate the economic system and to result in massive unemployment	E/S
	8	The disintegration of the European Union and the establishment of the Eurasian Union becoming a monopoly in aerospace communication	Y
	9	Beginning to use planes that work with solar energy and provide round-trip communication around the world without landing	T
	10	Marginal groups to continue the civilization using optical communication channels after destruction of civilization by a nuclear world war	T/P/S/Env/L
	11	Discovery of new communication methods and sensors	T
	12	The young generation to become the decision maker	S
	13	Special legislation for spin-off (university) companies	L

Table 36 Type 4 Wild Card Statements

TYPES OF WILD CARDS	NO	WILD CARDS (17 ITEMS)	P/T/S/E/Env/L
Type 4 Wild Card High probability - High affect - High credibility	1	Communication with software based devices and radar and electronic warfare technologies using single system/device	T
	2	The inclusion of all devices in the world to Internet of Things (IoT)	T
	3	Construction of quantum radar taking place of military radars (the existence of the theory, difficulty of practice, not detecting its detection, non-existance of counterfeit)	T
	4	The minimum impact of the human factor in war	T/P(S
	5	Increased need for space and air observation due to regional intense but intermittent conflict	P/S/E/Env
	6	The earthquake to occur due to high mobility of the faults in Turkey	P/S/E/Env/L
	7	Serious damage to the Istanbul and around due to a very strong earthquake	T/S/E/Env
	8	Shooting enemy satellites using missiles	T
	9	Satellite operation lifetime to be at least 50 years	T
	10	The widespread of satellites that can target and hit other satellites	T/P
	11	The collapse of the banking system, beginning of crypto coin era	P/E
	12	Decrease in trade of intermediate goods, reduction in transportation and logistics activities, widespread of semi-colonial countries as a result of Industry 4.0	P/E
	13	Turkey to have the ability to send manned vehicle sand-settling in space without being dependent on other countries	T
	14	Turkey to become the leading country in the Middle East with its own developed communication technology	E
	15	At the end of World War III the humanity to survive just under oceans but only the ones with capability of optical or LF (low frequency) technologies for communication over water can be colonized	T/P/S/Env/L
	16	Development of powerful and reusable rocket systems	T
	17	Widespread of space tourism	T

4.2.2.8 Researcher Comment on Wild Cards

The analysis was done for all types of wild cards but the researcher commented on just Type 1 Wild Cards. In analyzed form done by the researcher, the statements were resolved to words as seen in Table 37; all words were counted with COUNTIF and sorted according to repetitive ones in the Excel. Some of different words were grouped since they evoked the same subject. The prominent ones were found and reviewed again by the researcher.

For the future studies, the analysis of other wild card types was presented in Appendix J.

As seen in Table 38, when the most frequently words related with the subject such as space, communication, aerospace, system, technology, World, Turkey, country are omitted; the red colored words colonization, agriculture and war came into prominence. These may relate with the colonization in space, managing war from space and agriculture in space or disruption of agriculture in earth because of space. All these developments mean bringing the requirements in aerospace communication technologies together. But when the list is checked over with different point of view, some words evoking the same subjects become clarified. The words about education (blue colored) such as high school, research, training, analytical thinking, course, exam, new generation, questioning, school, secondary school, student, university written by different experts emerged as 17 times totally. This means that in Turkey, the wild card for education is expected. Additionally, the words about material (green colored) such as dark matter, neutrino, superconductor and teleportation appeared as 6 times. This means that material technologies for example providing teleportation might be strong wild card for the future.

Table 37 Resolved Form of Type 1 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (33 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words
Type 1 Wild Card Low probability-High effect-High credibility	1	Communication using neutrinos due to non-blocking nature as it is not affected like materials.	T	neutrino	material	communication	non-blocking			
	2	No requirement of remote communication by using teleportation.	T	teleportation	remote	communication				
	3	Determination of the properties of dark matter and the emergence of new technologies.	T	dark matter	technology					
	4	Realization of space colonization.	T/P/S	colonization	space					
	5	Turkey to become the most powerful country in Europe after 2050.	P/E	powerful	europe	Turkey	country			
	6	Turkey to become a global power with sustainable aviation / aerospace technologies.	P	powerful	aviation	aerospace	global	Turkey	sustainable	aerospace
	7	Realization of space colonization.	S	space	colonization					
	8	Recording the undergrounding sources and archeological remains in Turkey by means of earth observation and probing satellites	P/T/S/E/Env/L	underground	archeological	probing	satellite	source	remains	
	9	The disruption of life and agriculture by shifting the poles of the earth's magnetic field	P/T/S/E/Env	earth	poles	human life	agriculture	magnetic field	shifting	
	10	Providing a training in secondary school and high school education where maximum 6 courses are determined in depth according to the curiosity of the students	P/T	training	education	course	secondary school	high school	student	
	11	Ensure that high school students are elected by research universities in high school-3 without entering the university entrance exam	P/T	research	education	university	high school	exam		

Table 37 (cont’d) Resolved Form of Type 1 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (33 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words
	12	Turkey to reach economic and social level of the world's leading civilized countries and to become a leading country fully integrated with these countries	P/S/E	leading	country	Turkey	economy	social	world	civilization
	13	Education in schools to be compatible with or even better than with the best systems in the world	P/S	education	world	school	world	compatible	system	
	14	Travelling to planets by nuclear powered space vehicles carrying humans	T	space	planet	nuclear	vehicle	travel	power	human
	15	Construction of non-fuel driven propulsion engines	T	non-fuel	engine	propulsion				
	16	The end of humanity by artificial intelligence	S/T	artificial intelligence	human	humanity				
	17	Producing energy in space using radiation and X-ray emission from the sun	T	energy	radiation	x-ray	Sun	space	emission	
	18	Space mining	E	mining	Space					
	19	The Third World War	P	world	war					
Type 1 Wild Card Low probability-High effect-High credibility	20	To take precautions against satellites falling out of orbit and creating danger in some regions on earth	T/P/E/Env	orbit	satellite	precaution	danger	earth		
	21	To be able to listen and observe other planets using telescopic systems and increase the capabilities of these systems	T/P	planet	observation	telescobic	listen	system		
	22	To become completely dependent on domestic resources due to an international embargo against the country	P/E	resource	embargo	domestic	international	country		
	23	Development of a single technological system involving all kinds of aerospace communication technologies	T	aerospace	communication	technology	system			
	24	Use of communication satellite with infinite operation life-time	T	communication	satellite	operation	lifetime	Infinite		

Table 37 (cont'd) Resolved Form of Type 1 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (33 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words
Type 1 Wild Card Low probability-High effect-High credibility	25	Achieving the ability to transfer images, data and audio with the least delay and the highest quality in the world	T	image	data	audio	transfer	delay	quality	world
	26	Discovering that some neurons in the brain that communicate between the human brain and the soul and determining that the electrical activity measured in the human brain reflects only the perceived part of this communication	T/S	neuron	brain	soul	communication	electrical	measure	human
	27	Using low-cost ammunition-packed WWIs in battle as kamikaze	P/T	ammunition	low-cost	WWI	battle	kamikaze		
	28	Food discovery and initiation of agricultural activities for people in space	E	food	agriculture	space	life			
	29	Directing wars over space	P	war	space					
	30	Reduction of losses and noises by exploration or production of superconducting materials working at room temperature	T	loss	noise	superconductor	material	room temperature	production	reduction
	31	Training new generations supporting them to use analytical thinking and questioning	P/S	training	new generation	analytical thinking	questioning			
	32	Realization of colonization on lunar surface	T	colonization	lunar	moon	surface			
	33	Wide use of free, independent research infrastructures	L	research	infrastructure	independent	free			

Table 38 Number of Common Words' Occurrances in Type 1 Wild Cards

Words	Number of Occurance	Words	Number of Occurance	Words	Number of Occurance
space	7	economy	1	observation	1
communication	5	electrical	1	operation	1
world	5	embargo	1	orbit	1
aerospace	3	emission	1	poles	1
colonization	3	energy	1	power	1
country	3	engine	1	precaution	1
education	3	europe	1	probing	1
human	3	exam	1	production	1
satellite	3	food	1	propulsion	1
system	3	free	1	quality	1
Turkey	3	global	1	questioning	1
agriculture	2	human life	1	radiation	1
earth	2	humanity	1	reduction	1
high school	2	image	1	remains	1
material	2	independent	1	remote	1
planet	2	infinite	1	resource	1
powerful	2	infrastructure	1	room temperature	1
research	2	international	1	school	1
technology	2	kamikaze	1	secondary school	1
training	2	leading	1	shifting	1
war	2	life	1	social	1
ammunition	1	lifetime	1	soul	1
analytical thinking	1	listen	1	source	1
archeological	1	loss	1	student	1
artificial intelligence	1	low-cost	1	Sun	1
audio	1	lunar	1	superconductor	1
aviation	1	magnetic field	1	surface	1
battle	1	measure	1	sustainable	1
brain	1	mining	1	teleportation	1
civilization	1	moon	1	telescobic	1
compatible	1	neuron	1	transfer	1
course	1	neutrino	1	travel	1
danger	1	new generation	1	underground	1
dark matter	1	noise	1	university	1
data	1	non-blocking	1	vehicle	1
delay	1	non-fuel	1	WWI	1
domestic	1	nuclear	1	x-ray	1

4.2.3 Data Analysis of the Delphi Survey

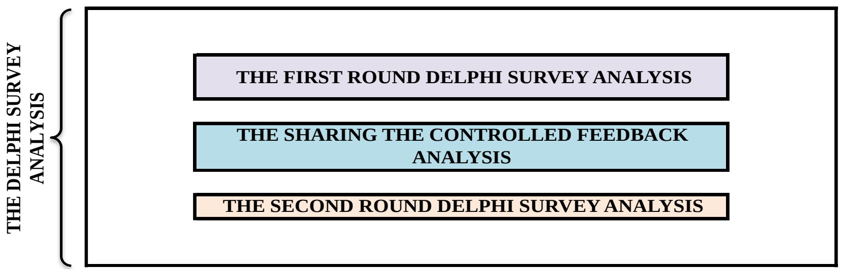

Figure 28 The Flow of Delphi Survey Analysis

The two round Delphi Survey was applied and the flow of its analysis was given in Figure 28.

4.2.3.1 The First Round Delphi Survey Analysis

It was established in the Google Forms, and was analyzed with the tools of the same form. There were built-in functions to create charts, numbers and percentages. 120 participants sent the first round Delphi Survey responses over the Google forms in translated forms of E-Tables. The first round survey analysis was given in the Appendix K.

4.2.3.2 Sharing the Controlled Feedback

It included the participants' answers of the first round. Delphi Survey answers were collected according to their e-mail addresses on Google forms in translated forms of E-Tables automatically. The results of the first round were added onto the first round Delphi Survey for all participants. Different links to each participant were sent for the easiness and provided them to change their first answers in the same form.

4.2.3.3 The Second Round Delphi Survey Analysis

It included sending the second questionnaire to the 120 participants who respond to the first questionnaire and assessment. In the literature there are some studies sending the second round survey to the initial sample; even those that did not respond. Generally in other studies, "only those who participated in the previous round are included in the subsequent rounds (Skulmoski, Hartman, & Krahn, 2007)". The second round Delphi Survey was prepared according to each participants of the first round also by showing their answers. In the same form, there were also general results. The researcher tried to provide user-friendly interface for the second round Delphi Survey to see all needed information including their previous answers and all statistics. The participants had chances to see old answers and change them immediately if they need within this survey form. The second round survey was given in the Appendix L.

Since the second survey results were used to create the future scenarios, strategies and roadmaps, its analysis was done by the researcher within this point of view and presented in Chapter 5.

CHAPTER 5

RESULTS AND CONCLUSION

5.1 The Second Round Delphi Survey Results

There were 120 experts participated to the first round Delphi Survey. In the second round Delphi Survey while 32 experts changed their opinions, 88 of them kept their first evaluation. The second round Delphi Survey analysis for the purpose of creating futures scenarios was done by taking final evaluations of these 120 experts' into account. Since the percentages of answers by field experts to Delphi Statements are low (not more that 14.17% for any question) all evaluations were done over the answers of 120 participants. For the tentative answers of the second Delphi interrogation, the answers of field experts were used in decision making by the researcher.The numbers related with expertise for Delphi Statements were given in Table 39.

As given in section 4.2.1.14 in Figure 25 and 26, K3 (the criterion *to meet national security*) was the most important criterion according to AHP. To reveal the importance of especially this criterion for each Delphi Statement, Delphi interrogation question of Contribution to National Security was used. The averages of all 120 experts' grading were taken for *each* Delphi Statement and also the average of grading for *all* Delphi Statements were calculated as shown in Table 40.

Likewise, Averages of Grading for Delphi Statements in Contribution to National Economy was found as seen in Table 41, since this interrogation question related with all criteria (K1, K2, K3).

Table 39 The Expertise for Delphi Statements in the Second Delphi Survey

Expertise for Delphi Statements				
Delphi Statement	**Not Knowledged**	**Knowledged (BV)**	**Field Expert (KU)**	**Percentage of Field Experts**
D1	70	46	4	3,33
D2	46	71	3	2,50
D3	35	80	5	4,17
D4	75	42	3	2,50
D5	47	65	8	6,67
D6	35	73	12	10,00
D7	70	44	6	5,00
D8	54	57	9	7,50
D9	73	39	8	6,67
D10	67	42	11	9,17
D11	43	66	11	9,17
D12	57	54	9	7,50
D13	43	63	14	11,67
D14	55	55	10	8,33
D15	88	29	3	2,50
D16	54	58	8	6,67
D17	77	37	6	5,00
D18	76	37	7	5,83
D19	48	61	11	9,17
D20	86	31	3	2,50
D21	67	42	11	9,17
D22	72	42	6	5,00
D23	75	36	9	7,50
D24	84	27	9	7,50
D25	48	55	17	14,17
D26	70	41	9	7,50
D27	88	28	4	3,33

Table 40 Averages of Grading for Delphi Statements in Contribution to National Security

Averages of Grading for Delphi Statements in Contribution to National Security	
Delphi Statement	**Average for each Delphi Statement**
D4	4,76
D19	4,68
D11	4,65
D3	4,62
D12	4,61
D26	4,54
D6	4,52
D25	4,48
D24	4,45
D9	4,45
D7	4,36
D8	4,36
D10	4,31
D5	4,31
D14	4,30
D16	4,29
D27	4,28
D23	4,23
D13	4,22
D1	4,18
D18	4,17
D17	4,14
D22	4,10
D2	4,05
D15	4,03
D21	3,96
D20	3,94
Average of Averages for all Delphi Statements: 4.33	

Table 41 Averages of Grading for Delphi Statements in Contribution to National Economy

Averages of Gradins for Delphi Statements in Contribution to National Economy	
Delphi Statements	**Average**
D25	4,22
D21	4,17
D26	4,04
D13	3,98
D5	3,95
D8	3,94
D23	3,92
D27	3,92
D24	3,88
D17	3,85
D14	3,84
D12	3,78
D4	3,77
D11	3,75
D6	3,70
D1	3,65
D20	3,64
D10	3,64
D19	3,64
D3	3,60
D7	3,54
D16	3,54
D18	3,52
D22	3,49
D15	3,45
D9	3,42
D2	3,32
Averages of Averages for all Delphi Statements: 3.75	

The realization time periods given in Table 42 were also counted with COUNTIF function in the Excel for each Delphi statement. Realization time periods were adjusted for a five-year period and *never* was presented as a choice for unnecessary or impossible conditions. Maximum number of votes was processed with MAX function in the Excel and the corresponding time period for the maximum votes was selected as realization time.

Table 42 Realization Time Periods for Delphi Statements

Delphi Statements and Realization Time Periods According to Maximum Number Of Votes			
Delphi Statement	**Maximum Number of Votes**	**Realization Time**	**Realization Time Period**
D13	47	2018-2023	1
D3	45	2018-2023	1
D11	40	2018-2023	1
D25	40	2018-2023	1
D2	39	2024-2029	2
D1	35	2018-2023	1
D6	34	2018-2023	1
D19	33	2018-2023	1
D14	32	2018-2023	1
D18	31	2018-2023	1
D5	30	2018-2023	1
D10	29	2024-2029	2
D17	29	2018-2023	1
D26	28	2018-2023	1
D7	27	2024-2029	2
D8	26	2024-2029	2
D16	26	2018-2023	1
D12	24	2018-2023	1
D9	22	2024-2029	2
D24	22	2024-2029	2
D22	21	2030-2035	3
D15	20	2024-2029	2
D21	20	2024-2029	2
D23	20	2036-2040	4
D27	20	2024-2029	2
D4	19	2030-2035	3
D20	14	2030-2035	3

The statistics in Table 39, 40, 41 and 42 were used for building the futures scenarios which explained in the next section. The literature definition and explanations for the futures scenarios and strategies given in section 2.5.3 were used as a guide. Scenarios and strategies were shaped by the researcher taking into account of the difference which was defined as "scenarios show states while strategies show stances" by Yüksel & Çifci (2017).

5.2 The Futures Scenarios of Aerospace Communication Technologies until 2040 in Turkish Defense Sector

The scenarios for different futures were established according to interrogation questions of *Contribution to National Security, Contribution to National Economy, Realization Time Periods.* Four different scenarios were explained in the following sections with figures.

5.2.1 The Fast Scenario

In Figure 30 Delphi Statements were given with respect to their realization time periods. The Fast Scenario was selected as the one which includes Delphi Statements for the first period (the near-future period) and shown in Figure 29 in the rectangular frame.

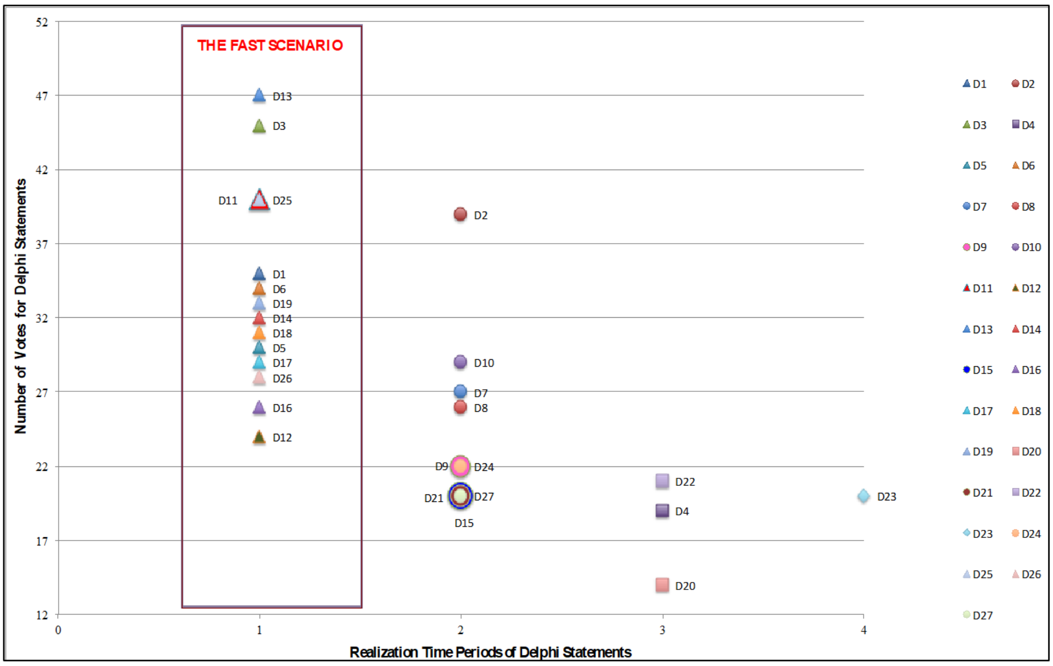

Figure 29 The Fast Scenario

According to the Fast Scenario; D13, D3, D11 and D25 came as the first ranks in the votes and it seems that they can be realized more easily for 2018-2023 time interval. Additionally, for better understanding the histogram graph for the realization time of each Delphi Statement was given in Figure 30.

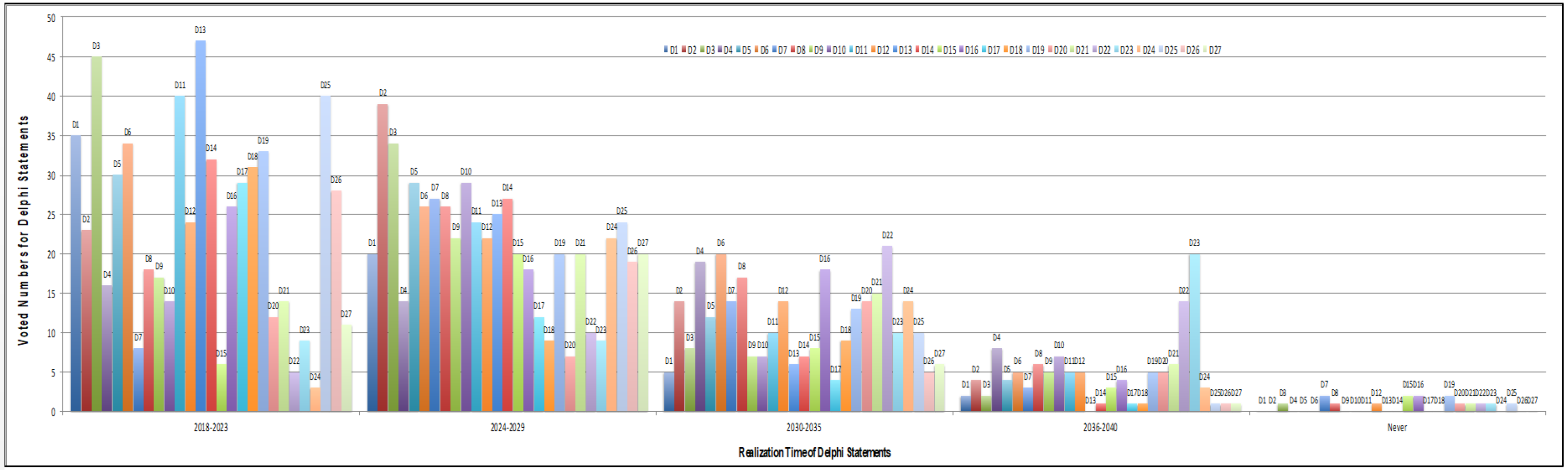

Figure 30 Histogram for Realization Time of Delphi Statements

5.2.2 The Profitable Scenario

Delphi Statements were given with respect to their contributions to national economy in Figure 31. The average of gradings for each Delphi Statement was calculated with the AVERAGE function in the Excel for taking all participants choices in the five point Likert Scale. The Profitable Scenario was selected according to average of all Delphi Statements' averages, which was calculated as 3.75 and marked as red dashed-line in Table 41. All Delphi Statements of which contribution to national economy above 3.75 were chosen as the Profitable Scenario. In Figure 31 the realization time was also shown as the third dimension, which is seen as the sizes of the circles. The biggest circles correspond to the first realization period which is 2018-2023, the smallest ones correspond to the last realization period which is 2036-2040.

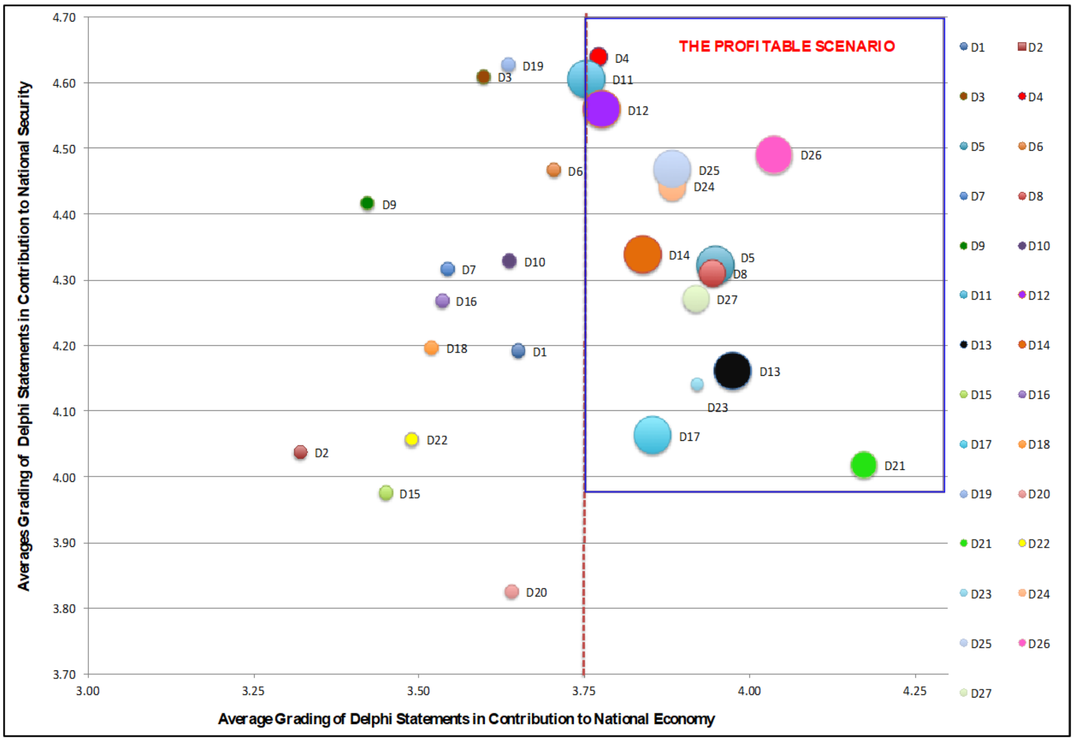

Figure 31 The Profitable Scenario

According to the Profitable Scenario; D26, D25, D13 and D8 have remarkable contribution to national economy in addition to their advantage to realization time period, which is 2018-2023, whereas D21 has the most contribution but its realization time is the second period, which is 2024-2029.

5.2.3 The Preferred Scenario

Delphi Statements were given with respect to their contributions to national security in Figure 32. The criterion of K3, which is *to meet national security needs* was determined as the most important criterion with AHP explained in section 4.2.1.14 Since K3 is the most important criterion, the interrogation according to the question about the contribution to national security was selected as preferred scenario. Hence, the average of evaluations for each Delphi Statement was calculated with the AVERAGE function in the Excel by taking all participants choices in the five point Likert Scale. The Preferred Scenario was selected according to the average of all Delphi Statements' averages, which was calculated as 4.33 and shown as red dashed-line in Table 40. All Delphi Statements with contribution to national security above 4.33 were chosen as the Preferred Scenario and shown with their realization time periods in Figure 32.

According to the Preferred Scenario; despite its disadvantage in realization time D4 has the most contribution to national security. D19, D11, D3 and D12 have remarkable contributions to national security in addition to their advantages of realization time, which is 2018-2023 period, whereas D8 and D7 have the least contributions in the Preferred Scenario.

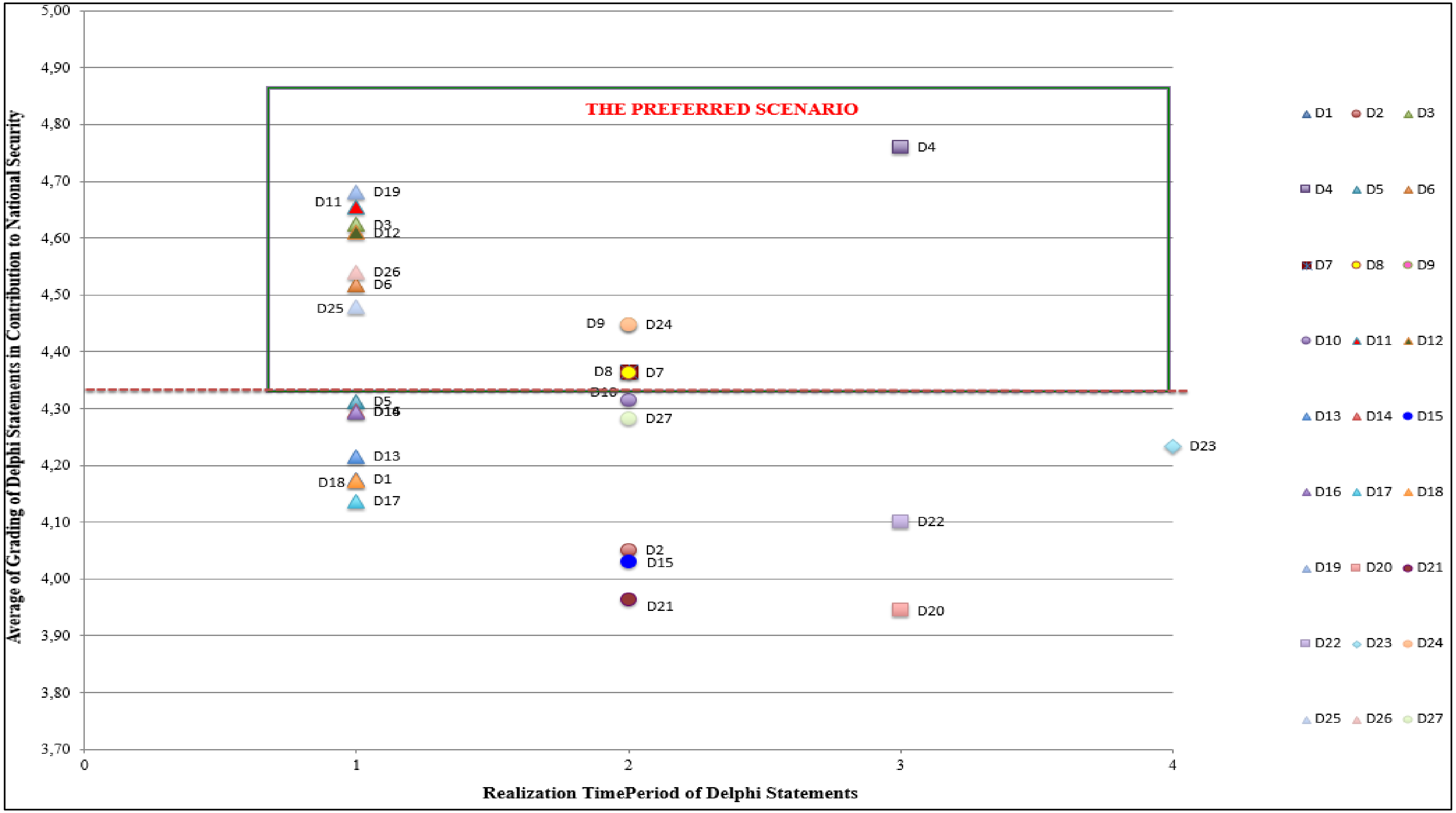

Figure 32 The Preferred Scenario

5.2.4 The Optimum Scenario

Delphi Statements were given with respect to their contributions to national security and economy in Figure 33. The Optimum Scenario was selected according to the average of all Delphi Statements' averages for contribution to both national security and economy, which are 4.33 and 3.75 respectively, and shown as red dashed-lines in y- and x-axis respectively. The Delphi Statements with national security contribution was above 4.33 and national economy contribution above 3.35 within the rectangular established the Optimum Scenario while the realization time was also given as the third dimension shown as the sizes of the circles. The biggest circles correspond to the first realization period which is 2018-2023, the one level smaller ones are used for the second realization period which is 2024-2029.

According to the Optimum Scenario; D11, D12, D26 and D25 are the best optimum ones when taking the realization time period into account, which is 2018-2023, in comparison to the realization time period of D8 and D24 of which is 2024-2029.

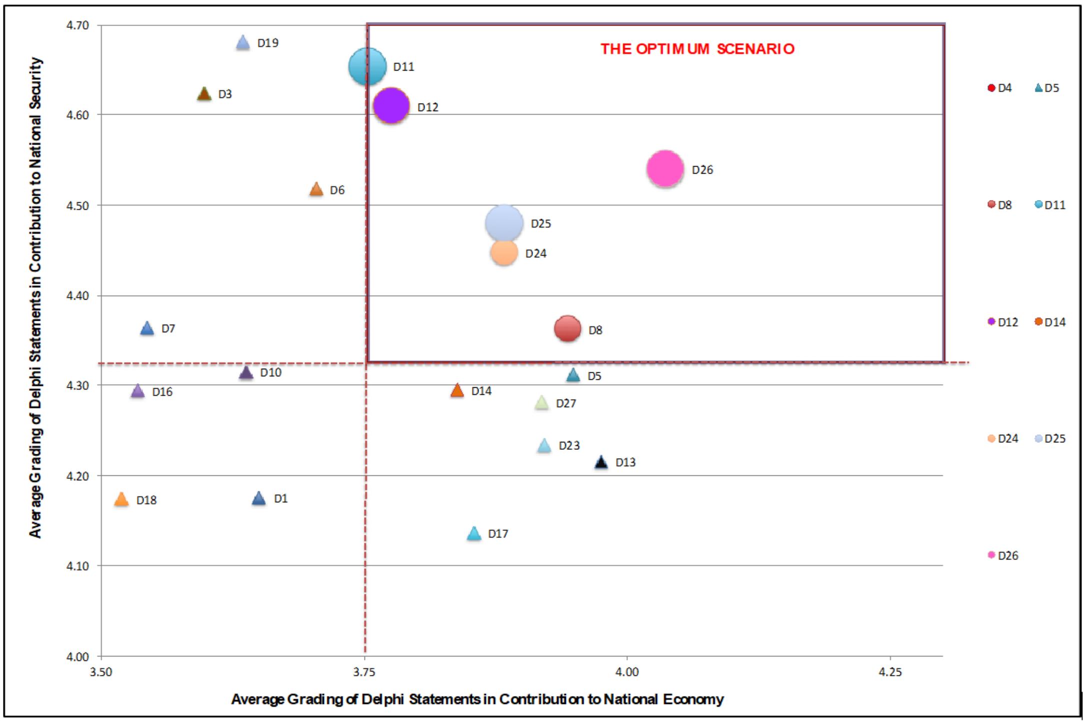

Figure 33 The Optimum Scenario

5.3 The Policy Recommendations' Analysis

The SEEPL Delphi Statements in the second expert panel pre-written by the researcher by taking the STEEPL analysis results of the first expert panel into account was analyzed according to importance level of the votes given by the experts. Since it was not surveyed, it was analyzed by the researcher. The importance levels were weighted using SUMPRODUCT and SUM functions and sorted in the Excel. All analyzed SEEPL Delphi Statements with the importance levels for Turkey were given in Table 43. The added SEEPL Delphi Statements by the experts were also analyzed and listed with the consecutive numbering in Table 44. All these Delphi Statements were taken as policy recommendations.

Table 43 Analyzed Pre-written SEEPL Delphi Statements

Social Delphi No	**Delphi Statements**	**Importance for Turkey**
SD4	The human resource working in the field of aerospace communications has been increased in number and quality, being composed of specialists in the field, scientists and engineers with triadic patents.	7,33
SD2	Competition programs, workshops and camps have been organized, including radio/small satellite/UAV, to guide young people to this area by providing awareness to first/middle/high school about aerospace communications.	5,83
SD1	Managers and project managers have been trained to have awareness to take responsibility, control and follow-up aerospace plans and projects.	5,67
SD3	The participation of representatives, graduated and postgraduated from space law programs of universities in national level, to international space law organizations has been provided.	5,67
SD5	Conciliatory activities/trainings have been developed to establish trust between stakeholders operating in aerospace communications and progress has been made in confidence and confidence indices.	5,67
Economical Delphi No	**Delphi Statements**	**Importance for Turkey**
ED1	Turkey has been the leading country in the software-based radio export market in the Middle East, Africa, South America and the Balkans.	6,17
ED2	Turkey has been the only source in the region as service provider of internet from space to the allied countries.	6,17
EnvDelphi No	**Delphi Statements**	**Importance for Turkey**
EnvD1	Aerospace communication systems have been developed with subsystems providing power from renewable energy sources (solar, wind).	6,17
Political Delphi No	**Delphi Statements**	**Importance for Turkey**
PD6	The National Space Agency has carried out aerospace communications R&D investments assessment analysis annually and impact analysis every 5 years.	6,71
PD7	The comprehensive reform focusing on STEM (Science- Technology-Engineering-Mathematics) based team work for creative young population has been done starting from the elementary education.	6,00
PD3	The National Space Agency has been founded as merit-based and has provided co-ordination among stakeholders.	5,00

Table 43 (cont'd) Analyzed Pre-written SEEPL Delphi Statements

Political Delphi No	Delphi Statements	Importance for Turkey
PD1	Turkey has become a full member of the European Space Agency (ESA) and with prior and continuing membership has been active in studies of the Asia-Pacific Space Cooperation Organization (APSCO).	4,71
PD2	Technological Readiness Level-TRL 1-2-3 has been mainly carried out by the university, 4-5-6 by SME, 7-8-9 by the integrator company.	4,71
PD4	Economical income of leading scientists working in space communications abroad have been at least doubled and incentives have been given to their families 3 times a year to bring them in Turkey.	4,57
PD5	In order to increase interest in basic sciences, incentives at a rate of monthly minimum wage have been provided for successful university and graduate students.	4,14
Legal Delphi No	**Delphi Statements**	**Importance for Turkey**
LD2	Necessary restrictions for aerospace communication organizations have been determined by participation of stakeholders and a legal arrangement has been established to provide common use of infrastructures.	7,00
LD3	The legal infrastructure to ensure the permannce of researchers has been developed to improve the personal rights of researchers in research centers established/to be established in universities.	6,50
LD1	The legal infrastructure for the integration of technological intelligence and foresight studies into the TAF Plan/Program/Budgeting system has been established.	5,67

Table 44 Added SEEPL Delphi Statements by Experts

Economical Delphi No	The mid-long range systematic futures studies in aerospace tehnologies have been planned and carried out with the commitment of crucial instituitons.
ED3	Turkey has been the country that develops all equipment needed in LEO satellites and sells them on system/hardware basis.
ED4	Turkey has been the only source in the region as service provider of internet from space to the allied countries.
Political Delphi No	**Delphi Statements**
PD8	Technology Readiness Level-THS (TRL) calculators have been developed and used on a sectoral basis.
PD9	Current economic conditions of Turkey have been improved to at least the level of European Countries to attract the leading scientists, especially in space technologies, to be brought, mechanisms have been developed to increase the number of these scientists 10% every year.
PD10	Each year, at least 5% of the budget has been allocated for the development of space communication technologies.
PD11	To prevent brain drain, common studies have been done with all stakeholders of aerospace sector and needed political and economical precautions have been taken.
PD12	The mid-long range systematic futures studies in aerospace tehnologies have been planned and carried out with the commitment of crucial instituitons.
PD13	The international cooperations in space technologies have been increased.
Legal Delphi No	**Delphi Statements**
LD4	The legal infrastructure for open innovation in aerospace communications has been completed.
LD5	The legal infrastucture based on increasing budgetary incentives in steps according to success of aerospace institutions has been provided.
LD6	The legal arrangement about finalizing the incentive decision of any project especially related with aerospace technologies in the interval of one to three months has been made.
LD7	For the purpose of expanding the coverages of communication satellites, new orbit rights have been taken.
LD8	Light pollution legislation has enacted and observatories have been protected by laws.
LD9	The legislation for the providing incentives like allocation of band and orbit to NGOs in space communication has been enacted.
LD10	The coordination and cooperation between university and industry have been facilitated by new laws

5.4 The Futures Strategies of Aerospace Communication Technologies Until 2040 in Turkish Defense Sector

The future strategies of aerospace communication technologies until 2040 in Turkish Defense sector can be determined for different scenarios explained in the previous sections by taking the initiation capability in Delphi Survey interrogation question as base. To establish the strategy, the consistency between the initiation capability and realization of the scenarios can be evaluated with political recommendations analyzed. For this research, since the criterion K3 (*to meet national requirements*) came first, the Preferred Scenario based on the contribution to national security was used in strategy development by the researcher. So, Delphi Statements were analyzed according to initiation capability first. As the results of initiation capability analysis for each Delphi Statement was given in Table 46. In the analysis, maximum numbers of votes were calculated with MAX function in the Excel for each initiation capability. In general, the initiation capability with the maximum number of votes was accepted as the initiation capability for the related Delphi Statement as seen in Table 45. However, some Delphi statements D13, D17 and D19 which are shown as purple were needed to be re-evaluated by the researcher because of the proximity of the number of votes. Re-evaluation was done according to field experts' votes and the final decisions were given in Table 46.

In Figure 34 the initiation capability of each Delphi Statements was given graphically in a sorted form.

According to Figure 34 and Table 46, 19 of 27 Delphi Statements were evaluated as Applied Industrial Research, 6 of them as Basic Research, 1 of them as Industrial Development Before Competition, and 1 as Industrial Development. The researcher interprets these results as most of the Delphi Statements have some time for realization.

Table 45 Delphi Statements and Number of Votes for Initiation Capability

Delphi Statements and Number of Votes for Initiation Capability				
Delphi Statement	**Basic Research**	**Applied Industrial Research**	**Industrial Research Before Competition**	**Industrial Development**
D1	11	35	8	6
D2	26	37	7	10
D3	18	50	5	17
D4	35	15	5	2
D5	15	33	10	17
D6	16	43	10	16
D7	19	26	2	6
D8	20	32	9	7
D9	6	23	12	9
D10	8	33	7	9
D11	11	40	5	22
D12	12	30	10	14
D13	10	27	13	27
D14	12	30	12	13
D15	27	11	1	0
D16	22	32	5	9
D17	2	16	13	16
D18	9	25	4	11
D19	13	24	6	29
D20	20	15	3	1
D21	17	26	6	7
D22	28	18	3	2
D23	20	17	6	6
D24	7	25	5	5
D25	6	35	14	20
D26	5	23	6	19
D27	8	15	6	9

Table 46 Initialization Capability for Delphi Statements

Delphi Statements	Decided Initiation Capability	Rank for Each Initiation Capability
D3	Applied Industrial Research	1
D6	Applied Industrial Research	2
D11	Applied Industrial Research	3
D1	Applied Industrial Research	4
D25	Applied Industrial Research	5
D5	Applied Industrial Research	6
D10	Applied Industrial Research	7
D8	Applied Industrial Research	8
D16	Applied Industrial Research	9
D12	Applied Industrial Research	10
D14	Applied Industrial Research	11
D7	Applied Industrial Research	12
D21	Applied Industrial Research	13
D18	Applied Industrial Research	14
D24	Applied Industrial Research	15
D19	Applied Industrial Research	16
D9	Applied Industrial Research	17
D26	Applied Industrial Research	18
D27	Applied Industrial Research	19
D2	Basic Research	1
D4	Basic Research	2
D22	Basic Research	3
D15	Basic Research	4
D20	Basic Research	5
D23	Basic Research	6
D17	Industrial Development Before Competition	1
D13	Industrial Development	1

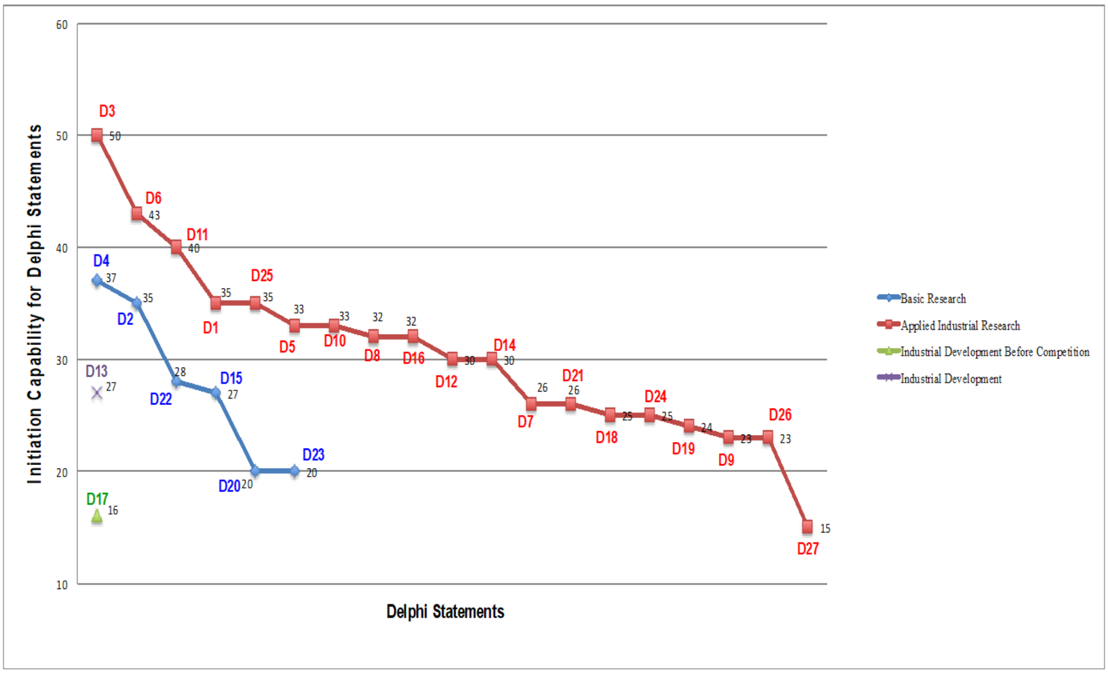

Figure 34 Initiation Capabilities of Delphi Statements

5.4.1 The Strategy for Preferred Scenario

In Table 47 the Delphi Statements for the Preferred Scenario with respect to their initiation capabilities were given.

Table 47 Delphi Statements' Initiation Capability in Preferred Scenario

No	Delphi Statement	Realization Time	Realization Time Period	Initiation Capability
1	D4	2030-2035	3	Basic Research
2	D19	2018-2023	1	Applied Industrial Research
3	D11	2018-2023	1	Applied Industrial Research
4	D3	2018-2023	1	Applied Industrial Research
5	D12	2018-2023	1	Applied Industrial Research
6	D26	2018-2023	1	Applied Industrial Research
7	D6	2018-2023	1	Applied Industrial Research
8	D25	2018-2023	1	Applied Industrial Research
9	D24	2024-2029	2	Applied Industrial Research
10	D9	2024-2029	2	Applied Industrial Research
11	D7	2024-2029	2	Applied Industrial Research
12	D8	2024-2029	2	Applied Industrial Research

When the initiation capability of Delphi Statements are interpreted, it is clearly seen that most of them as applied industrial research, 7 of them are expected to be realized in the first period whereas 4 of them in the second period. However the one (D4), of which highest contribution to national security, related with the quantum technologies, has the third period of realization time. It is reasonable since its initiation capability is basic research.

In the strategy for Preferred Scenario, it is apparent that the policies such as founding a national space agency which effectively creates relations between university and industry mechanisms should be carried out. Since almost all Delphi Statements' initiation capability are in the research phase the policies about the incentives for the academics and precautions for brain drain to abroad should be activated immediately. About the ones which are in the applied industrial research, the policies for the common and effective use of infrastructures should be forefront. Especially, for D4, the educational factors should be evaluated and needed futures studies should be taken into account immediately. Since there is no Delphi Statement for development in industry for preferred strategy, the policies for improving industrial conditions may come in the second stage. All policy recommendations for these prominent requirements with the voted importance values for Turkey and the ones added by the experts were presented in Table 48 as the Strategy for the Preferred Scenario. The ones with importance values were extracted from the analysis of pre-written (by researcher) SEEPL Delphi Statements evaluated by experts. The ones without importance levels were selected by the researcher from the added ones by the experts in the same panel. This selection was made by the researcher by taking the Preferred Scenario's Delphi Statements' initiation capability into account.

Table 48 The Strategy for Preferred Scenario

No	Policy Recommendations according to Voted Delphi Statements	Importance for Turkey
1	The human resource working in the field of aerospace communications has been increased in qualiy and number, being composed of specialists in the field, scientists and engineers with triadic patents.	7,33
2	Necessary restrictions for aerospace communication organizations have been determined by participation of stakeholders and a legal arrangement has been established to provide common use of infrastructures.	7,00
3	The National Space Agency has carried out aerospace communications R&D investments assessment analysis annually and impact analysis every 5 years.	6,71
4	The legal infrastructure to ensure the permance of researchers has been developed to improve the personal rights of researchers in research centers established/to be established in universities.	6,50
5	The comprehensive reform focusing on STEM (Science- Technology-Engineering-Mathematics) based team work for creative young population has been done starting from the elemantary education.	6,00
6	Competition programs, workshops and camps have been organized, including radio/small satellite/UAV, to guide young people to this area by providing awareness to first/middle/high school about aerospace communications.	5,83
7	The legal infrastructure for the integration of technological intelligence and foresight studies into the TAF Plan/Program/Budgeting system has been established.	5,67
8	Conciliatory activities/trainings have been developed to establish trust between stakeholders operating in aerospace communications and progress has been made in confidence and confidence indices.	5,67
9	The National Space Agency has been founded as merit-based and has provided co-ordination among stakeholders.	5,00
10	Turkey has become a full member of the European Space Agency (ESA) and with prior and continuing membership has been active in studies of the Asia-Pacific Space Cooperation Organization (APSCO).	4,71
11	Technological Readiness Level-TRL 1-2-3 has been mainly carried out by the university, 4-5-6 by SME, 7-8-9 by the integrator company.	4,71
12	Economical income of leading scientists working in space communications abroad have been at least doubled and incentives have been given to their families 3 times a year to bring them in Turkey.	4,57

Table 48 (cont'd) The Strategy for Preferred Scenario

No	Policy Recommendations according to Voted Delphi Statements	Importance for Turkey
13	In order to increase interest in basic sciences, incentives at a rate of monthly minimum wage have been provided for successful university and graduate students.	4,14
	Added Policy Recommendations Analyzed by Researcher	
	To prevent brain drain, common studies have been done with all stakeholders of aerospace sector and needed political and economical precautions have been taken.	
	The mid-long range systematic futures studies in aerospace tehnologies have been planned and carried out with the commitment of crucial instituitons.	
	The legal infrastructure for open innovation in aerospace communications has been completed.	
	The international cooperations in space technologies have been increased.	
	Current economic conditions of Turkey have been improved to at least the level of European Countries to attract the leading scientists, especially in space technologies, to be brought, mechanisms have been developed to increase the number of these scientists 10% every year.	
	The coordination and cooperation between university and industry have been facilitated by new laws in aerospace technologies.	
	The legislation for the providing incentives like allocation of band and orbit to NGOs in space communication has been enacted.	
	Technology Readiness Level (TRL) calculators have been developed and used on a sectoral basis.	

5.4.2 The Roadmap for the Preferred Scenario

In the roadmap of the Preferred Scenario given by Figure 35, the most related system level and underpinning level technologies to the Delphi Statements were listed with respect to period of time of the whole system. The system and underpinning technologies were mainly extracted from the selections done by the experts, which was performed in the second expert panel, related with the Delphi Statements given in Table 21 which includes the prioritized and coded system and underpinning technologies in the taxonomy analysis of the first expert panel. In addition, the researcher revised and finalized the list by using the Delphi Statements' system and underpinning technologies mostly by taking the experts choices into account with some self-additions by using taxonomy sorting list in Table 49.

Table 49 Re-evaluated Form of Delphi Statements for Related System and Underpinning Technologies

Delphi No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
D1	S2, S4, S5, S9,S11, S12, S15, S16, S27, S22,	U1, U8, U9, U11, U16, U18	A network-based communication system capable of Interference Management with Directional Medium Access-DMA has been developed.
D2	S1, S2, S3, S4, S5, S6, S7, S9, S10, S12, S16, S19, S20, S27, S28, S29, S30, S36, S38	U1, U2, U3, U4, U5, U6, U7, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18	Regional communication and positioning systems which use stratospheric balloons in coordination with satellites and independent of satellites have been developed.
D3	S7, S10, S16, S20	U5, U8, U15, U17	Information Technologies (IT) that intreprets the intelligence obtained from the big data in SWARM UAV/Armed UAV communication network have been developed.
D4	S1, S4, S8, S10, S11, S18, S37	U1, U11, U19	Quantum cryptology techniques have been used.
D5	S1, S4, S5, S7, S9, S10, S16, S27	U3, U5, U6, U8, U11, U15, U18	Smart communication networks that have the ability to do self organizing-healing and optimizing the network load (with edge computing) have been used.
D6	S2, S4, S12, S15, S16, S22, S27	U1, U3, U5, U8, U9, U10, U11, U12, U13, U14, U16, U17, U18	Communication and information systems network in a mobile environment by constructing relative navigation infrastructure with the satellite and air platforms have been developed.
D7	S4, S5, S27, S10, S11, S16, S20, S27	U5, U8, U11, U12, U16, U18	Air and space platforms able to communicate over an intelligent network, correct position codes despite the deterioration caused by the ionosphere and protect the network structure in a robust manner using narrow communication have been developed.
D8	S1, S5, S6, S7, S9, S10, S11, S16	U1, U3, U5, U6, U8, U11, U12	Between aerospace platforms, encoding and decoding technologies have been used to provide secure communication, high-speed communication (> = 100GB/s) and efficient communication (> 1pJ/bit).
D9	S1, S3, S6	U4, U12	Air-based network between the air platforms having the capacity of narrow-beam AD-HOC (ECCM, LPI-enabled) interconnected to each other, providing mid-short range, two-way mass data communication have been developed.
D10	S1, S3, S4, S7	U1, U11	Ka band software based radio systems programmable in orbit were developed.
D11	S1, S2, S3, S4, S7, S31	U1, U3, U4, U5, U8, U11, U12	Tactical (between vehicles) and satellite (satellite-vehicle) links that provides uninterrupted and safe mass communication of SWARM UAV/Armed UAV/Manned AV have been used.
D12	S1, S4, S5, S6, S7, S9, S10, S11, S36	U3, U4, U5, U8, U11, U12, U15, U16	Tracking and data relay satellites have been developed and in use.
D13	S2, S3, S6, S7, S12, S13, S31	U2, U3, U4, U9, U11, U12, U13, U14, U17	Low-cost, easily-producible, electronically directive based, digital beam-forming antenna technologies have been used.
D14	S2, S4, S7, S13	U8, U11, U18	Cognitive network technologies and protocols have been made available.

Table 49 (cont'd) Re-evaluated Form of Delphi Statements for Related System and Underpinning Technologies

Delphi No	Related System Technologies	Related Underpinning Technologies	Delphi Statements
D15	S13, S35, S36	U2, U9, U14, U17	Frequency reconfigurable graphene-based Terahertz Antenna technologies have been developed.
D16	S1, S3, S4, S8, S31	U4, U8, U11, U12	Outdoor optical wireless communication has been used between satellite and UAV /Armed UAV/Airplan/Balloon/Zeppelin/Helicopter.
D17	S4, S6	U3, U11, U15, U17 U18	Software based networks with virtualized network functions and low power consumption have been used commonly.
D18	S1, S4, S5, S8, S9, S10, S18, S20, S27, S32, S42	U1, U3, U5, U6, U8, U15, U16, U18, U19	Effective detection, tracking and display (ATP) systems have been used to reach optical beam from moving platforms to the receiver reliably.
D19	S1, S5, S6, S7, S9, S10, S17, S26	U1, U3, U4, U6, U8, U9, U16	Identification of Friend or Foe System (IFF) has been implemented via satellite communications.
D20	S6, S36, S41, S38, S44	U3, U5, U6, U8, U9, U11, U15, U17	Smart multi-band plasma antennas that can direct the beam of radio waves have been developed and have replaced the use of common antennas by more than 50%.
D21	S4, S5, S10, S11, S27, S36, S38	U1, U2, U3, U4, U5, U6, U8, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18	Internet space satellite technologies in LEO orbit have been developed and in use.
D22	S4, S16, S27, S8	U18, U19, U20	Inter-satellites space-based optical mesh-networks have been used.
D23	S4, S5, S10, S11, S27, S36	U1, U2, U3, U4, U5, U6, U8, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18	The multi-band inter-satellites communication capability in GEO orbit has been developed and in use.
D24	S4, S5, S6, S10, S11, S27, S36	U1, U2, U3, U4, U5, U6, U8, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18	High throughput multi spot beam satellite have been developed and in use.
D25	S20, S30	U7, U14, U17	Inertial meters (gyro, accelerometer) have been developed and in use for all levels (strategic, navigation, tactical).
D26	S8, S18, S42	U7, U19	The fiber optic navigation system has been developed for aerospace platforms.
D27	S1, S12	U4, U14	High power/high efficiency (> 50%) goals in wideband have been achieved with modules containing GaN-based power components.

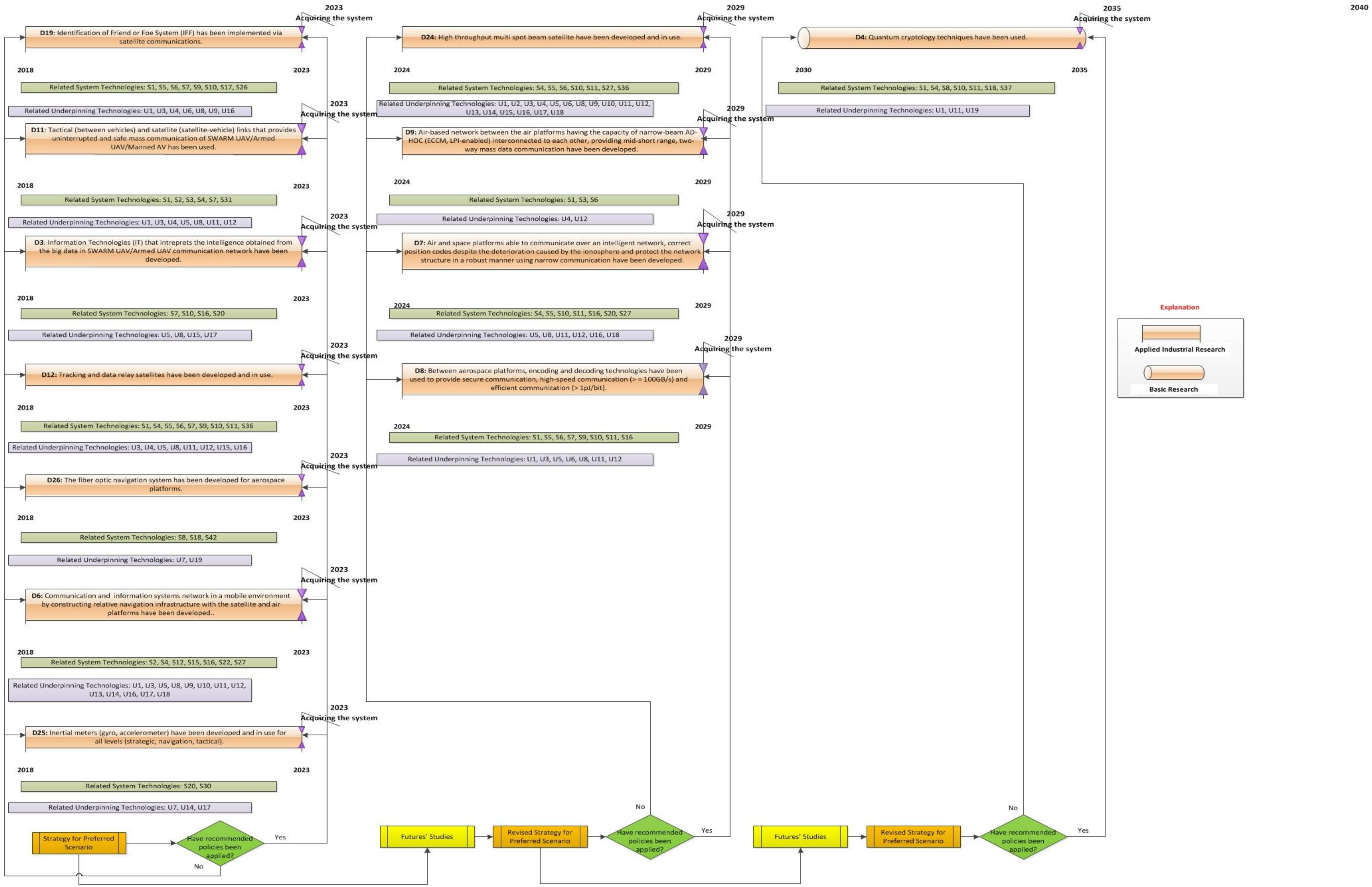

Figure 35 The Roadmap of the Preferred Strategy

5.5 Conclusion

Foresight as one of the futures' studies is an effective tool for anticipating different futures by evaluating past and present to take action especially if it is applied based on a systematic manner. In this research a new model, Foresight Periscope Model (FPM) which was developed by the researcher in 2017, has been used as the base for the application of foresight study of aerospace communication technologies until 2040 in Turkish Defense sector. A new and unique algorithm, Foresight Method Selection Algorithm (FMSA) was developed and integrated with the FPM within this research. In the FPM, Foresight Functional Framework (FFF), which was also developed by the researcher, were used to explain the functions of the foresight by its easily memorable acronym (FORESIGHT) of where each letter corresponds to one function. To construct FFF, all foresight' generations were also researched, interpreted by the researcher including with setting forth a new generation as Foresight 6.0. In the FPM, three segments were defined to model foresight as *resources, methodology* and *futures strategies*. Since the resources should be evaluated primarily to initialize and shape the foresight study, the *resources* segment takes place at the bottom of the periscope model. The resources are divided into two groups as tangible (infrastructural, financial and human resources) and intangible (time; structure, processes and culture; information and knowledge; science, technology and innovation capabilities). These grouped of resources are generic in organizational, sectoral, national and international levels. At the upper level of resources, there is a *methodology* segment which is selected according to resources. In the methodology, the selection of suitable methods and their proper integration to create one methodology specific to those resources and foresight level are realized. In this dissertation, evaluating the resources and establishing the methodology according to resources are done by means of the FMSA. For the sectoral level, which in our case is Turkish Defense sector, the resources are evaluated using the answers given by the researcher according to the literature review to the questions-created again by the researcher- asked automatically in the algorithm. The answers are processed within the algorithm according to some criteria determined by the researcher. The criteria differentiate the methods as core and supportive methods and as the output a methodology is suggested in a sequential form suitable to FFF. The foresight approach as normative or explorative is also interrogated in the algorithm. The criteria set by the researcher are determined by taking the priorities of Turkish Defense sector. At the top segment of the FPM, the Futures' Strategies are established according to the results of methods' applications. The methods used in constructing the futures' strategies are also given by FMSA. According to scenarios which show the states determined by previous methods, the stances which are strategies are set forth.

The model, frameworks and the algorithm explained used as a base for the application of Foresight of Aerospace Communication Technologies until 2040 in Turkish Defense Sector. The main reason behind the selection of this subject is that there has not been any study for such a specific area in the literature. Moreover, the researcher evaluates that the foresight studies are more effective when they are performed in specific topics such as aerospace communication technologies instead of aerospace technologies. The following reason is that, the researcher's academic (electrical electronics engineering) and professional career (engineer in Turkish Defense sector) support the study to be more effective. When lessons learned are considered which is not given in this dissertation (since it is planned as the subject for another future studies of the researcher) the capability, background and the expertise of the conductor of foresight studies is crucial as much as performing the study as planned and systematic manner on the models. Since the nature of foresight is participative and encouraging to learning process with stakeholders, conducting foresight studies within restricted time and budget requires clear explanations of the methods with some pre-prepared templates to prevent long speeches of dominant participants. Therefore, by taking all these comments into account in the following paragraph the application of model with the methods and sub-methods are given.

The output of the FMSA recommended literature review, expert panel, Delphi Survey and roadmapping as the core methods whereas STEEPL, SOAR, Trends, Weak Signal, Wild Card Analyses and Scenario Building as the supportive methods. Literature review was done by the researcher for aerospace communication technologies for defense sector as well as the foresight methods. All templates and explanations, which are presented in this dissertation, about the methods and the technologies were prepared beforehand the expert panels with the light of the literature review. All methods' analyses were performed by the researcher for the next methods' applications. Only two expert panels were realized due to the absence of the budget, time and sponsor. The first expert panel was held in SSB with the partial support of SSB with 44 participants from the academics, defense sector's public and private organizations and NGOs. The first expert panel's purpose was to create awareness between the stakeholders about catching the future of aerospace communication technologies in Turkish Defense sector for the year of 2040. Hence, in the first stage to determine the current condition of the aerospace technologies STEEPL, SOAR, Single Source, Trends, Visioning, Prioritization of Weighting Criteria for Taxonomy, Grading the system and underpinning level technologies in the taxonomy applications were performed within 2.5 hours. After explaining the purpose and the flow of the study (with timetables for each methods) STEEPL and SOAR templates in paper format pre-written by the researcher was subjected to experts to add their own ideas and vote all of them together. In the single source study it was expected from the experts to add the technologies of which Turkey is the single source. For the trends study, the pre-written template of trends in aerospace communication technologies was asked to experts to evaluate by voting. Since, the seating arrangement of the experts to the tables in the first panel was done according to their institutions by the researcher, the aerospace communication technologies visions in defense for the year of 2040 was collected from them independently. That arrangement was essential to conduct the participative visioning study in very short time and also useful to analyze the results of other methods. In this way, the researcher had a chance to see the differences between groups in the analysis. In the weighting the criteria study, after explanation of the pre-defined criteria by the researcher to the experts, the pairwise comparison of the criteria in importance level were collected from experts. *To create competitive advantage* as K1, *to create other research areas* as K2 and *to meet national security needs* as K3 were the determined criteria. In the following application, which is grading the system related and underpinning related technologies in taxonomy for aerospace communication, the taxonomy created by the researcher by taking the EDA and NASA taxonomies by adding the researcher's own interpretation (since there is no taxonomy specific to aerospace communication technologies in the literature) was used. The experts gave the grades (between 0-10) to the technologies for each criterion.

In the second expert panel to which SSB gave just the location support because of its organizational change, there were 19 participants. The researcher informed the experts about the first expert panel analysis and gave the results of that through the web site which the researcher designed for that purpose. The first expert panel analysis was done before the realization of the second expert panel. All answers of the experts were interpreted, grouped, weighted and sorted for each method in the analysis done with the Excel's suitable functions. The histogram and prioritized average graphs for participant and table (different groups) levels were created and shared by the first and second expert panel participants through web site before the second expert panel was held. The weak signal analysis was also performed by the researcher with the evaluation of the differences between the histogram and the averages of the prioritizations. The purpose of the second expert panel was to create the Delphi Statements which were defined as hypothetical detections by the researcher for aerospace communication technologies. According to current situation of aerospace communication technologies set forth by the analysis of the first expert panel, it was expected from the experts of the second one to prioritize the pre-written (by the researcher) Technical Delphi statements of aerospace communication technologies. Experts were also asked for writing their own technical Delphi Statements. The same procedure was followed for the SEEPL Delphi Statements. Delphi interrogation questions were shared with the experts for their reviews and Wild Cards study was performed. Four types of wild cards and their differences were explained to experts and expected from them to fill the template pre-prepared by the researcher.

The researcher analyzed the Delphi Statements which were evaluated by the experts and written by them with grouping, comparing and prioritizing. 27 of 104 Delphi Statements were selected for Delphi Survey also by thinking about the survey filling time and saturation point of the evaluators. Delphi Survey was established in the Google Forms and sent to 2120 participants online for the first round. 120 participants answered the first round survey within four weeks because of some limitations and restrictions explained in dissertation in detail. The second round Delphi Survey was sent to first round participators including their answers and the analyzed statistics of the first round. The purpose of this controlled feedback was to let the participants know the general opinions and change their answers, if there is a need, to provide the convergence for consensus. 34 of them changed their answers and the analysis of Delphi Survey was done according to last answers of 120 participants by the researcher. The SEEPL Delphi Statements which were voted and created in the second expert panel was not surveyed and kept for analyzing in policy recommendations together with strategy development.

Establishing the roadmap of the aerospace communication technologies to 2040 in Turkish Defense sector required determining the futures scenarios first. Four different scenarios were created by the researcher according to the analysis of the *contribution to national security*, *contribution to national economy* and *realization time* of the Delphi survey. The first scenario named as The Fast Scenario included the Delphi Statements of highest grades in realization time of 2018-2023. The Profitable Scenario -the second scenario- was comprised of the Delphi Statements with gradings' averages of contribution to national economy above than the average of all Delphi Statements' average in the same criteria. The Preferred Scenario was built with respect to the criterion of contribution to national security. In the Preferred Scenario, the Delphi Statements with gradings' averages of contribution to national security above the average of all Delphi Statements' average in the same criteria. In the last scenario which is the Optimum Scenario, Delphi Statements with gradings' averages above the averages of all Delphi Statements in both criteria which are contribution to national security and contribution to national economy. Strategy was shaped according to the initiation capability by the researcher due to the fact that the strategy includes the actions. Therefore, the results of SEEPL analysis in the second expert panel were used in strategy making and the social, economical, environmental, political and legal factors which were evaluated and voted according to their gradings were included in the policy recommendations. At the same time, the additional SEEPL factors created by the experts were analyzed with grouping and merging by the researcher and presented. The strategy for this research was determined for the Preferred Scenario since the criterion of meeting the national security needs came at the first rank by far in weighting the prioritization criteria study in the first expert panel with AHP analyzing. The Preferred Strategy was constructed by taking the Delphi Statements' initiation capabilities of the Preferred Scenario into account. Since most of them are in applied research phase, the policy recommendations in the strategy were selected to improve that condition for the required realization time. Finally, the visual illustration of the actions in the strategy was illustrated with the roadmap of aerospace communication technologies until the year of 2040 in Turkish Defense sector.

This research study is evaluated as important in both aspects of being model based and its practical application. A new model including a new framework and a new generation with the addition of a new method selection algorithm are applied practically for the subject of Foresight of Aerospace Communication Technologies until 2040 in Turkish Defense Industry. Any technological results about the research subject was not mentioned in this conclusion since lots of details were presented in Data Analysis section and in the appendices with the comments of the researcher. It is expected to be re-evaluated and used the results of this research by effective institutions of defense sector. In this way, it is assessed that the difficulties and the lessons learned from this research will be shed light on the following studies to improve model and the application.

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APPENDICES

APPENDIX A SOME CODES OF FORESIGHT METHOD SELECTION ALGORITHM

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

namespace WindowsFormsApplication2
{
    public partial class Form1FPM : Form
    {
        //Type definitions of FPM Resources Names and Answers
        bool SSPC1Yes;
        bool SSPC1No;
        bool SSPC2Yes;
        bool SSPC2No;
        bool SSPC3Yes;
        bool SSPC3No;
        bool SSPC4Yes;
        bool SSPC4No;
        bool SSPC5Yes;
        bool SSPC5No;
        bool SSPC6Yes;
        bool SSPC6No;
        bool SSPC7Yes;
        bool SSPC7No;
        bool SSPC8Yes;
        bool SSPC8No;
        bool SSPC9Yes;
        bool SSPC9No;
        bool SSPC10Yes;
        bool SSPC10No;
        bool SSPC11Yes;
        bool SSPC11No;
        bool SSPC12Yes;
        bool SSPC12No;
        bool IK1Yes;
        bool IK1No;
```

```
bool IK2Yes;
bool IK2No;
bool IK3Yes;
bool IK3No;
bool IK4Yes;
bool IK4No;
bool IK5Yes;
bool IK5No;

bool HUMRES1Yes;
bool HUMRES1No;
bool STIC1Yes;
bool STIC1No;
bool STIC2Yes;
bool STIC2No;
bool STIC3Yes;
bool STIC3No;
bool STIC4Yes;
bool STIC4No;
bool STIC5Yes;
bool STIC5No;
bool ForeTimeHorizonYes;
bool ForeTimeHorizonNo;
public Form1FPM()
{
   InitializeComponent();
}
int width = 1280;
int height = 800;

//Activating-deactivating Foresight Level Section
private void comboBoxForesightLevel_SelectedIndexChanged(object sender,
EventArgs e)
{
   if (comboBoxForesightLevel.SelectedIndex == 2)
   {
      label2.Visible = true;
      comboBoxSectors.Visible = true;
      label1.ForeColor = Color.Black;
   }
   else
   {
      label2.Visible =false;
      comboBoxSectors.Visible = false;
   }
}
   //Adjusting the program visual window for all resolutions
private void Form1_Load(object sender, EventArgs e)
{
   Rectangle ClientRes = new Rectangle();
   ClientRes = Screen.GetBounds(ClientRes);
   float widthoran = ((float)ClientRes.Width / (float)width);
   float heightoran = ((float)ClientRes.Height / (float)height);
   this.Scale(widthoran, heightoran);
}
private void comboBoxSectors_SelectedIndexChanged_1(object sender,
EventArgs e)
```

```
        {
            if (comboBoxSectors.SelectedIndex == 0)
            {
                groupBox8.Visible = true;
                label2.ForeColor = Color.Black;
                groupBoxTangible.Visible = true;
                groupBoxIntangible.Visible = true;
                labelForesightRes.Visible = true;
            }
            else groupBox8.Visible = false;
            groupBoxTangible.Enabled = true;
            groupBoxIntangible.Enabled = true;
        }

        Point pointgroupBoxTangible;
        Point pointgroupBoxInTangible;

        // Foresight Approach Decision
        private void buttonFApprch_Click(object sender, EventArgs e)
        {

            SSPC1Yes = dialogIntgbl_SSPC1 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC1No = dialogIntgbl_SSPC1 ==
System.Windows.Forms.DialogResult.No;
            SSPC2Yes = dialogIntgbl_SSPC2 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC2No = dialogIntgbl_SSPC2 ==
System.Windows.Forms.DialogResult.No;
            SSPC3Yes = dialogIntgbl_SSPC3 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC3No = dialogIntgbl_SSPC3 ==
System.Windows.Forms.DialogResult.No;
            SSPC4Yes = dialogIntgbl_SSPC4 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC4No = dialogIntgbl_SSPC4 ==
System.Windows.Forms.DialogResult.No;
            SSPC5Yes = dialogIntgbl_SSPC5 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC5No = dialogIntgbl_SSPC5 ==
System.Windows.Forms.DialogResult.No;
            SSPC6Yes = dialogIntgbl_SSPC6 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC6No = dialogIntgbl_SSPC6 ==
System.Windows.Forms.DialogResult.No;
            SSPC7Yes = dialogIntgbl_SSPC7 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC7No = dialogIntgbl_SSPC7 ==
System.Windows.Forms.DialogResult.No;
            SSPC8Yes = dialogIntgbl_SSPC8 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC8No = dialogIntgbl_SSPC8 ==
System.Windows.Forms.DialogResult.No;
            SSPC9Yes = dialogIntgbl_SSPC9 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC9No = dialogIntgbl_SSPC9 ==
System.Windows.Forms.DialogResult.No;
```

```
        SSPC10Yes = dialogIntgbl_SSPC10 ==
System.Windows.Forms.DialogResult.Yes;
        SSPC10No = dialogIntgbl_SSPC10 ==
System.Windows.Forms.DialogResult.No;
        SSPC11Yes = dialogIntgbl_SSPC11 ==
System.Windows.Forms.DialogResult.Yes;
        SSPC11No = dialogIntgbl_SSPC11 ==
System.Windows.Forms.DialogResult.No;
        SSPC12Yes = dialogIntgbl_SSPC12 ==
System.Windows.Forms.DialogResult.Yes;
        SSPC12No = dialogIntgbl_SSPC12 ==
System.Windows.Forms.DialogResult.No;

        IK1Yes = dialogIntgbl_IK1 == System.Windows.Forms.DialogResult.Yes;
        IK1No = dialogIntgbl_IK1 == System.Windows.Forms.DialogResult.No;
        IK2Yes = dialogIntgbl_IK2 == System.Windows.Forms.DialogResult.Yes;
        IK2No = dialogIntgbl_IK2 == System.Windows.Forms.DialogResult.No;
        IK3Yes = dialogIntgbl_IK3 == System.Windows.Forms.DialogResult.Yes;
        IK3No = dialogIntgbl_IK3 == System.Windows.Forms.DialogResult.No;
        IK4Yes = dialogIntgbl_IK4 == System.Windows.Forms.DialogResult.Yes;
        IK4No = dialogIntgbl_IK4 == System.Windows.Forms.DialogResult.No;
        IK5Yes = dialogIntgbl_IK5 == System.Windows.Forms.DialogResult.Yes;
        IK5No = dialogIntgbl_IK5 == System.Windows.Forms.DialogResult.No;

        HUMRES1Yes = dialogTgbl_HUMRES1 ==
System.Windows.Forms.DialogResult.Yes;
        HUMRES1No = dialogTgbl_HUMRES1 ==
System.Windows.Forms.DialogResult.No;

        STIC1Yes = dialogIntgbl_STIC1 ==
System.Windows.Forms.DialogResult.Yes;
        STIC1No = dialogIntgbl_STIC1 ==
System.Windows.Forms.DialogResult.No;
        STIC2Yes = dialogIntgbl_STIC2 ==
System.Windows.Forms.DialogResult.Yes;
        STIC2No = dialogIntgbl_STIC2 ==
System.Windows.Forms.DialogResult.No;
        STIC3Yes = dialogIntgbl_STIC3 ==
System.Windows.Forms.DialogResult.Yes;
        STIC3No = dialogIntgbl_STIC3 ==
System.Windows.Forms.DialogResult.No;
        STIC4Yes = dialogIntgbl_STIC4 ==
System.Windows.Forms.DialogResult.Yes;
        STIC4No = dialogIntgbl_STIC4 ==
System.Windows.Forms.DialogResult.No;
        STIC5Yes = dialogIntgbl_STIC5 ==
System.Windows.Forms.DialogResult.Yes;
        STIC5No = dialogIntgbl_STIC5 ==
System.Windows.Forms.DialogResult.No;

        ForeTimeHorizonYes = dialogIntgbl_ForeTimeHorizon ==
System.Windows.Forms.DialogResult.Yes;
        ForeTimeHorizonNo = dialogIntgbl_ForeTimeHorizon ==
System.Windows.Forms.DialogResult.No;

        RCHTBFApproach.Visible = true;
        if (SSPC1Yes|| SSPC3Yes)
```

```
        {
            RCHTBFApproach.Text = "Normative";
        }
        else if (SSPC1No && SSPC3No)
        {
            RCHTBFApproach.Text = "Explorative";
        }
        else
        {
            RCHTBFApproach.Text = "N/A";
        }
        groupBox9.Visible = true;
        button15_SgstdMthds.Visible = true;
        buttonFApprch.ForeColor = Color.Black;
    }

    DialogResult dialogIntgbl_IK1;
    DialogResult dialogIntgbl_IK2;
    DialogResult dialogIntgbl_IK3;
    DialogResult dialogIntgbl_ForeTimeHorizon;
    DialogResult dialogIntgbl_IK4;
    DialogResult dialogIntgbl_IK5;

    // Activating-deactivating FPM Resources Questions

    private void button8_Click(object sender, EventArgs e)

        {

        dialogIntgbl_IK1 = MessageBox.Show("Are there available accurate
historical data?", "DataAmount", MessageBoxButtons.YesNo);
        dialogIntgbl_IK2 = MessageBox.Show("Are data valid?", "DataValidity",
MessageBoxButtons.YesNo);
        dialogIntgbl_IK3 = MessageBox.Show("Is extend of data availability large?",
"Extend of Data", MessageBoxButtons.YesNo);
        dialogIntgbl_ForeTimeHorizon = MessageBox.Show("Is Foresight Time
Horizon 10 years or longer?", "Time Horizon", MessageBoxButtons.YesNo);
        dialogIntgbl_IK4 = MessageBox.Show("Is there correspondence between the
existing and the most advanced technology", "Correspondence",
MessageBoxButtons.YesNo);
        dialogIntgbl_IK5 = MessageBox.Show("Are there well-defined and clear
assumptions?", "Assumptions", MessageBoxButtons.YesNo);
        button3.Enabled = false;
        button8_IK.Enabled = false;
        button2.Enabled = true;
        button9_SSPC.Enabled = true;
        button8_IK.BackColor = Color.LightGray;
        button9_SSPC.BackColor = Color.NavajoWhite;

    }

    DialogResult dialogIntgbl_SSPC1=new DialogResult();
    DialogResult dialogIntgbl_SSPC2 = new DialogResult();
    DialogResult dialogIntgbl_SSPC3 = new DialogResult();
    DialogResult dialogIntgbl_SSPC4 = new DialogResult();
    DialogResult dialogIntgbl_SSPC5 = new DialogResult();
    DialogResult dialogIntgbl_SSPC6 = new DialogResult();
```

```
        DialogResult dialogIntgbl_SSPC7 = new DialogResult();
        DialogResult dialogIntgbl_SSPC8 = new DialogResult();
        DialogResult dialogIntgbl_SSPC9 = new DialogResult();
        DialogResult dialogIntgbl_SSPC10 = new DialogResult();
        DialogResult dialogIntgbl_SSPC11 = new DialogResult();
        DialogResult dialogIntgbl_SSPC12 = new DialogResult();

        private void button9_Click(object sender, EventArgs e)

            {
            dialogIntgbl_SSPC1 = MessageBox.Show("Is there already shared goal or
common preferred future?", "Approach", MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC2 = MessageBox.Show("Are there rapid changes,
qualitative breaks and social/technological innovations?", "Changes",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC3 = MessageBox.Show("Are  there satisfying objectives
for technological competitiveness?", "Objectives of Competitiveness",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC4 = MessageBox.Show("Is it largely affected by macro
level conditions or open to experience turbulence?", "Conditions",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC5 = MessageBox.Show("Are there situations with distinct
levels of complexity?", "Complexity", MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC6 = MessageBox.Show("Are systems' costs huge?",
"Cost", MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC7 = MessageBox.Show("Is it market-driven?", "Market",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC8 = MessageBox.Show("Is it science-driven?", "Science",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC9 = MessageBox.Show("Is it innovation-driven?",
"Innovation", MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC10 = MessageBox.Show("Are there lots of stakeholders
and target audience?", "Stakeholders and Target Audience",
MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC11 = MessageBox.Show("Does RD take long time?", "RD
Duration", MessageBoxButtons.YesNo);
            dialogIntgbl_SSPC12 = MessageBox.Show("Is Life-Cycle-Period of systems
more than 10 years?", "Life Cycle Period", MessageBoxButtons.YesNo);

            button2.Enabled = false;
            button9_SSPC.Enabled = false;
            button10.Enabled = true;
            button1.Enabled = true;
            button9_SSPC.BackColor = Color.LightGray;
            button10.BackColor = Color.NavajoWhite;
        }
        DialogResult dialogIntgbl_STIC1;
        DialogResult dialogIntgbl_STIC2;
        DialogResult dialogIntgbl_STIC3;
        DialogResult dialogIntgbl_STIC4;
        DialogResult dialogIntgbl_STIC5;
        DialogResult dialogIntgbl_STIC6;

        private void button10_Click(object sender, EventArgs e)
        {
            dialogIntgbl_STIC1 = MessageBox.Show("Is GERD  %2.5 or higher?",
"RD", MessageBoxButtons.YesNo);
```

```
            dialogIntgbl_STIC2 = MessageBox.Show("Is there a capability to catch or
create emerging patterns?", "Emerging Patterns", MessageBoxButtons.YesNo);
            dialogIntgbl_STIC3 = MessageBox.Show("Are there effective networks
between stakeholders?", "Effective Network", MessageBoxButtons.YesNo);
            dialogIntgbl_STIC4 = MessageBox.Show("Are triadic patent families
number is bigger than 500 (priority year)?", "Triadic Patents",
MessageBoxButtons.YesNo);
            dialogIntgbl_STIC5 = MessageBox.Show("Does it depend on multivariables
of which interactions are not linear?", "Variables", MessageBoxButtons.YesNo);
            dialogIntgbl_STIC6= MessageBox.Show("Is doctoral graduation rate,
science and engineering, % of cohort at typical graduation age bigger than 0.4?",
"Doctoral Rate", MessageBoxButtons.YesNo);

            button10.Enabled = false;
            button1.Enabled = false;
            button4.Enabled = true;
            button11.Enabled = true;
            button10.BackColor = Color.LightGray;
            button11.BackColor = Color.NavajoWhite;
        }
        DialogResult dialogIntgbl_ForeImpTime;
        private void button11_Click(object sender, EventArgs e)
        {
            dialogIntgbl_ForeImpTime = MessageBox.Show("Is Foresight
Implementation Time 1 year or longer?", "Implementation Time",
MessageBoxButtons.YesNo);
            button4.Enabled = false;
            button11.Enabled = false;
            button7.Enabled = true;
            button12.Enabled = true;
            button11.BackColor = Color.LightGray;
            button12.BackColor = Color.NavajoWhite;
        }
        DialogResult dialogTgbl_INF1;
        DialogResult dialogTgbl_INF2;
        DialogResult dialogTgbl_INF3;
        DialogResult dialogTgbl_INF4;
        DialogResult dialogTgbl_FNS1;
        DialogResult dialogTgbl_HUMRES1;

        //Activating-deactivating Foresight Approach Button in visibility
        private void button14_Click(object sender, EventArgs e)
        {
            dialogTgbl_HUMRES1 = MessageBox.Show("Are there required domain
experts and technical sophistication?", "Expertise", MessageBoxButtons.YesNo);
            button14.BackColor=Color.LightGray;
            button5.Enabled = false;
            button14.Enabled = false;
            buttonFApprch.Visible = true;
            label29.Visible = true;
            richTextBox2.Visible = true;
        }

       // It is hidden for supportive methods decision...
        private void button15_SptrvMthds_Click(object sender, EventArgs e)
        {
        }
```

```
        private void button3_MouseMove(object sender, MouseEventArgs e)
        {
            button8_IK.BackColor = Color.NavajoWhite;
            button8_IK.FlatStyle = FlatStyle.Standard;
        }

        //Decision Algorithm for Core Methods when button9 is clicked
        private void button9_coreMthds_Click(object sender, EventArgs e)
        {
            SSPC1Yes = dialogIntgbl_SSPC1 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC1No = dialogIntgbl_SSPC1 ==
System.Windows.Forms.DialogResult.No;
            SSPC2Yes = dialogIntgbl_SSPC2 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC2No = dialogIntgbl_SSPC2 ==
System.Windows.Forms.DialogResult.No;
            SSPC3Yes = dialogIntgbl_SSPC3 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC3No = dialogIntgbl_SSPC3 ==
System.Windows.Forms.DialogResult.No;
            SSPC4Yes = dialogIntgbl_SSPC4 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC4No = dialogIntgbl_SSPC4 ==
System.Windows.Forms.DialogResult.No;
            SSPC5Yes = dialogIntgbl_SSPC5 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC5No = dialogIntgbl_SSPC5 ==
System.Windows.Forms.DialogResult.No;
            SSPC6Yes = dialogIntgbl_SSPC6 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC6No = dialogIntgbl_SSPC6 ==
System.Windows.Forms.DialogResult.No;
            SSPC7Yes = dialogIntgbl_SSPC7 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC7No = dialogIntgbl_SSPC7 ==
System.Windows.Forms.DialogResult.No;
            SSPC8Yes = dialogIntgbl_SSPC8 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC8No = dialogIntgbl_SSPC8 ==
System.Windows.Forms.DialogResult.No;
            SSPC9Yes = dialogIntgbl_SSPC9 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC9No = dialogIntgbl_SSPC9 ==
System.Windows.Forms.DialogResult.No;
            SSPC10Yes = dialogIntgbl_SSPC10 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC10No = dialogIntgbl_SSPC10 ==
System.Windows.Forms.DialogResult.No;
            SSPC11Yes = dialogIntgbl_SSPC11 ==
System.Windows.Forms.DialogResult.Yes;
            SSPC11No = dialogIntgbl_SSPC11 ==
System.Windows.Forms.DialogResult.No;
            SSPC12Yes = dialogIntgbl_SSPC12 ==
System.Windows.Forms.DialogResult.Yes;
```

```
        SSPC12No = dialogIntgbl_SSPC12 ==
System.Windows.Forms.DialogResult.No;

        IK1Yes = dialogIntgbl_IK1 == System.Windows.Forms.DialogResult.Yes;
        IK1No = dialogIntgbl_IK1 == System.Windows.Forms.DialogResult.No;
        IK2Yes = dialogIntgbl_IK2 == System.Windows.Forms.DialogResult.Yes;
        IK2No = dialogIntgbl_IK2 == System.Windows.Forms.DialogResult.No;
        IK3Yes = dialogIntgbl_IK3 == System.Windows.Forms.DialogResult.Yes;
        IK3No = dialogIntgbl_IK3 == System.Windows.Forms.DialogResult.No;
        IK4Yes = dialogIntgbl_IK4 == System.Windows.Forms.DialogResult.Yes;
        IK4No = dialogIntgbl_IK4 == System.Windows.Forms.DialogResult.No;
        IK5Yes = dialogIntgbl_IK5 == System.Windows.Forms.DialogResult.Yes;
        IK5No = dialogIntgbl_IK5 == System.Windows.Forms.DialogResult.No;

        HUMRES1Yes = dialogTgbl_HUMRES1 ==
System.Windows.Forms.DialogResult.Yes;
        HUMRES1No = dialogTgbl_HUMRES1 ==
System.Windows.Forms.DialogResult.No;

        STIC1Yes = dialogIntgbl_STIC1 ==
System.Windows.Forms.DialogResult.Yes;
        STIC1No = dialogIntgbl_STIC1 ==
System.Windows.Forms.DialogResult.No;
        STIC2Yes = dialogIntgbl_STIC2 ==
System.Windows.Forms.DialogResult.Yes;
        STIC2No = dialogIntgbl_STIC2 ==
System.Windows.Forms.DialogResult.No;
        STIC3Yes = dialogIntgbl_STIC3 ==
System.Windows.Forms.DialogResult.Yes;
        STIC3No = dialogIntgbl_STIC3 ==
System.Windows.Forms.DialogResult.No;
        STIC4Yes = dialogIntgbl_STIC4 ==
System.Windows.Forms.DialogResult.Yes;
        STIC4No = dialogIntgbl_STIC4 ==
System.Windows.Forms.DialogResult.No;
        STIC5Yes = dialogIntgbl_STIC5 ==
System.Windows.Forms.DialogResult.Yes;
        STIC5No = dialogIntgbl_STIC5 ==
System.Windows.Forms.DialogResult.No;

        ForeTimeHorizonYes = dialogIntgbl_ForeTimeHorizon ==
System.Windows.Forms.DialogResult.Yes;
        ForeTimeHorizonNo = dialogIntgbl_ForeTimeHorizon ==
System.Windows.Forms.DialogResult.No;
        richTextBox1_CoreMthds.Visible = true;
        if (SSPC1No && SSPC3No)
        {
           if (IK1No&& IK2No&& IK3No&& HUMRES1Yes)
           {
              richTextBox1_CoreMthds.Text = "Literature Review\nExpert
Panel\nDelphi\nRoadMapping" + "\n";
           }
            if (IK1Yes && IK2Yes && IK3Yes)
            {
            richTextBox1_CoreMthds.Text = "Correlation Analysis\nText Mining" +
"\n";
            }
```

```
            if (IK1Yes && IK2Yes && dialogIntgbl_IK3 ==
System.Windows.Forms.DialogResult.No&& ForeTimeHorizonNo)
            {
            richTextBox1_CoreMthds.Text = "Trend Analysis\nExtrapolation" + "\n";
            }
        }
        if (SSPC1Yes|| SSPC3Yes)
        {
            if (IK1No|| IK2No|| IK3No&& HUMRES1Yes)
            {
                richTextBox1_CoreMthds.Text = "Expert Panel\nGenious
Forecasting\nBackcasting\nGoals Delphi" + "\n";
            }
            if (IK1Yes && IK2Yes && IK3Yes)
            {
                richTextBox1_CoreMthds.Text = "Relevance Trees\nMorphological
Analysis" + "\n";
            }
        }
            button8.Visible = true;
            button9_coreMthds.ForeColor = Color.Black;
    }
// It is hidden for supportive methods decision...
    private void button8_Click_1(object sender, EventArgs e)
    {
    }
     private void button9_Click_2(object sender, EventArgs e)
    {
        if (Application.OpenForms[0] == this)
        {
            Application.Restart();
        }
    }

  }
}
```

APPENDIX B LIST OF PARTICIPANTS' NUMBER AND INSTITUTIONS FOR THE EXPERT PANELS

Institutions	Participants' Number
Bilkent University-Electrical Electronics Engineering	3
Hacettepe University-Electrical Electronics Engineering	1
Middle East Technical University (METU)-Physics	1
Public Administration Institute For Turkey And The Middle East	1
Turkish Air Forces	2
Turkish Armed Forces	3
Presidency Of The Republic Of Turkey Undersecretariat For Defense Industries-SSB	3
Başkent University-Electrical Electronics Engineering	1
Brensan Energy And Defense Inc.	1
Turkish Aerospace Inc.-TAI	2
Metra Electronics	1
Aselsan Inc.	8
METU-MEMS	1
Havelsan Inc.	1
TÜBİTAK	3
TÜRKSAT	1
Meteksan Savunma	2
Space & Defence Technologies-SDT	2
STM Savunma Teknolojileri Mühendislik Ve Ticaret A.Ş.	2
Onur Engineering Experience Results	1
Turkish Amateur Satellite Technologies Organization-TAMSAT	2
Remote Sensing Technologies-RST	2
	Total: 44

LIST OF PARTICIPANTS' NUMBER AND INSTITUTIONS FOR THE SECOND EXPERT PANEL

Institutions	Participants' Number
Bilkent University-Electrical Electronics Engineering	2
The University Of Illinois At Chicago College Of Liberal Arts And Sciences-Physics	1
Hacettepe University-Electrical Electronics Engineering	1
Middle East Technical University (METU)-Physics	1
Turkish Air Forces	1
Presidency Of The Republic Of Turkey Undersecretariat For Defense Industries -SSB	1
Brensan Energy And Defense Inc.	1
Turkish Aerospace Inc. -TAI	3
Metra Electronics	1
Aselsan Inc.	3
METU-MEMS	1
Republic Of Turkey Ministry Of Development	1
TÜBİTAK	1
STM Savunma Teknolojileri Mühendislik Ve Ticaret A.Ş.	1
	Total: 19

APPENDIX C DELPHI INTERROGATION QUESTIONS

DELPHI QUESTIONS AND EXPLANATIONS FOR THE DELPHI INTERROGATIONS

Table 1 The First Delphi Interrogation

The First Delphi Interrogation		
Questions		**Explanations**
Expertise	Field Expert (KU)	They were used in the analysis to determine the Delphi Survey Technological Statements and in the analysis of the SEEPL for policy recommendations
	Knowledged (BV)	
Importance for Turkey	Very Much	
	Normal	
	Little	
	Non	
Time of Realization	2019-2023	In decision taking for tentative answers of Delphi Survey
	2024-2029	
	2030-2035	
	2036-2040	
	Never	
Initiation Capability	Basic Research	
	Applied Industrial Research	
	Industrial Development Before Competition	
	Industrial Development	

Table 2 The Second Delphi Interrogation

The Second Delphi Interrogation		
Questions		**Explanations**
Expertise	Field Expert	They were used in scenario building for different futures.
	Not Knowledged	
	Knowledged	
Contribution to National Security	1	
	2	
	3	
	4	
	5	
Contribution to National Economy	1	
	2	
	3	
	4	
	5	
Time of Realization	2019-2023	
	2024-2029	
	2030-2035	
	2036-2040	
	Never	
Initiation Capability	Basic Research	They were used in strategies with policy recommendations and roadmaps for different futures' scenarios together with the answersof the first Delphi Interrogation.
	Applied Industrial Research	
	Industrial Development Before Competition	
	Industrial Development	

APPENDIX D LIST OF EXPERTS' NUMBER AND INSTITUTIONS FOR DELPHI SURVEY

Table 1 Academics and Institutions to Which First Round Delphi Survey Sent

Number of Universities	Electrical and Electronics Engineering, Aeronautics and Astronautics Engineering and Related Departments of the Universities Listed in Council Of Higher Education-2018	Number of Academics to Whom First Round Delphi Survey Sent
1	Abdullah Gül University	12
2	Adana Science and Technology University	15
3	Adıyaman University	7
4	Adnan Menderes University	10
5	Akdeniz University	12
6	Aksaray University	5
7	Altınbaş University	5
8	Amasya University	13
9	Anadolu University	29
10	Ankara University	18
11	Ankara Yıldırım Beyazıt University	8
12	Ardahan University	4
13	Atatürk University	13
14	Atılım University	13
15	Avrasya University	4
16	Bahçeşehir University	11
17	Balıkesir University	5
18	Bartın University	7
19	Başkent University	16
20	Batman University	14
21	Bayburt University	9
22	Beykent University	4
23	Bilecik Şeyh Edabali University	14
24	Bilkent University	27
25	Bingöl University	12
26	Bitlis University	10
27	Boğaziçi University	26
28	Bursa Technical University	14
29	Bursa Uludağ University	32
30	Çankaya University	13
31	Çankırı Karatekin University	9
32	Çukurova University	19
33	Dicle University	12
34	Doğuş University	6
35	Dokuz Eylül University	32
36	Düzce University	14
37	Ege University	11
38	Erciyes University	6
39	Erzincan University	11
40	Erzurum Technical University	12
41	Eskişehir Osman Gazi University	24
42	Fırat University	3
43	Gazi University	32
44	Gaziantep University	41
45	Gebze Technical University	14
46	Gelişim University	8
47	Giresun University	6
48	Gümüşhane University	8

Table 1 (cont'd) Academics and Institutions to Which First Round Delphi Survey Sent

Number of Universities	Electrical and Electronics Engineering, Aeronautics and Astronautics Engineering and Related Departments of the Universities Listed in Council Of Higher Education-2018	Number of Academics to Whom First Round Delphi Survey Sent
49	Hacettepe University	39
50	Hakkari University	7
51	Haliç University	5
52	Harran University	16
53	Hasan Kalyoncu University	10
54	Hitit University	14
55	Iğdır University	8
56	İnönü University	29
57	Işık University	13
58	Isparta Uygulamalı Bilimler Universitesi	12
59	İstanbul Arel University	7
60	İstanbul Aydın University	30
61	İstanbul Ayvansaray University	4
62	İstanbul Bilgi University	6
63	İstanbul Esenyurt University	2
64	İstanbul Gedik University	5
65	İstanbul Medeniyet University	12
66	İstanbul Medipol University	7
67	İstanbul Şehir University	9
68	İstanbul Technical University	49
69	İstanbul Technical University Space	12
70	İstanbul Yeniy Yüzyıl University	13
71	İstinye University	3
72	İzmir Demokrasi University	3
73	İzmir Institute of Technology	16
74	Kadir Has University	9
75	Karabük University	13
76	Karadeniz Technical University	24
77	Karatay University	8
78	Kastamonu University	5
79	Kırıkkale University	16
80	Kırlareli University	3
81	Kırşehir Ahi Evran University	2
82	Koç University	4
83	Kocaeli University	25
84	Kütahya Dumlupınar University	10
85	Manisa Celal Bayar University	4
86	Marmara University	14
87	MEF University	6
88	Mersin University	11
89	Middle East Technical University	95
90	Muğla University	9
91	Muş Alparslan University	1
92	Necmettin Erbakan University	17
93	Nişantaşı University	4
94	Nuh Naci Yazgan University	14
95	Okan University	8
96	Ondokuz Mayıs University	7

Table 1 (cont'd) Academics and Institutions to Which First Round Delphi Survey Sent

Number of Universities	Electrical and Electronics Engineering, Aeronautics and Astronautics Engineering and Related Departments of the Universities Listed in Council Of Higher Education-2018	Number of Academics to Whom First Round Delphi Survey Sent
97	Özyeğin University	11
98	Pamukkale University	11
99	Piri Reis University	9
100	Recep Tayyip Erdoğan University	5
101	Sabancı University	15
102	Sakarya University	24
103	Selçuk University	29
104	Siirt University	3
105	Sivas Cumhuriyet University	13
106	Süleyman Demirel University	8
107	TED University	10
108	TOBB Economy and Technology University	12
109	Tokat Gaziosmanpaşa University	5
110	Toros University	4
111	Trakya University	6
112	Türk Hava Kurumu University	16
113	Üsküdar University	4
114	Van Yüzüncü Yıl University	2
115	Yaşar University	10
116	Yeditepe University	16
117	Yıldız Teknik University	26
118	Yozgat Bozok University	6
119	Zonguldak Bülent Ecevit University	6
119	**TOTAL**	**1541**

Table 2 The First Expert Panel Participants to Which First Round Delphi Survey Sent

Number of Institutions	Institutions	Number of Experts in Institutions to Whom First Round Delphi Survey Sent (The First Expert Panel Participants)
1	Bilkent University-Electrical Electronics Engineering	3
2	Hacettepe University-Electrical Electronics Engineering	1
3	Middle East Technical University (METU)-Physics	1
4	Public Administration Institute For Turkey And The Middle East	1
5	Turkish Air Forces	2
6	Turkish Armed Forces	3
7	Presidency Of The Republic Of Turkey Undersecretariat For Defense Industries-SSB	3
8	Başkent University-Electrical Electronics Engineering	1
9	Brensan Energy And Defense Inc.	1
10	Turkish Aerospace Inc.-TAI	2
11	Metra Electronics	1
12	Aselsan Inc.	8
13	METU-MEMS	1
14	Havelsan Inc.	1
15	TÜBİTAK	3
16	TÜRKSAT	1
17	Meteksan Savunma	2
18	Space & Defence Technologies-SDT	2
19	STM Savunma Teknolojileri Mühendislik Ve Ticaret A.Ş.	2
20	Onur Engineering Experience Results	1
21	Turkish Amateur Satellite Technologies Organization-TAMSAT	2
22	Remote Sensing Technologies-RST	2
23	**TOTAL**	**44**

Table 3 The Second Expert Panel Participants to Which First Round Delphi Survey Sent

Number of Institutions	Institutions	Number of Experts in Institutions to Whom First Round Delphi Survey Sent (The Second Expert Panel Participants)
1	Bilkent University-Electrical Electronics Engineering	2
2	The University Of Illinois At Chicago College Of Liberal Arts And Sciences-Physics	1
3	Hacettepe University-Electrical Electronics Engineering	1
4	Middle East Technical University (METU)-Physics	1
5	Turkish Air Forces	1
6	Presidency Of The Republic Of Turkey Undersecretariat For Defense Industries -SSB	1
7	Brensan Energy And Defense Inc.	1
8	Turkish Aerospace Inc. -TAI	3
9	Metra Electronics	1
10	Aselsan Inc.	3
11	METU-MEMS	1
12	Republic Of Turkey Ministry Of Development	1
13	TÜBİTAK	1
14	STM Savunma Teknolojileri Mühendislik Ve Ticaret A.Ş.	1
14	**TOTAL**	**19**

Table 4 The 11th Development Plan for Space Studies' Participants to Which First Round Delphi Survey Sent

Number of Institutions	Institutions	Number of Experts in Institutions to Whom First Round Delphi Survey Sent (The 11th Development Plan for Space Studies' Participants)
1	Ankara University	3
2	ASELSAN Inc.	3
3	Atatürk University	2
4	CTECH Information Technologies	1
5	Dokuz Eylül University	1
6	Gazi University	1
7	Hacettepe University	1
8	HAVELSAN Inc.	1
9	Turkish Air Forces	2
10	İstanbul Technical University	1
11	Ministery of Development	1
12	Middle East Technical University	4
13	Republic of Turkey Ministery of Foreign Affairs	3
14	ROKETSAN Inc.	2
15	Ministery of Industry and Technology	2
16	Space & Defence Technologies-SDT	1
17	Presidency of the republic of Turkey Undersecretariat for Defense Industries-SSB	4
18	STM Savunma Teknolojileri Mühendislik ve Ticaret A.Ş.	5
19	Turkish Aerospace Inc. -TAI	6
20	Türk Hava Kurumu University	1
21	The Scientific and Technological Research Council of Turkey-TÜBİTAK	19
22	TURKSAT	4
23	Ministry of Transport, Maritime Affairs and Communication	4
24	Unknown	2
25	Yıldırım Beyazıt University	2
25	**TOTAL**	**76**

Table 5 Participants of ASELSAN to Which First Round Delphi Survey Sent

Number of Institutions	**Institution**	**Number of Experts in Institutions to Whom First Round Delphi Survey Sent**
1	ASELSAN Inc.	440
1	**TOTAL**	440

APPENDIX E CHARTS OF STEEPL ANALYSIS

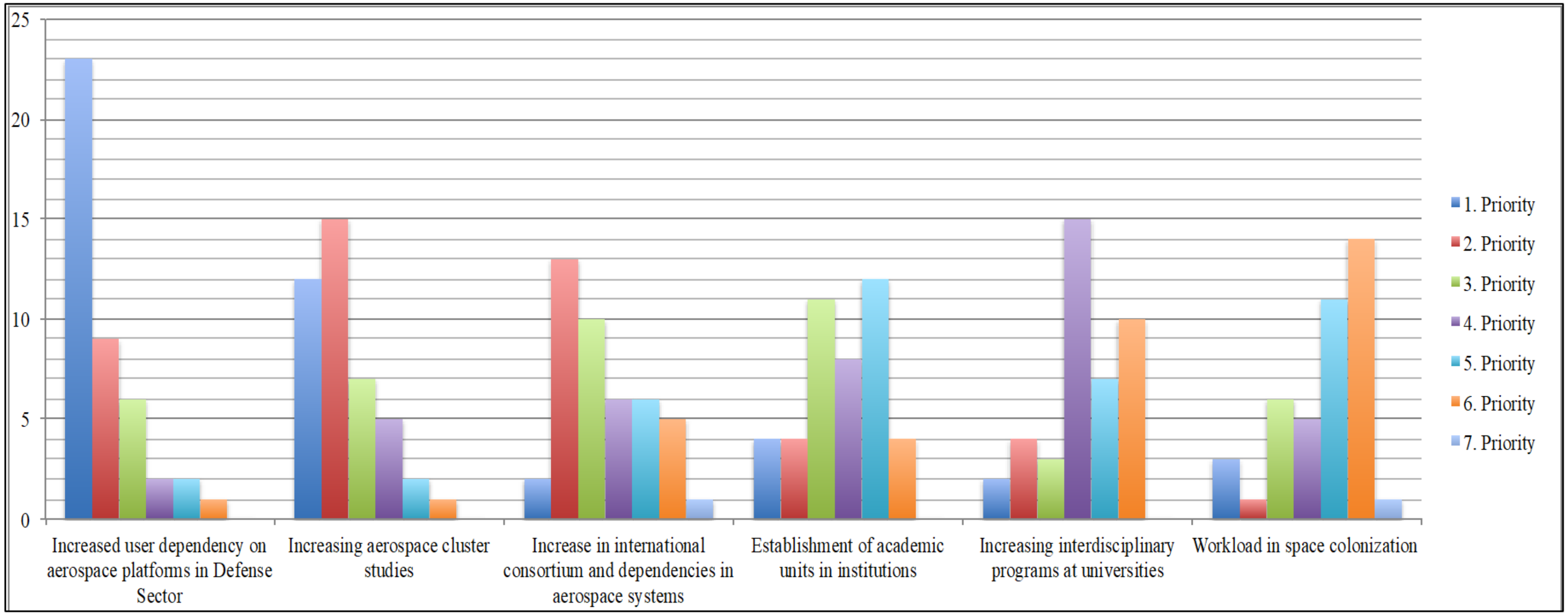


Figure 1 Priority Histogram for Voted Social Factors

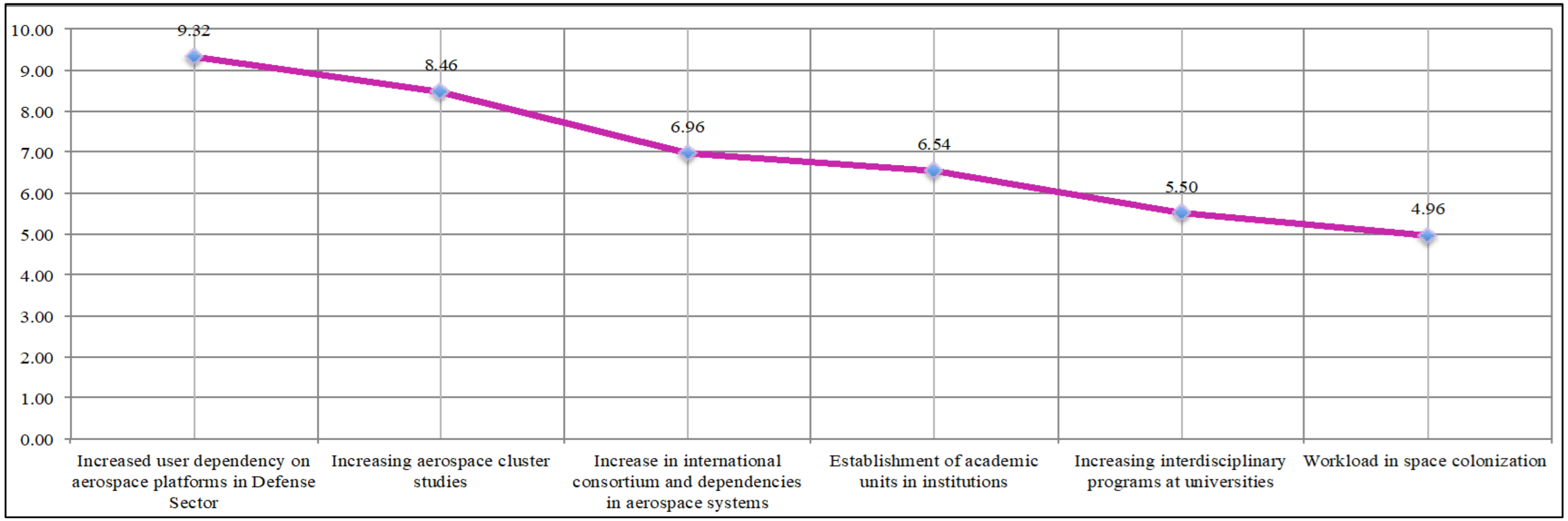


Figure 2 Prioritized Averages for Voted Social Factors

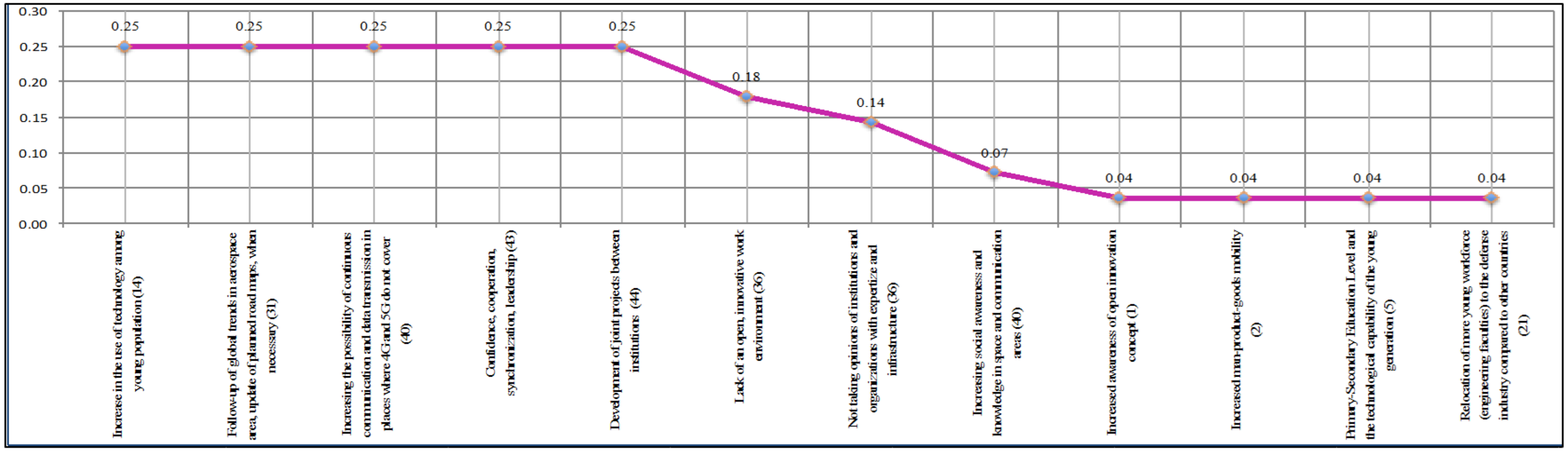


Figure 3 Prioritized Averages for Added Social Factors

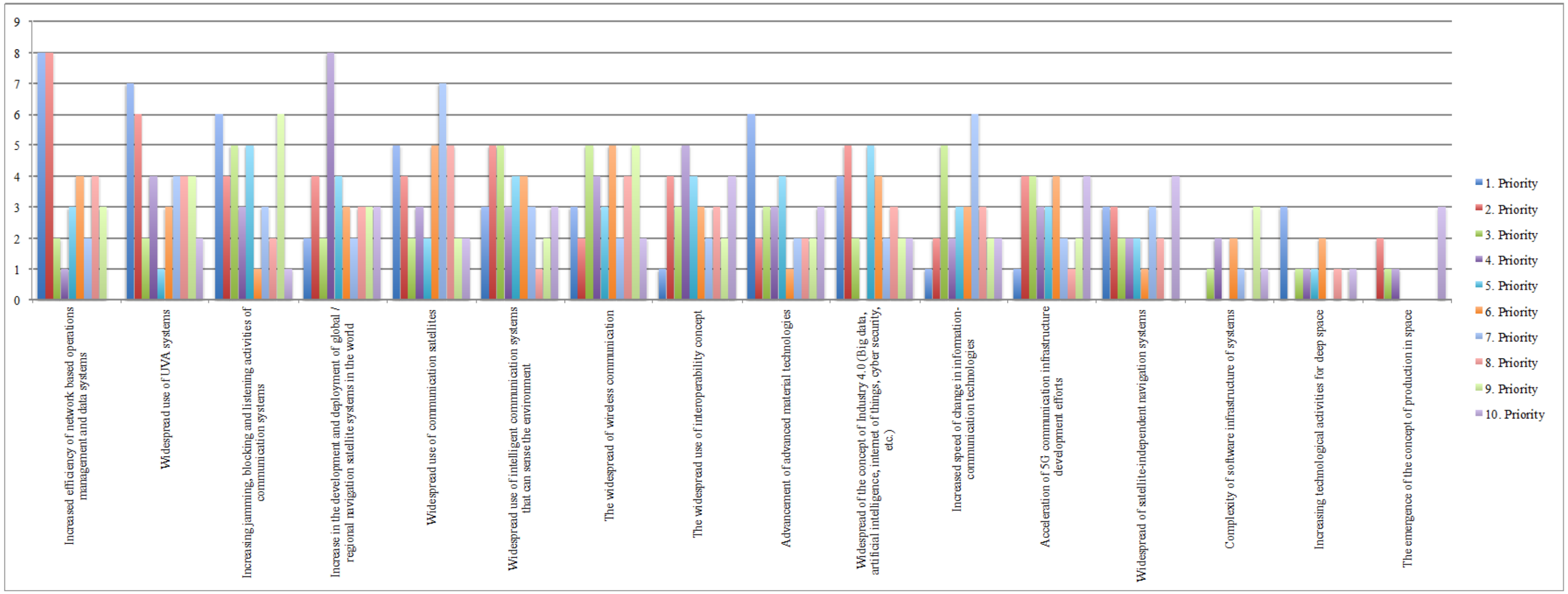


Figure 4 Priority Histogram for Voted Technological Factors

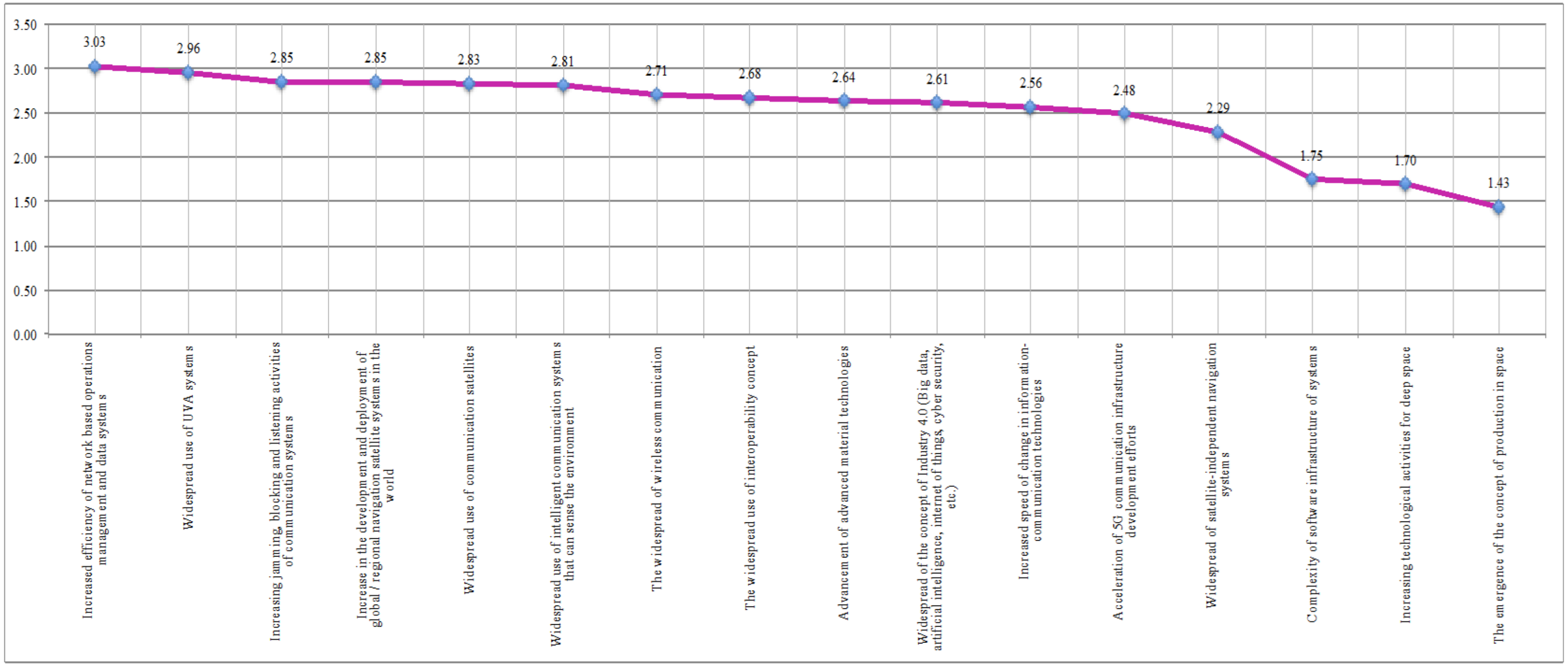


Figure 5 Prioritized Averages for Voted Technological Factors

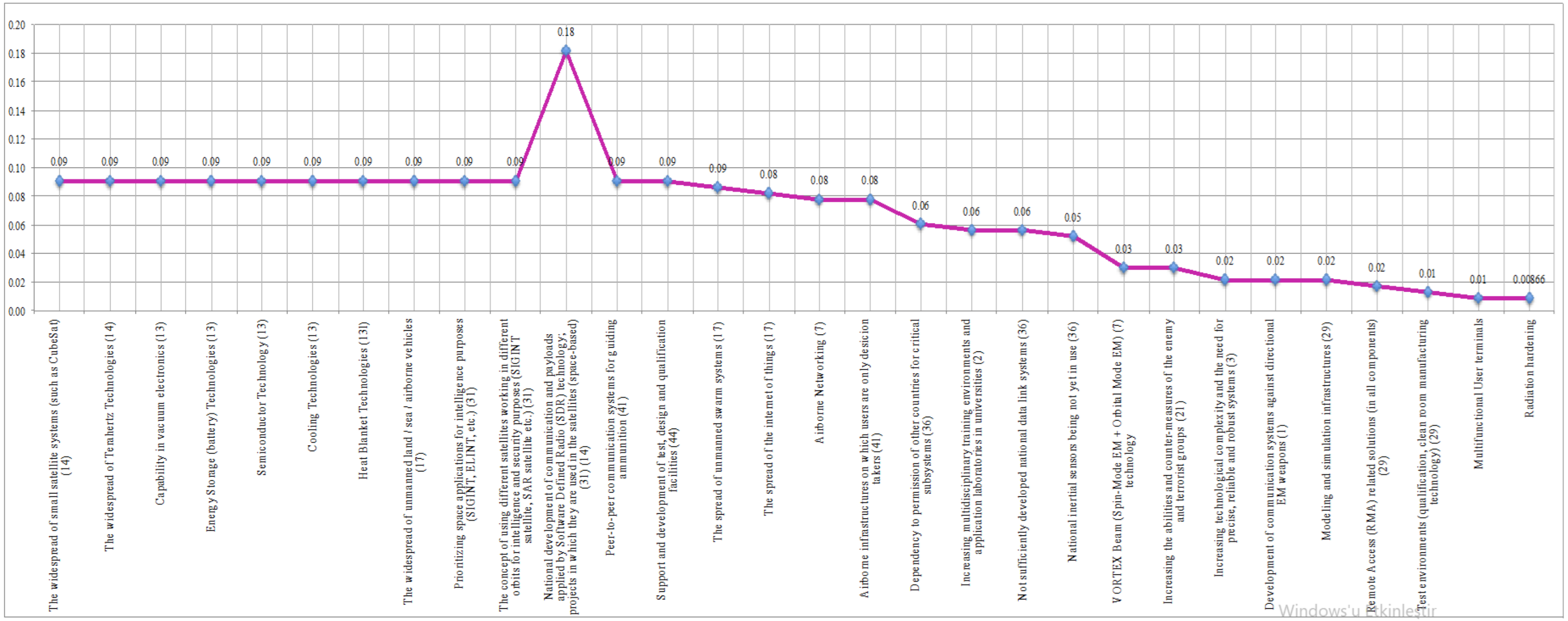


Figure 6 Prioritized Averages for Added Technological Factors

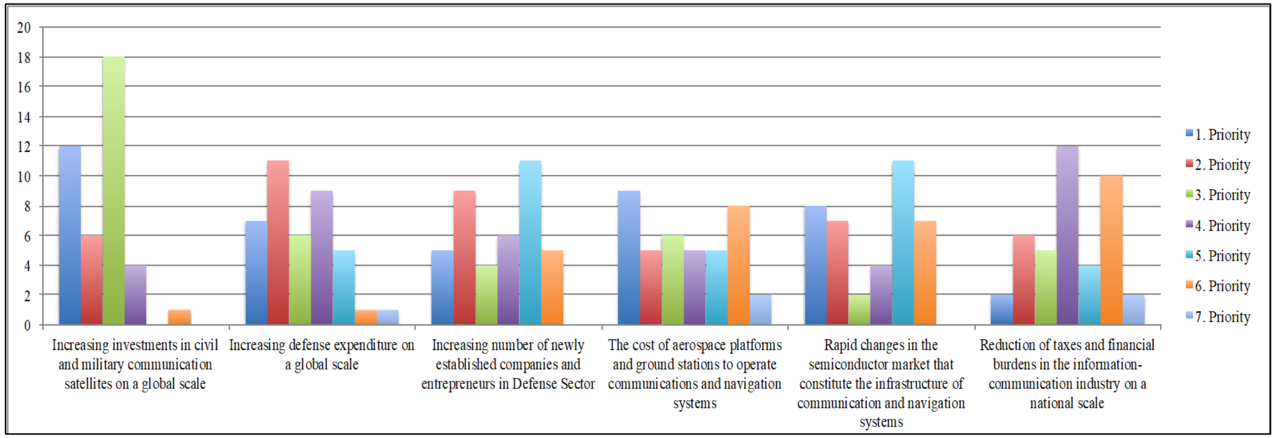


Figure 7 Priority Histogram for Voted Economical Factors

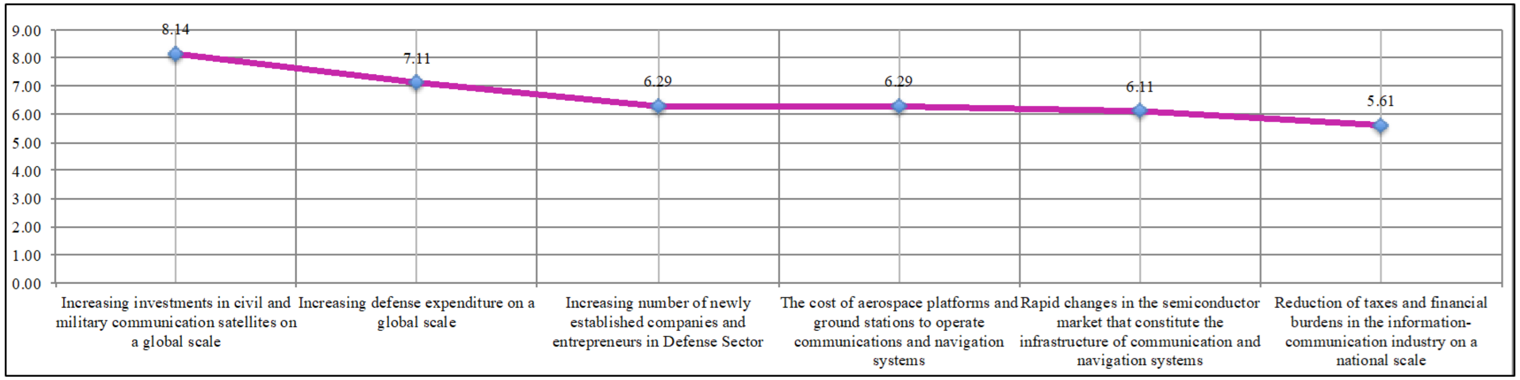


Figure 8 Prioritized Averag es for Voted Economical Factors

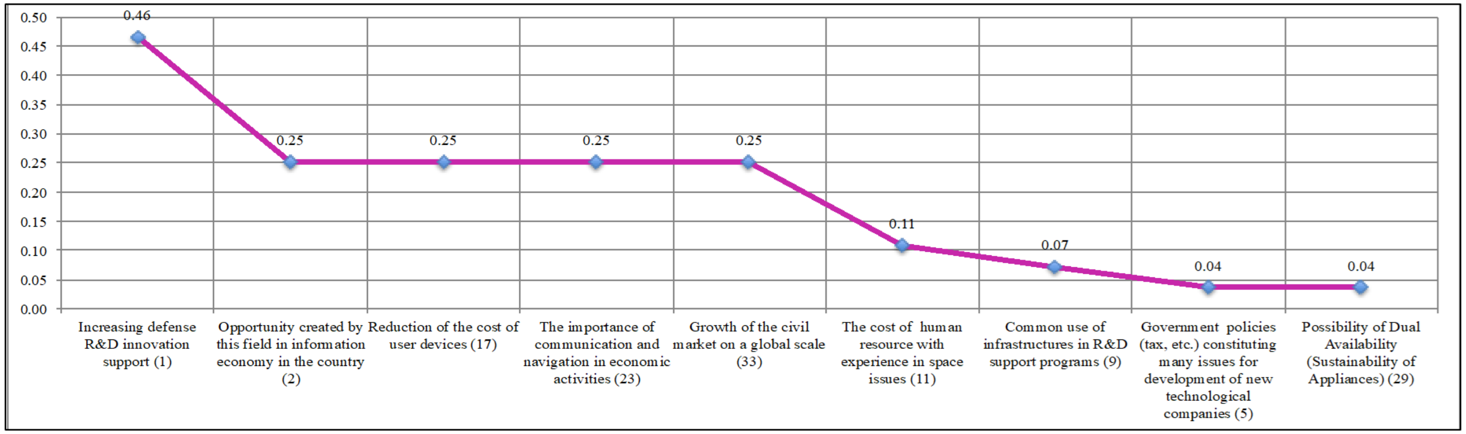


Figure 9 Prioritized Averages for Added Economical Factors

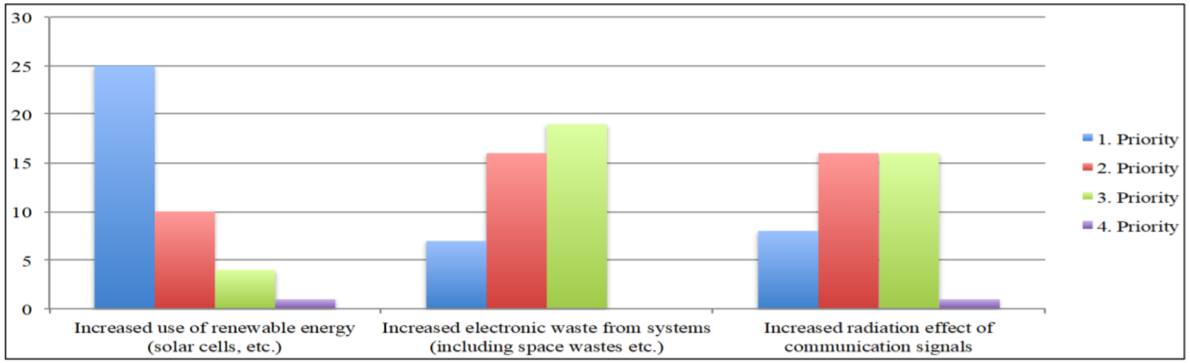


Figure 10 Priority Histogram for Voted Environmental Factors

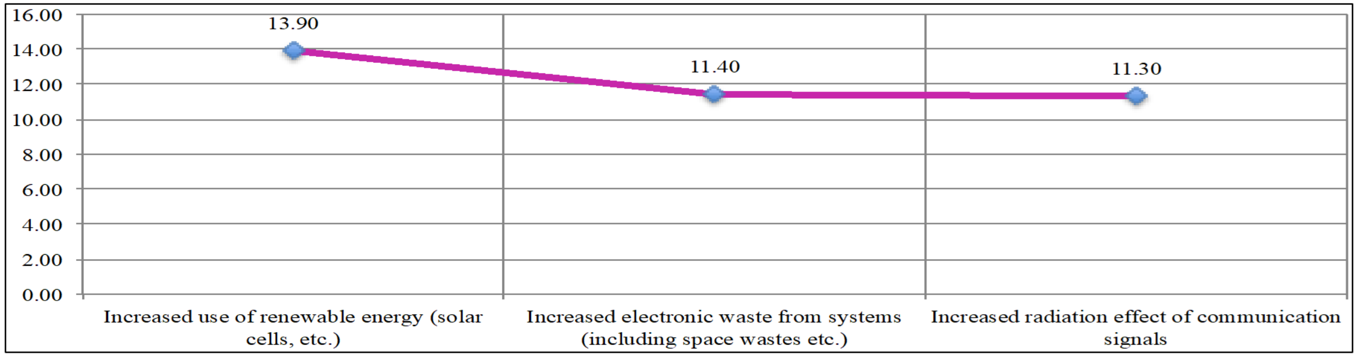


Figure 11 Prioritized Averages for Voted Environmental Factors

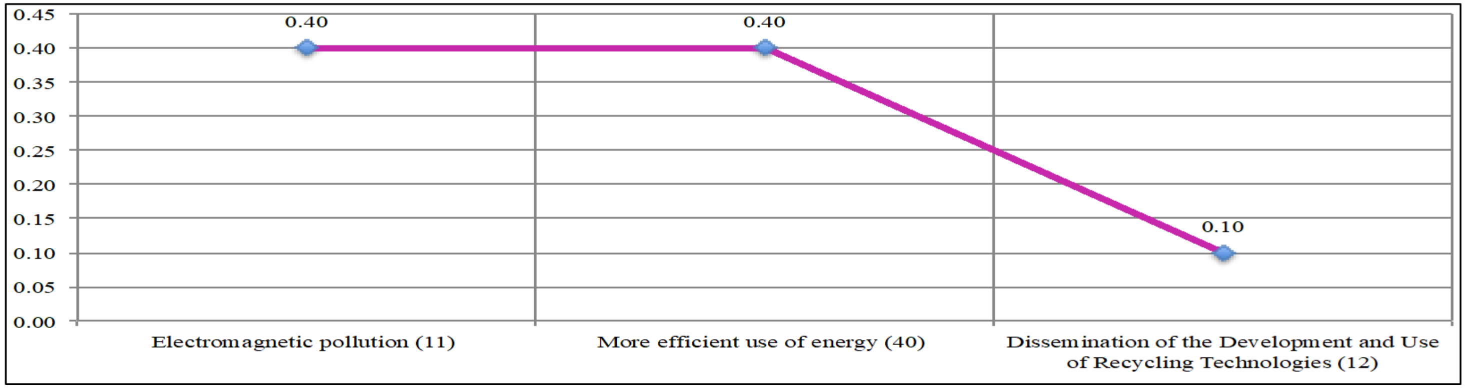


Figure 12 Prioritized Averages for Added Environmental Factors

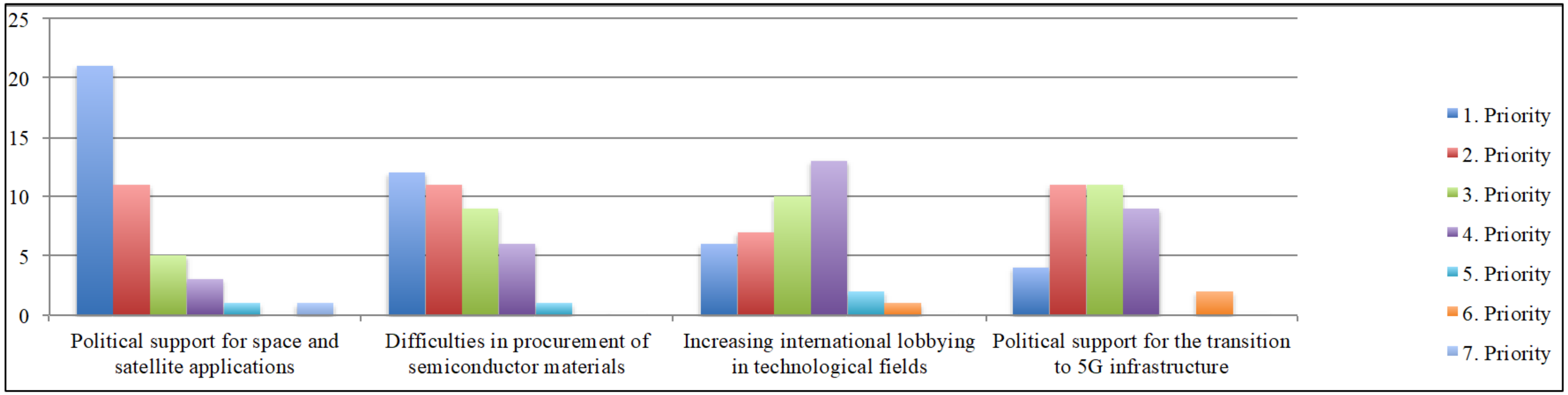


Figure 13 Priority Histogram for Voted Political Factors

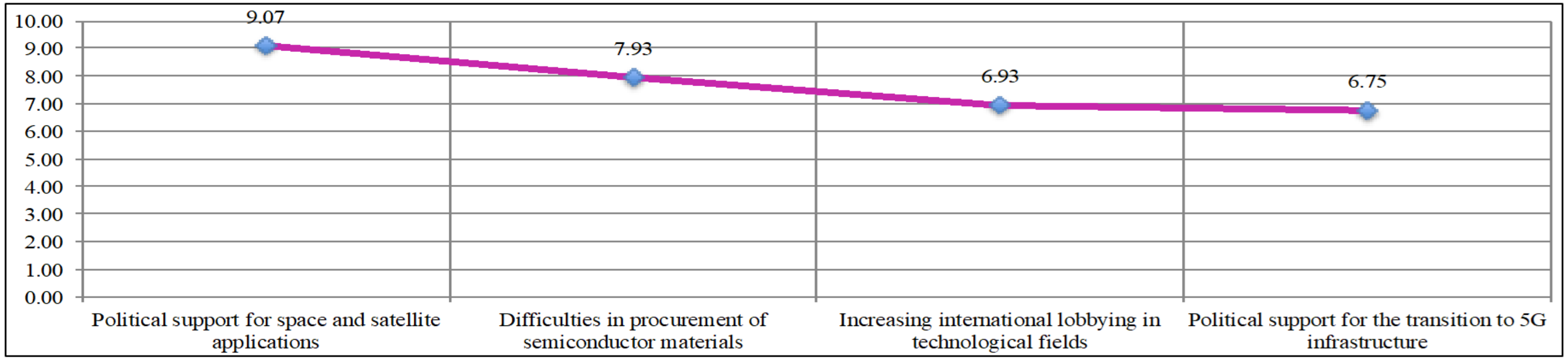


Figure 14 Prioritized Averages for Voted Political Factors

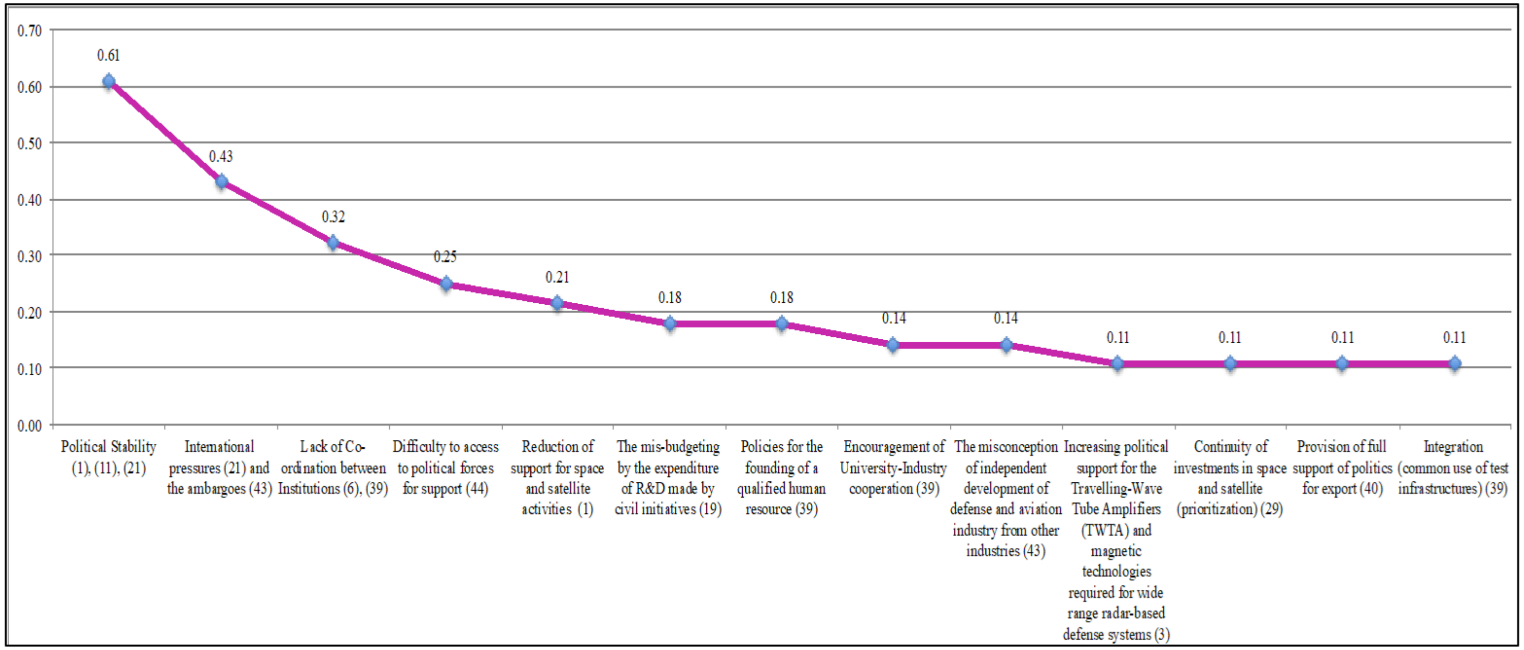


Figure 15 Prioritized Averages for Added Political Factors

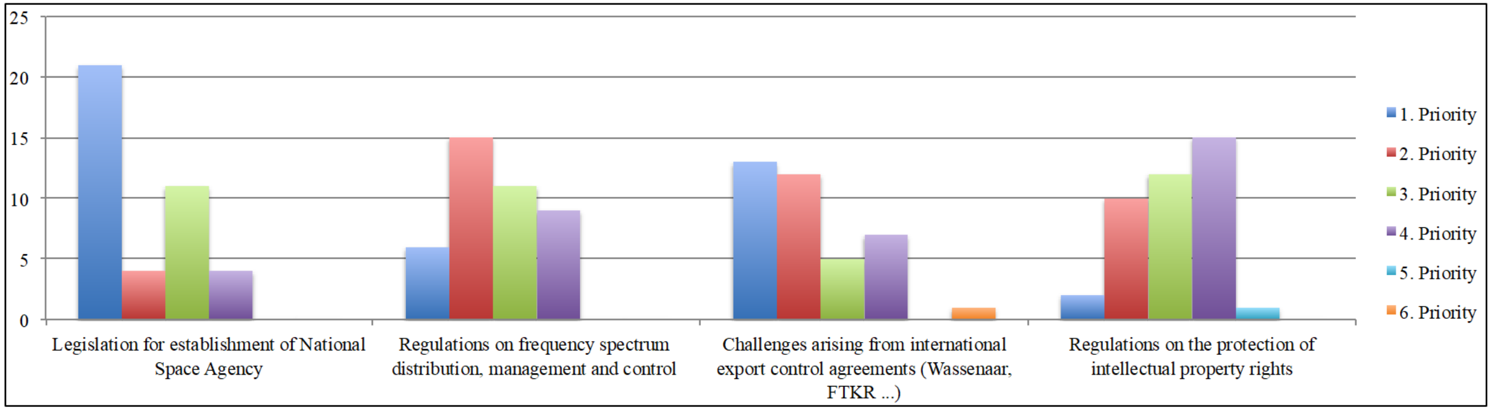


Figure 16 Priority Histogram for Voted Legal Factors

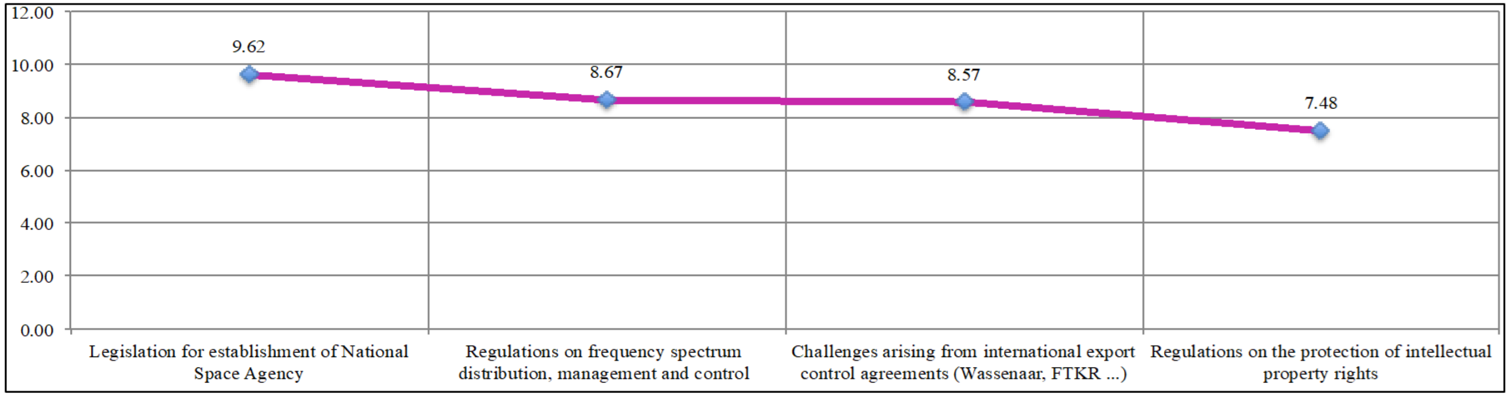


Figure 17 Prioritized Averages for Voted Legal Factors

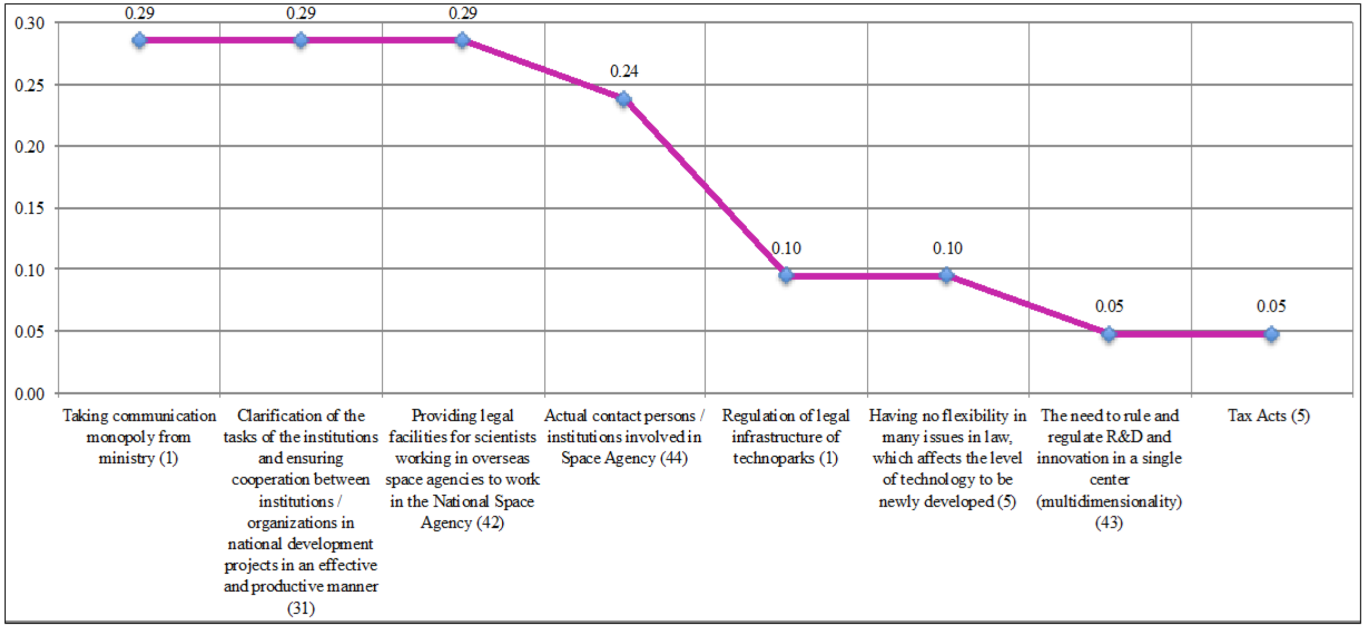


Figure 18 Prioritized Averages for Added Legal Factors

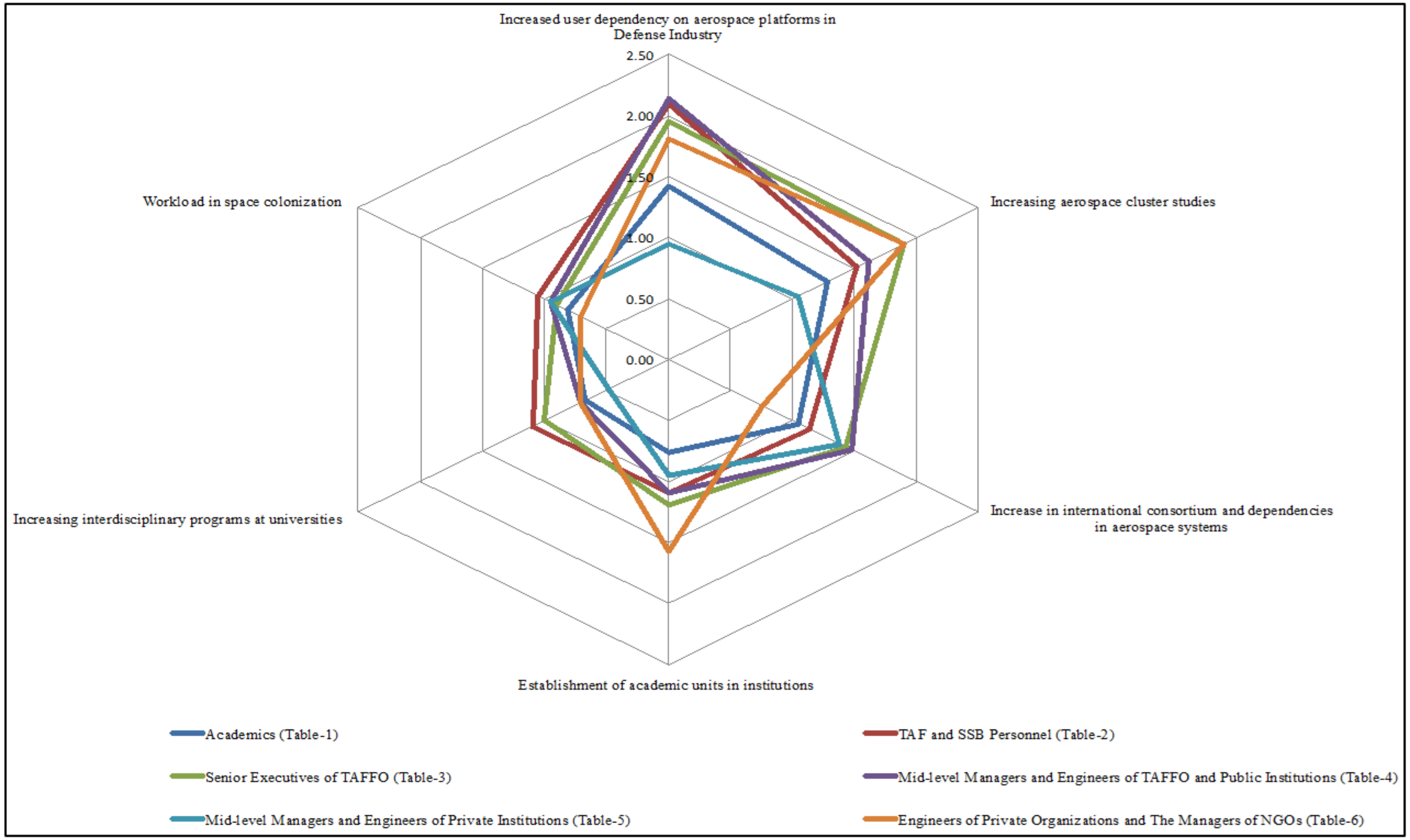


Figure 19 Radar Diagram of Priority Histo gram for Voted Social Factors According to Tables (Groups)

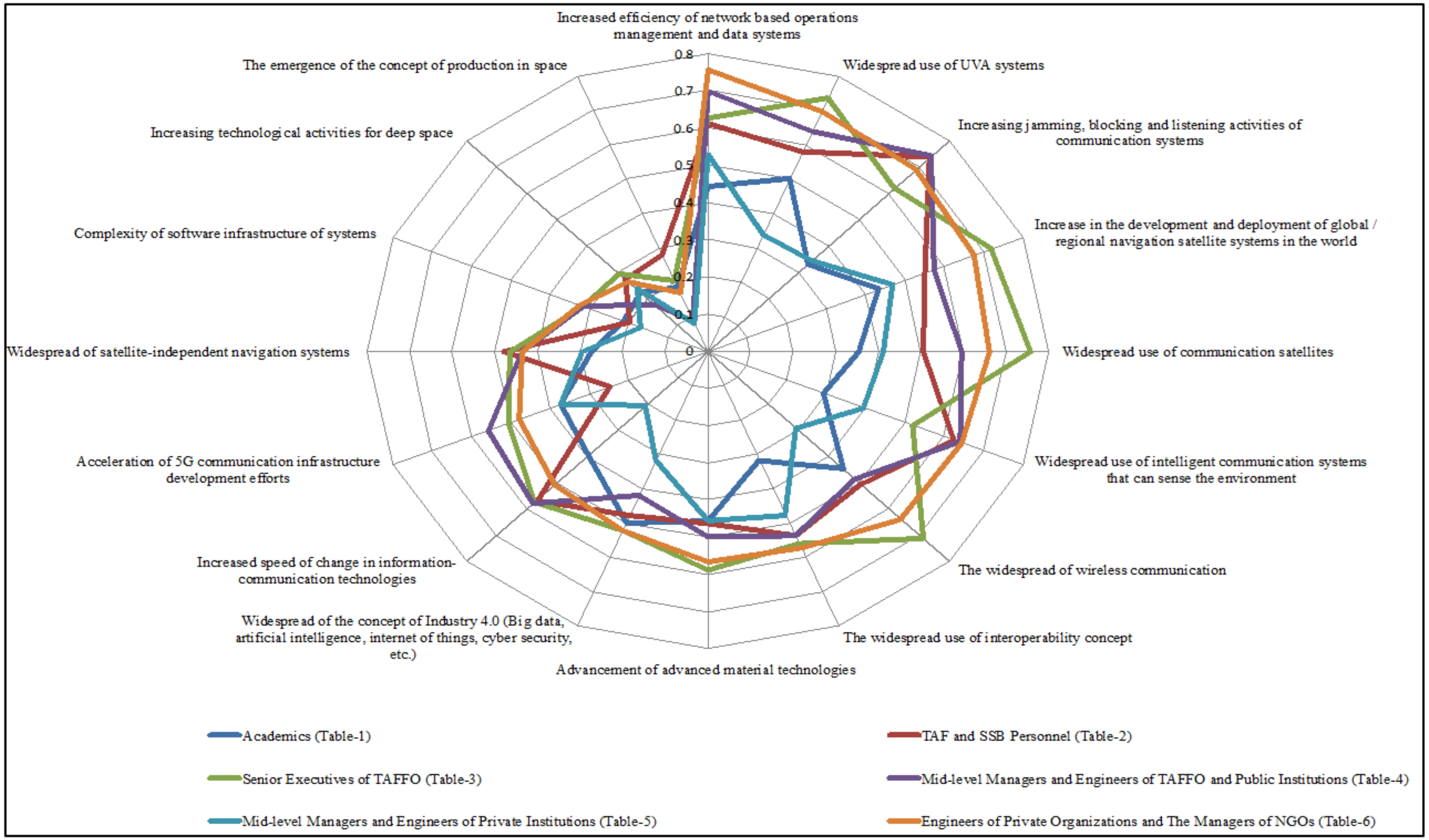


Figure 20 Radar Diagram of Priority Histogram for Voted Technological Factors According to Tables (Groups)

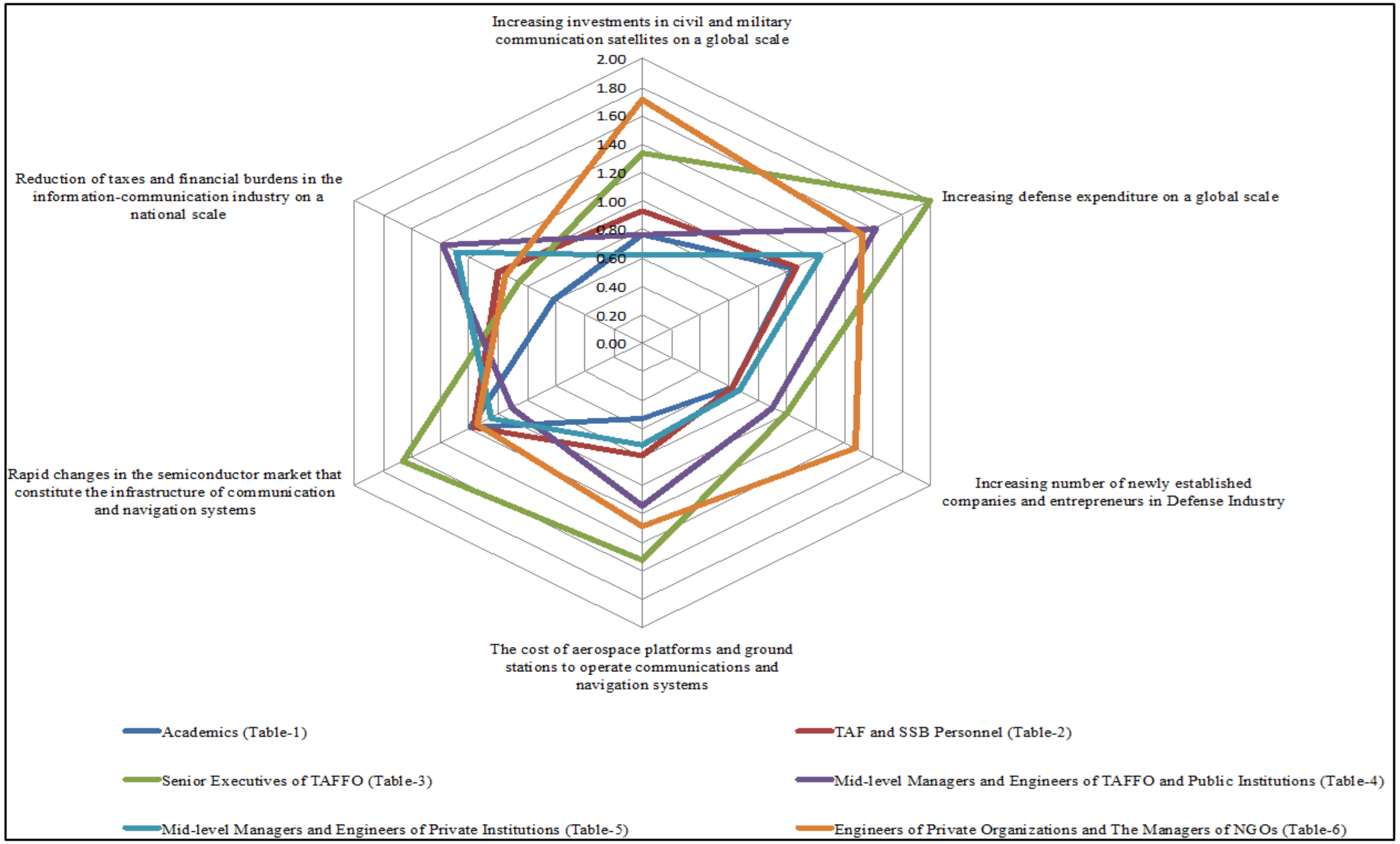


Figure 21 Radar Diagram of Priority Histogram for Voted Economic al Factors According to Tables (Groups)

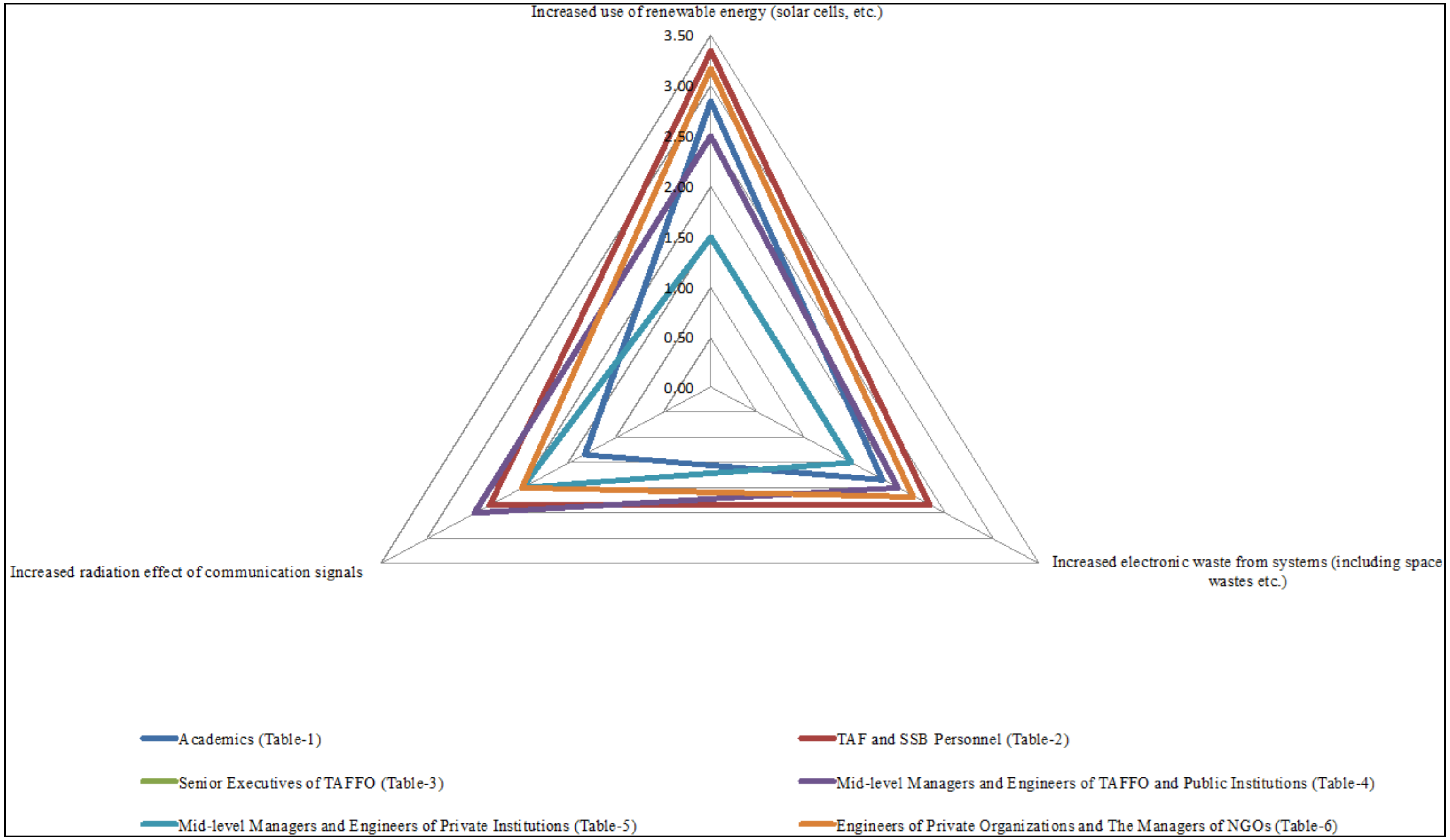


Figure 22 Radar Diagram of Priority Histogram for Voted Environmental Factors According to Tables (Groups)

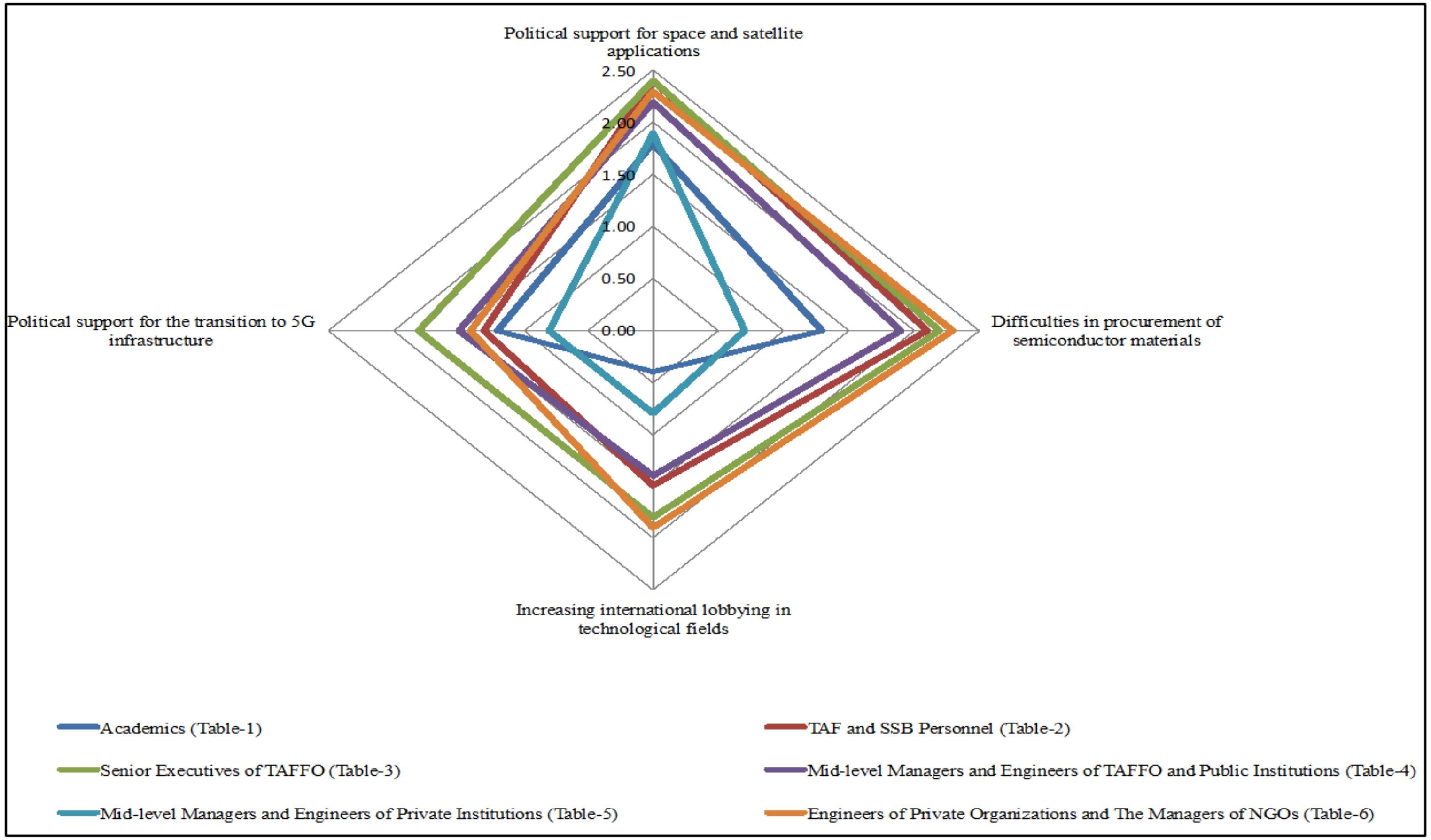


Figure 23 Radar Diagram of Priority Histogram for Voted Political Factors According to Tables (Groups)

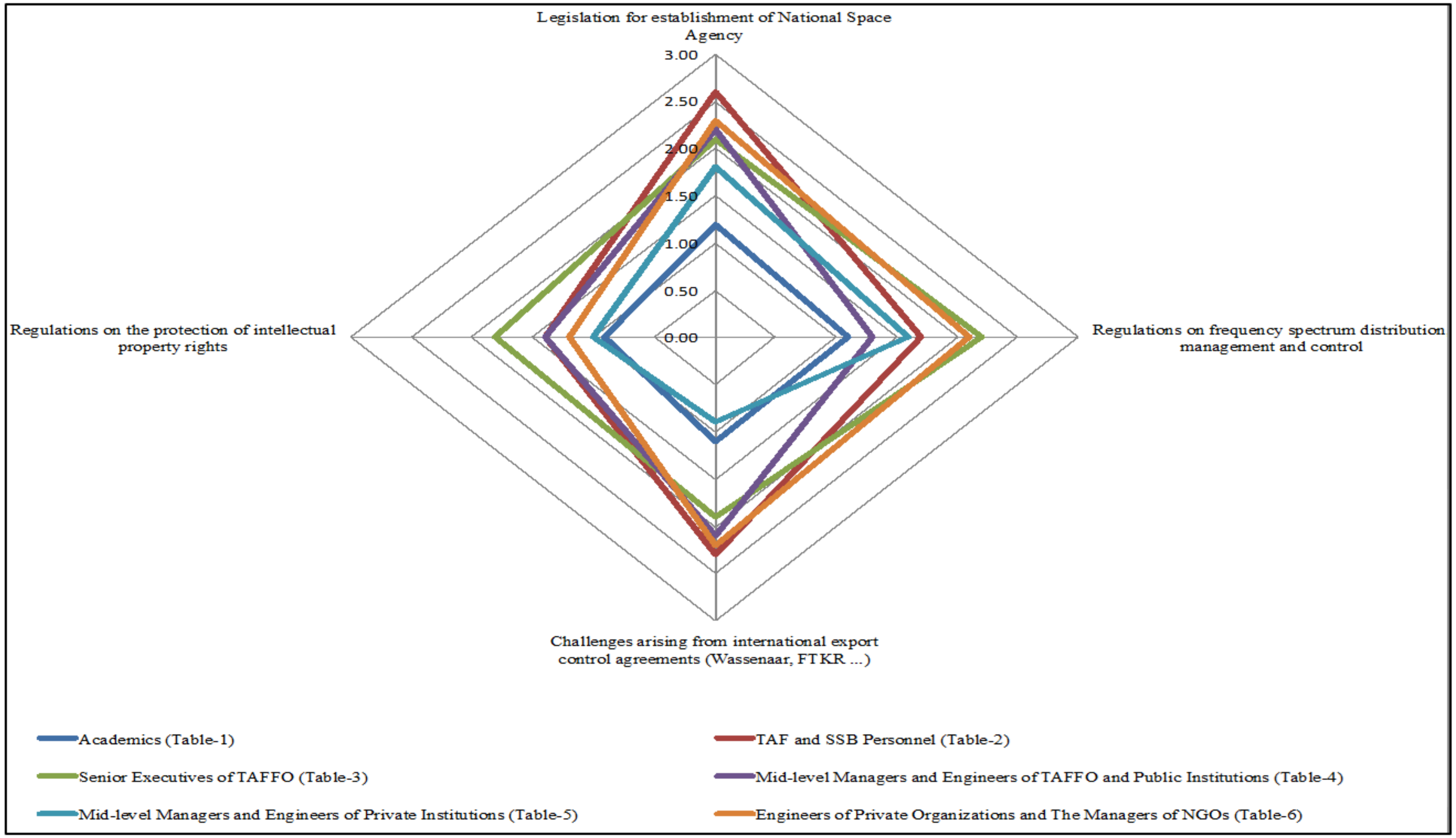


Figure 24 Radar Diagram of Priority Histogram for Voted Legal Factors According to Tables (Groups)

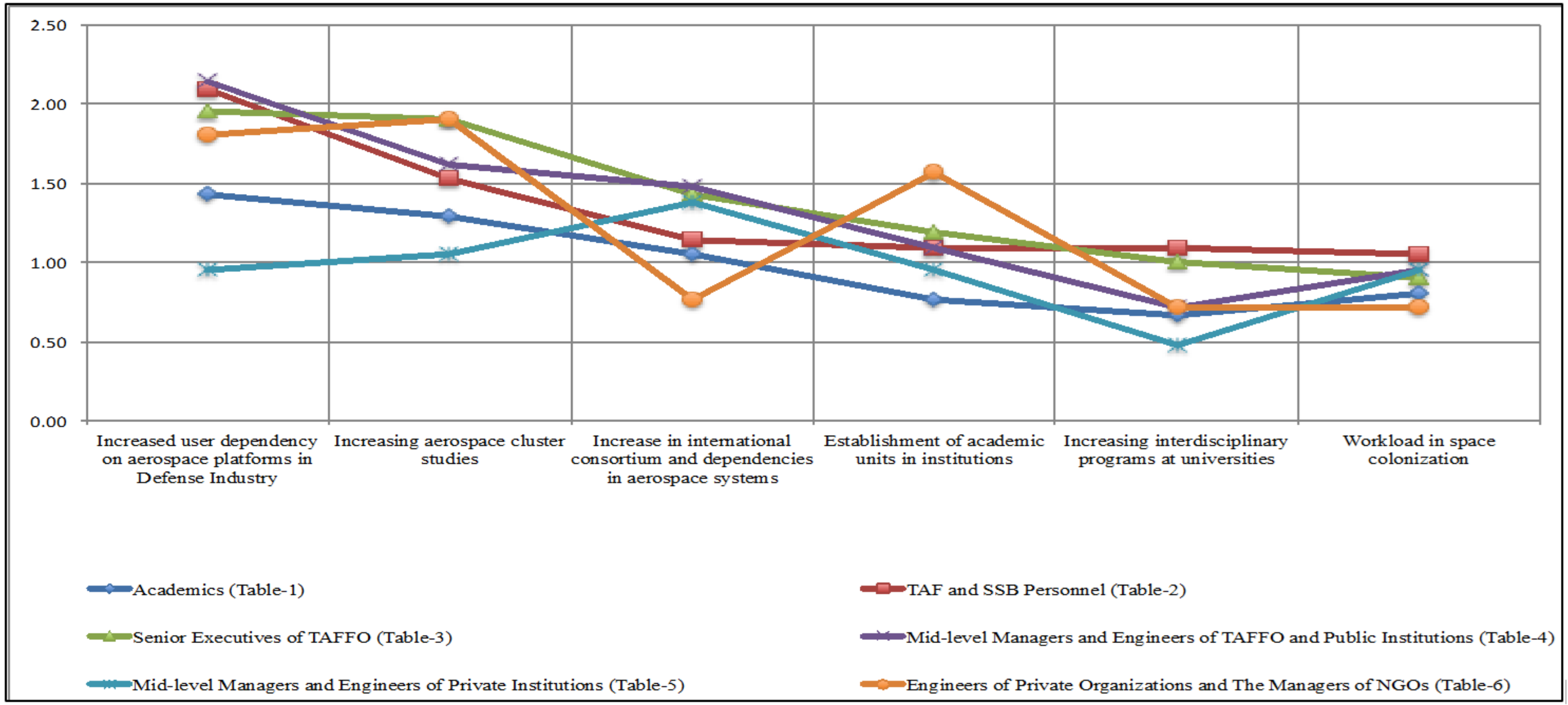


Figure 25 Prioritized Averages for Voted Social Factors According to Tables (Groups)

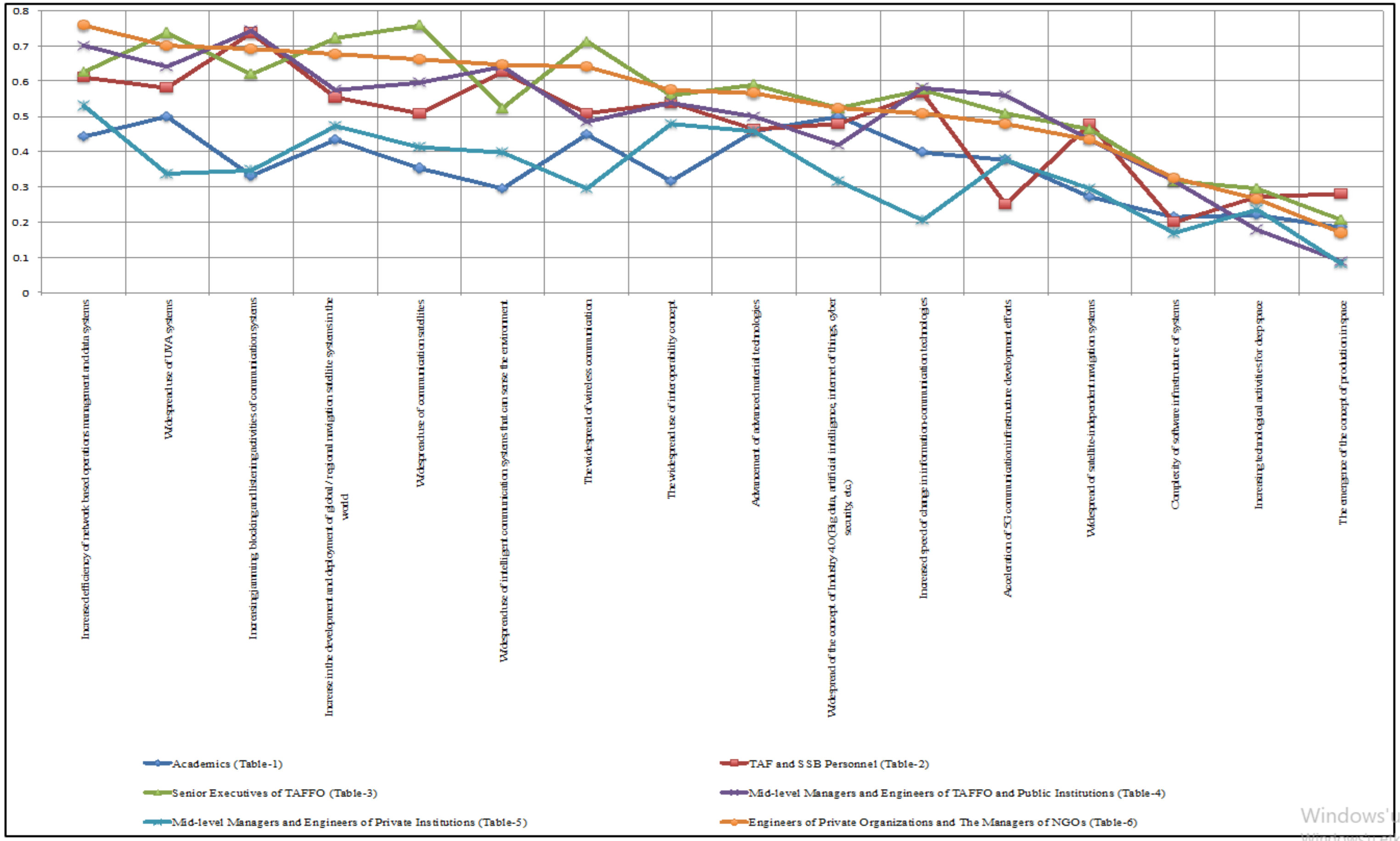


Figure 26 Prioritized Averages for Voted Technological Factors According to Tables (Groups)

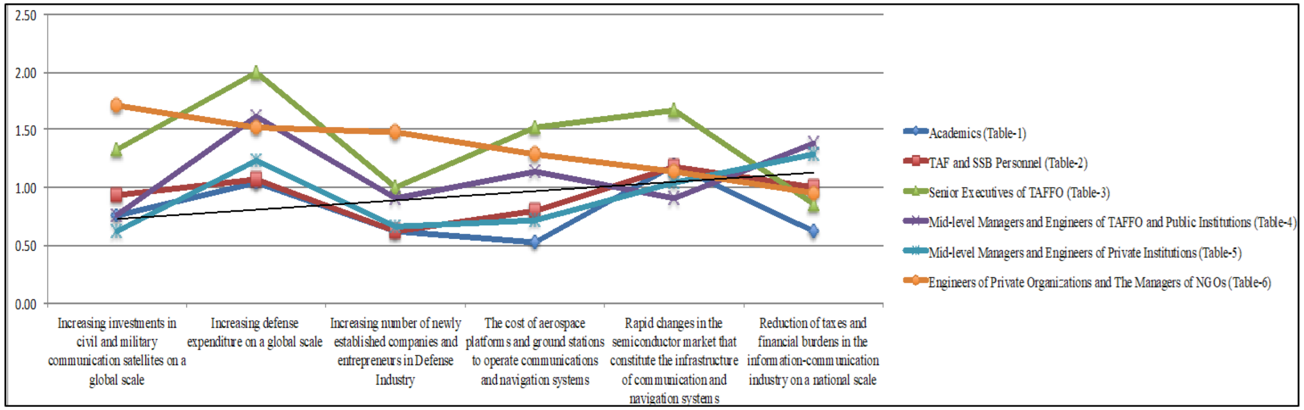


Figure 27 Prioritized Averages for Voted Economical Factors According to Tables (Groups)

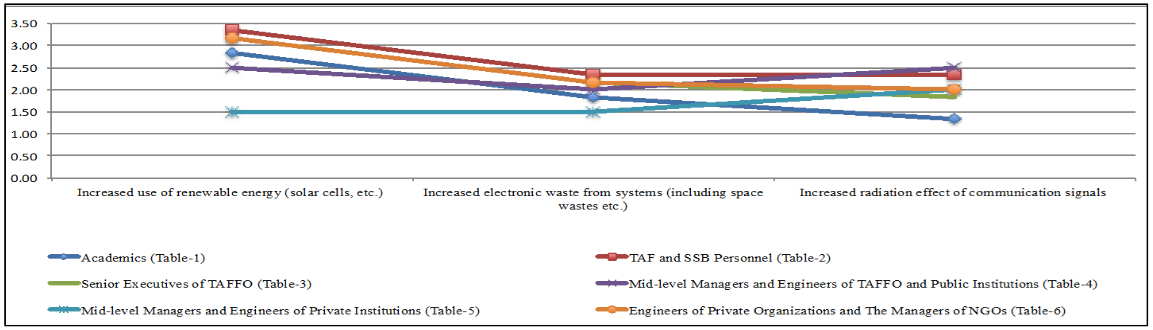


Figure 28 Prioritized Averages for Voted Environmental Factors According to Tables (Groups)

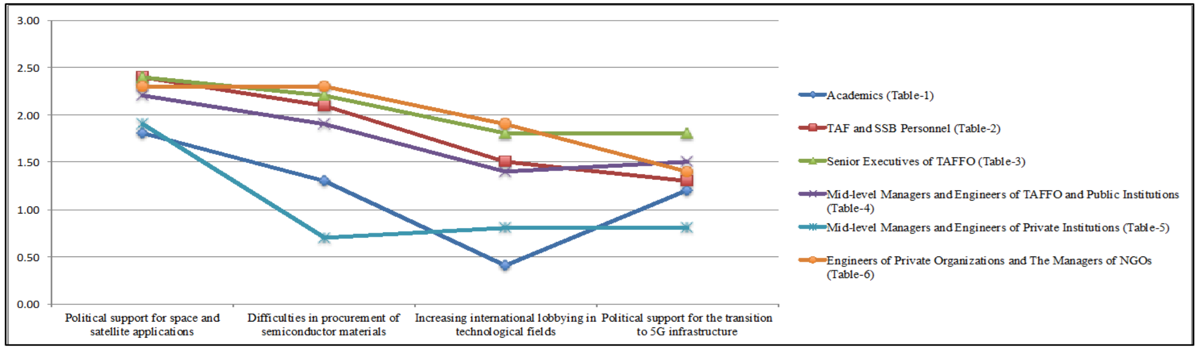


Figure 29 Prioritized Averages for Voted Political Factors According to Tables (Groups)

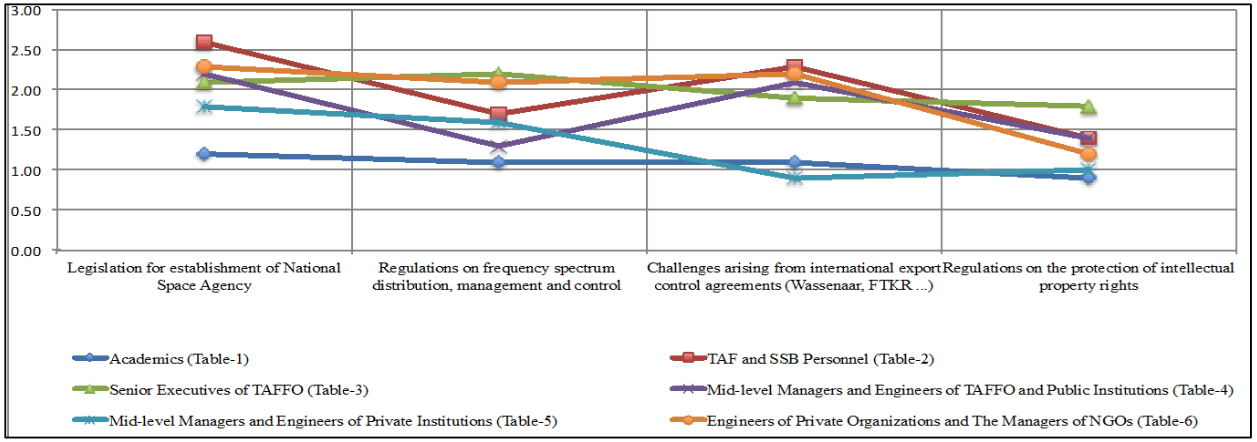


Figure 30 Prioritized Averages for Voted Legal Factors According to Tables (Groups)

APPENDIX F CHARTS OF SOAR ANALYSIS

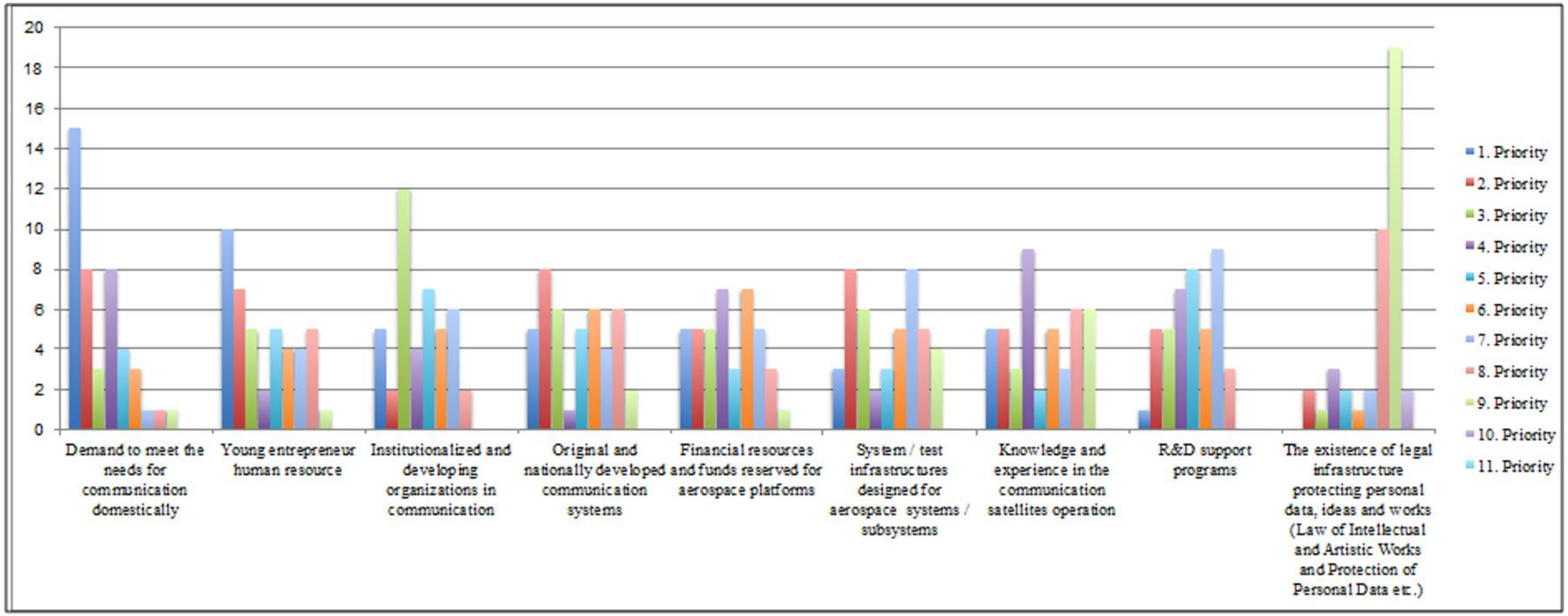


Figure 1 Priority Histogram for Voted Strengths

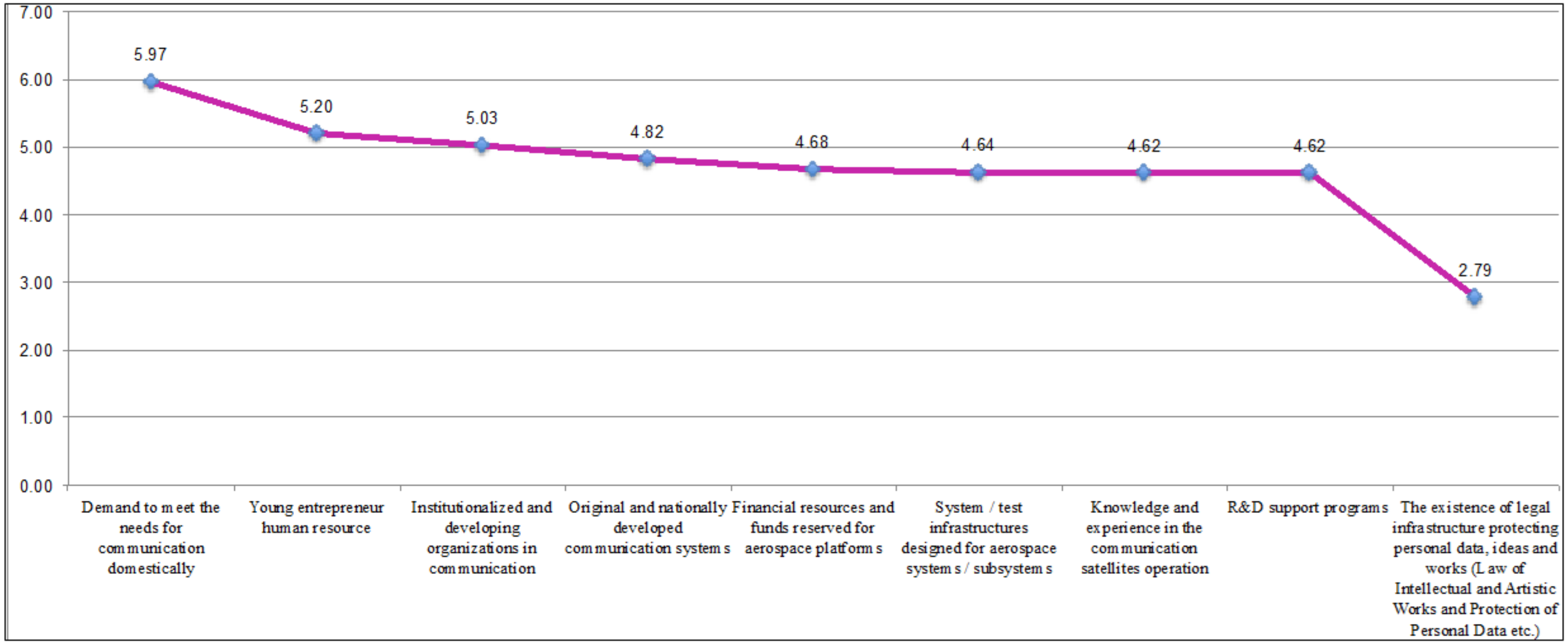


Figure 2 Prioritized Averages for Voted Strengths

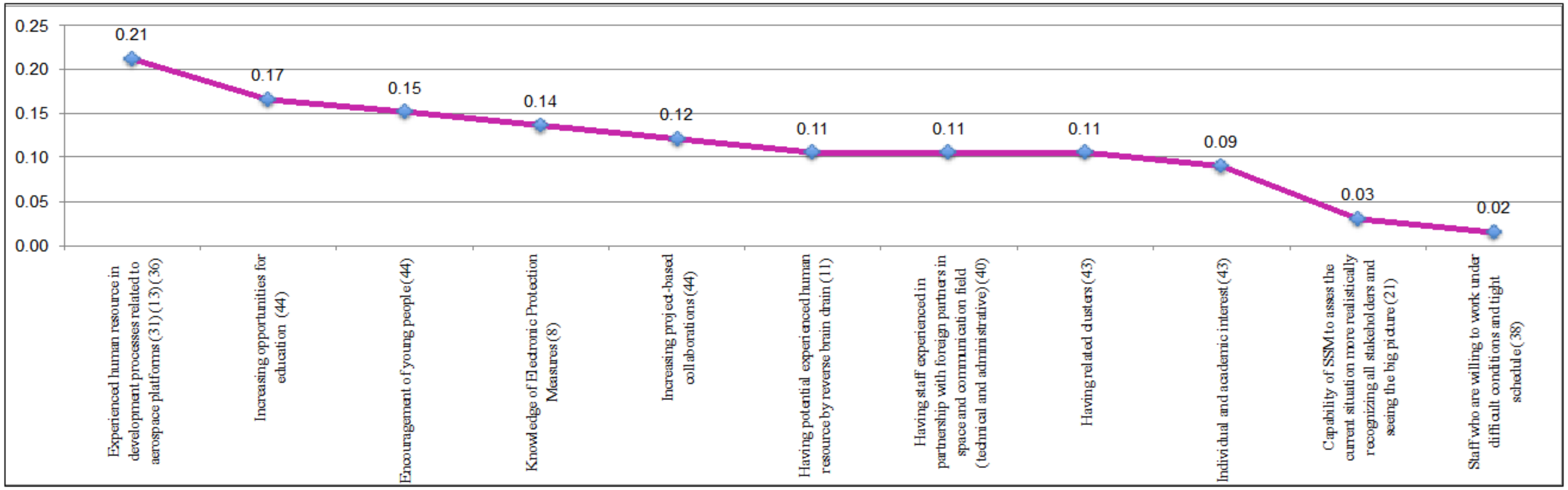


Figure 3 Prioritized Averages for Added Strengths

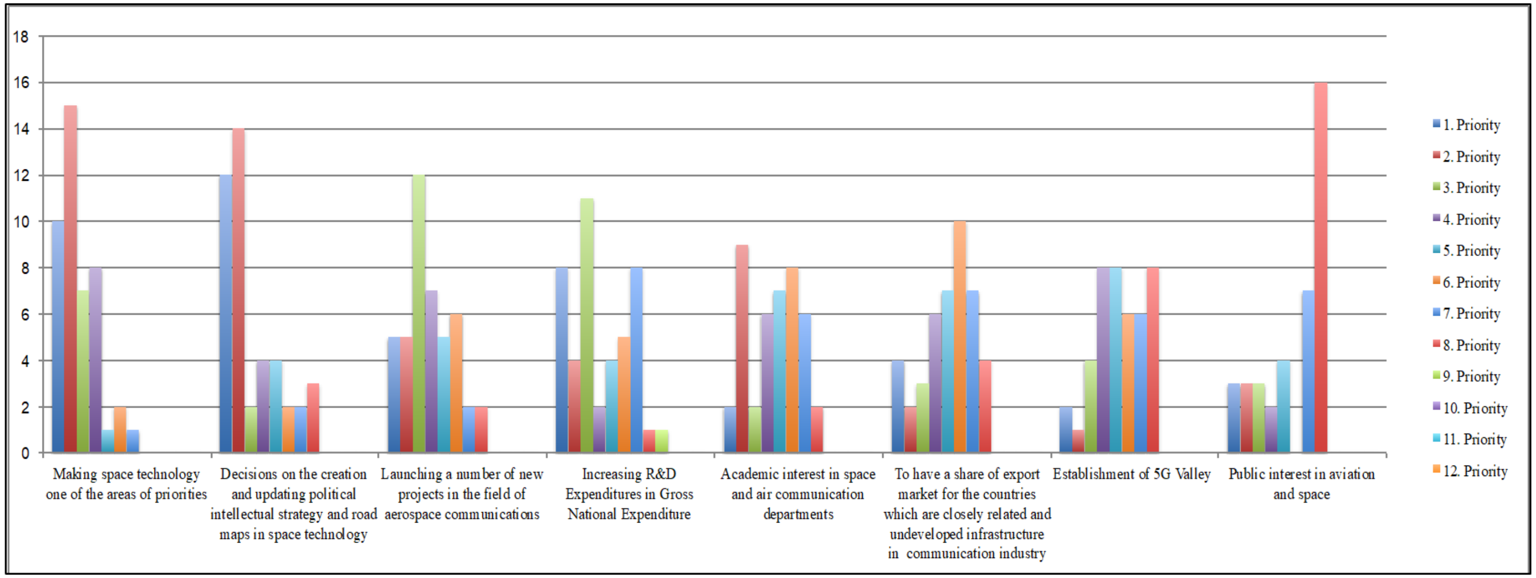


Figure 4 Priority Histogram for Voted Opportunities

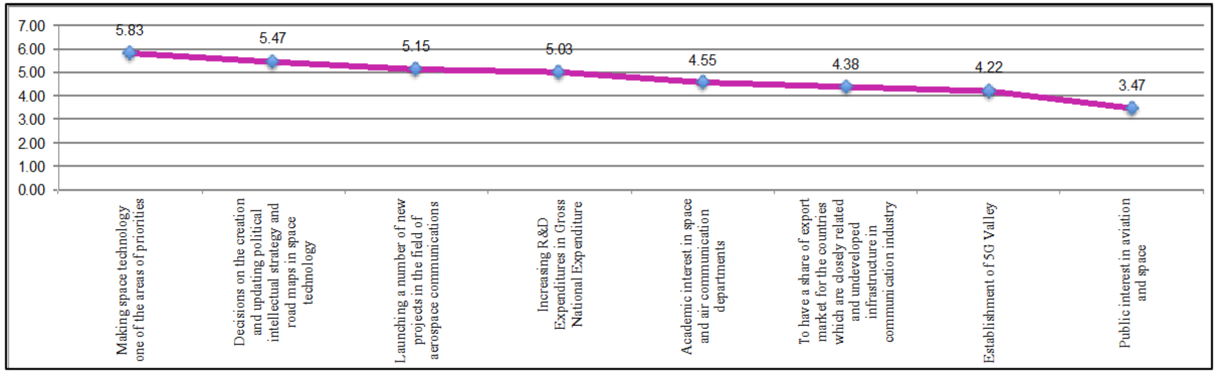


Figure 5 Prioritized Averages for Voted Opportunities

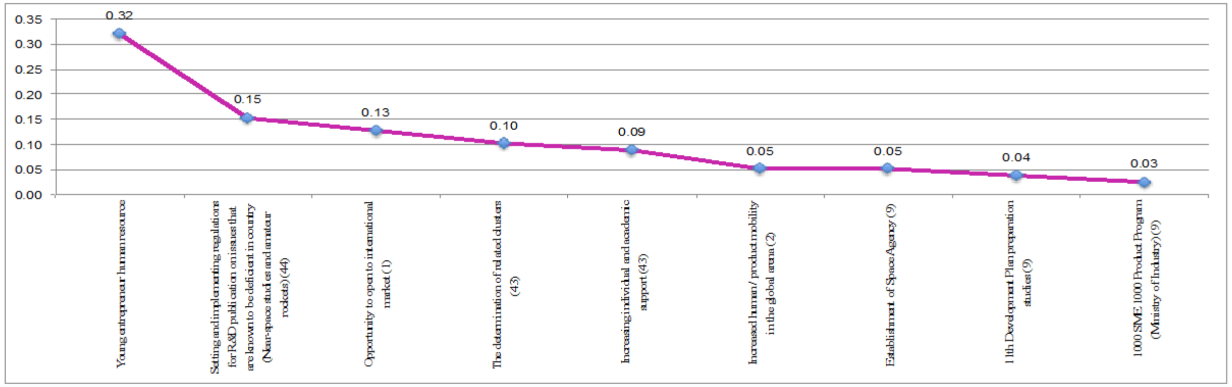


Figure 6 Prioritized Averages for Added Opportunities

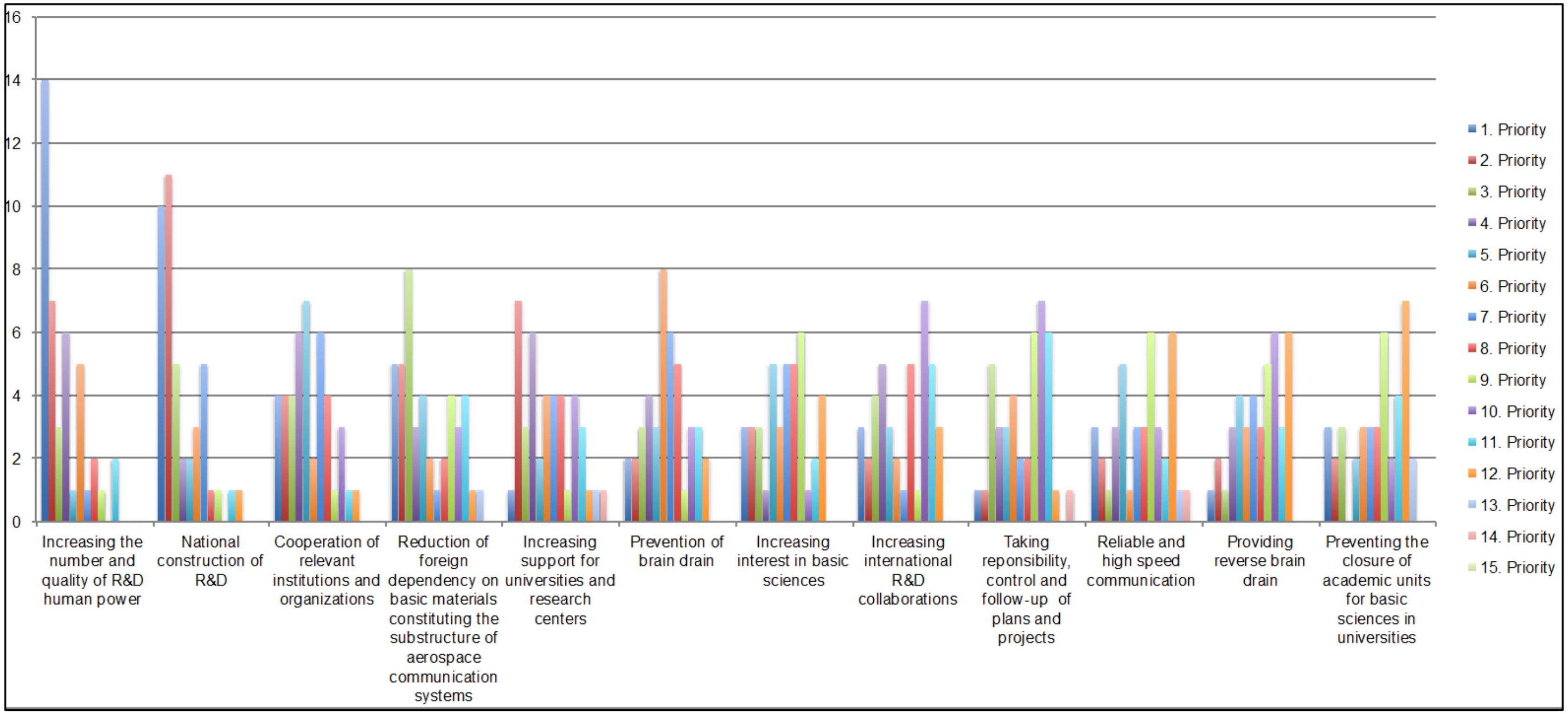


Figure 7 Priority Histogram for Voted Aspirations

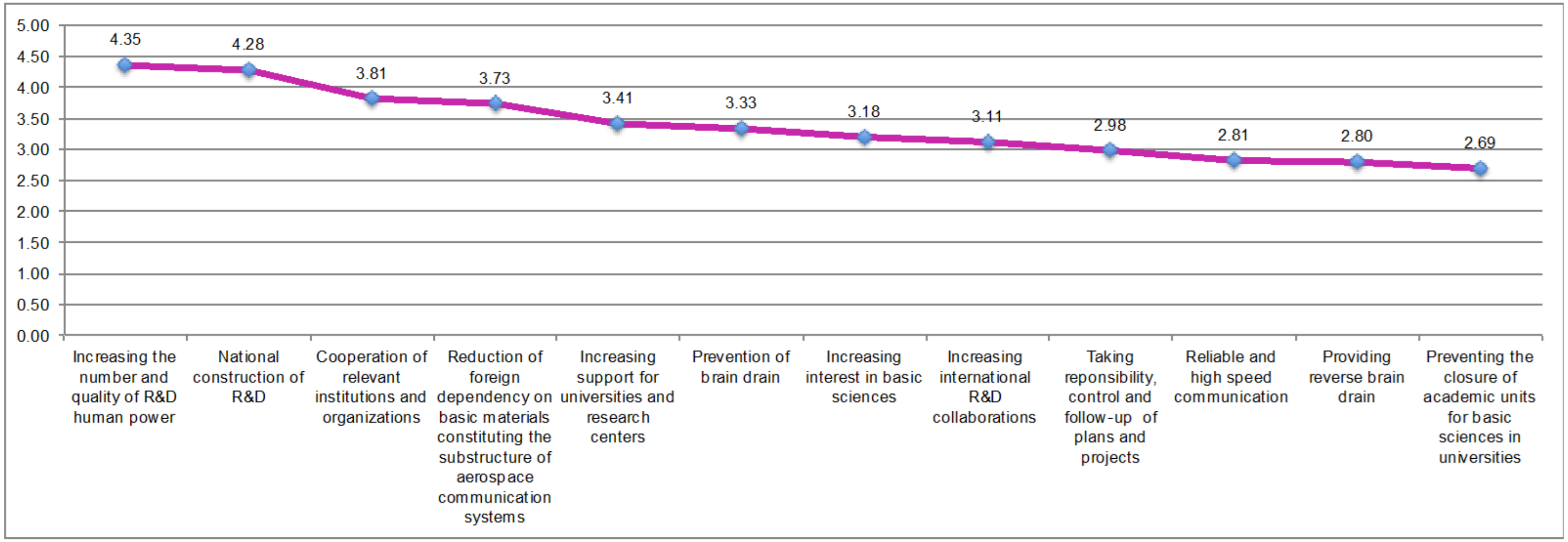


Figure 8 Prioritized Averages for Voted Aspirations

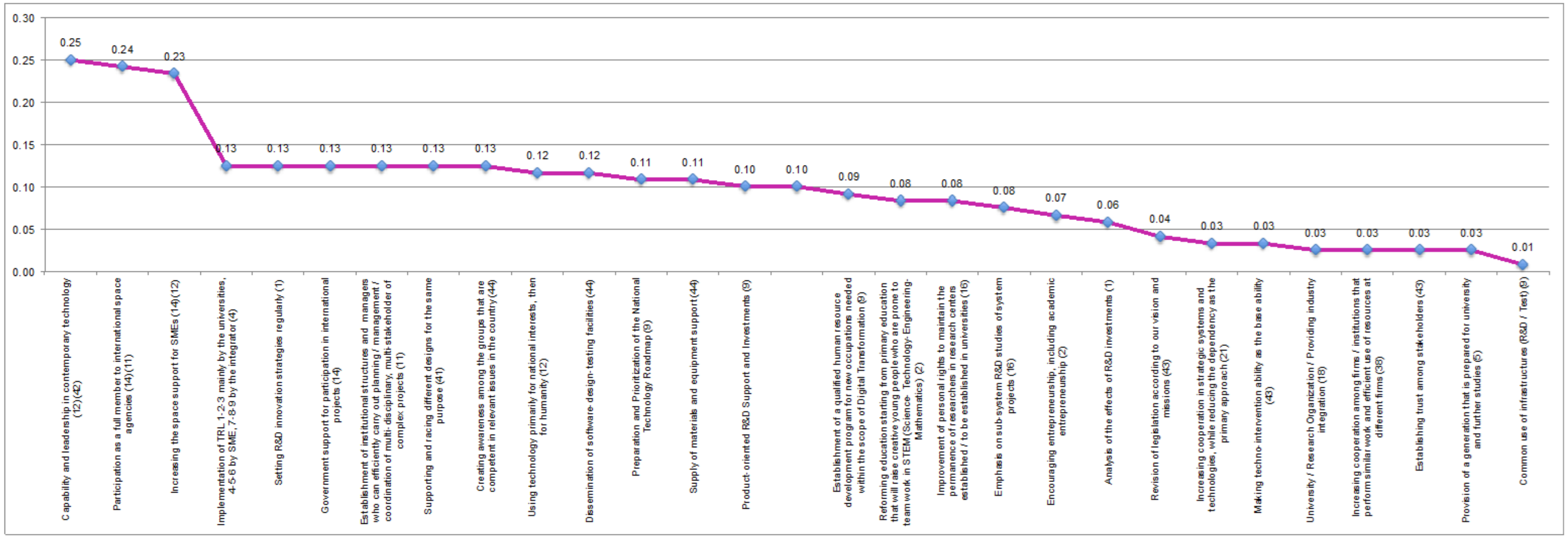


Figure 9 Prioritized Averages for Added Aspirations

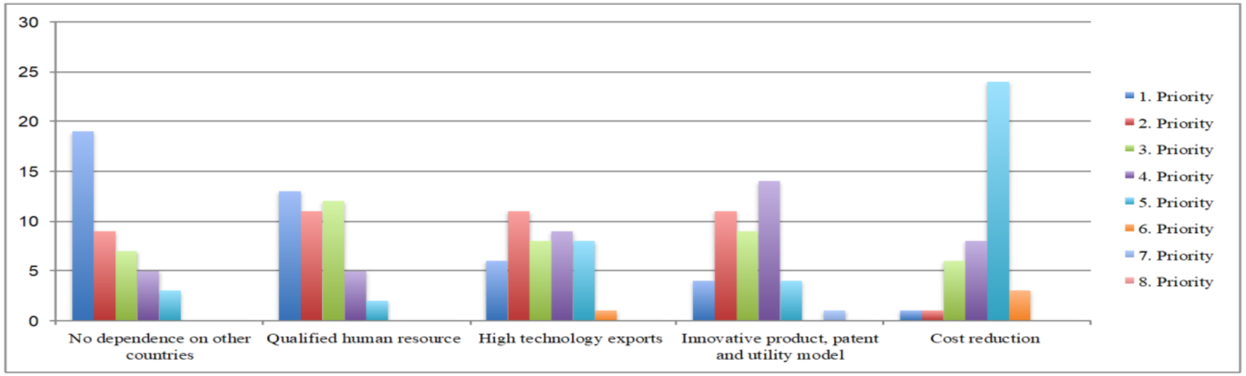


Figure 10 Priority Histogram for Voted Results

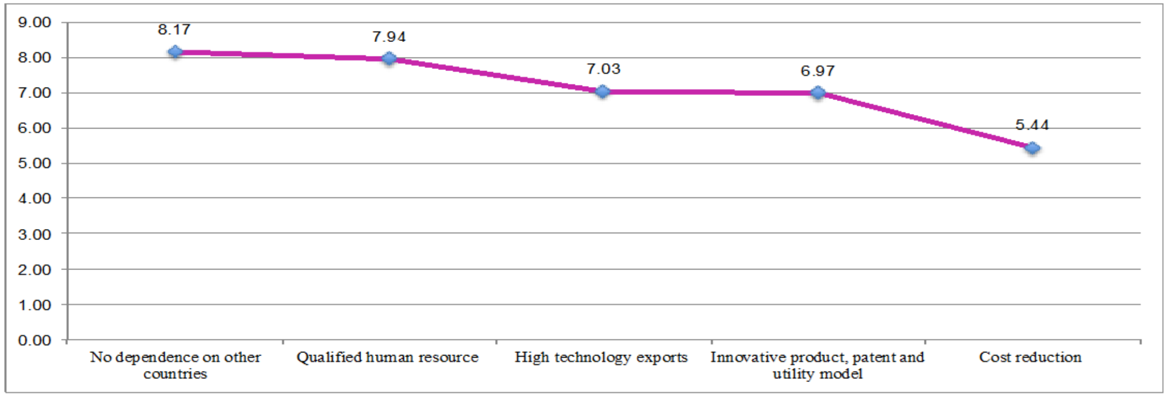


Figure 11 Prioritized Averages for Voted Results

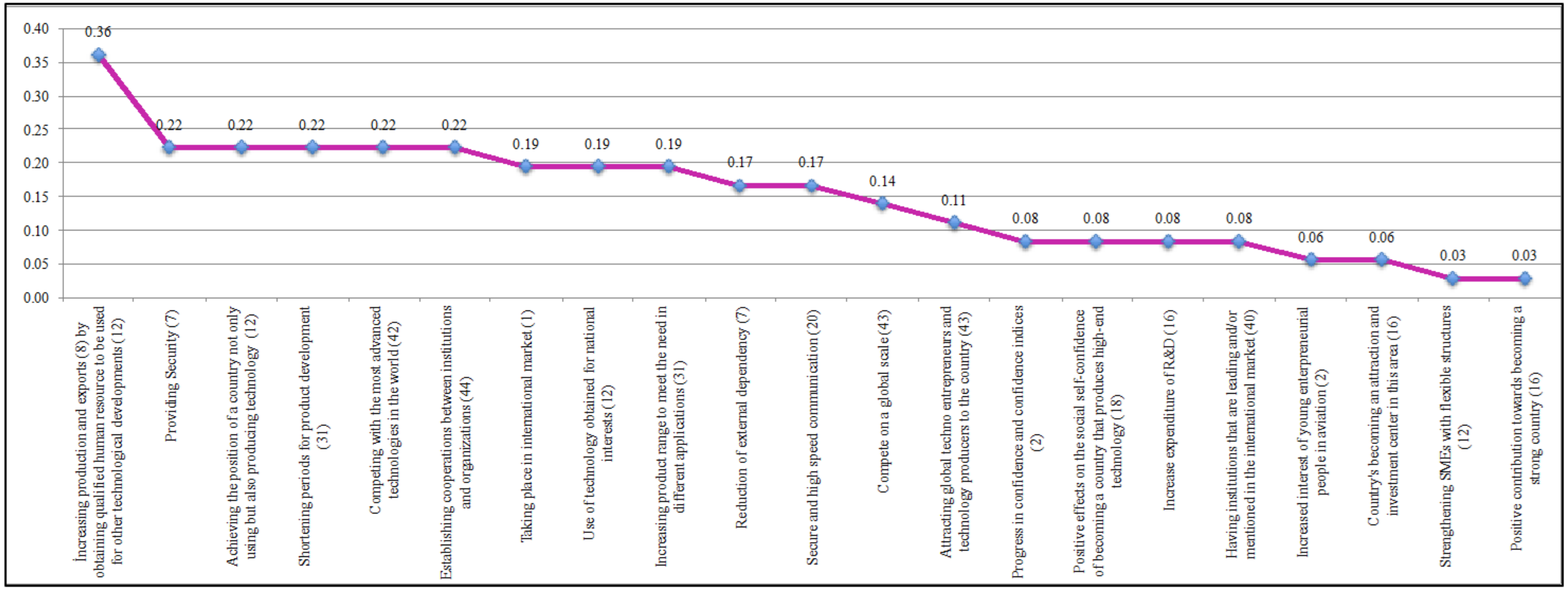


Figure 12 Prioritized Averages for Added Results

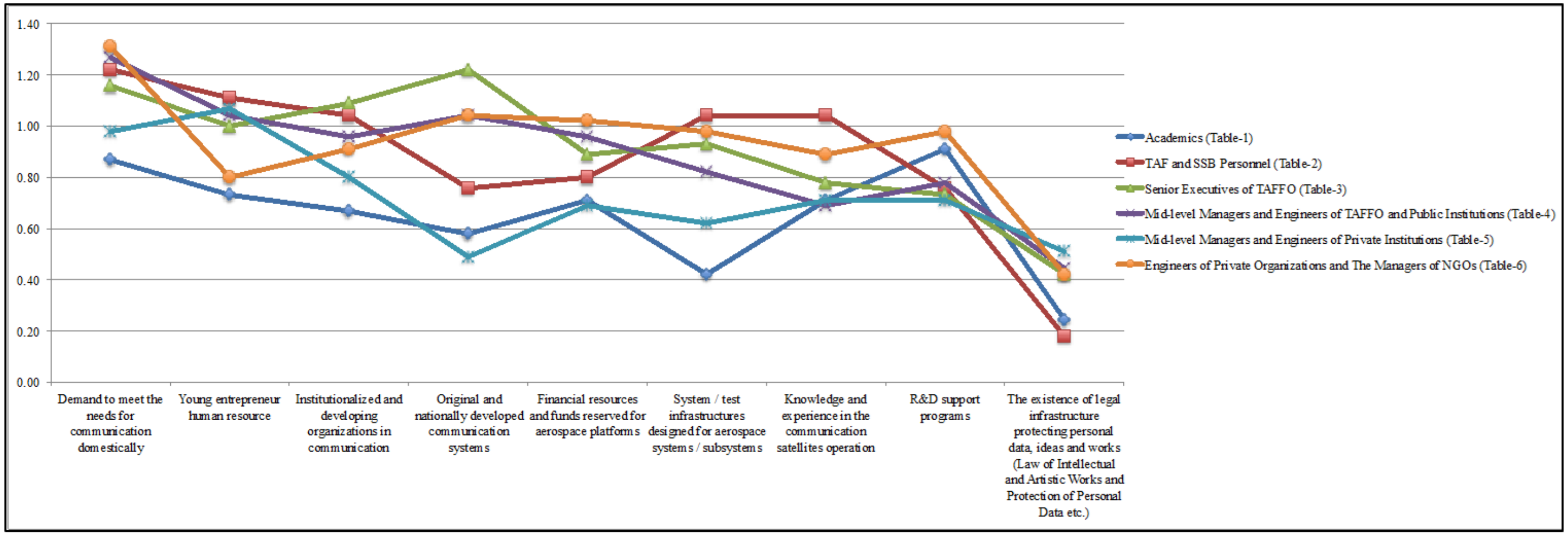


Figure 13 Prioritized Averages for Voted Strengths According to Tables (Groups)

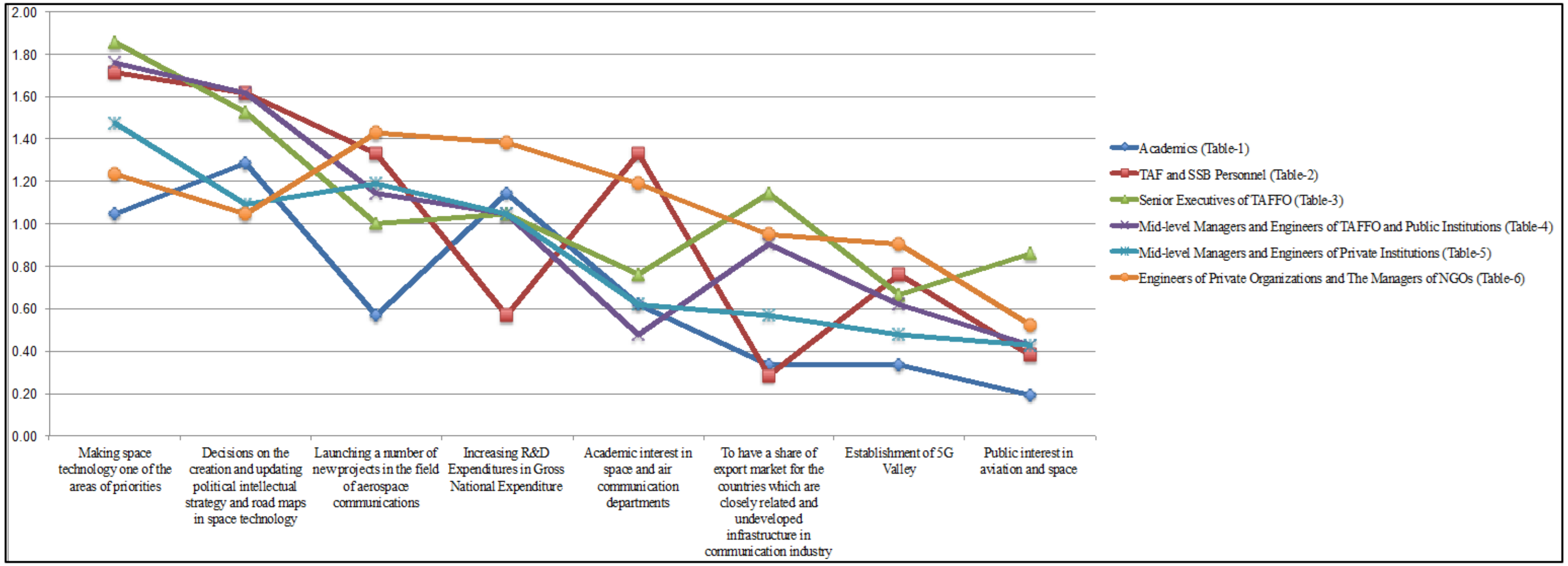


Figure 14 Prioritized Averages for Voted Opportunities According to Tables (Groups)

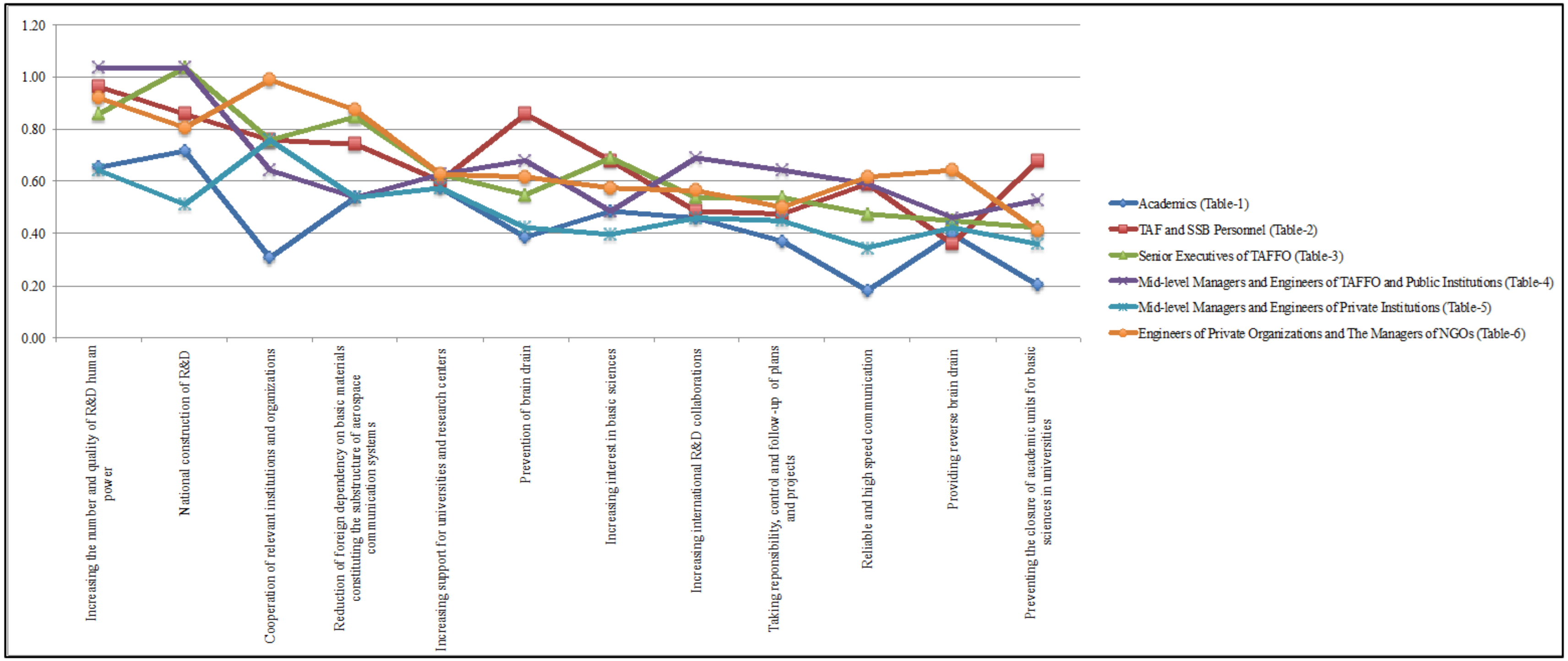


Figure 15 Prioritized Averages for Voted Aspirations According to Tables (Groups)

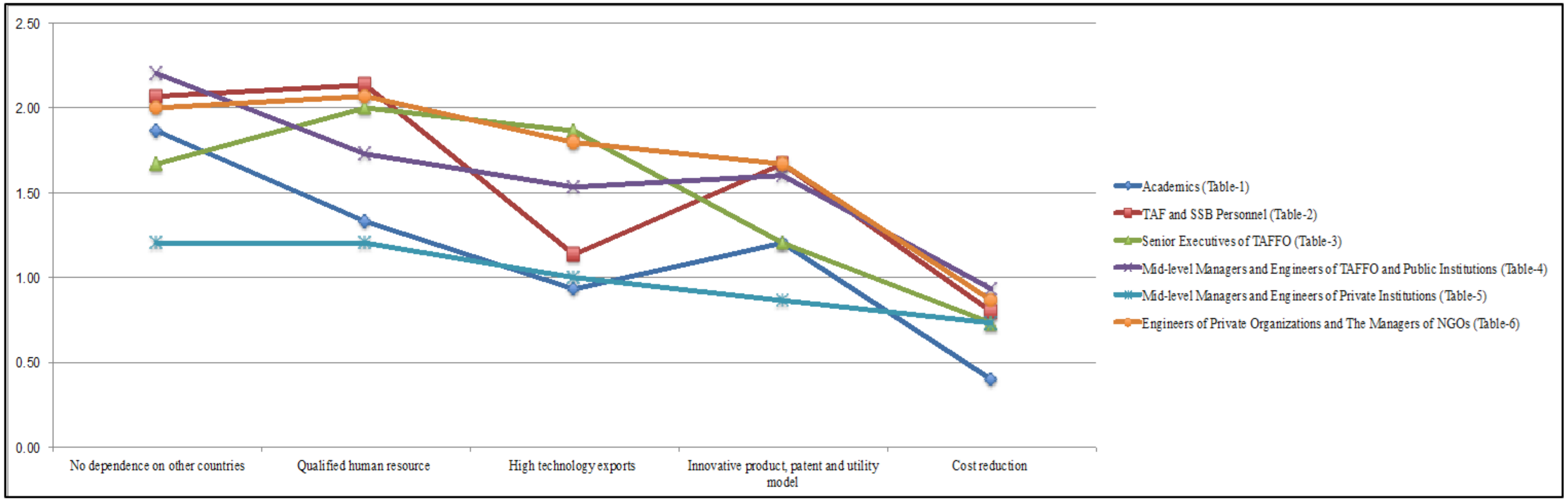


Figure 16 Prioritized Averages for Voted Results According to Tables (Groups)

APPENDIX G CHARTS OF TRENDS ANALYSIS

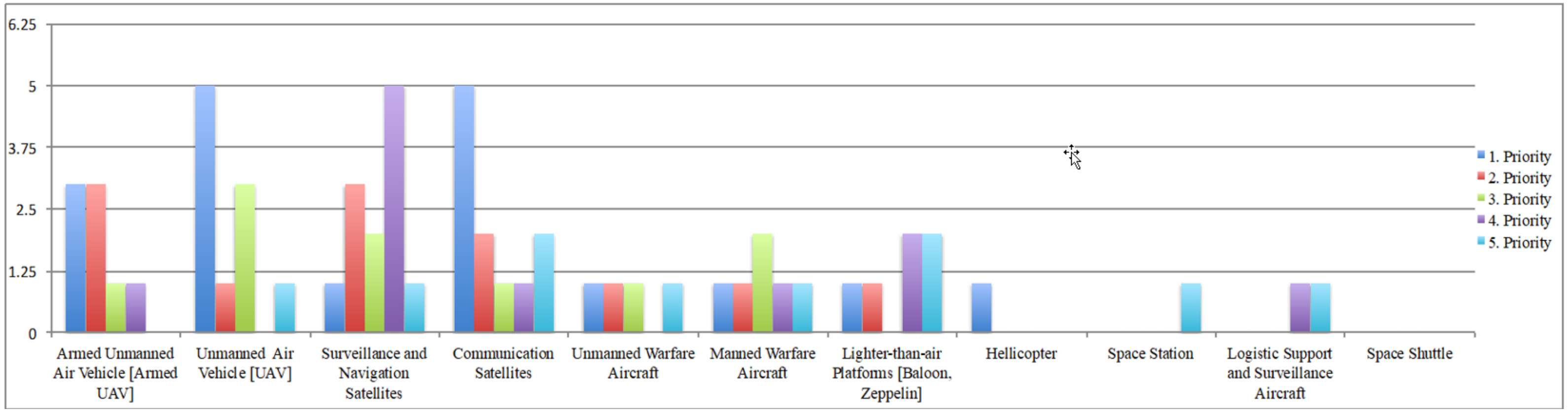


Figure 1 Priority Histogram for Aerospace Platforms (KU)

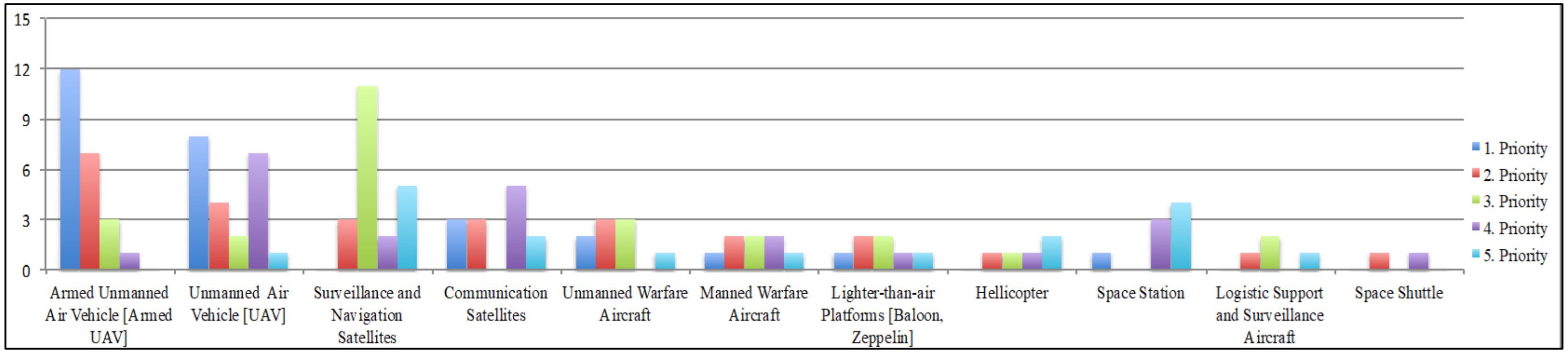


Figure 2 Priority Histogram for Aerospace Platforms (BV)

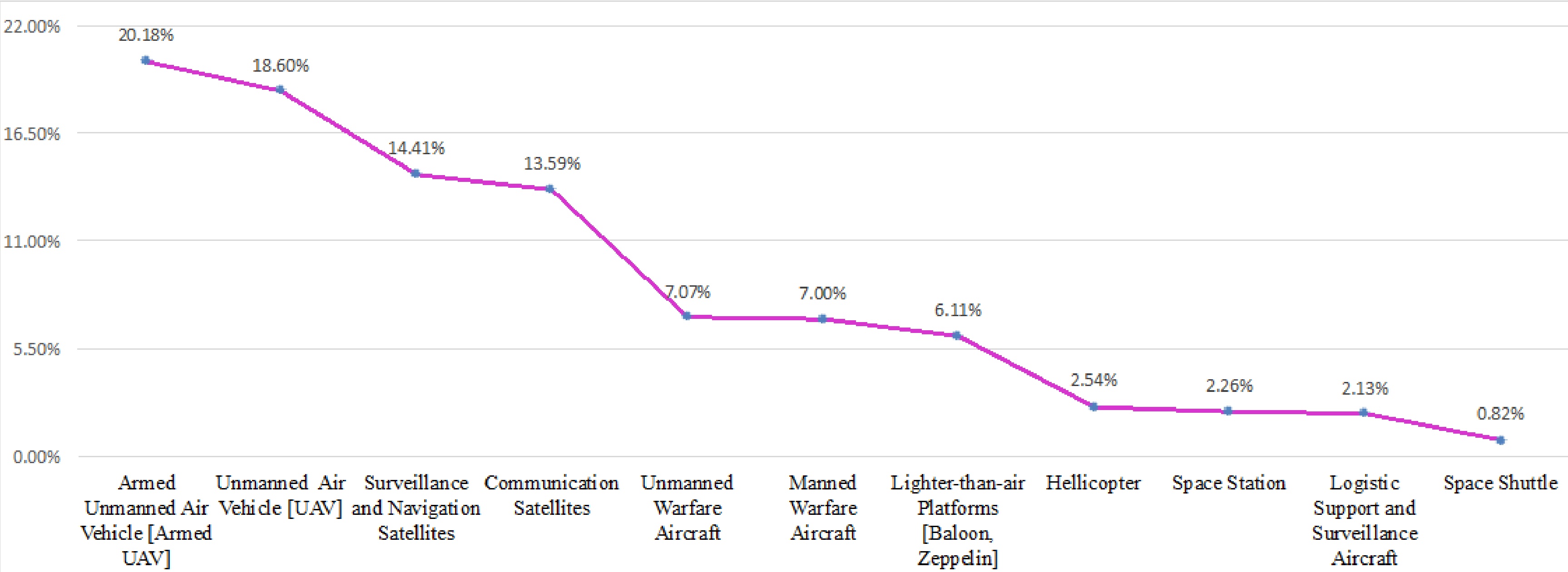


Figure 3 Prioritized Averages for Defined Aerospace Platforms
(Average of KU and BV)

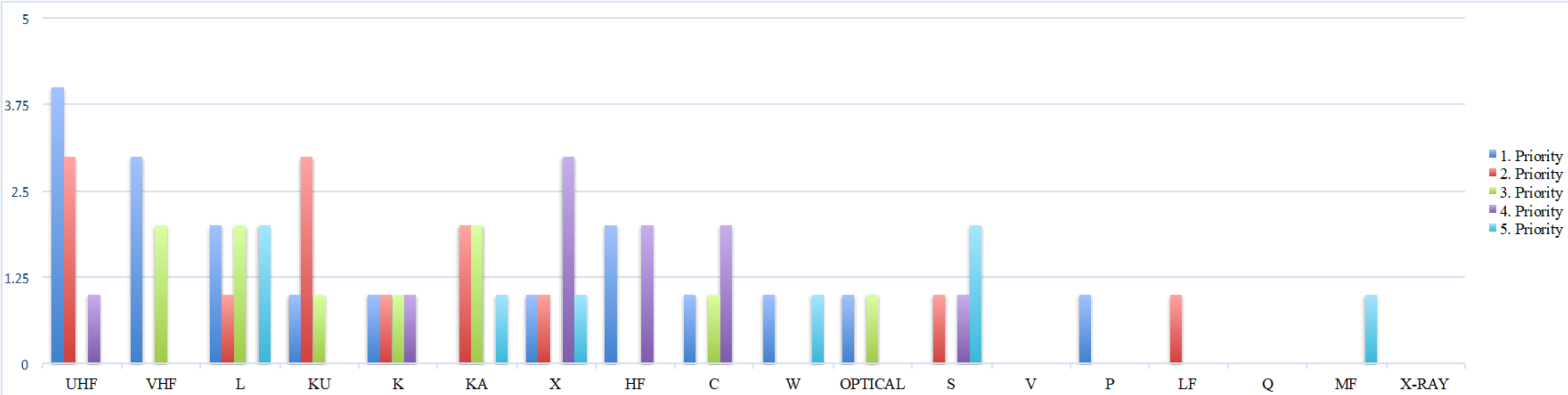


Figure 4 Priority Histogram for Air Communication Bands (KU)

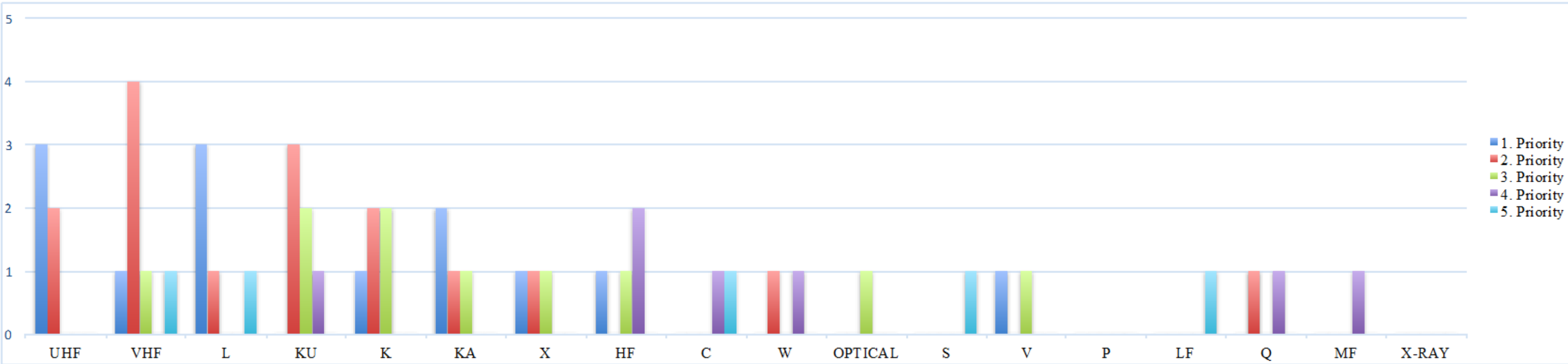


Figure 5 Priority Histogram for Air Communication Bands (BV)

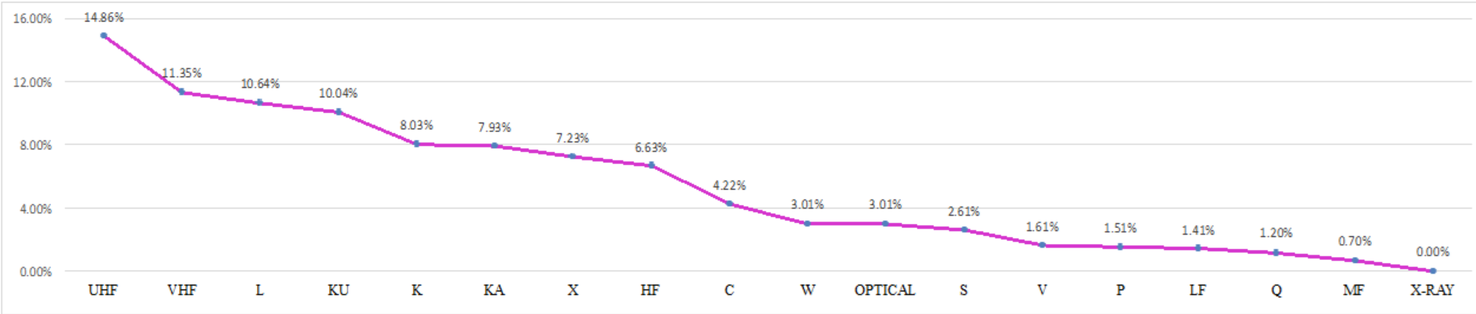


Figure 6 Prioritized Averages for Defined Air Communication Bands
(Average of KU and BV)

Figure 7 Prioritized Averages for Added Air Communication Bands
(Average of KU and BV)

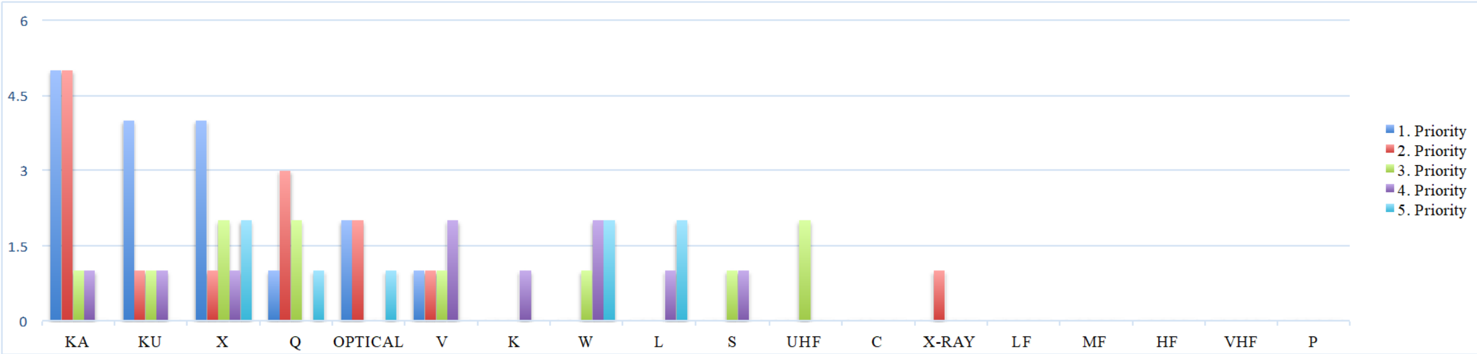


Figure 8 Priority Histogram for Space Communication Bands (KU)

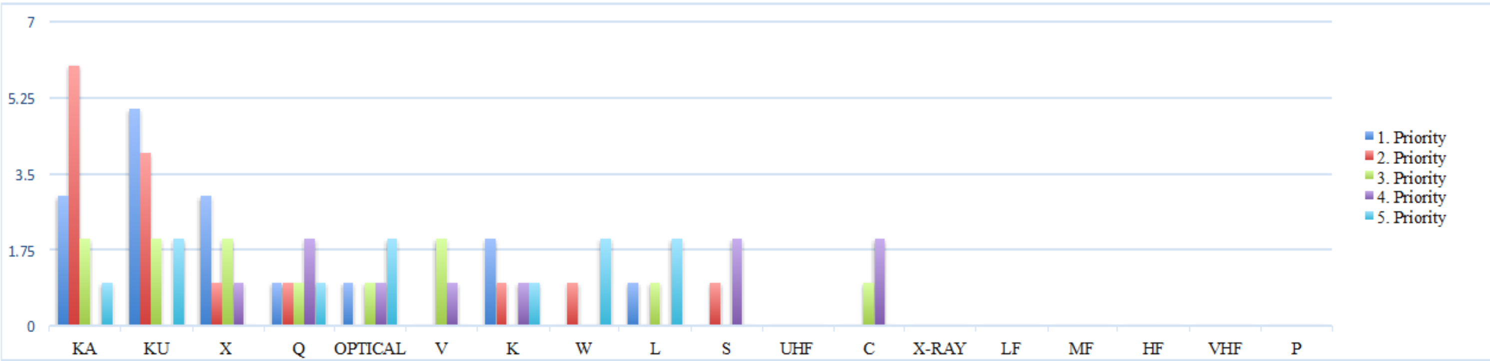


Figure 9 Priority Histogram for Space Communication Bands (BV)

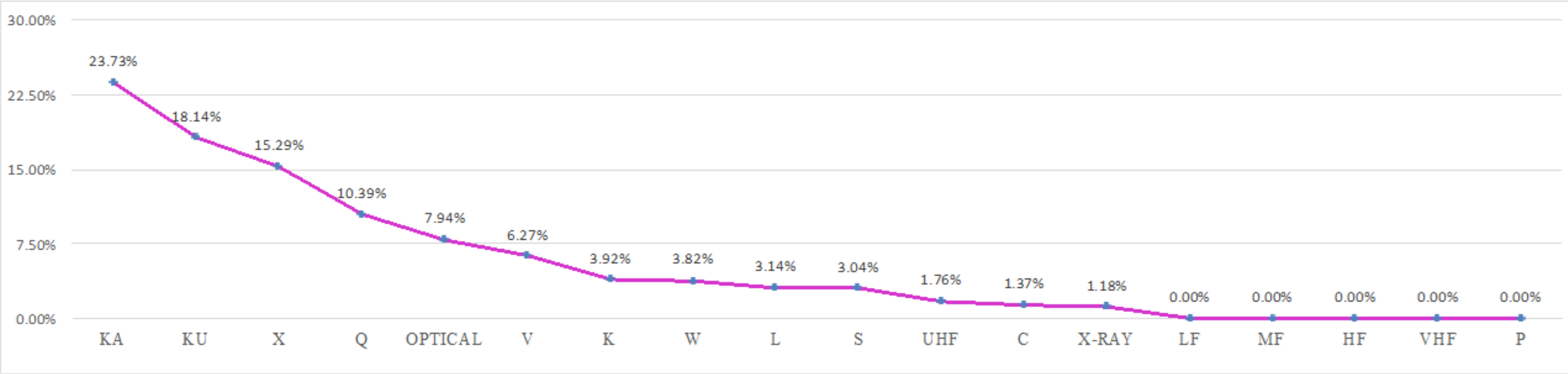


Figure 10 Prioritized Averages for Defined Space Communication Bands
(Average of KU and BV)

Note: There was no added Space Communication Band, so there is no graph.

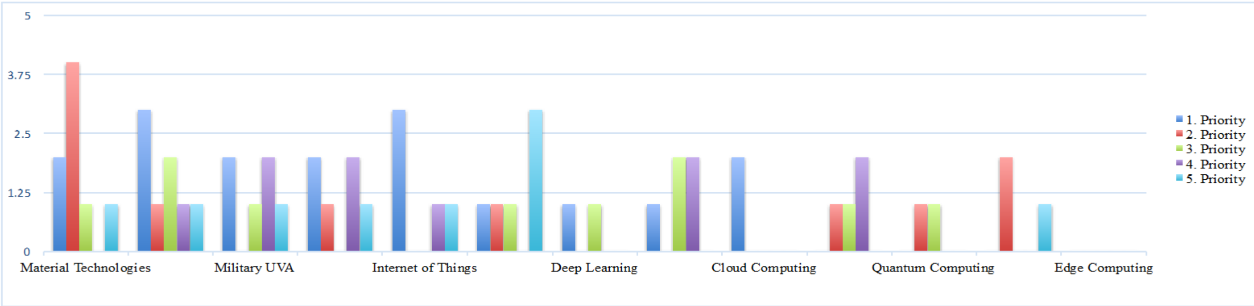


Figure 11 Priority Histogram for Defined Technologies Affecting Aerospace Communication (KU)

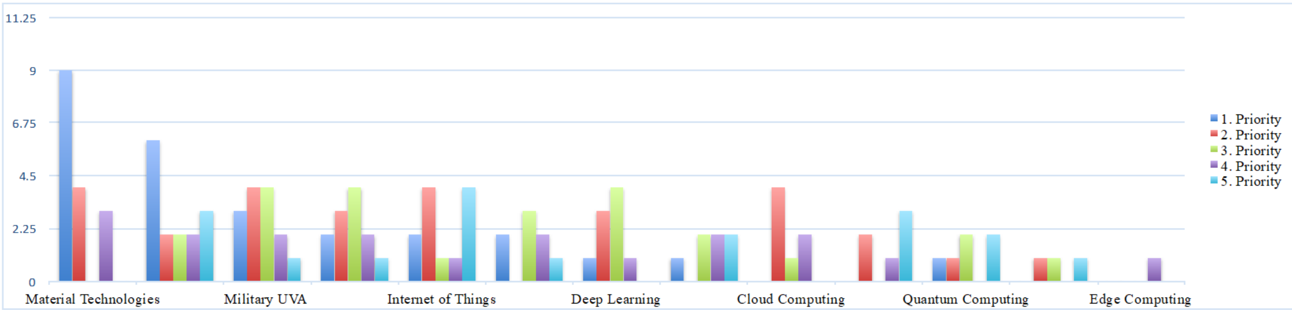


Figure 12 Priority Histogram for Defined Technologies Affecting Aerospace Communication (BV)

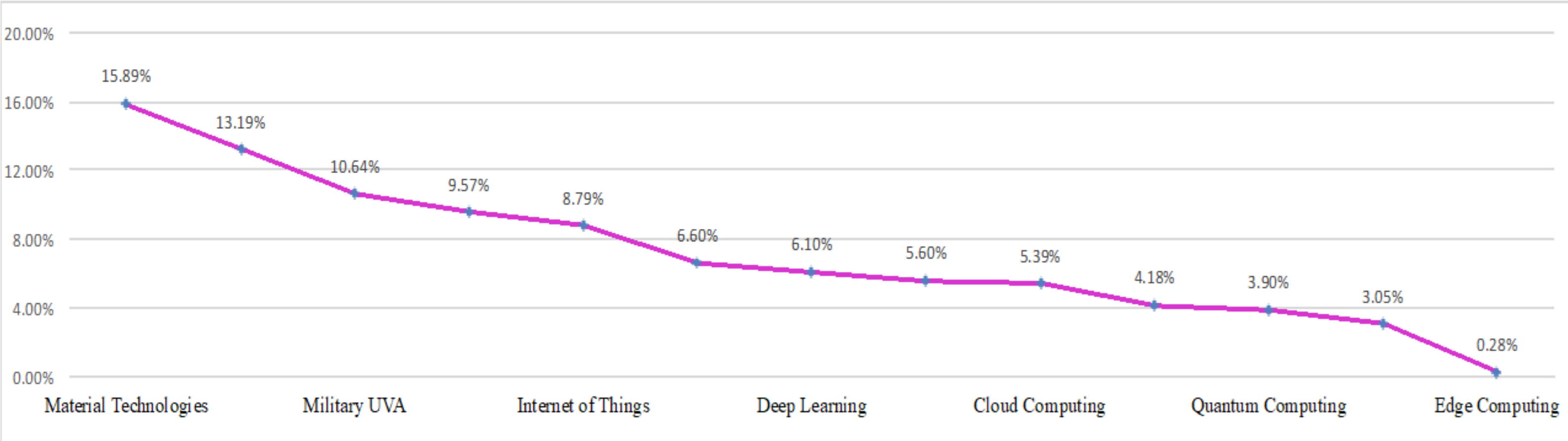


Figure 13 Prioritized Averages for Defined Technologies Affecting Aerospace Communication (Averages of KU and BV)

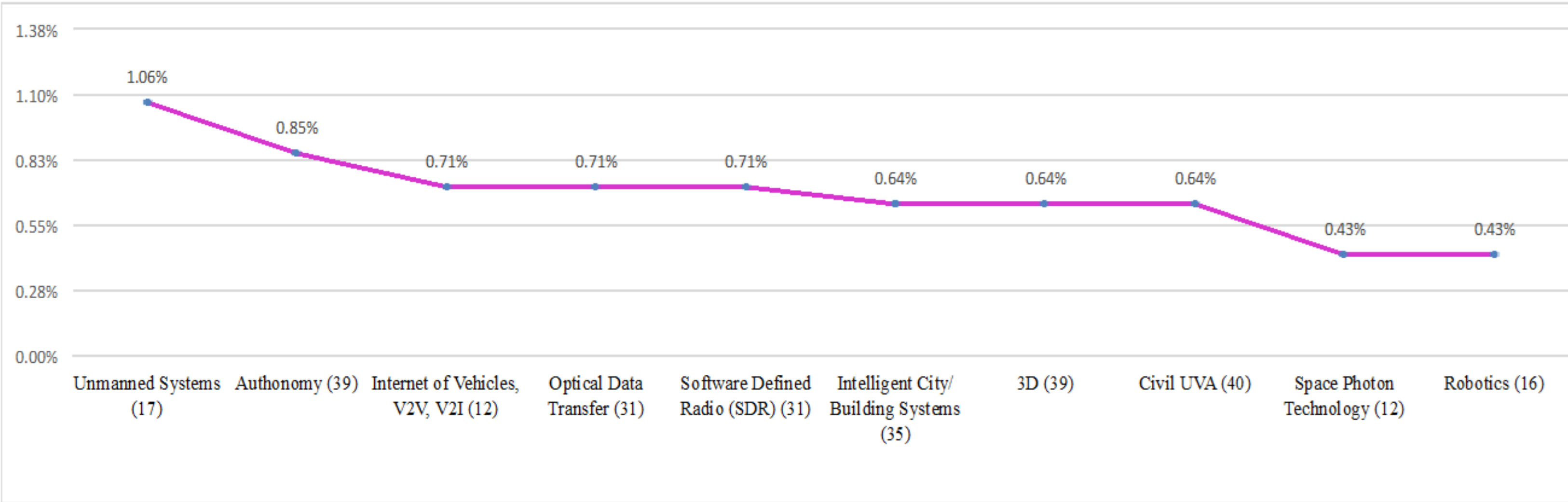


Figure 14 Prioritized Averages for Added Technologies Affecting Aerospace Communication (Average of KU and BV)

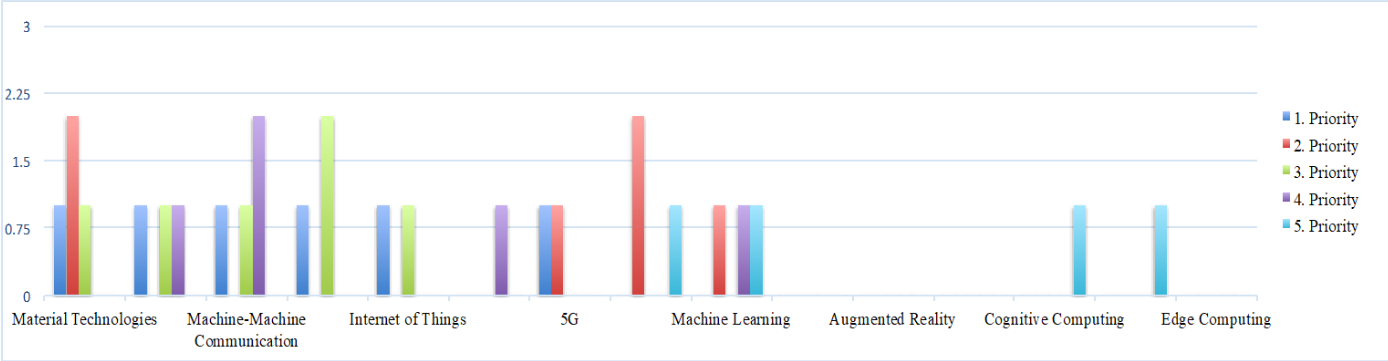


Figure 15 Priority Histogram for Defined Technologies Affecting Aerospace Navigation (KU)

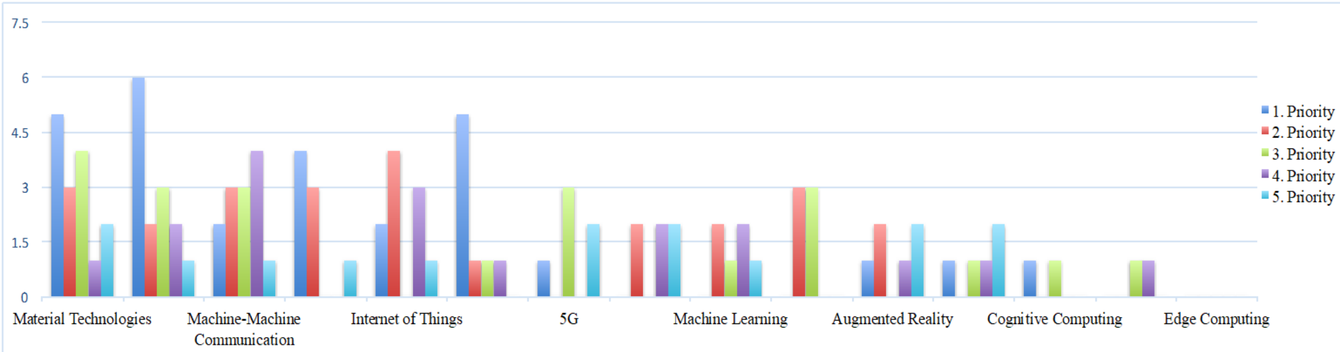


Figure 16 Priority Histogram for Defined Technologies Affecting Aerospace Navigation (BV)

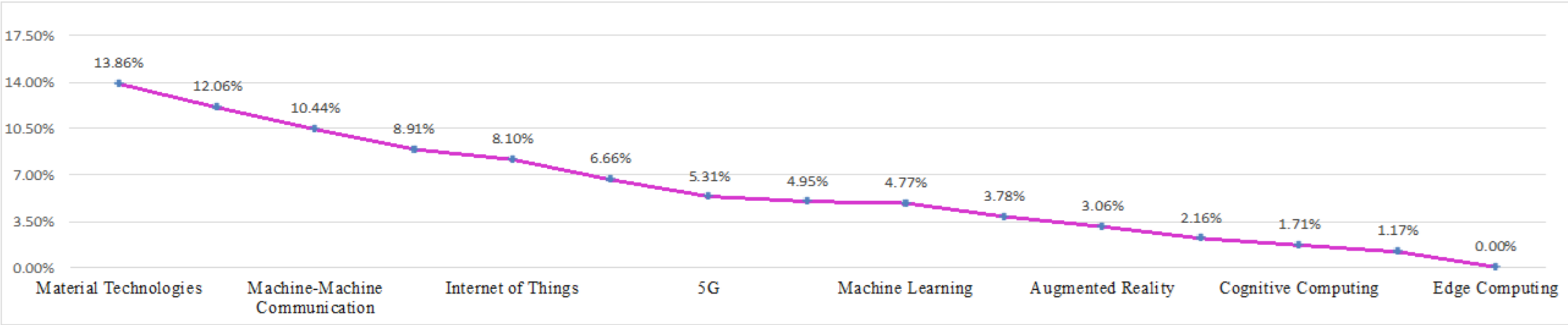


Figure 17 Prioritized Averages for Defined Technologies Affecting Aerospace Navigation (Average of KU and BV)

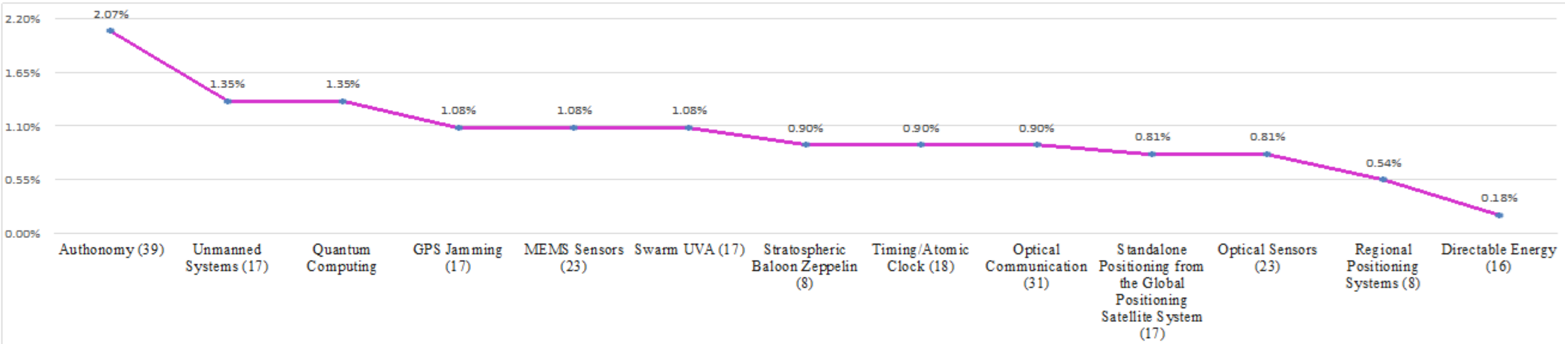


Figure 18 Prioritized Averages for Added Technologies Affecting Aerospace Navigation (Average of KU and BV)

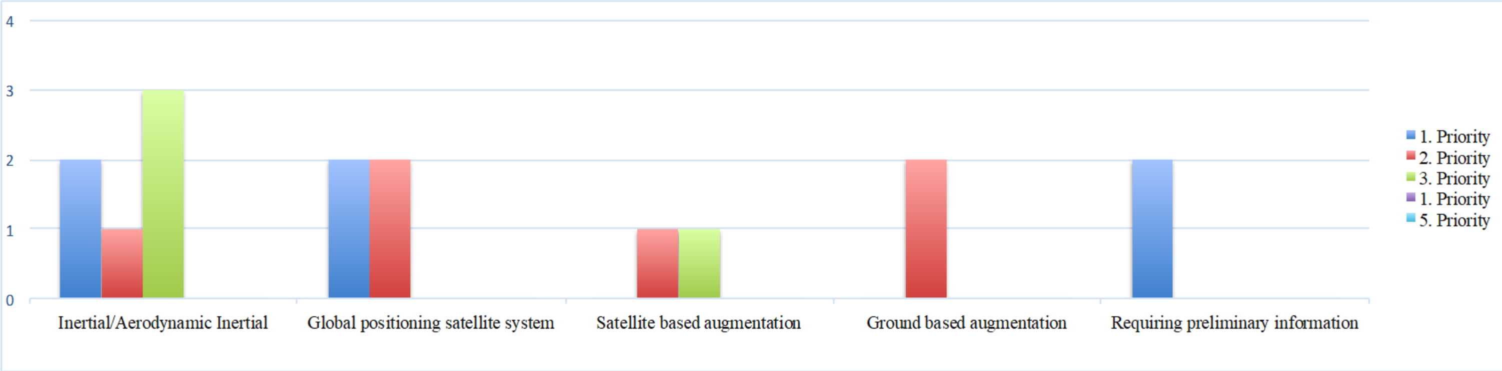


Figure 19 Priority Histogram for Defined Navigation Systems (KU)

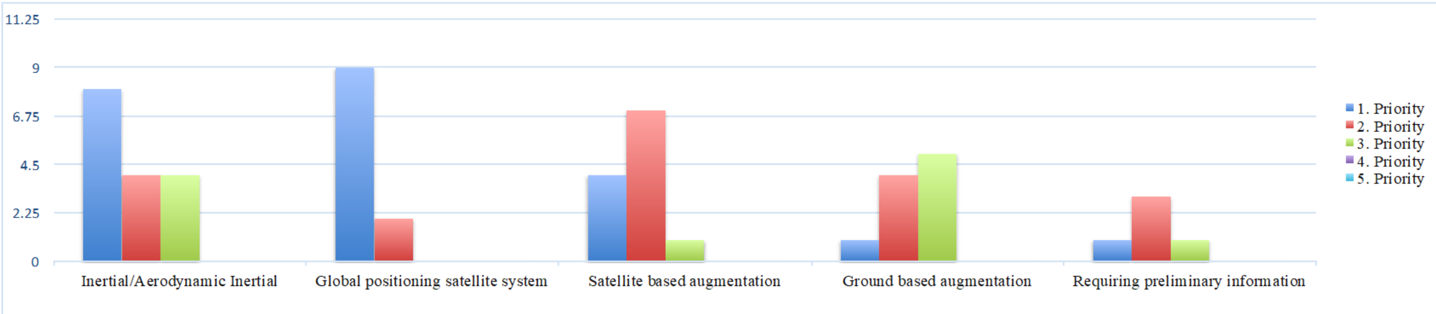


Figure 20 Priority Histogram for Defined Navigation Systems (BV)

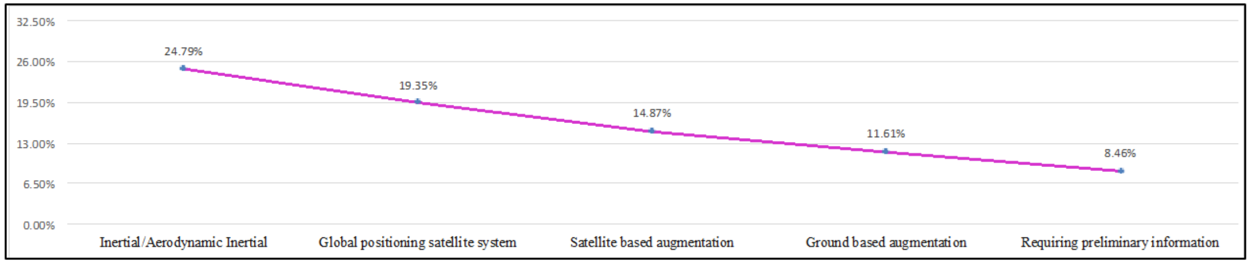


Figure 21 Prioritized Averages for Defined Navigation Systems
(Average of KU and BV)

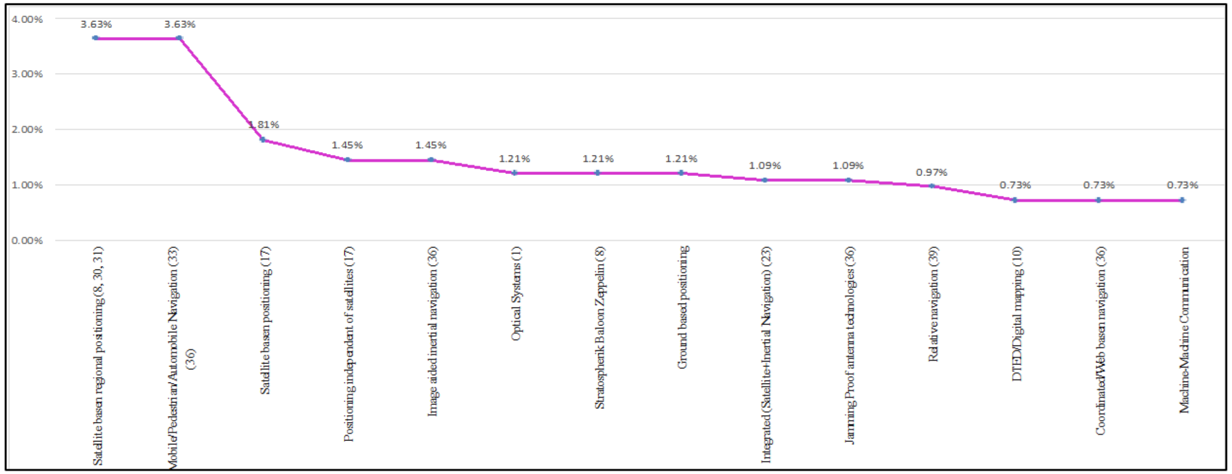


Figure 22 Prioritized Averages for Added Navigation Systems (Average of KU and BV)

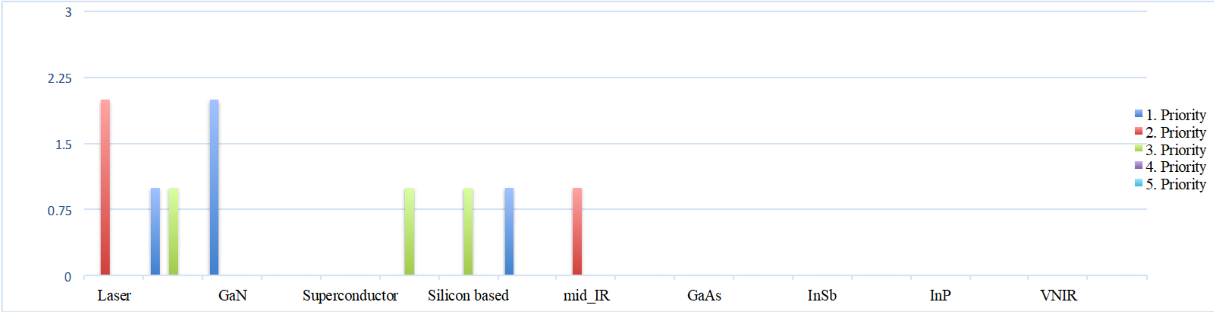


Figure 23 Priority Histogram for Defined Material Technologies (KU)

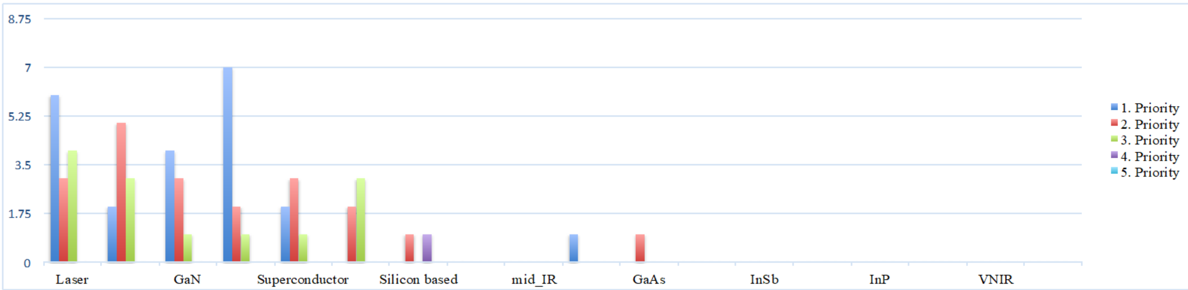


Figure 24 Priority Histogram for Defined Material Technologies (BV)

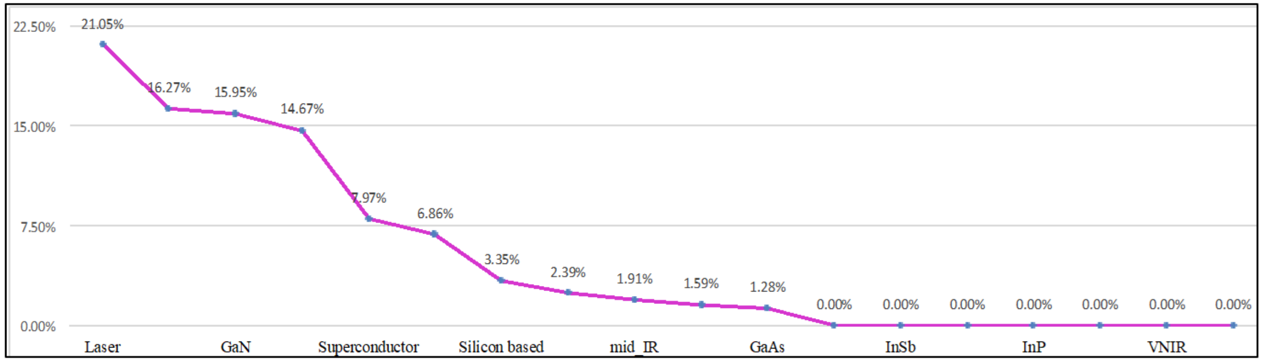


Figure 25 Prioritized Averages for Defined Material Technologies (Averages KU and BV)

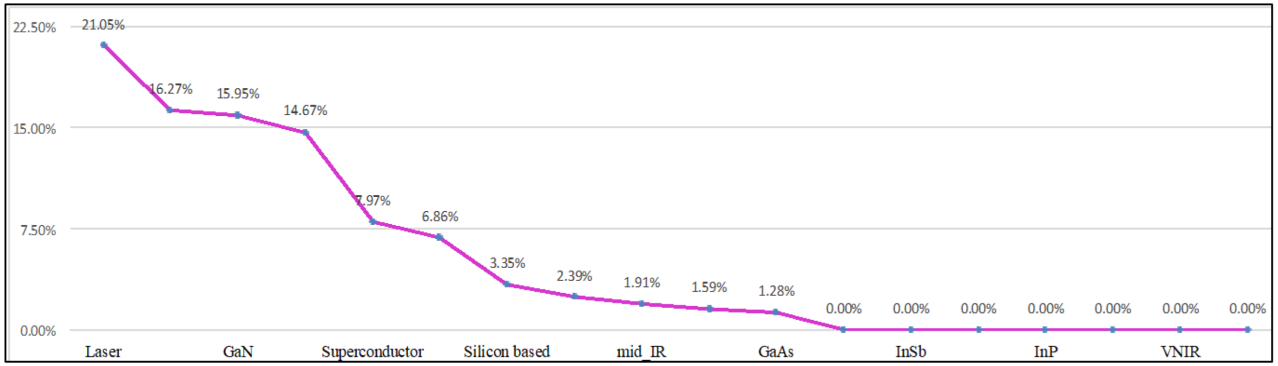


Figure 26 Prioritized Averages for Added Material Technologies (Average of KU and BV)

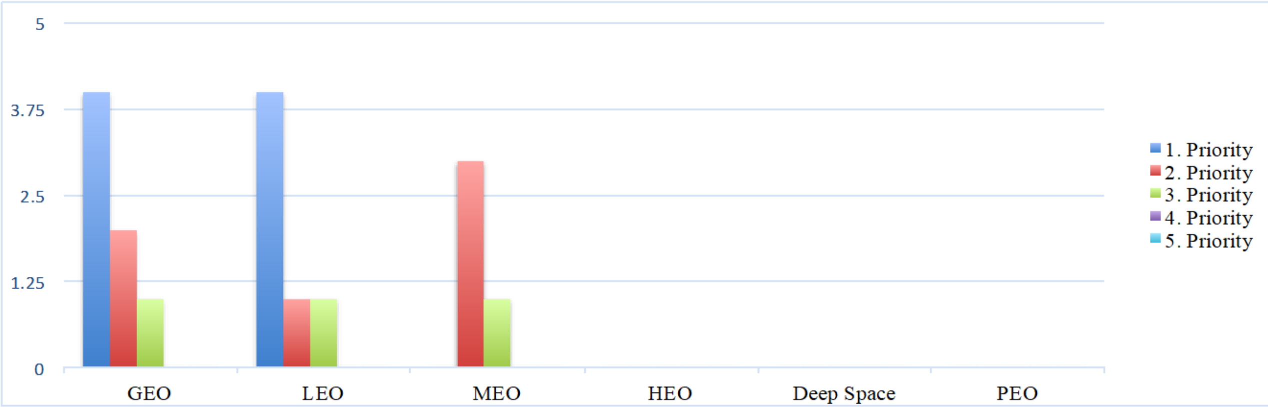


Figure 27 Priority Histogram for Defined Orbiting Satellites (KU)

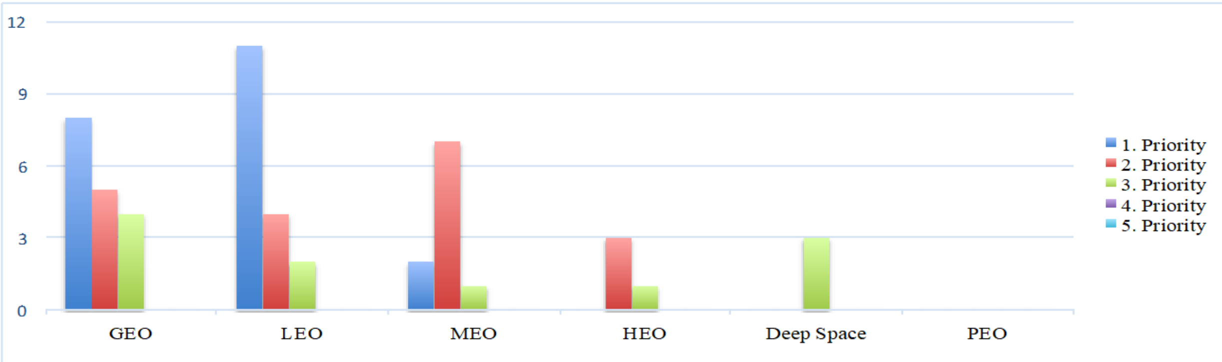


Figure 28 Priority Histogram for Defined Orbiting Satellites (BV)

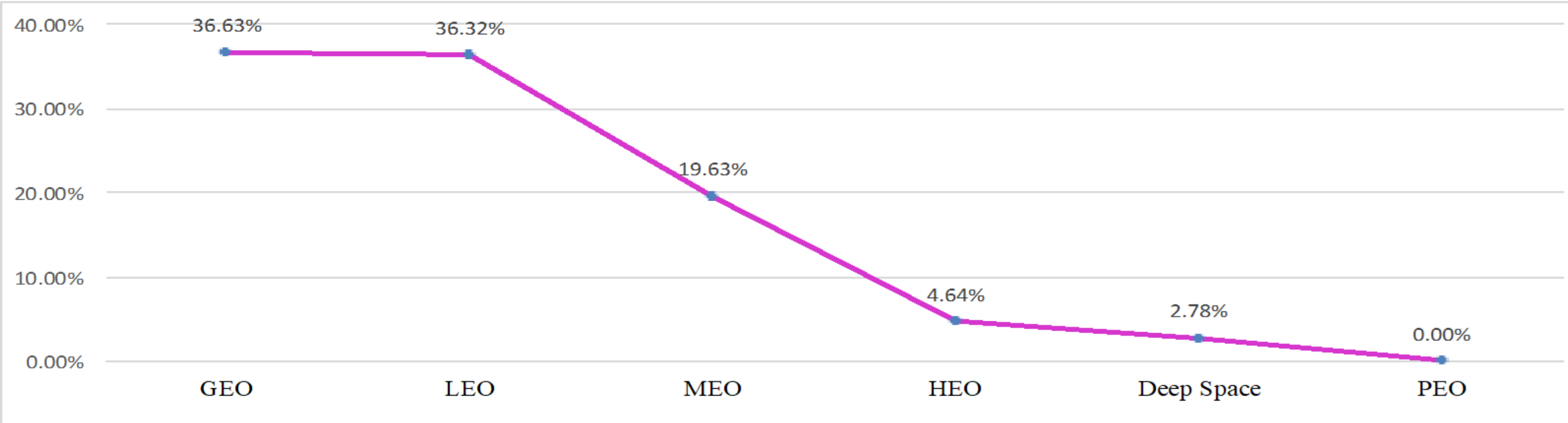


Figure 29 Prioritized Averages for Defined Orbiting Satellites
(Average of KU and BV)

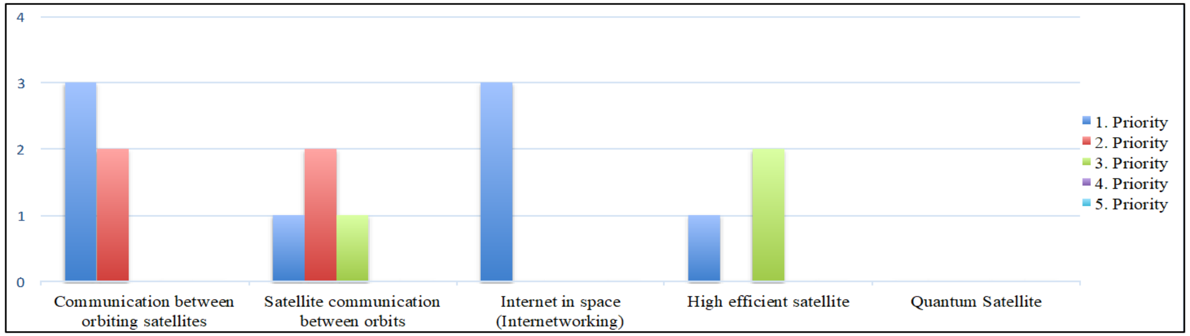


Figure 30 Priority Histogram for Defined Technologies Directly Affecting Satellite Communication (For KU)

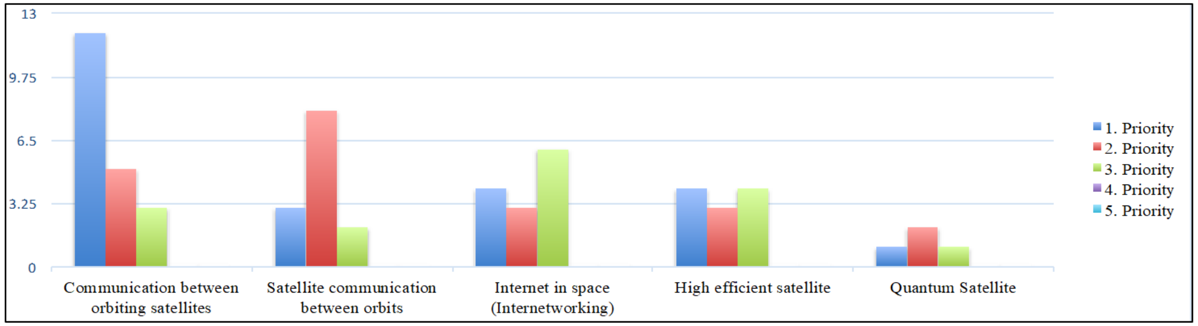


Figure 31 Priority Histogram for Defined Technologies Directly Affecting Satellite Communication (For BV)

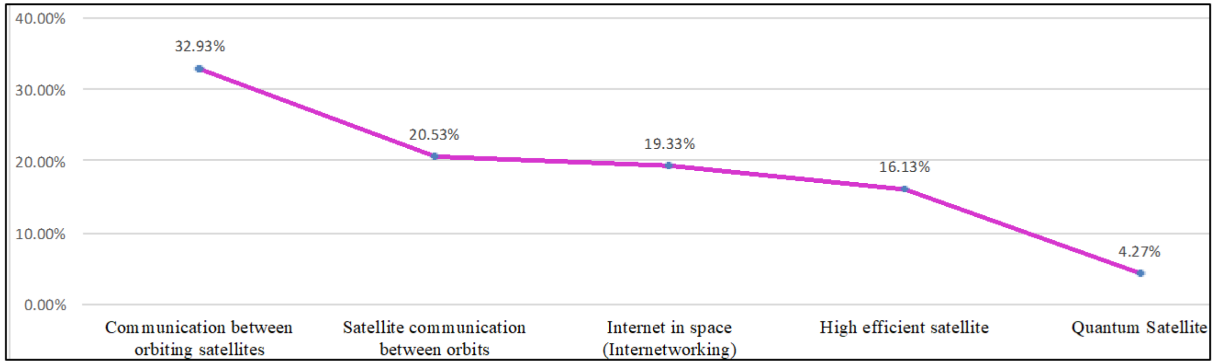


Figure 32 Prioritized Averages for Defined Technologies Directly Affecting Satellite Communication (Average of KU and BV)

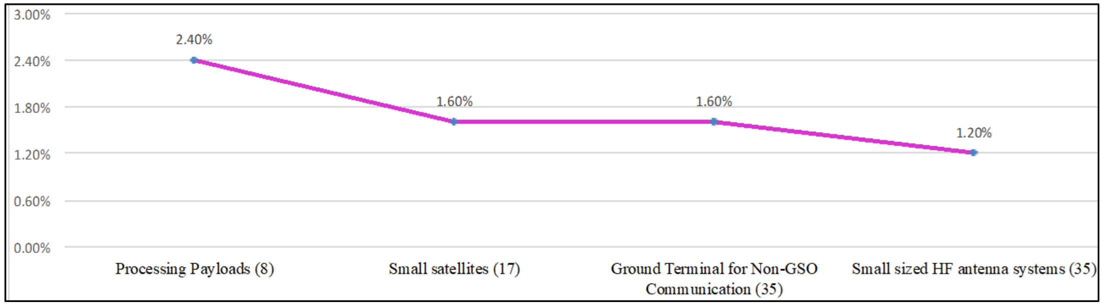


Figure 33 Prioritized Averages for Defined Technologies Directly Affecting Satellite Communication (Average of KU and BV)

APPENDIX H ANALYSIS' TABLES OF AHP

Table 1 Analysis of AHP with the Matrices for Each Participant

Participant	*A* Matrices for Each Participants			*Anorm* Matrices for Each Participants			*w* vector			
1	K1	K2	K3							
K1	1	5	7	0.74	0.56	0.84	0.71	K1	3.4129	consistency
K2	1/5	1	1/3	0.15	0.11	0.04	0.10		0.2065	CI
K3	1/7	3	1	0.11	0.33	0.12	0.19		0.3560	CR
				1.34	9.00	8.33			Not Consistent	
2	K1	K2	K3							
K1	1	3	1/9	0.10	0.43	0.08	0.20		3.9806	consistency
K2	1/3	1	1/3	0.03	0.14	0.23	0.14		0.4903	CI
K3	9	3	1	0.87	0.43	0.69	0.66	K3	0.8453	CR
				10.33	7.00	1.44			Not Consistent	
3	K1	K2	K3							
K1	1	1/7	1/3	0.09	0.11	0.05	0.08		3.1115	consistency
K2	7	1	5	0.64	0.74	0.79	0.72	K2	0.0557	CI
K3	3	1/5	1	0.27	0.15	0.16	0.19		0.0961	CR
				11.00	1.34	6.33			Consistent	
4	K1	K2	K3							
K1	1	1/7	1/5	0.08	0.07	0.09	0.08		3.0164	consistency
K2	7	1	1	0.54	0.47	0.45	0.49	K2	0.0082	CI
K3	5	1	1	0.38	0.47	0.45	0.44		0.0141	CR
				13.00	2.14	2.20			Consistent	
5	K1	K2	K3							
K1	1	1	1/5	0.14	0.14	0.14	0.14		3.0000	consistency
K2	1	1	1/5	0.14	0.14	0.14	0.14		0.0000	CI
K3	5	5	1	0.71	0.71	0.71	0.71	K3	0.0000	CR
				7.00	7.00	1.40			Consistent	
6	K1	K2	K3							
K1	1	1	1/5	0.14	0.14	0.14	0.14		3.0000	consistency
K2	1	1	1/5	0.14	0.14	0.14	0.14		0.0000	CI
K3	5	5	1	0.71	0.71	0.71	0.71	K3	0.0000	CR
				7.00	7.00	1.40			Consistent	
7	K1	K2	K3							
K1	1	3	7	0.68	0.60	0.78	0.69	K1	3.1298	consistency
K2	1/3	1	1	0.23	0.20	0.11	0.18		0.0649	CI
K3	1/7	1	1	0.10	0.20	0.11	0.14		0.1119	CR
				1.48	5.00	9.00			Consistent	
8	K1	K2	K3							
K1	1	1	1/7	0.11	0.20	0.10	0.14		3.1298	consistency
K2	1	1	1/3	0.11	0.20	0.23	0.18		0.0649	CI
K3	7	3	1	0.78	0.60	0.68	0.69	K3	0.1119	CR
				9.00	5.00	1.48			Consistent	
9	K1	K2	K3							
K1	1	9	7	0.80	0.47	0.86	0.71	K1	3.7954	consistency
K2	1/9	1	1/9	0.09	0.05	0.01	0.05		0.3977	CI
K3	1/7	9	1	0.11	0.47	0.12	0.24		0.6857	CR
				1.25	19.00	8.11			Not Consistent	
10	K1	K2	K3							
K1	1	1/9	1/7	0.06	0.01	0.11	0.06		3.9854	consistency
K2	9	1	1/7	0.53	0.12	0.11	0.25		0.4927	CI
K3	7	7	1	0.41	0.86	0.78	0.68	K3	0.8495	CR
				17.00	8.11	1.29			Not Consistent	
11	K1	K2	K3							
K1	1	5	1/3	0.24	0.45	0.22	0.30		3.1910	consistency
K2	1/5	1	1/5	0.05	0.09	0.13	0.09		0.0955	CI
K3	3	5	1	0.71	0.45	0.65	0.61	K3	0.1646	CR
				4.20	11.00	1.53			Consistent	
12	K1	K2	K3							
K1	1	1/3	1	0.20	0.08	0.43	0.24		3.6095	consistency
K2	3	1	1/3	0.60	0.23	0.14	0.32		0.3048	CI
K3	1	3	1	0.20	0.69	0.43	0.44	K3	0.5255	CR
				5.00	4.33	2.33			Not Consistent	
13	K1	K2	K3							
K1	1	1	1/9	0.09	0.09	0.09	0.09		3.0000	consistency
K2	1	1	1/9	0.09	0.09	0.09	0.09		0.0000	CI
K3	9	9	1	0.82	0.82	0.82	0.82	K3	0.0000	CR
				11.00	11.00	1.22			Consistent	
14	K1	K2	K3							
K1	1	1/7	1/3	0.09	0.02	0.23	0.11		4.4394	consistency
K2	7	1	1/7	0.64	0.12	0.10	0.29		0.7197	CI
K3	3	7	1	0.27	0.86	0.68	0.60	K3	1.2409	CR
				11.00	8.14	1.48			Not Consistent	

Table 1 (cont'd) Analysis of AHP with the Matrices for Each Participant

15	K1	K2	K3							
K1	1	3	1/5	0.16	0.27	0.15	0.19		3.1115	consistency
K2	1/3	1	1/7	0.05	0.09	0.11	0.08		0.0557	CI
K3	5	7	1	0.79	0.64	0.74	0.72	K3	0.0961	CR
				6.33	11.00	1.34			Consistent	

16	K1	K2	K3							
K1	1	1/7	1/7	0.07	0.02	0.11	0.07		3.7799	consistency
K2	7	1	1/7	0.47	0.12	0.11	0.23		0.3900	CI
K3	7	7	1	0.47	0.86	0.78	0.70	K3	0.6724	CR
				15.00	8.14	1.29			Not Consistent	

17	K1	K2	K3							
K1	1	1/5	1/9	0.07	0.02	0.09	0.06		3.5989	consistency
K2	5	1	1/9	0.33	0.10	0.09	0.17		0.2995	CI
K3	9	9	1	0.60	0.88	0.82	0.77	K3	0.5163	CR
				15.00	10.20	1.22			Not Consistent	

18	K1	K2	K3							
K1	1	5	1/7	0.12	0.38	0.11	0.21		3.5388	consistency
K2	1/5	1	1/7	0.02	0.08	0.11	0.07		0.2694	CI
K3	7	7	1	0.85	0.54	0.78	0.72	K3	0.4645	CR
				8.20	13.00	1.29			Not Consistent	

19	K1	K2	K3							
K1	1	7	1/3	0.24	0.47	0.23	0.31		3.1985	consistency
K2	1/7	1	1/7	0.03	0.07	0.10	0.07		0.0993	CI
K3	3	7	1	0.72	0.47	0.68	0.62	K3	0.1711	CR
				4.14	15.00	1.48			Consistent	

20	K1	K2	K3							
K1	1	1/5	1/9	0.07	0.02	0.09	0.06		3.5989	consistency
K2	5	1	1/9	0.33	0.10	0.09	0.17		0.2995	CI
K3	9	9	1	0.60	0.88	0.82	0.77	K3	0.5163	CR
				15.00	10.20	1.22			Not Consistent	

21	K1	K2	K3							
K1	1	1/5	1/9	0.07	0.02	0.09	0.06		3.5989	consistency
K2	5	1	1/9	0.33	0.10	0.09	0.17		0.2995	CI
K3	9	9	1	0.60	0.88	0.82	0.77	K3	0.5163	CR
				15.00	10.20	1.22			Not Consistent	

22	K1	K2	K3							
K1	1	1	1/9	0.09	0.09	0.09	0.09		3.0000	consistency
K2	1	1	1/9	0.09	0.09	0.09	0.09		0.0000	CI
K3	9	9	1	0.82	0.82	0.82	0.82	K3	0.0000	CR
				11.00	11.00	1.22			Consistent	

23	K1	K2	K3							
K1	1	1/5	1/7	0.08	0.03	0.11	0.07		3.3055	consistency
K2	5	1	1/5	0.38	0.16	0.15	0.23		0.1527	CI
K3	7	5	1	0.54	0.81	0.74	0.70	K3	0.2633	CR
				13.00	6.20	1.34			Not Consistent	

24	K1	K2	K3							
K1	1	1/5	1	0.14	0.02	0.47	0.21		4.9922	consistency
K2	5	1	1/7	0.71	0.12	0.07	0.30		0.9961	CI
K3	1	7	1	0.14	0.85	0.47	0.49	K3	1.7174	CR
				7.00	8.20	2.14			Not Consistent	

25	K1	K2	K3							
K1	1	7	1/7	0.12	0.47	0.11	0.23		3.7799	consistency
K2	1/7	1	1/7	0.02	0.07	0.11	0.07		0.3900	CI
K3	7	7	1	0.86	0.47	0.78	0.70	K3	0.6724	CR
				8.14	15.00	1.29			Not Consistent	

26	K1	K2	K3							
K1	1	1/3	1/7	0.09	0.05	0.11	0.08		3.1115	consistency
K2	3	1	1/5	0.27	0.16	0.15	0.19		0.0557	CI
K3	7	5	1	0.64	0.79	0.74	0.72	K3	0.0961	CR
				11.00	6.33	1.34			Consistent	

27	K1	K2	K3							
K1	1	1/7	1/7	0.07	0.07	0.07	0.07		3.0000	consistency
K2	7	1	1	0.47	0.47	0.47	0.47	K2	0.0000	CI
K3	7	1	1	0.47	0.47	0.47	0.47	K3	0.0000	CR
				15.00	2.14	2.14			Consistent	

28	K1	K2	K3							
K1	1	5	1/9	0.10	0.56	0.08	0.24		4.4869	consistency
K2	1/5	1	1/3	0.02	0.11	0.23	0.12		0.7434	CI
K3	9	3	1	0.88	0.33	0.69	0.64	K3	1.2818	CR
				10.20	9.00	1.44			Not Consistent	

29	K1	K2	K3							
K1	1	5	1	0.45	0.45	0.45	0.45	K1	3.0000	consistency
K2	1/5	1	1/5	0.09	0.09	0.09	0.09		0.0000	CI
K3	1	5	1	0.45	0.45	0.45	0.45	K3	0.0000	CR
				2.20	11.00	2.20			Consistent	

Table 1 (cont'd) Analysis of AHP with the Matrices for Each Participant

30	K1	K2	K3							
K1	1	5	5	0.71	0.56	0.79	0.69	K1	3.2194	consistency
K2	1/5	1	1/3	0.14	0.11	0.05	0.10		0.1097	CI
K3	1/5	3	1	0.14	0.33	0.16	0.21		0.1892	CR
				1.40	9.00	6.33			Consistent	
31	K1	K2	K3							
K1	1	1	1/5	0.14	0.14	0.14	0.14		3.0000	consistency
K2	1	1	1/5	0.14	0.14	0.14	0.14		0.0000	CI
K3	5	5	1	0.71	0.71	0.71	0.71	K3	0.0000	CR
				7.00	7.00	1.40			Consistent	
32	K1	K2	K3							
K1	1	1/5	1/5	0.09	0.05	0.13	0.09		3.1910	consistency
K2	5	1	1/3	0.45	0.24	0.22	0.30		0.0955	CI
K3	5	3	1	0.45	0.71	0.65	0.61	K3	0.1646	CR
				11.00	4.20	1.53			Consistent	
33	K1	K2	K3							
K1	1	1	9	0.47	0.47	0.47	0.47	K1	3.0000	consistency
K2	1	1	9	0.47	0.47	0.47	0.47	K2	0.0000	CI
K3	1/9	1/9	1	0.05	0.05	0.05	0.05		0.0000	CR
				2.11	2.11	19.00			Consistent	
34	K1	K2	K3							
K1	1	5	5	0.71	0.71	0.71	0.71	K1	3.0000	consistency
K2	1/5	1	1	0.14	0.14	0.14	0.14		0.0000	CI
K3	1/5	1	1	0.14	0.14	0.14	0.14		0.0000	CR
				1.40	7.00	7.00			Consistent	
35	K1	K2	K3							
K1	1	1	1	0.33	0.33	0.33	0.33	K1	3.0000	consistency
K2	1	1	1	0.33	0.33	0.33	0.33	K2	0.0000	CI
K3	1	1	1	0.33	0.33	0.33	0.33	K3	0.0000	CR
				3.00	3.00	3.00			Consistent	
36	K1	K2	K3							
K1	1	7	1/5	0.16	0.47	0.15	0.26		3.4819	consistency
K2	1/7	1	1/7	0.02	0.07	0.11	0.07		0.2410	CI
K3	5	7	1	0.81	0.47	0.74	0.68	K3	0.4155	CR
				6.14	15.00	1.34			Not Consistent	
37	K1	K2	K3							
K1	1	1	1/7	0.11	0.43	0.03	0.19		4.3102	consistency
K2	1	1	3	0.11	0.43	0.72	0.42	K2	0.6551	CI
K3	7	1/3	1	0.78	0.14	0.24	0.39		1.1294	CR
				9.00	2.33	4.14			Not Consistent	
38	K1	K2	K3							
K1	1	1/7	1/7	0.07	0.10	0.03	0.07		3.1985	consistency
K2	7	1	3	0.47	0.68	0.72	0.62	K2	0.0993	CI
K3	7	1/3	1	0.47	0.23	0.24	0.31		0.1711	CR
				15.00	1.48	4.14			Consistent	
39	K1	K2	K3							
K1	1	5	1/3	0.24	0.45	0.22	0.30		3.1910	consistency
K2	1/5	1	1/5	0.05	0.09	0.13	0.09		0.0955	CI
K3	3	5	1	0.71	0.45	0.65	0.61	K3	0.1646	CR
				4.20	11.00	1.53			Consistent	
40	K1	K2	K3							
K1	1	5	7	0.74	0.56	0.84	0.71	K1	3.4129	consistency
K2	1/5	1	1/3	0.15	0.11	0.04	0.10		0.2065	CI
K3	1/7	3	1	0.11	0.33	0.12	0.19		0.3560	CR
				1.34	9.00	8.33			Not Consistent	
41	K1	K2	K3							
K1	1	1/5	1/5	0.09	0.03	0.14	0.09		3.4652	consistency
K2	5	1	1/5	0.45	0.16	0.14	0.25		0.2326	CI
K3	5	5	1	0.45	0.81	0.71	0.66	K3	0.4010	CR
				11.00	6.20	1.40			Not Consistent	
42	K1	K2	K3							
K1	1	1	1/9	0.09	0.14	0.08	0.11		3.0723	consistency
K2	1	1	1/5	0.09	0.14	0.15	0.13		0.0362	CI
K3	9	5	1	0.82	0.71	0.76	0.77	K3	0.0624	CR
				11.00	7.00	1.31			Consistent	
43	K1	K2	K3							
K1	1	1/7	1/9	0.06	0.03	0.08	0.06		3.1222	consistency
K2	7	1	1/3	0.41	0.24	0.23	0.29		0.0611	CI
K3	9	3	1	0.53	0.72	0.69	0.65	K3	0.1053	CR
				17.00	4.14	1.44			Consistent	
44	K1	K2	K3							
K1	1	1/5	1/9	0.07	0.13	0.03	0.07		3.4508	consistency
K2	5	1	3	0.33	0.65	0.73	0.57	K2	0.2254	CI
K3	9	1/3	1	0.60	0.22	0.24	0.35		0.3886	CR
				15.00	1.53	4.11			Not Consistent	

Table 2 Total Numbers of Consistent and Inconsistent Responses

K1	6	
K2	5	
K3	29	
K1-K2	1	
K1-K3	1	
K2-K3	1	
K1-K2-K3	1	
	TOTAL	44

Consistent	24
Not Consistent	20

K1	3	
K2	3	
K3	14	
K1-K2	1	
K1-K3	1	
K2-K3	1	
K1-K2-K3	1	
	TOTAL	24

Consistent	24

APPENDIX I THE CHARTS AND TABLES FOR TAXONOMY ANALYSIS

Table 1 The Calculation Example of Related System Technologies by Weighting Each Participant’s Value with the Grades for each Criterion

Participants	1				2				3				4				5				6			
Weights	0.71	0.10	0.19		0.14	0.14	0.71		0.20	0.14	0.66		0.08	0.72	0.19		0.08	0.49	0.44		0.14	0.14	0.71	
Communication Technologies	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total
Microwave Antenna	9	6	7	8.3268				0	10	10	10	10.0000	8	8	9	8.1932	5	4	5	4.5134	10	7	10	9.5714
Power Amplification	9			6.4207				0	9		10	8.4463	4	3	8	4.0492	7	5	4	4.7211	10	7	10	9.5714
Terahertz Antenna	9	9	10	9.1866				0	8	10	7	7.6066	8	9	8	8.7235	9	8	8	8.0782	5	8	9	8.2857
CIS Security Systems				0.0000				0	10	10	9	9.3361	8	6	9	6.7462	7	4	9	6.4109	7	3	8	7.1429
Micro and Millimetre Wave (MMW) Communication				0.0000				0	10		10	8.6471	8	7	7	7.0833	9	9	9	9.0000	10	6	10	9.4286
Systems Engineering and Integrated Systems Design				0.0000				0	9	10	10	9.7992	7	8	4	7.1439				0.0000	6	3	8	7.0000

Table 2 The Calculation Example of Related Underpinning Technologies by Weighting Each Participant’s Value with the Grades for each Criterion

Participant	3				4				5				6				7			
Weights	0.20	0.14	0.66		0.08	0.72	0.19		0.08	0.49	0.44		0.14	0.14	0.71		0.69	0.18	0.14	
Structural &Smart Metarials&Structural Mechanics	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total	K1	K2	K3	Total
RF Power Sources & Devices	10	10	10	10.0000				0.0000				0.0000	8	4	9	8.1429	10	6	10	9.2841
Composite Technologies (Metals&Ceramics&Glass&Polymer)	10	10	10	10.0000				0.0000				0.0000				0.0000	10	10	10	10.0000
Information & Data Fusion Technology	10	10	10	10.0000	9	10	8	9.5303	7	8	9	8.3571				0.0000	8	8	6	7.7281
Secure Computing Techniques		10	10	2.8659	8	3	9	4.5757	8	8	9	8.4353				0.0000	10	6	8	9.0122
High Integrity and Safety Critical Computing (safety critical software,fault tolerance/detection...)	10		10	8.9998				0.0000	8	8	9	8.4353				0.0000	4	6	8	4.9018
Encryption / Crypto Technologies (quantum optical processing...)	10		10	8.9998	8	4	10	5.4923	8	5	9	6.9756				0.0000	4	4	10	4.8158
Inertial/Gravitational Devices	9	10	9	9.1000				0.0000				0.0000	7	6	8	7.5714	10	6	10	9.2841

The calculation methods to find the weighted grades and sorting for related system and underpinning technologies of aerospace communication in taxonomy are the same. The ranking for all criteria were made according to these calculations. But, K3 criterion was the most important criterion from AHP, all the comments were done by thinking about it as first. So, in the following tables Table 5 and Table8 were taken as bases for he criterion K3, but nevertheless Table 3, Table 4, Table 6 and Table 7 were given for the future or other advanced studies.

Table 3 System Related Aerospace Communication Technologies' Values in K1 Ranking with the Calculation in Table 1

System Related Aerospace Communication Technologies	Rank in K1	Value in K1 Ranking	Rank in K2	Rank in K3
Microwave Antenna	1	5.44	7	2
Power Amplification	2	5.40	12	6
Terahertz Antenna	3	5.30	5	13
CIS Security Systems	4	5.14	13	10
Micro and Millimetre Wave (MMW) Communication	5	5.00	2	3
Systems Engineering and Integrated Systems Design	6	4.73	11	7
Networking	7	4.57	1	4
Command & Information Systems Integration	8	4.39	17	16
Internet of Things (M2M)	9	4.34	10	31
Coding	10	4.30	4	1
Optical Communication	11	4.22	6	8
Modulation	12	4.04	3	9
Automated Intelligent Networked Systems	13	4.04	24	27
Synchronization	14	4.02	8	5
Integrated System Testing and Evaluation	15	3.95	38	36
Optical Navigation	16	3.89	41	42
Optical Antenna	17	3.88	16	18
Quantum Communication	18	3.76	15	37
Access	19	3.69	9	11
Geographic Information Systems	20	3.67	20	20
Network Management Systems	21	3.66	30	32
Radiation Hardening	22	3.59	44	35
MMW Communication Electronic Protection Measures (EPM-COMMs)	23	3.59	27	19
MMW Communication Electronic Counter Measures (ECM-COMMs)	24	3.58	19	12
Motion Sensor Systems	25	3.54	32	39
Electromagnetic Compatibility	26	3.47	40	26
Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)	27	3.44	39	30
Plasma Antenna	28	3.42	25	44
Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)	29	3.41	33	17
Environmental Monitoring Systems	30	3.40	21	33
Communication ElectroOptic Protection Measures (EOPM-COMMs)	31	3.27	31	21
Below Microwave Frequencies (BMF) Communication	32	3.21	18	29
Timekeeping and Time Distribution	33	3.17	22	34
BMF Communication Electronic Protection Measures (EPM-COMMs)	34	3.15	37	22
Air Traffic Control Systems	35	3.09	26	28
Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)	36	3.07	36	25
Earth Launch and Re- Entry Communications	37	3.05	14	38
Communication ElectroOptic Counter Measures (EOCM-COMMs)	38	2.95	28	14
MMW Communication Electronic Support Measures (ESM-COMMs)	39	2.91	29	24
Microsensor Systems for Active Control of Structures	40	2.87	47	45
A-Priori Data Based Navigation	41	2.81	42	40
BMF Communication Electronic Support Measures (ESM-COMMs)	42	2.68	35	23
Infrastructure to Support Information Management & Dissemination	43	2.64	46	43
BMF Communication Electronic Counter Measures (ECM-COMMs)	44	2.64	34	15
Middleware systems	45	2.37	45	46
In-Service Data Capture	46	2.11	48	41
X-Ray Communication (XCOM)	47	1.96	23	47
Neutrino-Based Navigation	48	1.62	49	48
X-Ray Navigation (XNAV)	49	1.47	43	49

Table 4 System Related Aerospace Communication Technologies' Values in K2 Ranking with the Calculation in Table 1

System Related Aerospace Communication Technologies	Rank in K2	Value in K2 Ranking	Rank in K1	Rank in K3
Networking	1	5.32	7	4
Micro and Millimetre Wave (MMW) Communication	2	5.03	5	3
Modulation	3	4.95	12	9
Coding	4	4.89	10	1
Terahertz Antenna	5	4.89	3	13
Optical Communication	6	4.74	11	8
Microwave Antenna	7	4.74	1	2
Synchronization	8	4.71	14	5
Access	9	4.62	19	11
Internet of Things (M2M)	10	4.35	9	31
Systems Engineering and Integrated Systems Design	11	4.30	6	7
Power Amplification	12	3.91	2	6
CIS Security Systems	13	3.88	4	10
Earth Launch and Re- Entry Communications	14	3.54	37	38
Quantum Communication	15	3.36	18	37
Optical Antenna	16	3.36	17	18
Command & Information Systems Integration	17	3.24	8	16
Below Microwave Frequencies (BMF) Communication	18	3.14	32	29
MMW Communication Electronic Counter Measures (ECM-COMMs)	19	2.85	24	12
Geographic Information Systems	20	2.79	20	20
Environmental Monitoring Systems	21	2.76	30	33
Timekeeping and Time Distribution	22	2.66	33	34
X-Ray Communication (XCOM)	23	2.62	47	47
Automated Intelligent Networked Systems	24	2.61	13	27
Plasma Antenna	25	2.61	28	44
Air Traffic Control Systems	26	2.59	35	28
MMW Communication Electronic Protection Measures (EPM-COMMs)	27	2.58	23	19
Communication ElectroOptic Counter Measures (EOCM-COMMs)	28	2.53	38	14
MMW Communication Electronic Support Measures (ESM-COMMs)	29	2.48	39	24
Network Management Systems	30	2.44	21	32
Communication ElectroOptic Protection Measures (EOPM-COMMs)	31	2.41	31	21
Motion Sensor Systems	32	2.41	25	39
Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)	33	2.35	29	17
BMF Communication Electronic Counter Measures (ECM-COMMs)	34	2.20	44	15
BMF Communication Electronic Support Measures (ESM-COMMs)	35	2.16	42	23
Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)	36	2.12	36	25
BMF Communication Electronic Protection Measures (EPM-COMMs)	37	2.09	34	22
Integrated System Testing and Evaluation	38	2.05	15	36
Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)	39	2.04	27	30
Electromagnetic Compatibility	40	1.98	26	26
Optical Navigation	41	1.98	16	42
A-Priori Data Based Navigation	42	1.91	41	40
X-Ray Navigation (XNAV)	43	1.58	49	49
Radiation Hardening	44	1.55	22	35
Middleware systems	45	1.46	45	46
Infrastructure to Support Information Management & Dissemination	46	1.41	43	43
Microsensor Systems for Active Control of Structures	47	1.40	40	45
In-Service Data Capture	48	1.11	46	41
Neutrino-Based Navigation	49	0.75	48	48

Table 5 System Related Aerospace Communication Technologies' Values in K3 Ranking with the Calculation in Table 1

System Related Aerospace Communication Technologies	Rank in K3	Value in K3 Ranking	Rank in K1	Rank in K2
Coding	1	5.28	10	4
Microwave Antenna	2	5.15	1	7
Micro and Millimetre Wave (MMW) Communication	3	4.97	5	2
Networking	4	4.92	7	1
Synchronization	5	4.79	14	8
Power Amplification	6	4.78	2	12
Systems Engineering and Integrated Systems Design	7	4.70	6	11
Optical Communication	8	4.67	11	6
Modulation	9	4.59	12	3
CIS Security Systems	10	4.53	4	13
Access	11	4.39	19	9
MMW Communication Electronic Counter Measures (ECM-COMMs)	12	4.27	24	19
Terahertz Antenna	13	4.17	3	5
Communication ElectroOptic Counter Measures (EOCM-COMMs)	14	4.13	38	28
BMF Communication Electronic Counter Measures (ECM-COMMs)	15	4.03	44	34
Command & Information Systems Integration	16	4.03	8	17
Non-Co-operative Target Recognition (Identification Friend or Foe-IFF...)	17	4.01	29	33
Optical Antenna	18	3.99	17	16
MMW Communication Electronic Protection Measures (EPM-COMMs)	19	3.90	23	27
Geographic Information Systems	20	3.90	20	20
Communication ElectroOptic Protection Measures (EOPM-COMMs)	21	3.82	31	31
BMF Communication Electronic Protection Measures (EPM-COMMs)	22	3.74	34	37
BMF Communication Electronic Support Measures (ESM-COMMs)	23	3.70	42	35
MMW Communication Electronic Support Measures (ESM-COMMs)	24	3.62	39	29
Infrastructure Based Navigation Systems (GNSS, LORAN, TACAN, VOR/DME, ILS/MLS, RNAV...)	25	3.46	36	36
Electromagnetic Compatibility	26	3.38	26	40
Automated Intelligent Networked Systems	27	3.37	13	24
Air Traffic Control Systems	28	3.33	35	26
Below Microwave Frequencies (BMF) Communication	29	3.22	32	18
Dead Reckoning Based Navigation (Inertial Navigation, Air Data Inertial Reference...)	30	3.21	27	39
Internet of Things (M2M)	31	3.20	9	10
Network Management Systems	32	3.16	21	30
Environmental Monitoring Systems	33	3.13	30	21
Timekeeping and Time Distribution	34	3.12	33	22
Radiation Hardening	35	3.11	22	44
Integrated System Testing and Evaluation	36	3.11	15	38
Quantum Communication	37	3.06	18	15
Earth Launch and Re- Entry Communications	38	2.96	37	14
Motion Sensor Systems	39	2.95	25	32
A-Priori Data Based Navigation	40	2.83	41	42
In-Service Data Capture	41	2.77	46	48
Optical Navigation	42	2.60	16	41
Infrastructure to Support Information Management & Dissemination	43	2.48	43	46
Plasma Antenna	44	2.32	28	25
Microsensor Systems for Active Control of Structures	45	2.28	40	47
Middleware systems	46	2.25	45	45
X-Ray Communication (XCOM)	47	2.10	47	23
Neutrino-Based Navigation	48	1.14	48	49
X-Ray Navigation (XNAV)	49	0.89	49	43

Table 6 Underpinning Related Aerospace Communication Technologies' Values in K1 Ranking with the Calculation in Table 1

Underpinning Related Aerospace Communication Technologies	Rank in K1	Value in K1 Ranking
RF Power Sources & Devices	1	4.65
Composite Technologies (Metals&Ceramics&Glass&Polymer)	2	4.58
Information & Data Fusion Technology	3	4.35
Secure Computing Techniques	4	4.34
High Integrity and Safety Critical Computing (safety critical software,fault tolerance/detection...)	5	4.30
Encryption / Crypto Technologies (quantum optical processing...)	6	4.22
Inertial/Gravitational Devices	7	4.17
Solar Cells	8	4.10
III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)	9	4.09
Device Concepts and Fabrication	10	4.03
Data & Information Management Technology	11	3.95
Mathematical Modeling Development (communication networks...)	12	3.91
Protocol Technology (satellite/terrestrial communication systems management and control, LANs, WANs...)	13	3.68
Optimisation & Decision Support Technology	14	3.57
Optical Signal Processing Technology	15	3.56
Structural Materials Processing, Joining and Surface Protection Technologies	16	3.52
Architectures	17	3.50
COTS Software Assessment (integration/maintenance technologies)	18	3.49
Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)	19	3.41
Device Integration/Reliability	20	3.35
Device Packaging	21	3.18
Electromagnetic Propagation in Air	22	3.13
Smart/Functional Materials for Structural Uses	23	2.88
Optical Materials & Devices	24	2.85
Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)	25	2.83
Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)	26	2.77
Speech & Natural Language Processing Technology	27	2.75
Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)	28	2.70
Non-Destructive Evaluation & Life Extension of Structural Materials	29	2.62
Terrain Science	30	2.61
Non-Linear Optical Materials & Devices	31	2.57
Structural Mechanics	32	2.55
Thermal & Thermodynamic Technologies & Devices	33	2.50
Fluid Dynamics Techniques	34	2.47
Meteorology (weather systems, ocean-atmosphere coupling, air movements...)	35	2.41
OA Tools and Techniques	36	2.41
Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)	37	2.41
Transparent Materials (diamond windows and coatings...)	38	2.32
Corrosion and Wear Control Technology	39	2.29
Structural Materials -Forming and Materials RemovalTechnologies	40	2.29
Fluid Mechanics - Phenomenological & Experimental	41	2.15
Insulating & Dielectric Materials	42	2.14
Non-Laser Devices (specific structures in III-V materials and in porous silicon...)	43	2.12
Mechanical/Hydraulic Technologies & Devices	44	2.08
Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)	45	2.06
Other Semiconducting Materials	46	2.00
Lubrication Technology	47	1.71

Table 7 Underpinning Related Aerospace Communication Technologies' Values in K2 Ranking with the Calculation in Table 1

Underpinning Related Aerospace Communication Technologies	**Rank in K2**	**Value in K2 Ranking**
Protocol Technology (satellite/terrestrial communication systems management and control, LANs, WANs...)	1	3.77
Solar Cells	2	3.58
High Integrity and Safety Critical Computing (safety critical software,fault tolerance/detection...)	3	3.46
Electromagnetic Propagation in Air	4	3.38
Meteorology (weather systems, ocean-atmosphere coupling, air movements...)	5	3.18
Data & Information Management Technology	6	3.17
Information & Data Fusion Technology	7	3.17
RF Power Sources & Devices	8	3.14
Mathematical Modeling Development (communication networks...)	9	3.09
Optimisation & Decision Support Technology	10	3.06
Inertial/Gravitational Devices	11	2.81
Encryption / Crypto Technologies (quantum optical processing...)	12	2.70
Architectures	13	2.62
Secure Computing Techniques	14	2.61
Device Concepts and Fabrication	15	2.60
Device Integration/Reliability	16	2.58
Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)	17	2.53
Composite Technologies (Metals&Ceramics&Glass&Polymer)	18	2.52
Structural Mechanics	19	2.40
III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)	20	2.40
Structural Materials -Forming and Materials RemovalTechnologies	21	2.28
COTS Software Assessment (integration/maintenance technologies)	22	2.23
Speech & Natural Language Processing Technology	23	2.10
Terrain Science	24	2.09
Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)	25	1.96
Optical Signal Processing Technology	26	1.96
Smart/Functional Materials for Structural Uses	27	1.93
Structural Materials Processing, Joining and Surface Protection Technologies	28	1.90
Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)	29	1.87
Device Packaging	30	1.65
OA Tools and Techniques	31	1.51
Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)	32	1.41
Other Semiconducting Materials	33	1.40
Optical Materials & Devices	34	1.26
Thermal & Thermodynamic Technologies & Devices	35	1.26
Corrosion and Wear Control Technology	36	1.23
Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)	37	1.20
Insulating & Dielectric Materials	38	1.17
Fluid Dynamics Techniques	39	1.13
Fluid Mechanics - Phenomenological & Experimental	40	1.06
Transparent Materials (diamond windows and coatings...)	41	1.02
Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)	42	0.95
Mechanical/Hydraulic Technologies & Devices	43	0.85
Non-Destructive Evaluation & Life Extension of Structural Materials	44	0.81
Non-Linear Optical Materials & Devices	45	0.74
Lubrication Technology	46	0.67
Non-Laser Devices (specific structures in III-V materials and in porous silicon...)	47	0.62

Table 8 Underpinning Related Aerospace Communication Technologies' Values in K3 Ranking with the Calculation in Table 1

Underpinning Related Aerospace Communication Technologies	Rank in K3	Value in K3 Ranking
Encryption / Crypto Technologies (quantum optical processing...)	1	4.50
Composite Technologies (Metals&Ceramics&Glass&Polymer)	2	4.28
Secure Computing Techniques	3	4.21
RF Power Sources & Devices	4	4.17
Information & Data Fusion Technology	5	3.89
High Integrity and Safety Critical Computing (safety critical software,fault tolerance/detection...)	6	3.85
Inertial/Gravitational Devices	7	3.66
Data & Information Management Technology	8	3.58
Device Concepts and Fabrication	9	3.47
Solar Cells	10	3.46
Mathematical Modeling Development (communication networks...)	11	3.37
Electromagnetic Propagation in Air	12	3.32
Structural Materials Processing, Joining and Surface Protection Technologies	13	3.30
III-V Compounds (GaAs, InAs, InSb, GaSb, AISb, AIN, InP, GaN...)	14	3.29
Optimisation & Decision Support Technology	15	3.27
Protocol Technology (satellite/terrestrial communication systems management and control, LANs, WANs...)	16	3.21
Device Integration/Reliability	17	3.21
Architectures	18	2.86
Optical Signal Processing Technology	19	2.71
Lasers -all types (FIR, VNIR, mid-IR, dye and frequency diversesources...)	20	2.66
Upper Atmosphere & Space Environment (ionospheric, exo-atmospherics, space radiation, debris effects...)	21	2.63
Device Packaging	22	2.52
Silicon-based Materials (Si, SiGe alloys, Silicon Carbide...)	23	2.50
Structural Mechanics	24	2.43
Optical Materials & Devices	25	2.43
COTS Software Assessment (integration/maintenance technologies)	26	2.28
Thermal & Thermodynamic Technologies & Devices	27	2.24
Smart/Functional Materials for Structural Uses	28	2.12
Insulating & Dielectric Materials	29	2.10
Corrosion and Wear Control Technology	30	2.10
Meteorology (weather systems, ocean-atmosphere coupling, air movements...)	31	2.08
Non-Destructive Evaluation & Life Extension of Structural Materials	32	2.01
Terrain Science	33	1.99
OA Tools and Techniques	34	1.94
Carbon-based Materials (carbon60, carbon suspensions, diamonds, diamond coatings...)	35	1.87
Superconducting Materials (HTS materials for ESM-Comms and ESM-non Comms Systems...)	36	1.85
Speech & Natural Language Processing Technology	37	1.81
Structural Materials -Forming and Materials RemovalTechnologies	38	1.74
Non-Linear Optical Materials & Devices	39	1.74
Fluid Dynamics Techniques	40	1.61
Other Semiconducting Materials	41	1.52
Transparent Materials (diamond windows and coatings...)	42	1.39
Mechanical/Hydraulic Technologies & Devices	43	1.37
Fluid Mechanics - Phenomenological & Experimental	44	1.37
Lubrication Technology	45	1.35
Non-Laser Devices (specific structures in III-V materials and in porous silicon...)	46	1.31
Display Materials & Devices (nanophase polydisperse tuneablefilters, liquid crystal materials...)	47	1.24

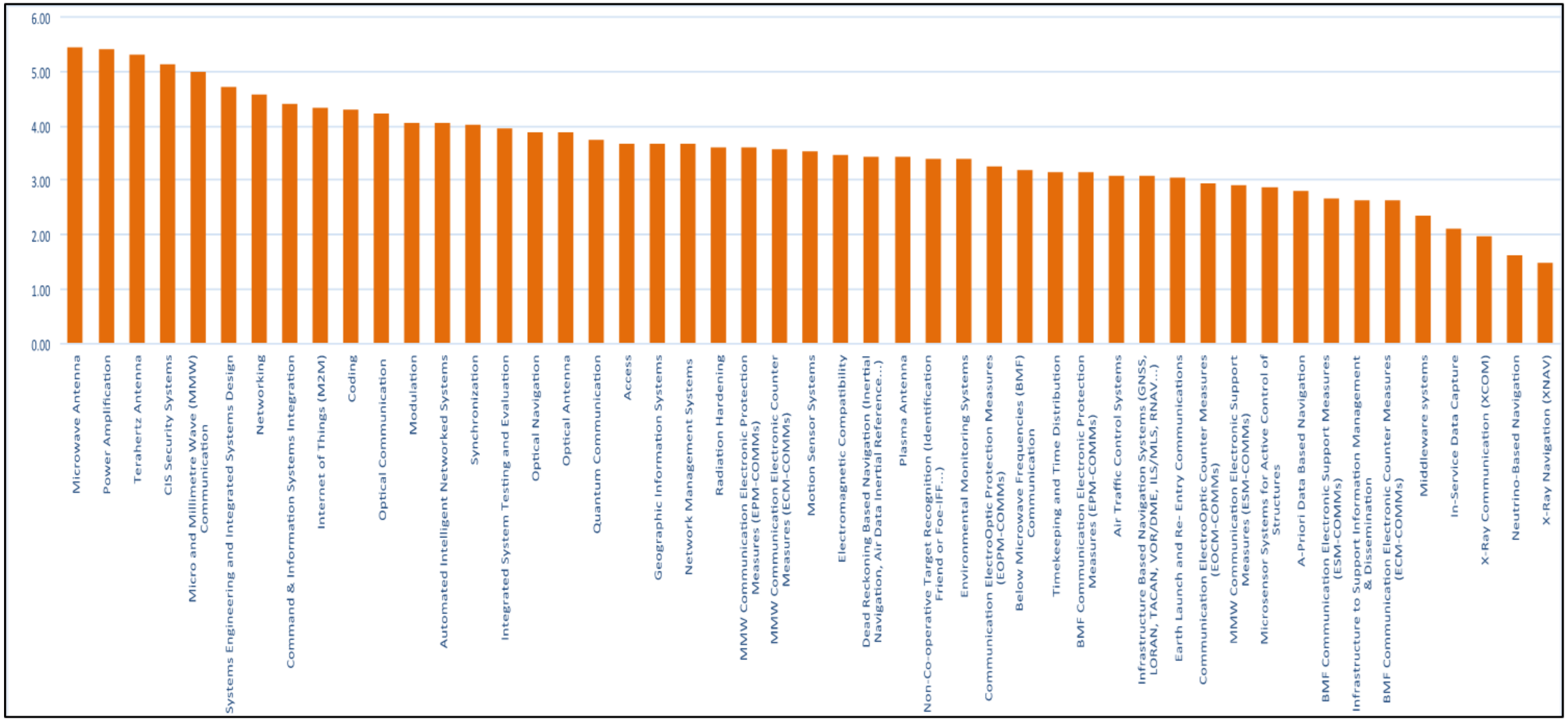


Figure 1 Sorting of System Related Technologies for K1 (To Create Competitive Advantage)

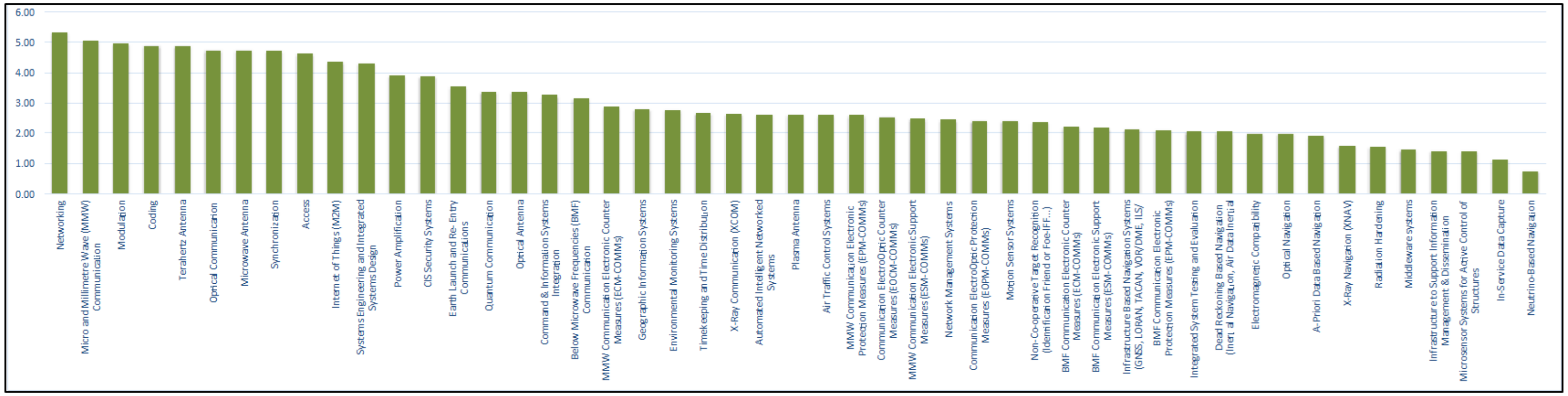


Figure 2 Sorting of System Related Technologies for K2 (To Create Other Technological Areas)

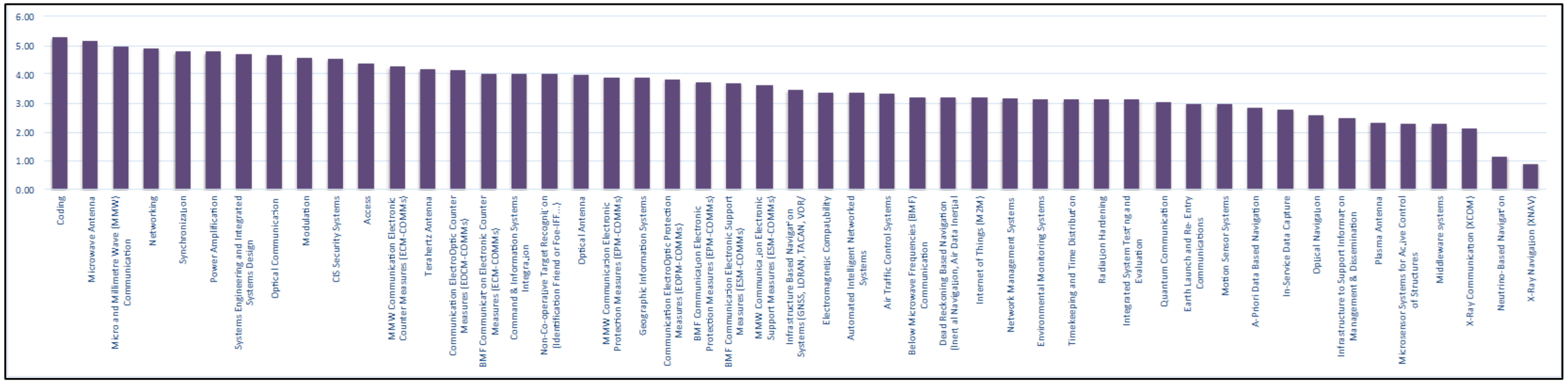


Figure 3 Sorting of System Related Technologies for K2 (To Meet National Security Needs)

APPENDIX J ANALYSIS OF WILD CARDS

Table 1 Resolved Form of Type 2 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (8 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words	Words	Words
Type 2 Wild Card High probability - High fffect - Low credibility	1	Using codes developed and modified with artificial intelligence in communication	T	code	artificial intelligence	communication						
	2	The development of systems using big data applications that control all the behavior of people and result in disappearence of free will	ST	big data	control	people	free-will	system				
	3	An extremely powerful geomagnetic storm in space to hit the space and ground systems, breaking down transformers, satellites and to make them fall, resulting in shortages of internet, electric and all technological systems	P/T/S/E/Env	geomagnetic	storm	space	ground system	transformer	satellite	technology	powerful	shortage
	4	Development of magnetic thrust technology	T	magnetic thrust	technology							
	5	The collapse of democracies, the widespread of authoritarian and protective policies in economy	P	collapse	democracy	authoritarian	policy	economy	protective			
	6	Monopoly of the USA in space and communication	P	monopoly	USA	space	communication					
	7	Satellite communication terminals to become low cost and obtainable by everyone	S	satellite	communication	terminal	low-cost	obtainable				
	8	The unipolar effect of the capitalist world to strengthen a formation similar to 'Internet of People' and this 'networked' living group to collapse the world and a new group to be formed that can reconstruct the destructed networks and to take the lead in the world	T/P/S/E/Env/L	unipolar	capitalist	internet of people	networked	reconstruct	world			

Table 2 Number of Common Words' Occurrances in Type 2 Wild Cards

Words	Number of Occurance
communication	3
satellite	2
space	2
technology	2
artificial intelligence	1
authoritarian	1
big data	1
capitalist	1
code	1
collapse	1
control	1
democracy	1
economy	1
free-will	1
geomagnetic	1
ground system	1
internet of people	1
low-cost	1
magnetic thrust	1
monopoly	1
networked	1
obtainable	1
owerful	1
people	1
policy	1
protective	1
reconstruct	1
shortage	1
storm	1
system	1
terminal	1
transformer	1
unipolar	1
USA	1
world	1

Table 3 Resolved Form of Type 3 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (13 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words
Type 3 Wild Card High probability - High effect - Unclear credibility	1	Carrying out coordinated tasks for a specific purpose with a small number of autonomous UVAs	T	autonomous	UVA	task				
	2	All battles to be done with armed UVAs	T/P	battle	UVA	armed				
	3	A nuclear war	P/S/E/Env	nuclear	war					
	4	Coastal flooding with the rise of sea level	P/S/E/Env/L	coastal flood	sea level					
	5	The beginning of a social and economic crisis in the world as a result of an epidemic disease	T/S/E/Env	social	economy	crisis	world	epidemic disease		
	6	Middle East countries to become the rising economy class	P/E	Middle East	economy	rising				
	7	Artificial intelligence and robots to dominate the economic system and to result in massive unemployment	E/S	artificial intelligence	robot	economy	unemployment	system	dominate	
	8	The disintegration of the European Union and the establishment of the Eurasian Union becoming a monopoly in aerospace communication	L	European union	Eurasian Union	union	monopoly	aerospace	communication	
	9	Beginning to use planes that work with solar energy and provide round-trip communication around the world without landing	T	plane	solar	energy	communication	round-trip	world	
	10	Marginal groups to continue the civilization using optical communication channels after destruction of civilization by a nuclear world war	T/P/S/Env/L	marginal	civilization	optical	communication	nuclear	world	war
	11	Discovery of new communication methods and sensors	T	communication	sensor	method				
	12	The young generation to become the decision maker	S	young generation	decision					
	13	Special legislation for spin-off (university) companies	L	legislation	spin-off	university	company			

Table 4 Number of Common Words' Occurrances in Type 3 Wild Cards

Words	Number of Occurance
communication	4
economy	3
world	3
nuclear	2
UVA	2
war	2
coastal flood	1
armed	1
artificial intelligence	1
autonomous	1
battle	1
civilization	1
company	1
crisis	1
decision	1
dominate	1
energy	1
Eurasian Union	1
European union	1
legislation	1
marginal	1
method	1
Middle East	1
monopoly	1
optical	1
plane	1
rising	1
robot	1
sea level	1
sensor	1
social	1
solar	1
spin-off	1
task	1
unemployment	1
union	1
university	1
young generation	1

Table 5 Resolved Form of Type 4 Wild Cards into Words

TYPES OF WILD CARDS	NO	WILD CARDS (17 ITEMS)	P/T/S/E/Env/L	Words	Words	Words	Words	Words	Words	Words	Words
Type 4 Wild Card High probability - High effect - High credibility	1	Communication with software based devices and radar and electronic warfare technologies using single system/device	T	communication	software	radar	electronic warfare	system	device		
	2	The inclusion of all devices in the world to Internet of Things (IoT)	T	internet of things	world						
	3	Construction of quantum radar taking place of military radars (the existence of the theory, difficulty of practice, not detecting its detection, non-existance of counterfeit)	T	quantum	radar	military	counterfeit	detection	practice	theory	
	4	The minimum impact of the human factor in war	T/P(S	impact	human	war					
	5	Increased need for space and air observation due to regional intense but intermittent conflict	P/S/E/Env	space	air	observation	intermittent	regional	conflict		
	6	The earthquake to occur due to high mobility of the faults in Turkey	P/S/E/Env/L	earthquake	mobility	faults	Turkey				
	7	Serious damage to the Istanbul and around due to a very strong earthquake	T/S/E/Env	damage	istanbul	earthquake					
	8	Shooting enemy satellites using missiles	T	shoot	enemy	satellite	missile				
	9	Satellite operation lifetime to be at least 50 years	T	satellite	lifetime	operation life-time					
	10	The widespread of satellites that can target and hit other satellites	T/P	satellite	target	hit					
	11	The collapse of the banking system, beginning of crypto coin era	P/E	collapse	banking	crypto coin	system				
	12	Decrease in trade of intermediate goods, reduction in transportation and logistics activities, widespread of semi-colonial countries as a result of Industry 4.0	P/E	trade	intermediate goods	transportation	logistics	semi-colonial	country	Industry 4.0	
	13	Turkey to have the ability to send manned vehicle sand-settling in space without being dependent on other countries	T	Turkey	manned	vehicle	sand-settling	space	dependent	country	
	14	Turkey to become the leading country in the Middle East with its own developed communication technology	E	Turkey	leading	country	Middle East	communication	technology		
	15	At the end of World War III the humanity to survive just under oceans but only the ones with capability of optical or LF (low frequency) technologies for communication over water can be colonized	T/P/S/Env/L	war	world	humanity	ocean	optical	LF	technology	colonization
	16	Development of powerful and reusable rocket systems	T	powerful	reusable	rocket	system				
	17	Widespread of space tourism	T	space	tourism						

Table 6 Number of Common Words' Occurrances in Type 3 Wild Cards

Words	Number of Occurance
country	3
satellite	3
space	3
system	3
Turkey	3
communication	2
earthquake	2
radar	2
technology	2
war	2
world	2
air	1
banking	1
collapse	1
colonization	1
conflict	1
counterfeit	1
crypto coin	1
damage	1
dependent	1
device	1
electronic warfare	1
enemy	1
faults	1
hit	1
human	1
humanity	1
impact	1
Industry 4.0	1

Words	Number of Occurance
intermediate goods	1
internet of things	1
intermittent	1
istanbul	1
leading	1
LF	1
lifetime	1
logistics	1
manned	1
Middle East	1
military	1
missile	1
mobility	1
observation	1
ocean	1
operation life-time	1
powerful	1
practice	1
quantum	1
reusable	1
rocket	1
sand-settling	1
shoot	1
software	1
target	1
theory	1
tourism	1
trade	1
transportation	1
vehicle	1

APPENDIX K THE FIRST ROUND DELPHI SURVEY

Türk Savunma Sanayii 2040 Yılı Uzay ve Hava Haberleşme Teknolojileri Öngörüsü

Bu ankette, 27 ifade değerlendirilecektir. Değerlendirme 20-25 dakika sürmektedir.

- Uzmanlık Düzeyiniz, Milli Güvenliğe Katkısı (öngördüğünüz), Ekonomiye Katkısı (öngördüğünüz), Gerçekleşme Zamanı (öngördüğünüz) ve Başlangıç Yeteneği (mevcut durumdaki) soru ana başlıklarıdır. Başlangıç yeteneği kısmındaki seçeneklerden Rekabet Öncesi Endüstriyel Geliştirme ile, bilgi alt yapısı ve finansman açısından işbirliği gerektiren prototip ve pilot üretimi de içeren faaliyetler kastedilmektedir.

Her bir ana başlık için sadece tek bir seçeneği seçmeniz beklenmektedir.

* Gerekli

1. **E-posta adresi** *

2. **Eğitim Durumunuz** *
   Yalnızca bir şıkkı işaretleyin.
   - Ön Lisans
   - Lisans
   - Yüksek Lisans
   - Doktora
   - Doktora sonrası

3. **Çalıştığınız Sektör** *
   Yalnızca bir şıkkı işaretleyin.
   - Akademi
   - Türk Silahlı Kuvvetleri (TSK)
   - Özel Sektör
   - Kamu
   - Sivil Toplum Kuruluşu (STK)

4. **Hava veya Uzay Haberleşme Teknolojileri Alanında Tecrübeniz** *
   Yalnızca bir şıkkı işaretleyin.
   - 0-5 yıl
   - 6-10 yıl
   - 11-15 yıl
   - 16-20 yıl
   - 21 yıl ve üzeri

1: Yönlü ortam erişimi (Directional Medium Access, DMA) ile girişim yönetimi (Interference Management) yapabilen ağ tabanlı haberleşme sistemi geliştirilmiştir.

5. **1.a: Uzmanlık** *
   Yalnızca bir şıkkı işaretleyin.

   - Konu Uzmanıyım
   - Bilgim Var
   - Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

6. **1.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
   Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

7. **1.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
   Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

8. **1.d: Gerçekleşme Zamanı**
   Yalnızca bir şıkkı işaretleyin.

   - 2018-2023
   - 2024-2029
   - 2030-2035
   - 2036-2040
   - Hiçbir Zaman

9. **1.e: Başlangıç Yeteneği**
   Yalnızca bir şıkkı işaretleyin.

   - Temel Araştırma
   - Uygulamalı Endüstriyel Araştırma
   - Rekabet Öncesi Endüstriyel Geliştirme
   - Endüstriyel Geliştirme

2: Stratosferik Balonlar kullanılarak uydular ile koordineli ve uydulardan bağımsız çalışabilen bölgesel haberleşme ve konumlandırma sistemleri geliştirilmiştir.

10. **2.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.] Bu bölümdeki son sorunun ardından, 14. soruya geçin.

11. **2.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

12. **2.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

13. **2.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

14. **2.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

3: Sürü (Swarm) İHA/SİHA haberleşme ağında büyük veri içinden elde edilecek istihbaratın anlamlandırılmasını sağlayan bilgi teknolojileri geliştirilmiştir.

15. **3.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sonraki sayfaya geçmek için en alttaki İLERLE düğmesine basınız.]

16. **3.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

17. **3.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

18. **3.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

19. **3.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

4: Kuantum Kriptoloji teknikleri kullanılmaktadır.

20. **4.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

21. **4.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

22. **4.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

23. **4.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

◯ 2018-2023
◯ 2024-2029
◯ 2030-2035
◯ 2036-2040
◯ Hiçbir Zaman

24. **4.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

◯ Temel Araştırma
◯ Uygulamalı Endüstriyel Araştırma
◯ Rekabet Öncesi Endüstriyel Geliştirme
◯ Endüstriyel Geliştirme

5: Kendi kendine organize olabilen, ağ yükü optimizasyonu yapma yeteneğine sahip (uç nokta hesaplaması vb.) ve kendi kendini iyileştirebilen akıllı haberleşme ağları kullanılmaktadır.

25. **5.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

◯ Konu Uzmanıyım
◯ Bilgim Var
◯ Bilgim Yok [Aşağıdaki soruları cevaplamadan, sonraki sayfaya geçmek için en alttaki İLERLE düğmesine basınız.]

26. **5.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

27. **5.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

28. **5.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

29. **5.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

6: Uydular ve hava platformları ile göreceli navigasyon alt yapısı oluşturularak hareketli durumda haberleşme ve bilgi sistemi ağı geliştirilmiştir.

30. **6.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- ◯ Konu Uzmanıyım
- ◯ Bilgim Var
- ◯ Bilgim yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

31. **6.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

32. **6.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

33. **6.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

34. **6.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

7: Hava ve uzay platformları akıllı bir ağ üzerinden haberleşebilme ve pozisyonel kodlarını iyonosferden kaynaklanan bozulmalara rağmen düzeltebilme ve bu sayede dar iletişim hüzmeleri kullanarak ağ yapısını gürbüz şekilde koruyabilme yeteneğine sahip şekilde geliştirilmiştir.

35. **7.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- ◯ Konu Uzmanıyım
- ◯ Bilgim Var
- ◯ Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

36. **7.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	⬭	⬭	⬭	⬭	⬭	Çok Önemli

37. **7.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	⬭	⬭	⬭	⬭	⬭	Çok Önemli

38. **7.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

39. **7.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

8: Hava ve uzay platformları arasında güvenli iletişim, yüksek hızlı iletişim (>=100GB/sn) ve verimli iletişim (>1pJ/bit) sağlayan kodlama ve kod çözme teknolojileri kullanılmaktadır.

40. **8.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

41. **8.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

42. **8.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

43. **8.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

44. **8.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

9: Hava platformları arasında orta-kısa menzilli, iki yönlü yüksek veri iletişimi sağlayan, birbirlerine kilitli dar hüzmeli Ad-Hoc (Electronic Counter Measure-ECM ve Low Probability of Intercept-LPI özellikli) hava tabanlı ağ oluşturulmuştur.

45. **9.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- ◯ Konu Uzmanıyım
- ◯ Bilgim Var
- ◯ Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

46. **9.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

47. **9.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

48. **9.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

49. **9.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

10: Orbitte uzaktan programlanabilen Ka band yazılım tabanlı telsiz sistemleri geliştirilmiştir.

50. **10.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- ◯ Konu Uzmanıyım
- ◯ Bilgim Var
- ◯ Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

51. **10.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

52. **10.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	○	○	○	○	○	Çok Önemli

53. **10.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

54. **10.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

11: Sürü (SWARM) İHA/SİHA ve insanlı hava araçlarının yoğun haberleşmesini kesintisiz/emniyetli olarak karşılayan taktik (araçlar arası) ve uydu (uydu-araç) linkleri kullanılmaktadır.

55. **11.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

56. **11.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	○	○	○	○	○	Çok Önemli

57. **11.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

58. **11.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

◯ 2018-2023
◯ 2024-2029
◯ 2030-2035
◯ 2036-2040
◯ Hiçbir Zaman

59. **11.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

◯ Temel Araştırma
◯ Uygulamalı Endüstriyel Araştırma
◯ Rekabet Öncesi Endüstriyel Geliştirme
◯ Endüstriyel Geliştirme

12: Takip ve veri aktarma haberleşme uydusu (Tracking and Data Relay Satellite) geliştirilip kullanıma alınmıştır.

60. **12.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

◯ Konu Uzmanıyım
◯ Bilgim Var
◯ Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

61. **12.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

62. **12.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz	◯	◯	◯	◯	◯	Çok Önemli

63. **12.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

64. **12.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

13: Düşük maliyetli, kolay üretilebilen, elektronik yönlendirme tabanlı sayısal hüzme biçimlendirmeli anten teknolojileri kullanılmaktadır.

65. **13.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

66. **13.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

67. **13.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

68. **13.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

69. **13.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

14: Bilişsel ağ teknolojilerine ve protokollerine sahip olunmuştur.

70. **14.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

71. **14.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

72. **14.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

73. **14.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

74. **14.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

15: Frekansa göre yeniden yapılandırılabilen grafen tabanlı Terahertz Anten teknolojileri geliştirilmiştir.

75. **15.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

76. **15.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

77. **15.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

78. **15.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

79. **15.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

16: Uydu ile İHA/SİHA/Uçak/Balon/Zeplin/Helikopter arasında açık alan optik kablosuz iletişim kullanılmaktadır.

80. **16.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

81. **16.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

82. **16.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

83. **16.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

84. **16.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

17: Sanallaştırılmış ağ fonksiyonları ile düşük güç tüketimli yazılım tabanlı ağ şebekeleri yaygın kullanılmaktadır.

85. **17.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

86. **17.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

87. **17.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

88. **17.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

89. **17.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

18: Optik hüzmenin hareketli platformlardan alıcıya güvenilir şekilde ulaşması için etkin tespit, izleme ve gösterme (Acquisition, Tarcking and Pointing- ATP) sistemleri kullanılmaktadır.

90. **18.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

91. **18.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

92. **18.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

93. **18.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

94. **18.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

19: Dost Düşman Tanıma ve Tanıtma Sistemi (Identification Friend or Foe- IFF) uydu haberleşmesi aracılığı ile gerçeklenmiştir.

95. **19.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

96. **19.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

97. **19.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

98. **19.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

99. **19.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

20: Radyo dalgalarının hüzmesini yönlendirebilen çoklu bant akıllı plazma antenleri geliştirilerek, %50'den fazla oranda geleneksel antenlerin yerine kullanılır hale gelmiştir.

100. **20.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

101. **20.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

102. **20.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

103. **20.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

104. **20.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

21: Uzayda LEO yörüngede internet uydu teknolojileri geliştirilmiş ve kullanıma alınmıştır.

105. **21.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

106. **21.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

107. **21.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

108. **21.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

109. **21.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

22: Uydular arası uzay tabanlı optik mesh-ağları kullanılmaktadır.

110. **22.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

111. **22.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

112. **22.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

113. **22.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

114. **22.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

23: GEO yörüngede uydular arası haberleşme kapasitesine sahip çoklu bant uydu geliştirilmiştir.

115. **23.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

116. **23.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

117. **23.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

118. **23.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

119. **23.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

24: Yüksek verimli çoklu nokta hüzmeli (High Throughput Multi Spot Beam) uydu geliştirilip kullanıma alınmıştır.

120. **24.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

121. **24.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

122. **24.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

123. **24.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

124. **24.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

25: Ataletsel ölçerler (dönüölçer, ivmeölçer) tüm seviyelerde (stratejik, navigasyon, taktik) geliştirilip kullanıma alınmıştır.

125. **25.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

126. **25.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

127. **25.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

128. **25.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

129. **25.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

26: Uzay ve hava platformları için fiber optik tabanlı navigasyon sistemi geliştirilmiştir.

130. **26.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

131. **26.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

132. **26.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

133. **26.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

134. **26.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

27: GaN tabanlı güç elemanı içeren modüllerde yüksek güç/yüksek verimlilik (>%50) hedeflerine geniş bant için erişilmiştir.

135. **27.a: Uzmanlık** *
Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok [Aşağıdaki soruları cevaplamadan, sayfanın sonundaki SONRAKİ düğmesine basınız.]

136. **27.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

137. **27.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**
Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Önemsiz						Çok Önemli

138. **27.d: Gerçekleşme Zamanı**
Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

139. **27.e: Başlangıç Yeteneği**
Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

Powered by
Google Forms

APPENDIX L THE SECOND ROUND DELPHI SURVEY WITH THE CONTROLLED FEEDBACK OF THE FIRST ROUND

Türk Savunma Sanayii 2040 Yılı Uzay ve Hava Haberleşme Teknolojileri Öngörüsü

İlk turdaki cevaplarınız işaretlenmiştir. Uzmanların ve diğer katılımcıların cevaplarına da bakarak, dilerseniz bu turda kendi cevabınızı değiştirebilirsiniz.

- Uzmanlık Düzeyiniz, Milli Güvenliğe Katkısı (öngördüğünüz), Ekonomiye Katkısı (öngördüğünüz), Gerçekleşme Zamanı (öngördüğünüz) ve Başlangıç Yeteneği (mevcut durumdaki) soru ana başlıklarıdır. Başlangıç yeteneği kısmındaki seçeneklerden Rekabet Öncesi Endüstriyel Geliştirme ile, bilgi alt yapısı ve finansman açısından işbirliği gerektiren prototip ve pilot üretimi de içeren faaliyetler kastedilmektedir.

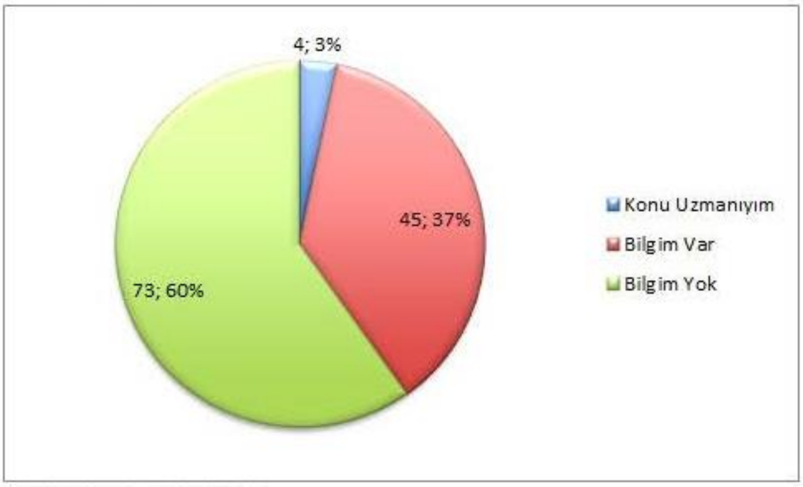
Her bir ana başlık için sadece tek bir seçeneği seçmeniz beklenmektedir.

* Gerekli

1. **E-posta adresi** *

1: Yönlü ortam erişimi (Directional Medium Access, DMA) ile girişim yönetimi (Interference Management) yapabilen ağ tabanlı haberleşme sistemi geliştirilmiştir.

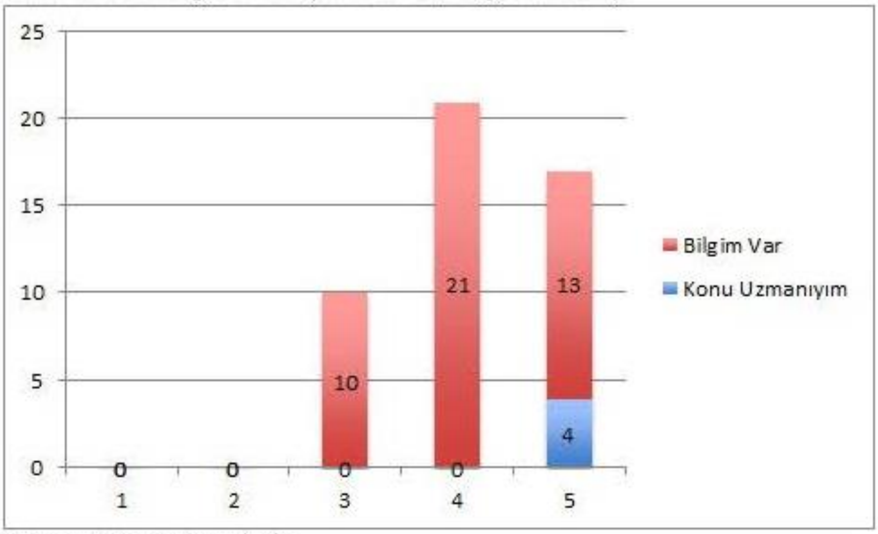
2. **1.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

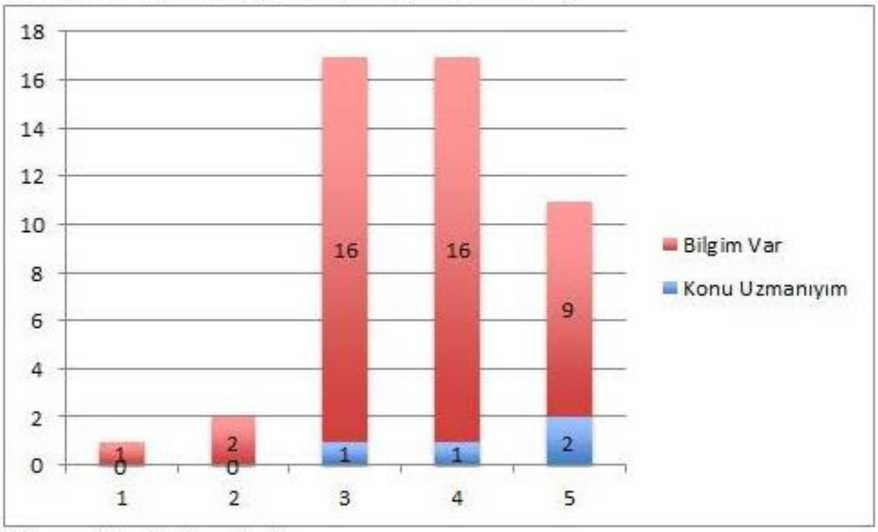
3. **1.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

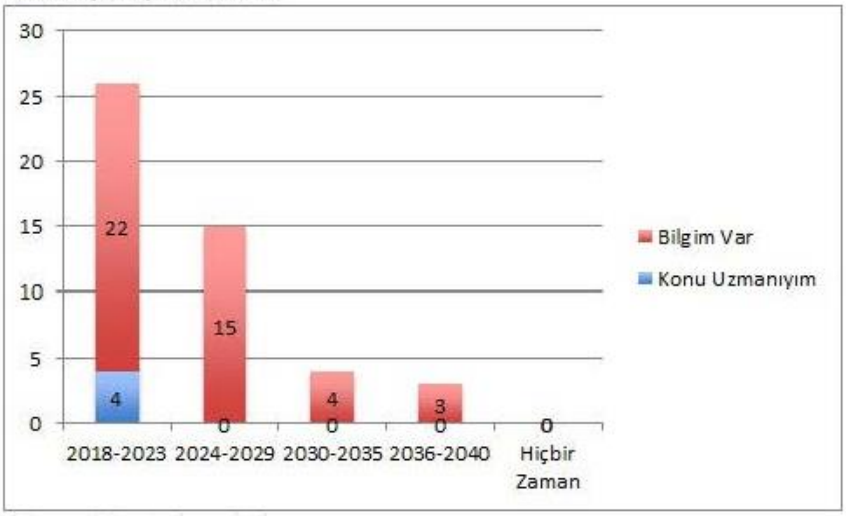
4. **1.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

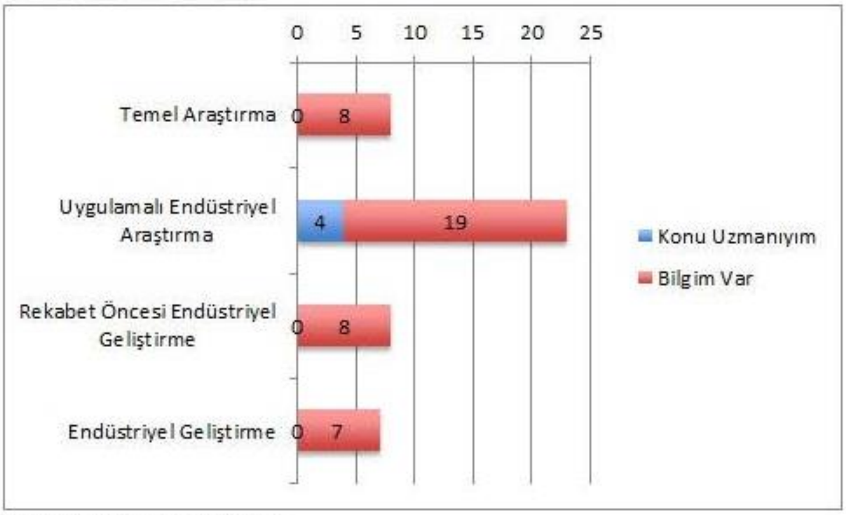
5. **1.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

6. **1.e: Başlangıç Yeteneği**

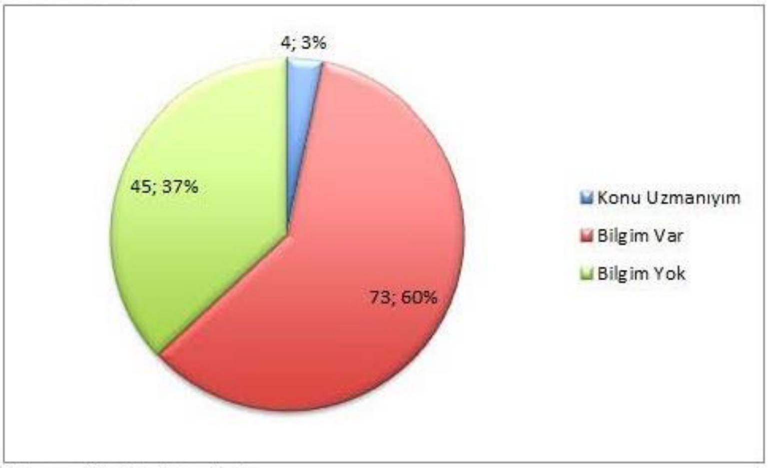


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

2: Stratosferik Balonlar kullanılarak uydular ile koordineli ve uydulardan bağımsız çalışabilen bölgesel haberleşme ve konumlandırma sistemleri geliştirilmiştir.

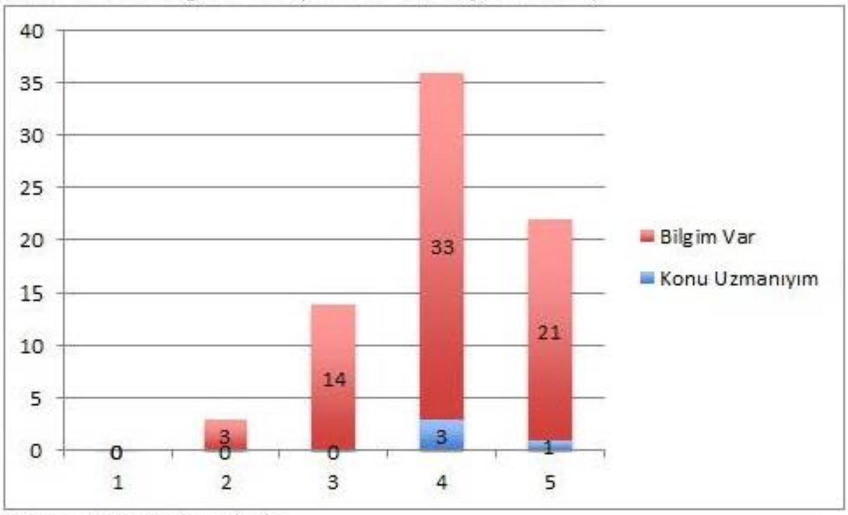
7. **2.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

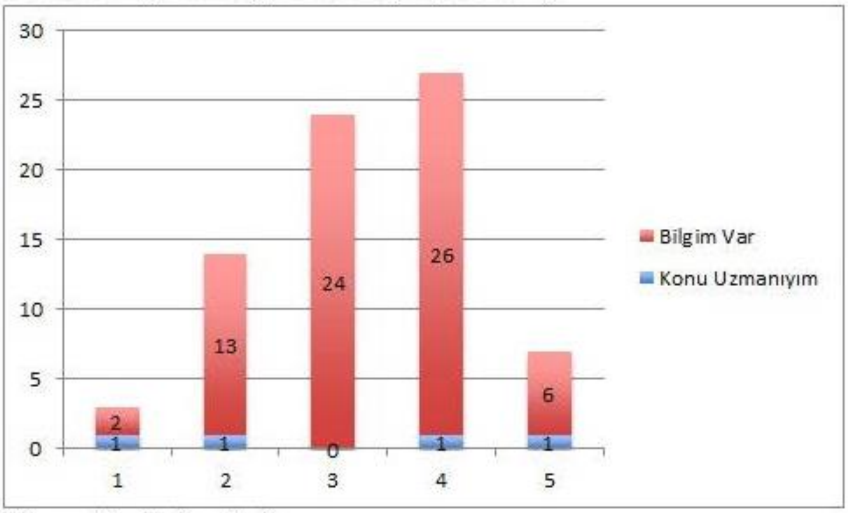
8. **2.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

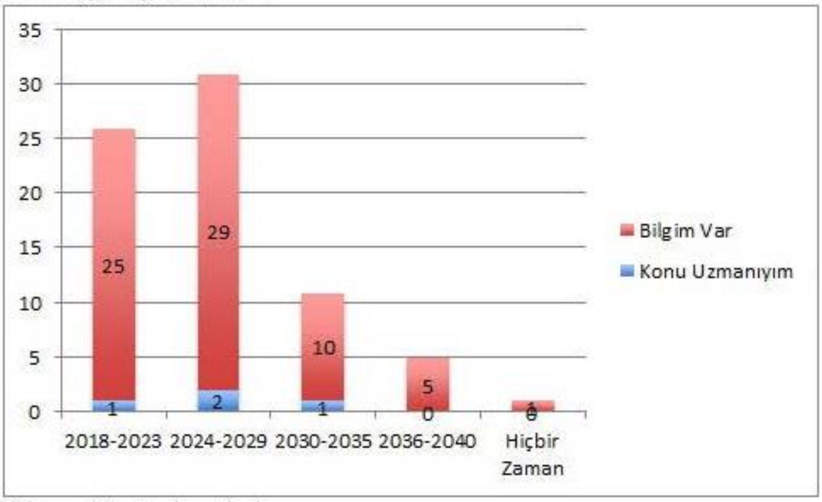
9. **2.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

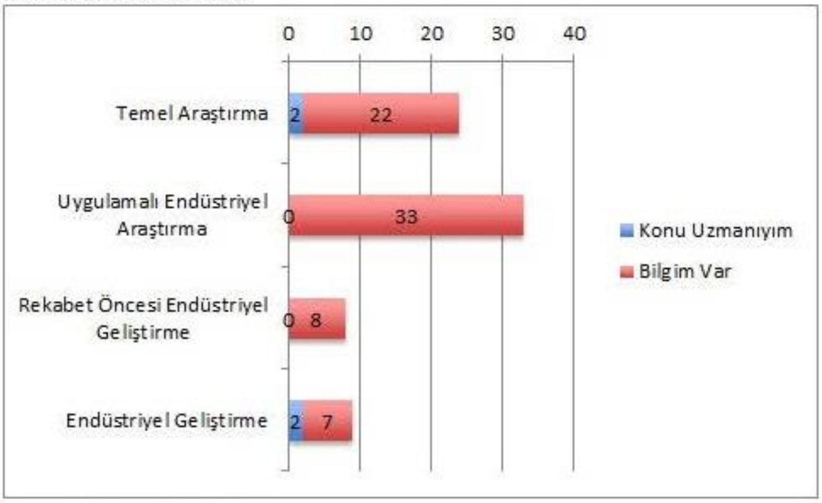
10. **2.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

11. **2.e: Başlangıç Yeteneği**

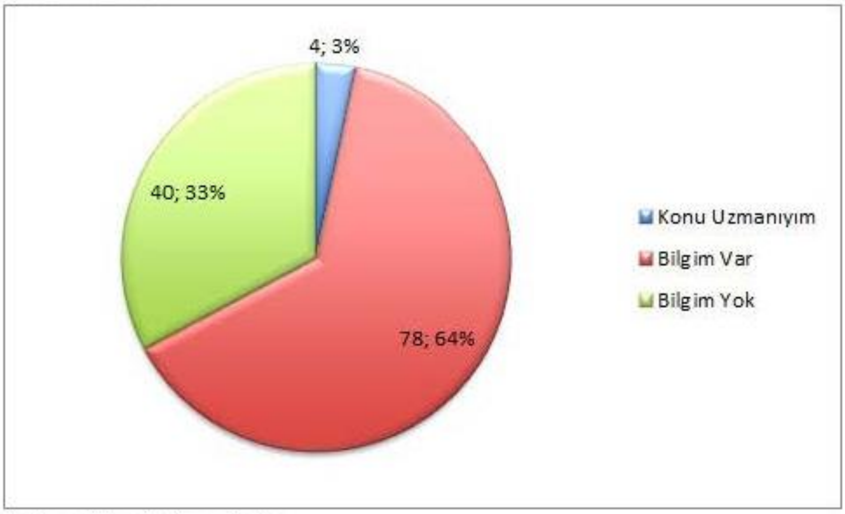


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

3: Sürü (Swarm) İHA/SİHA haberleşme ağında büyük veri içinden elde edilecek istihbaratın anlamlandırılmasını sağlayan bilgi teknolojileri geliştirilmiştir.

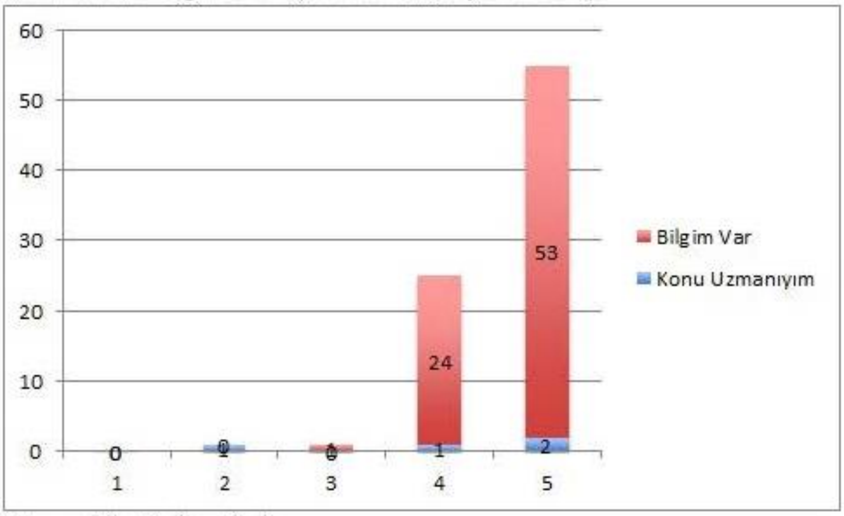
12. **3.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

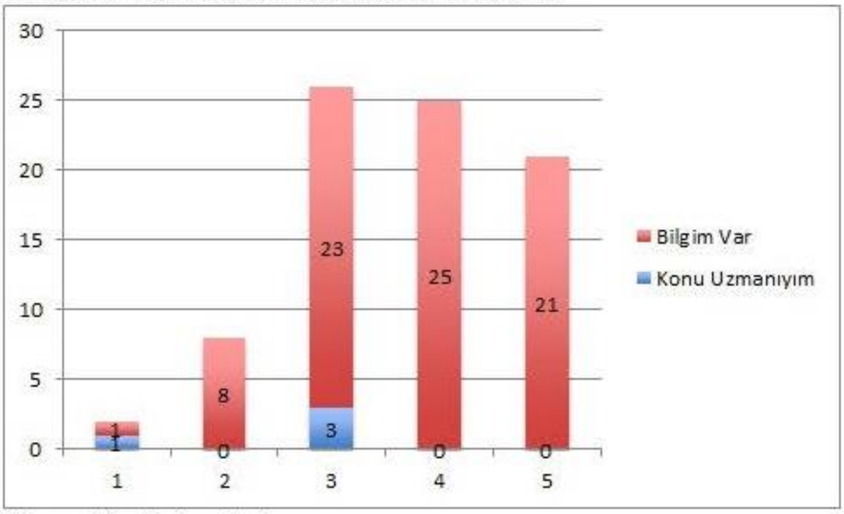
13. **3.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

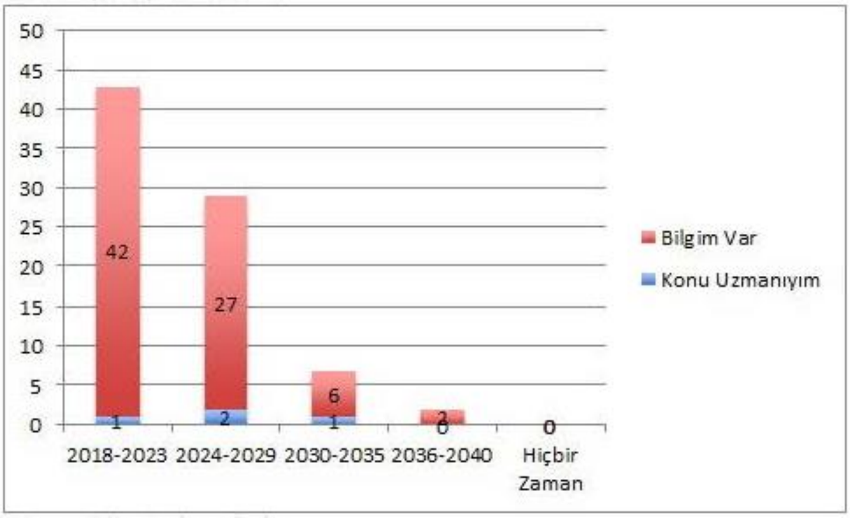
14. **3.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

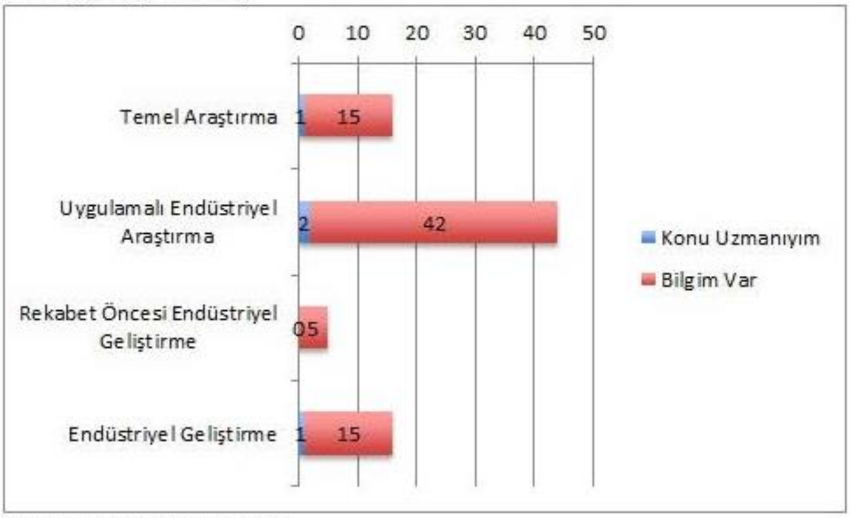
15. **3.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

16. **3.e: Başlangıç Yeteneği**

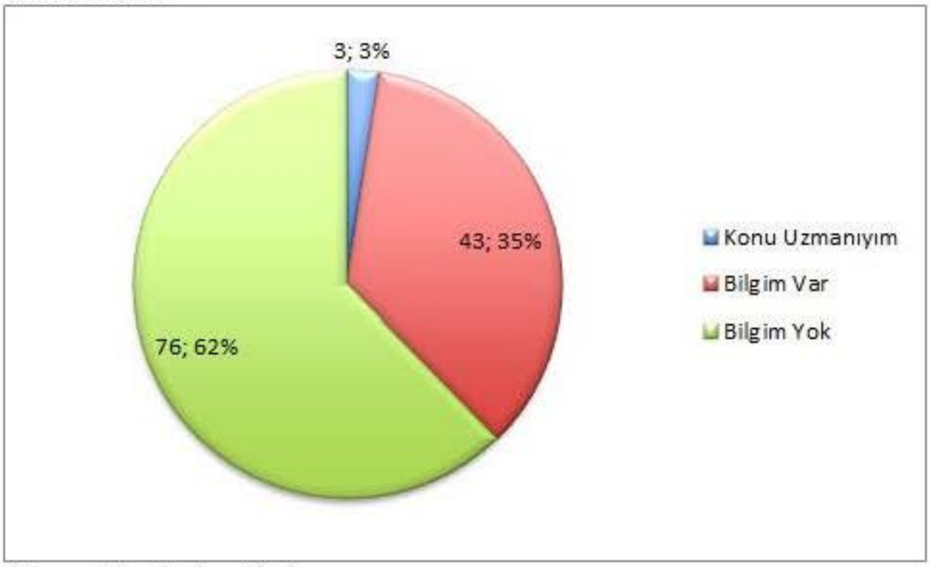


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

4: Kuantum Kriptoloji teknikleri kullanılmaktadır.

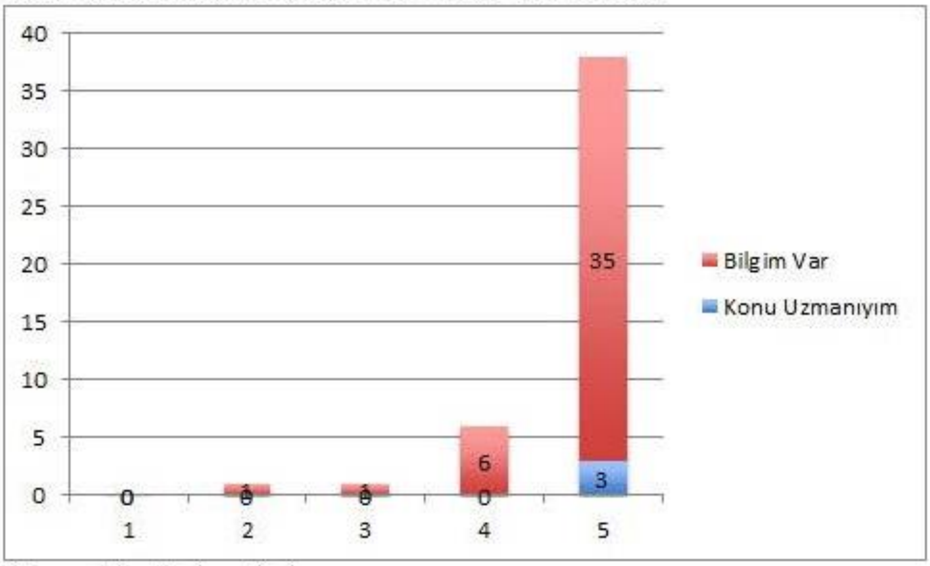
17. **4.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

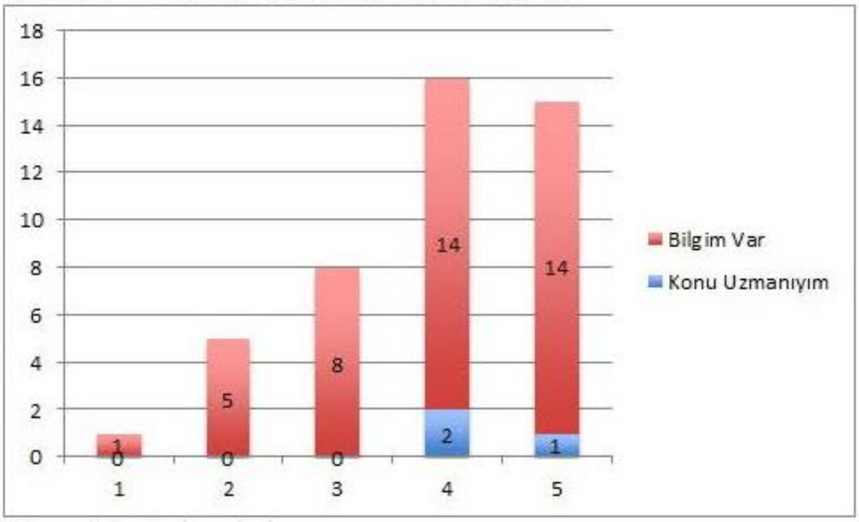
18. **4.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

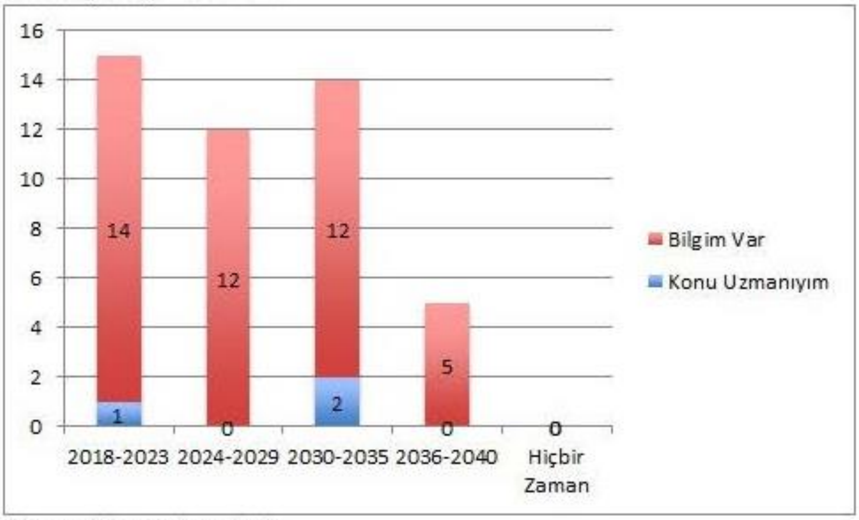
19. **4.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

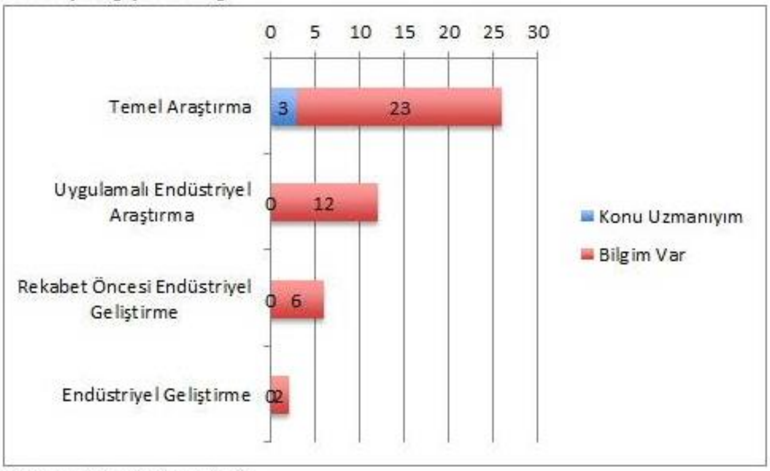
20. **4.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

21. **4.e: Başlangıç Yeteneği**

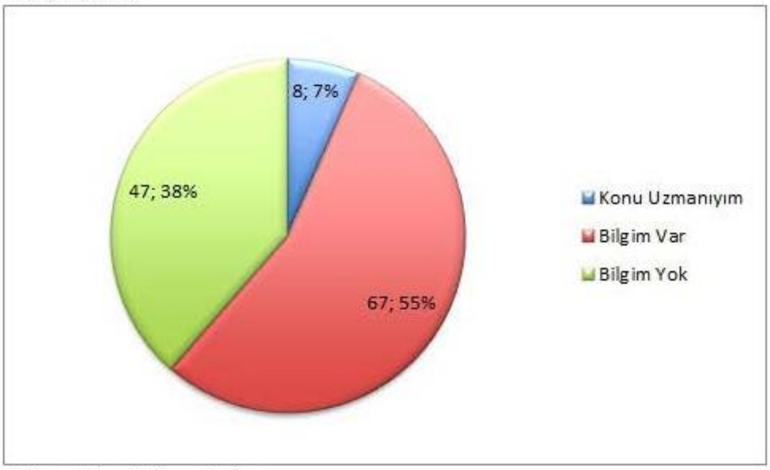


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

5: Kendi kendine organize olabilen, ağ yükü optimizasyonu yapma yeteneğine sahip (uç nokta hesaplaması vb.) ve kendi kendini iyileştirebilen akıllı haberleşme ağları kullanılmaktadır.

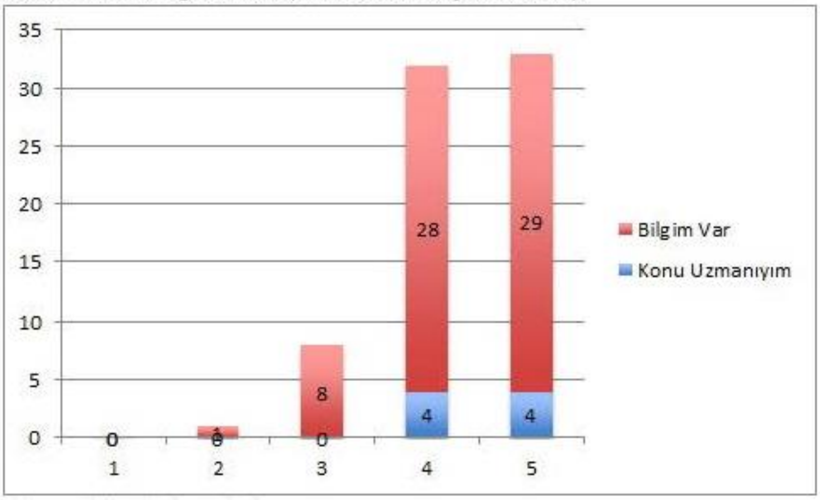
22. **5.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

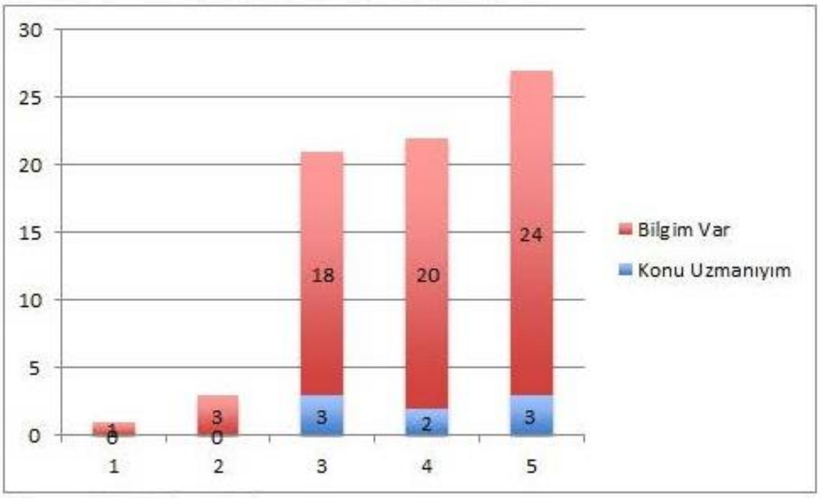
23. **5.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

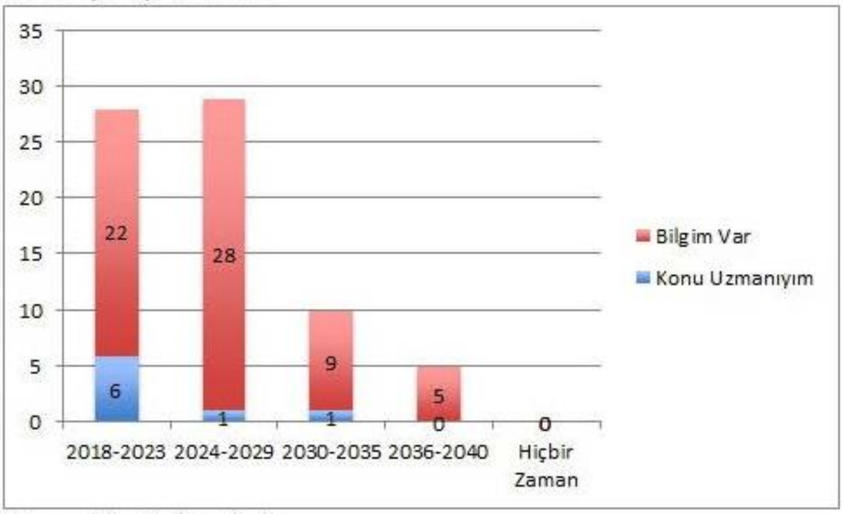
24. **5.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

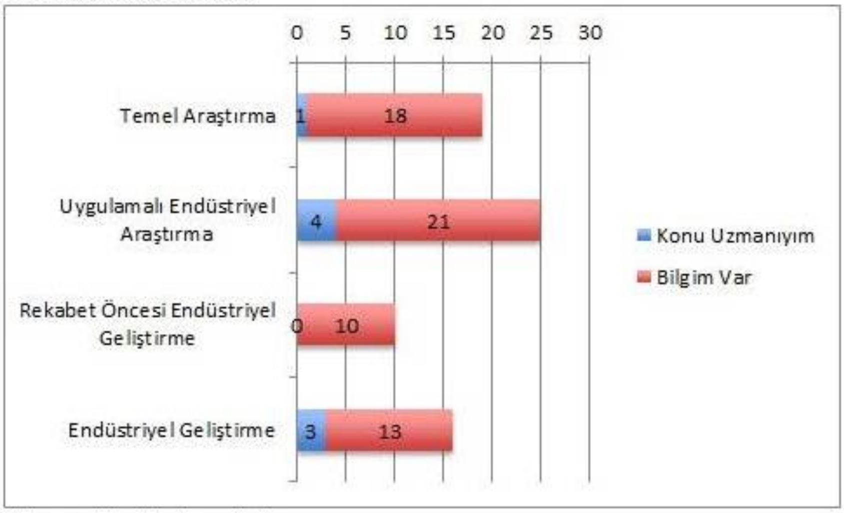
25. **5.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

26. **5.e: Başlangıç Yeteneği**

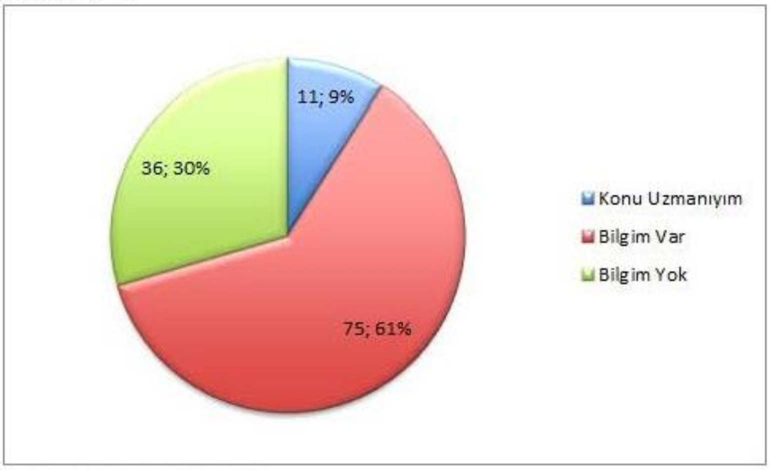


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

6: Uydular ve hava platformları ile göreceli navigasyon alt yapısı oluşturularak hareketli durumda haberleşme ve bilgi sistemi ağı geliştirilmiştir.

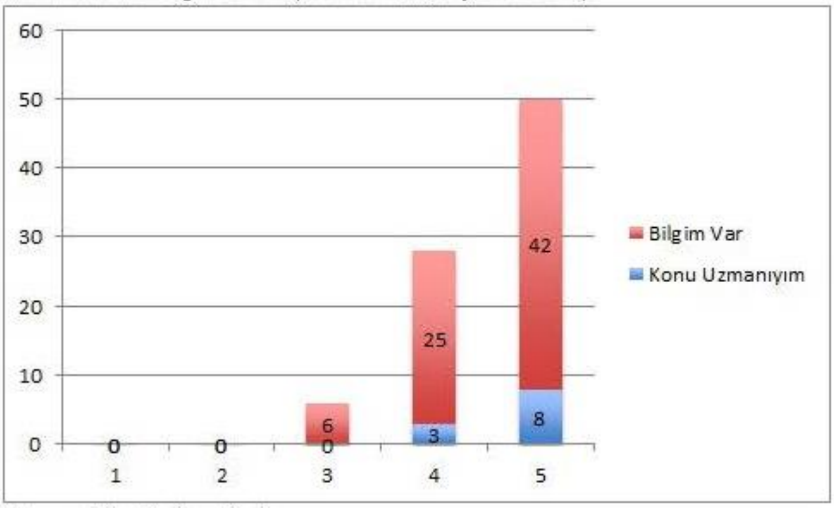
27. **6.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

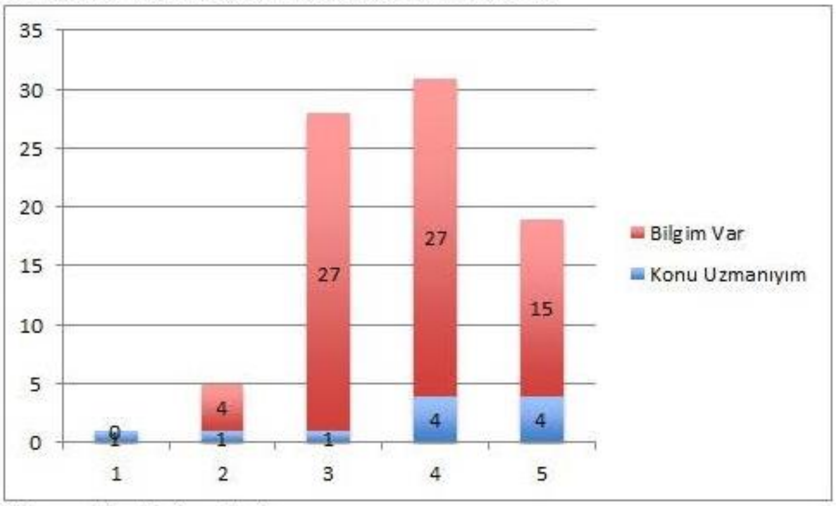
28. **6.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

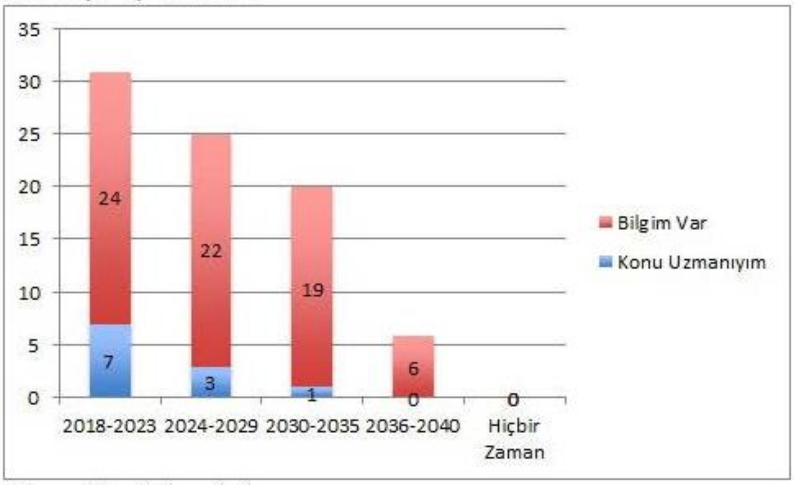
29. **6.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

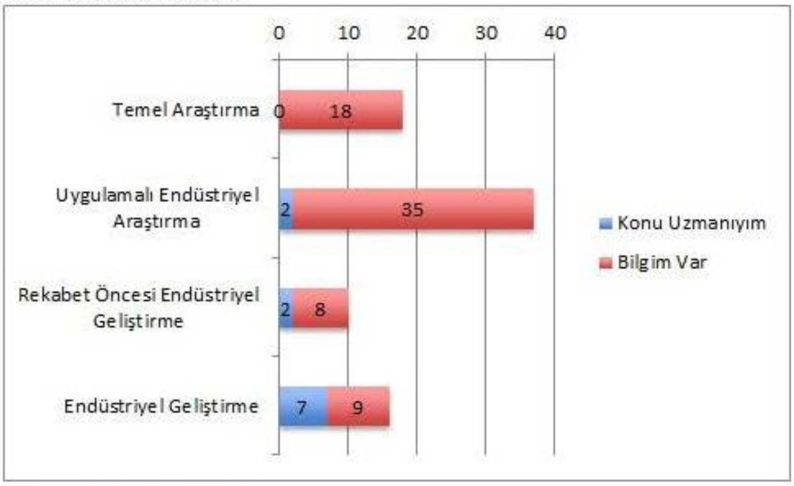
30. **6.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

31. **6.e: Başlangıç Yeteneği**

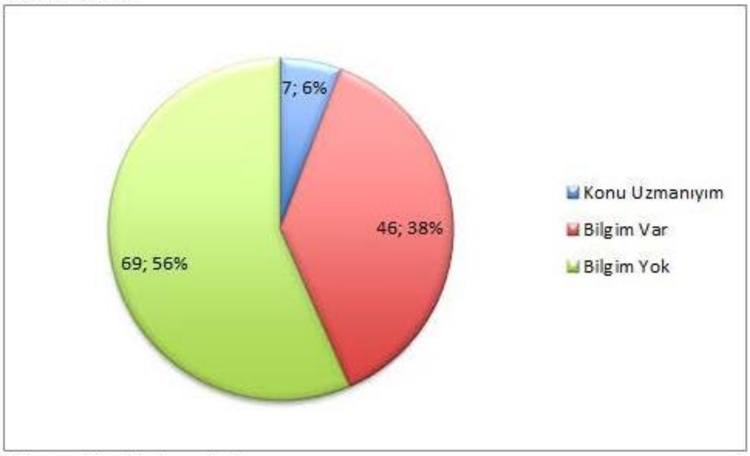


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

7: Hava ve uzay platformları akıllı bir ağ üzerinden haberleşebilme ve pozisyonel kodlarını iyonosferden kaynaklanan bozulmalara rağmen düzeltebilme ve bu sayede dar iletişim hüzmeleri kullanarak ağ yapısını gürbüz şekilde koruyabilme yeteneğine sahip şekilde geliştirilmiştir.

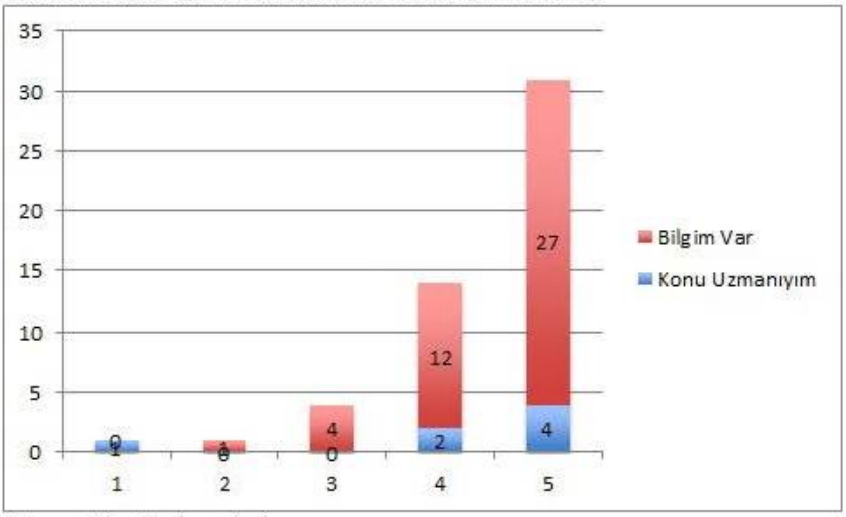
32. **7.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

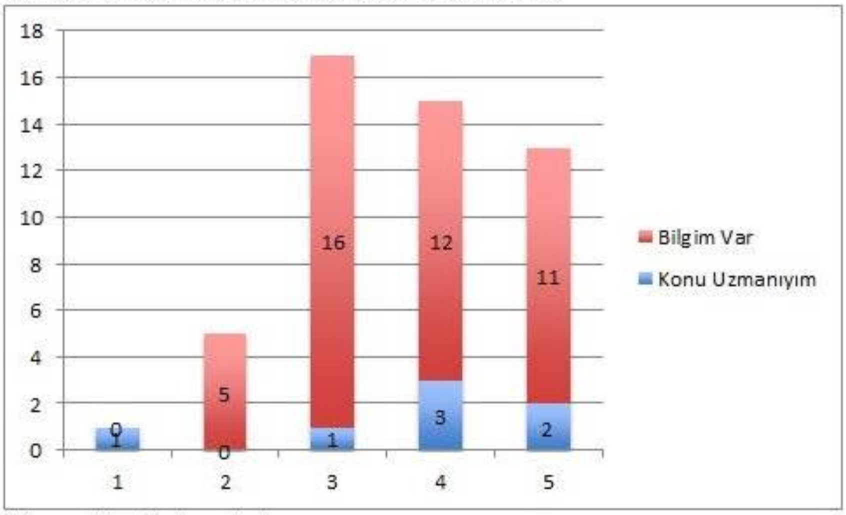
33. **7.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

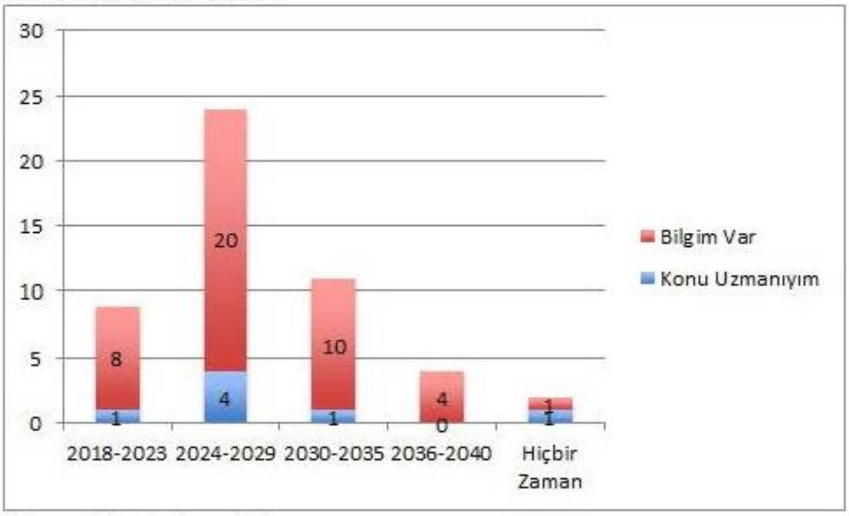
34. **7.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

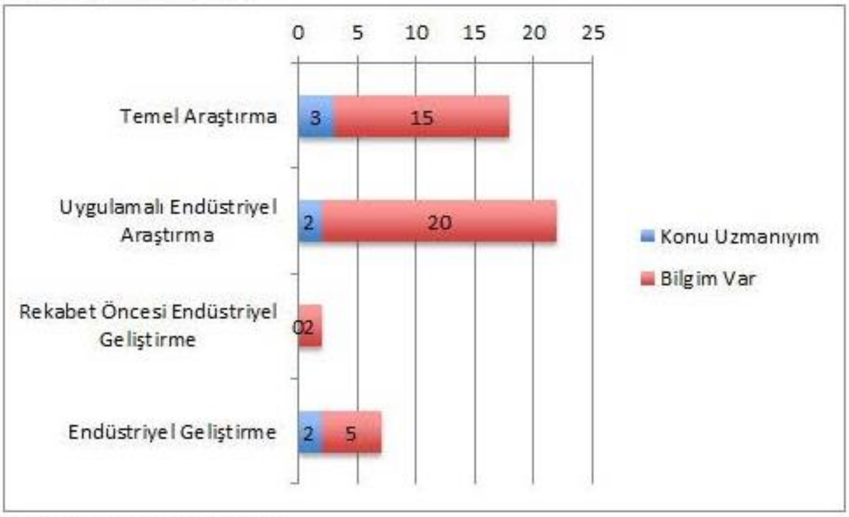
35. **7.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

36. **7.e: Başlangıç Yeteneği**

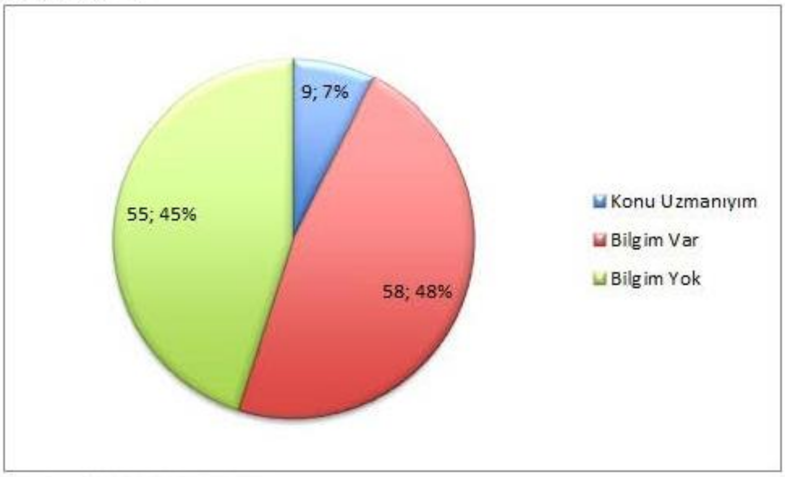


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

8: Hava ve uzay platformları arasında güvenli iletişim, yüksek hızlı iletişim (>=100GB/sn) ve verimli iletişim (>1pJ/bit) sağlayan kodlama ve kod çözme teknolojileri kullanılmaktadır.

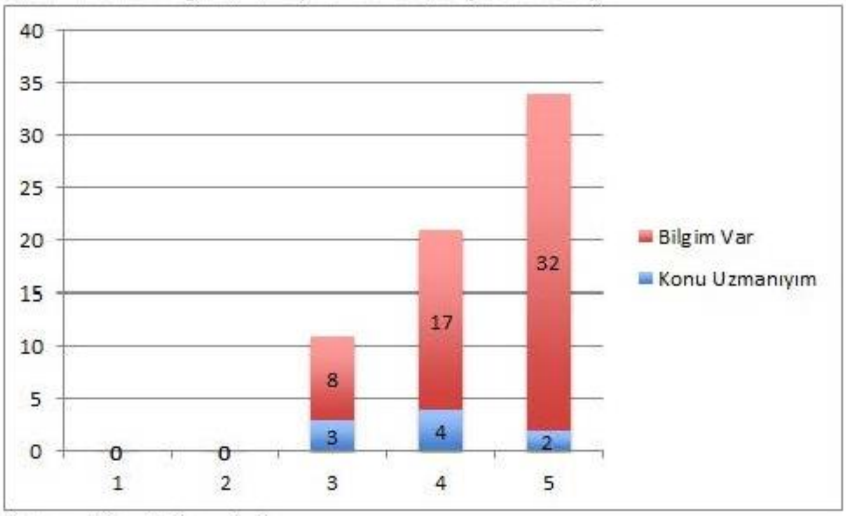
37. **8.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

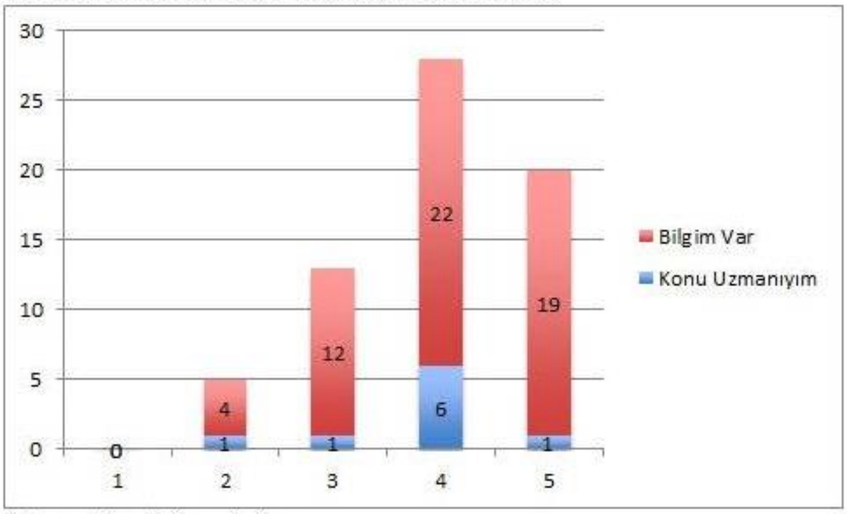
38. **8.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

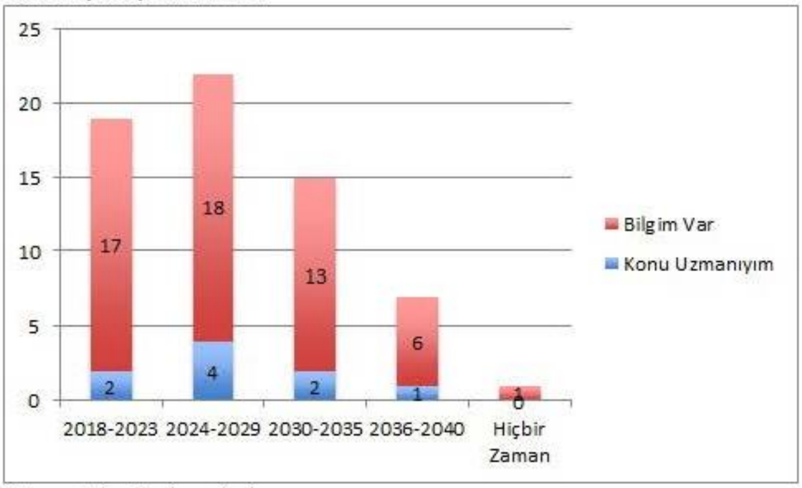
39. **8.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

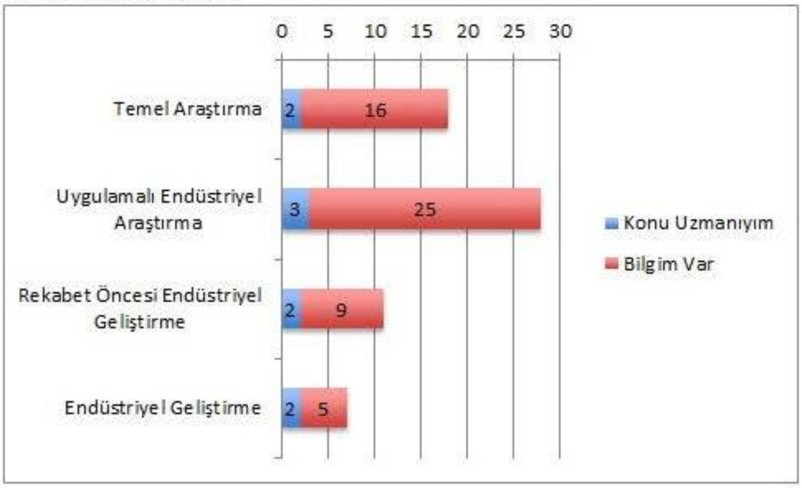
40. **8.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

41. **8.e: Başlangıç Yeteneği**

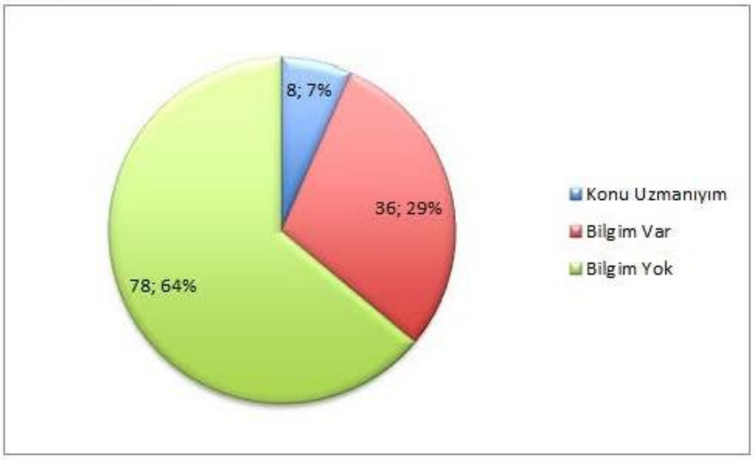


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

9: Hava platformları arasında orta-kısa menzilli, iki yönlü yüksek veri iletişimi sağlayan, birbirlerine kilitli dar hüzmeli Ad-Hoc (Electronic Counter Measure-ECM ve Low Probability of Intercept-LPI özellikli) hava tabanlı ağ oluşturulmuştur.

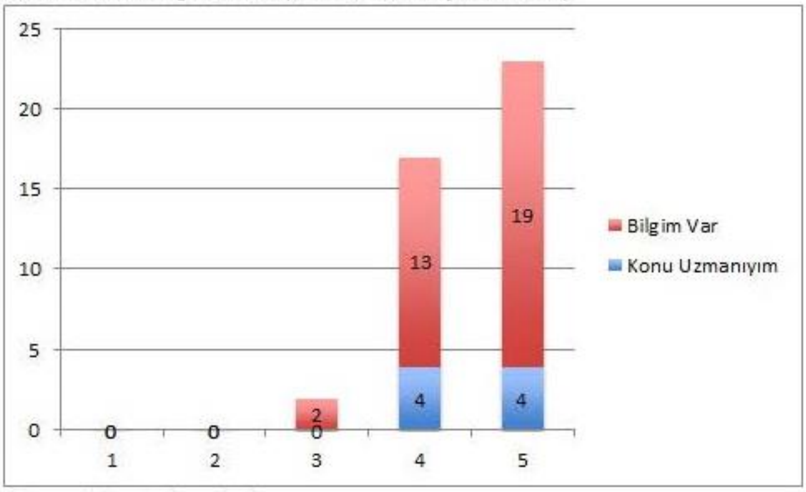
42. **9.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

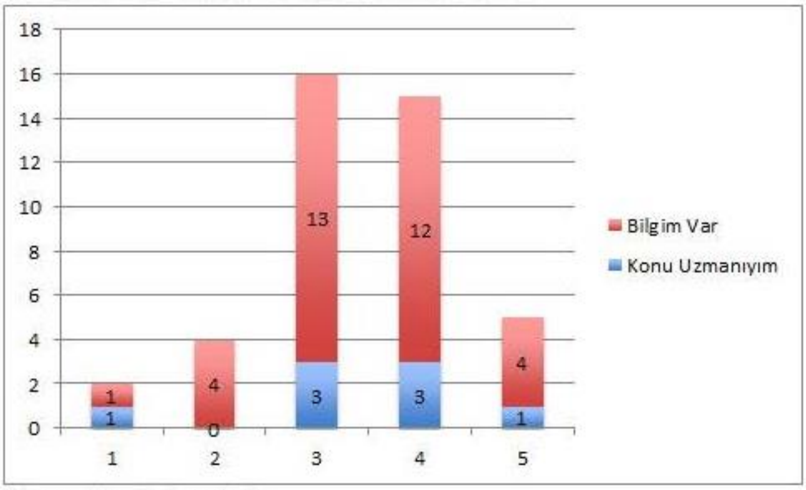
43. **9.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

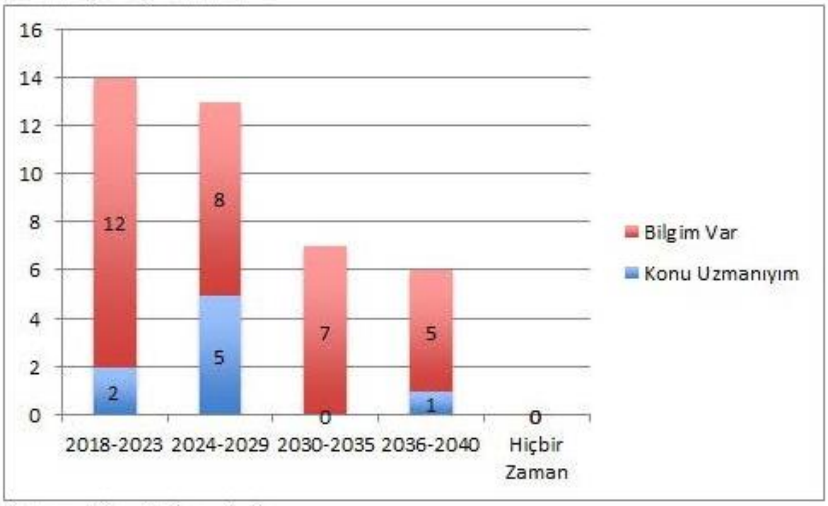
44. **9.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

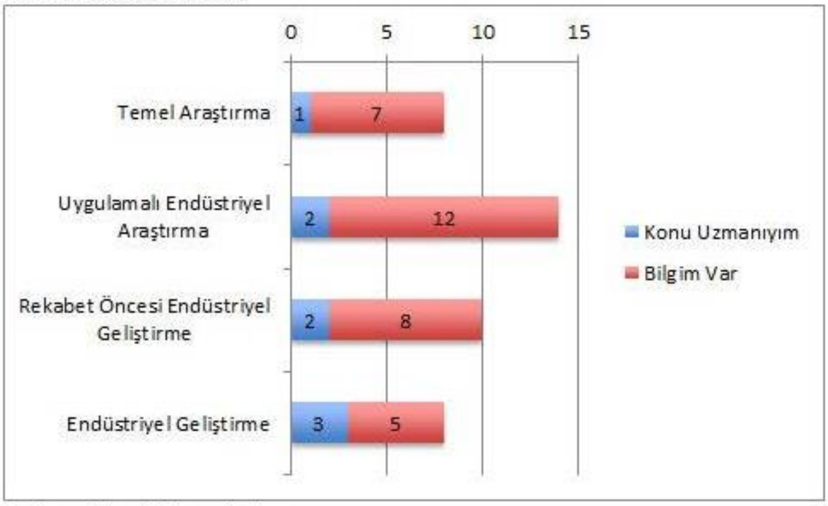
45. **9.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

46. **9.e: Başlangıç Yeteneği**

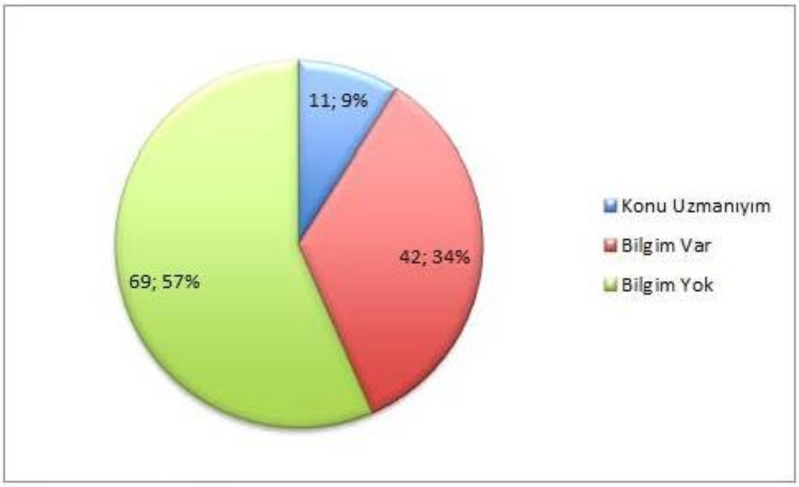


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

10: Orbitte uzaktan programlanabilen Ka band yazılım tabanlı telsiz sistemleri geliştirilmiştir.

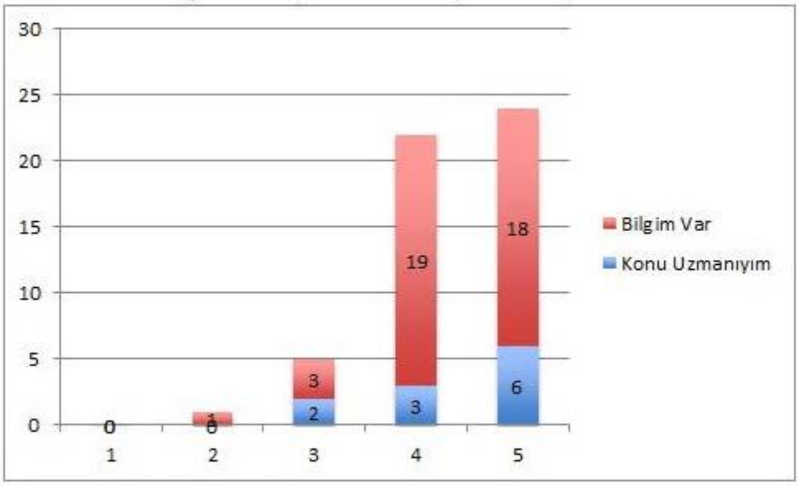
47. **10.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

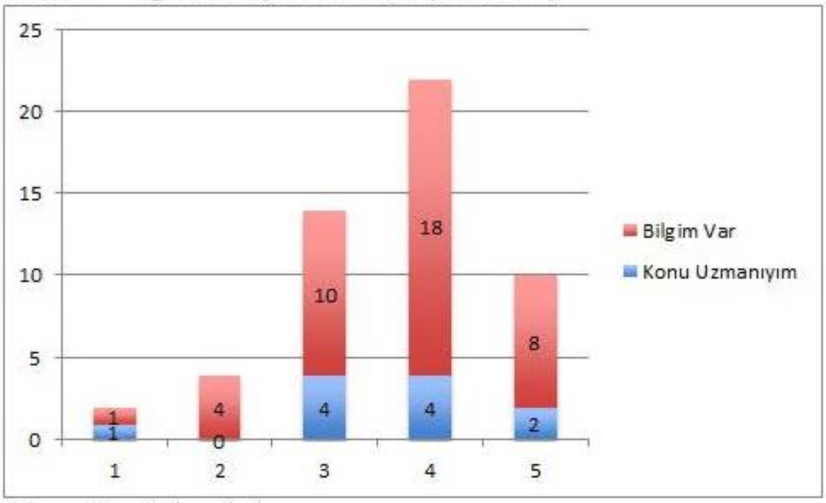
48. **10.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

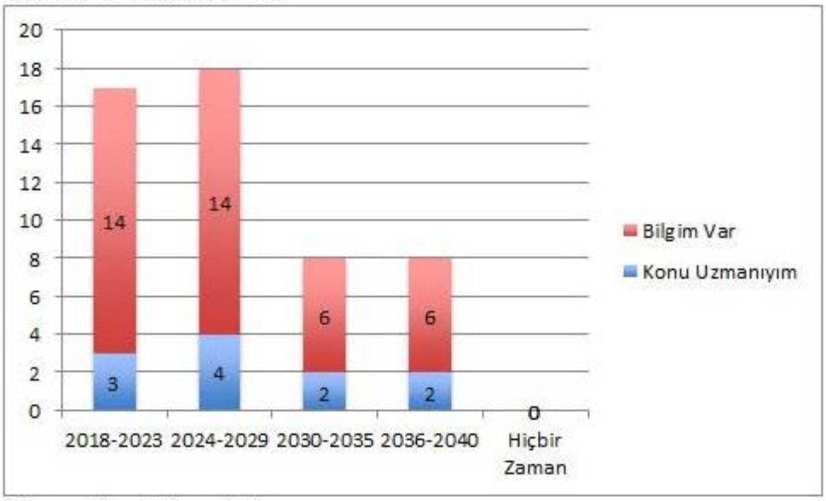
49. **10.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

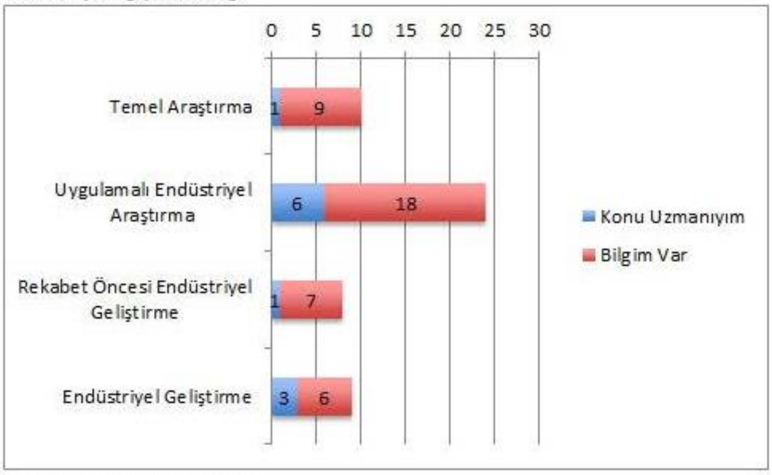
50. **10.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

51. **10.e: Başlangıç Yeteneği**

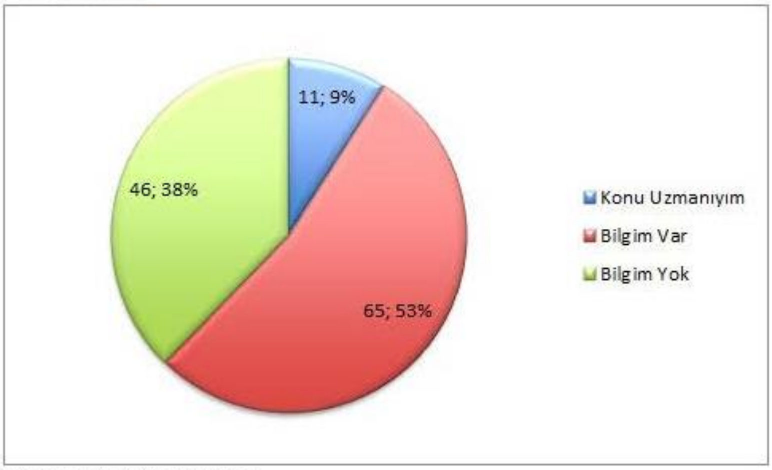


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

11: Sürü (SWARM) İHA/SİHA ve insanlı hava araçlarının yoğun haberleşmesini kesintisiz/emniyetli olarak karşılayan taktik (araçlar arası) ve uydu (uydu-araç) linkleri kullanılmaktadır.

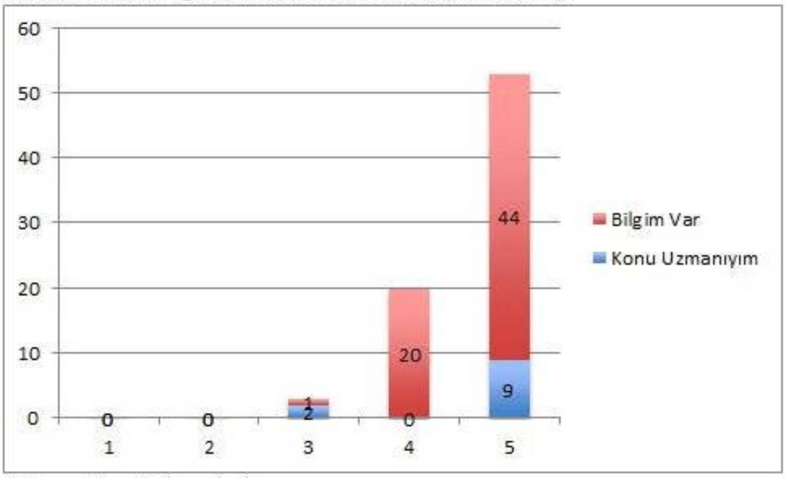
52. **11.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

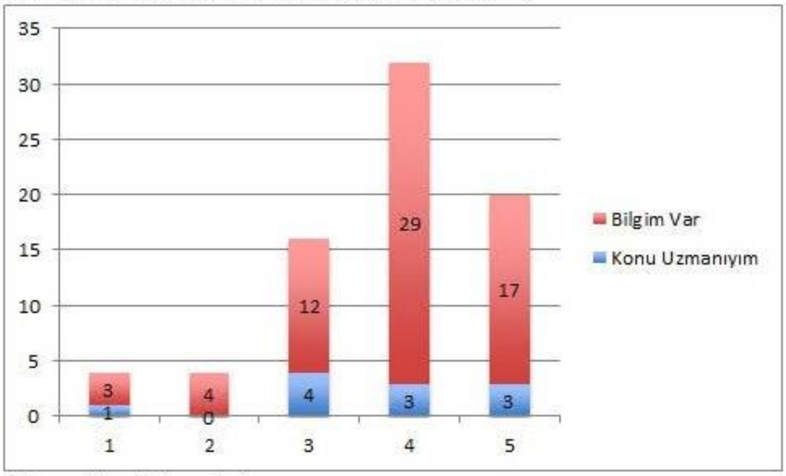
53. **11.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

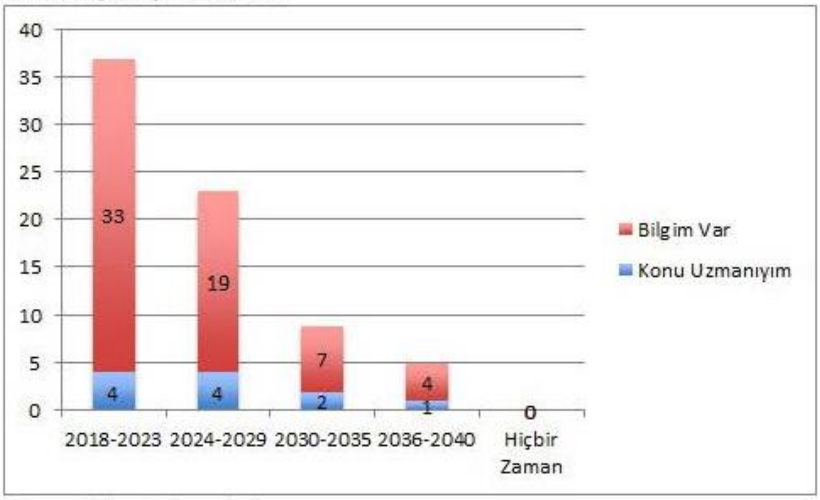
54. **11.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

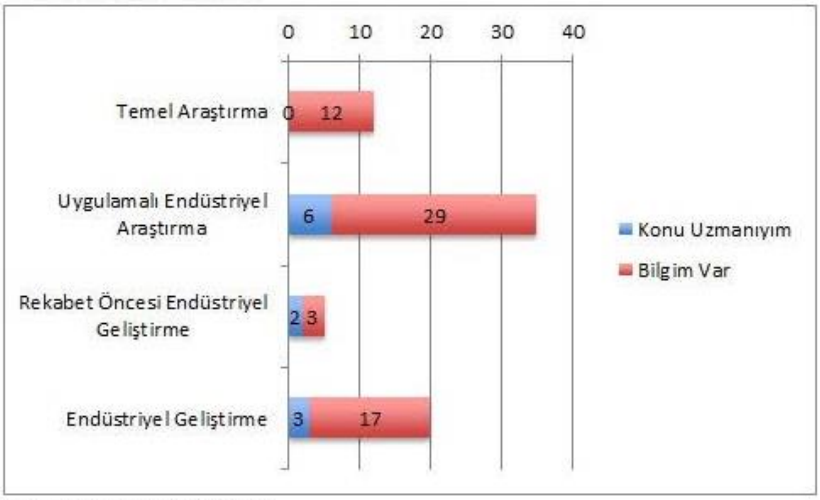
55. **11.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

56. **11.e: Başlangıç Yeteneği**

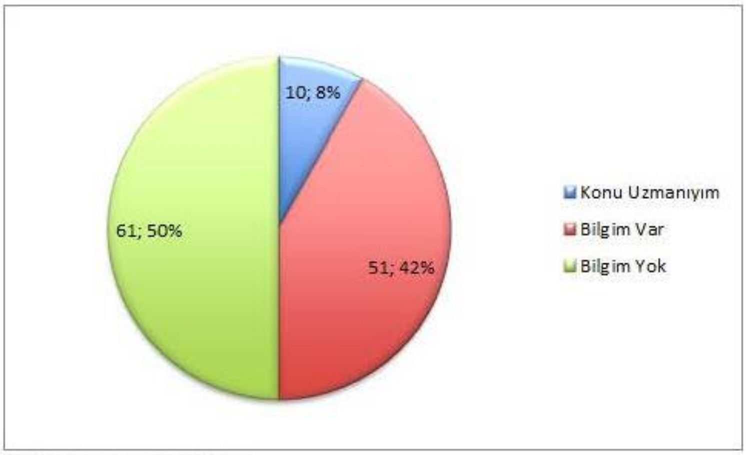


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

12: Takip ve veri aktarma haberleşme uydusu (Tracking and Data Relay Satellite) geliştirilip kullanıma alınmıştır.

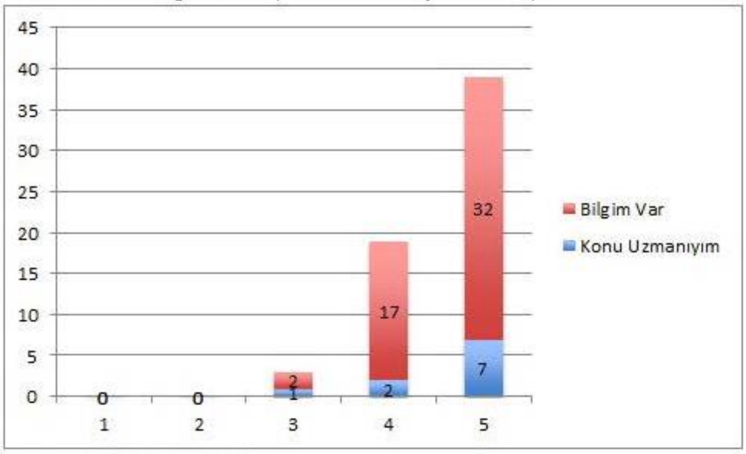
57. **12.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

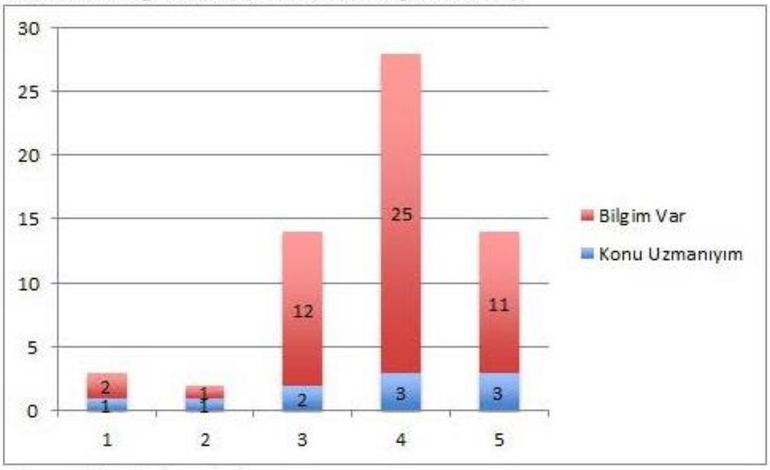
58. **12.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

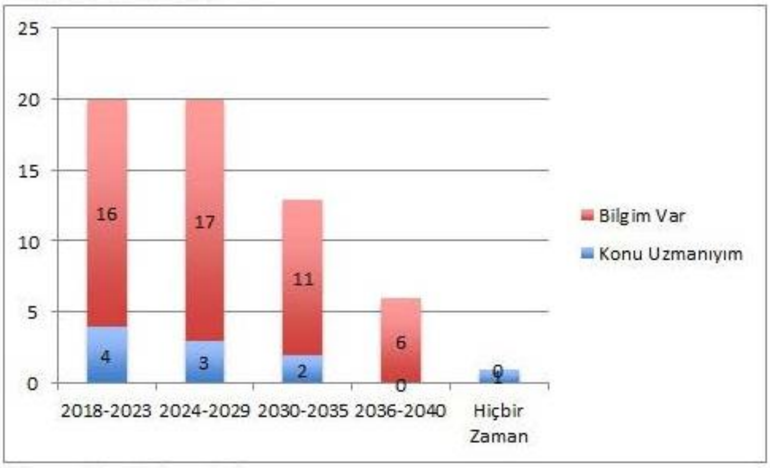
59. **12.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ⬭ 1
- ⬭ 2
- ⬭ 3
- ⬭ 4
- ⬭ 5

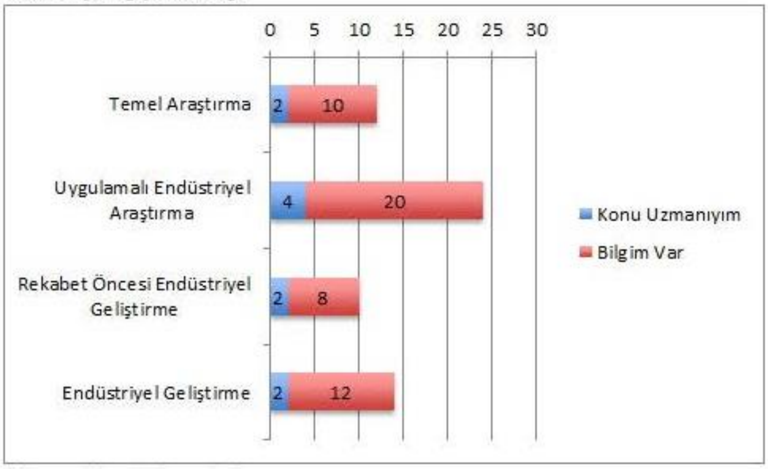
60. **12.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- ⬭ 2018-2023
- ⬭ 2024-2029
- ⬭ 2030-2035
- ⬭ 2036-2040
- ⬭ Hiçbir Zaman

61. **12.e: Başlangıç Yeteneği**

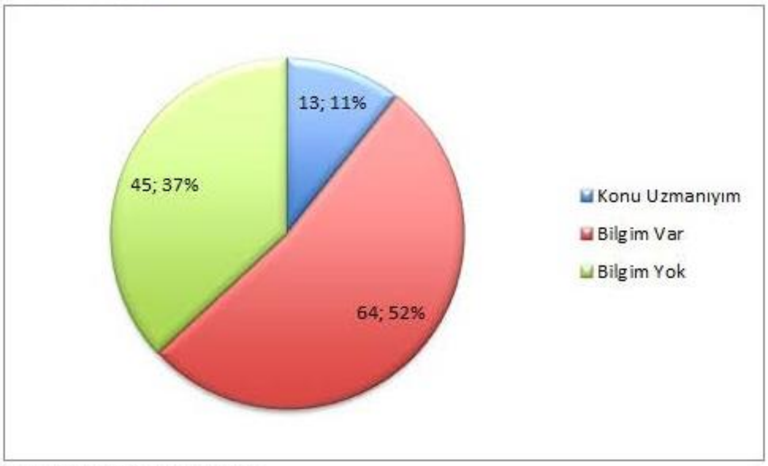


Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

13: Düşük maliyetli, kolay üretilebilen, elektronik yönlendirme tabanlı sayısal hüzme biçimlendirmeli anten teknolojileri kullanılmaktadır.

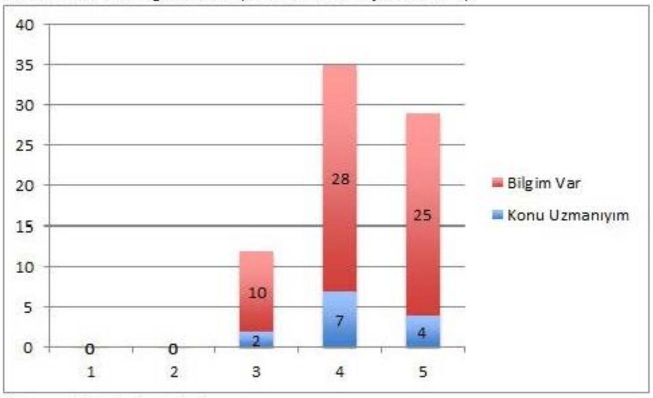
62. **13.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- ◯ Konu Uzmanıyım
- ◯ Bilgim Var
- ◯ Bilgim Yok

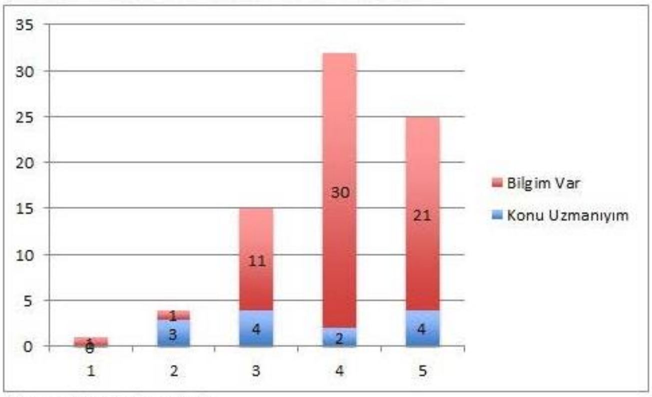
63. **13.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

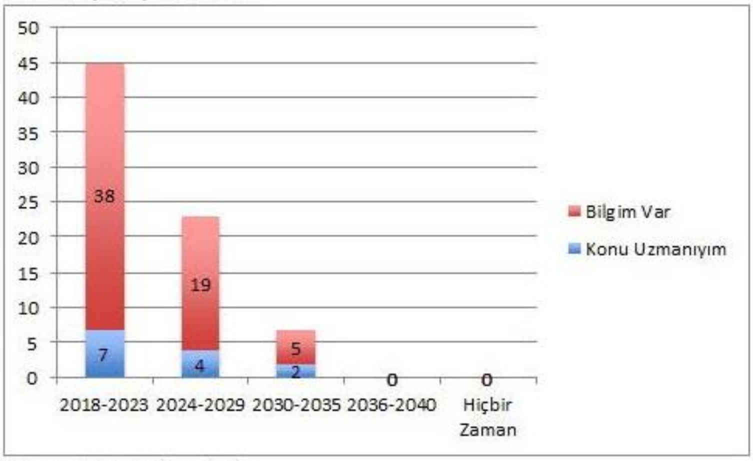
64. **13.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

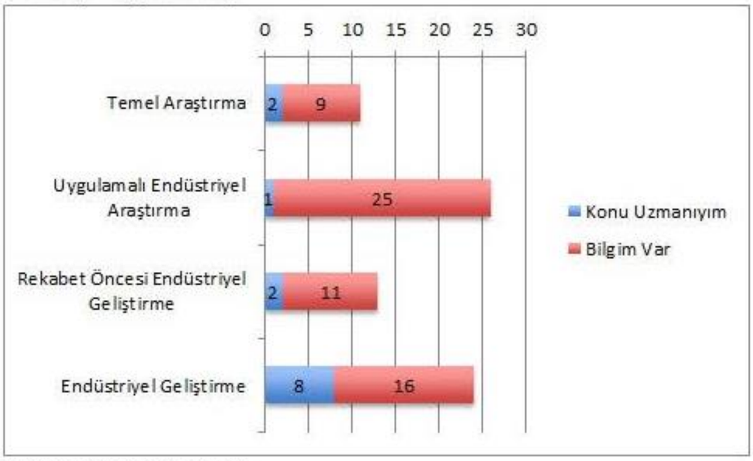
65. **13.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

66. **13.e: Başlangıç Yeteneği**

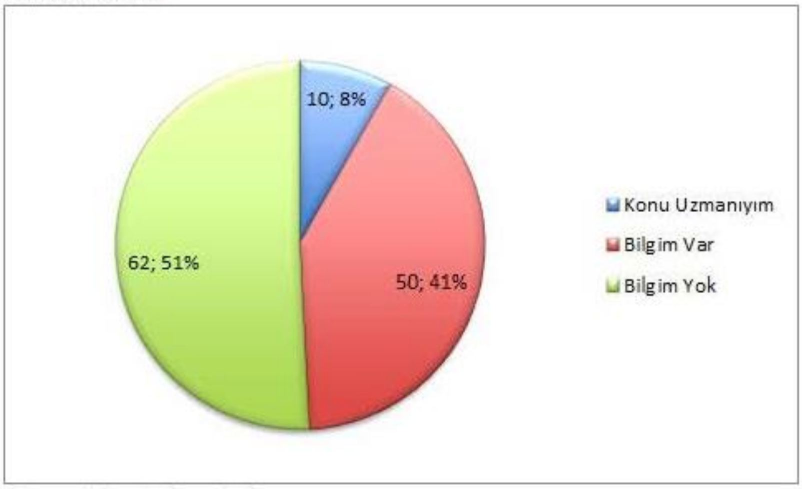


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

14: Bilişsel ağ teknolojilerine ve protokollerine sahip olunmuştur.

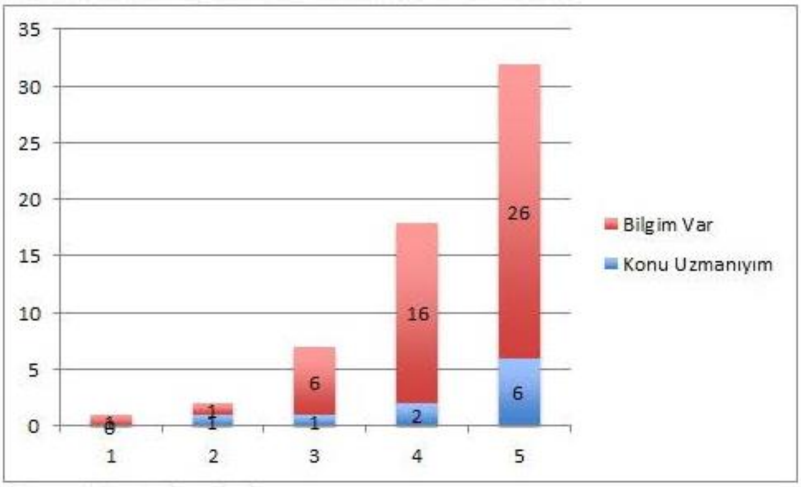
67. **14.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

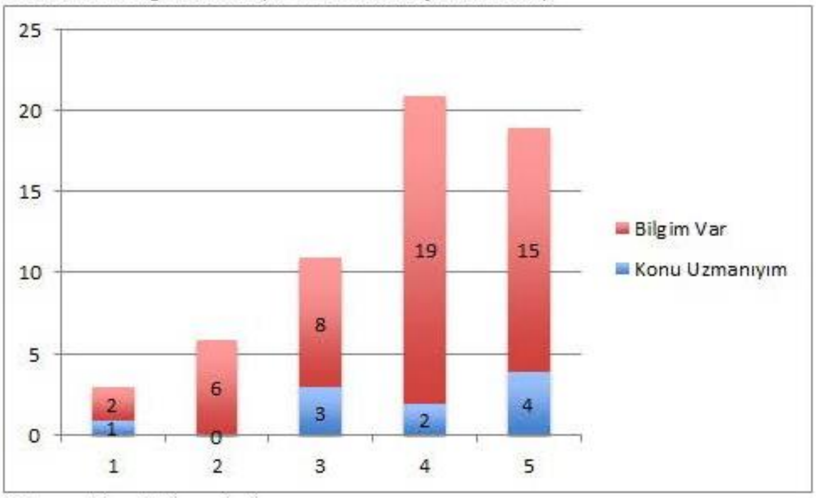
68. **14.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

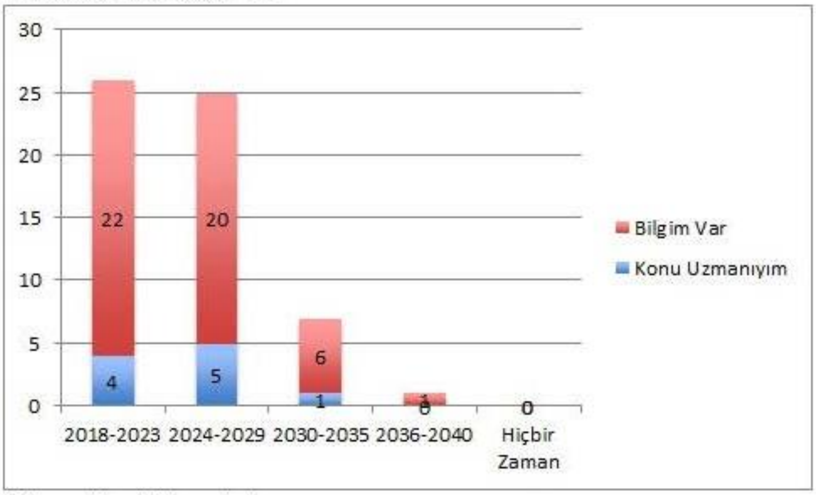
69. **14.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

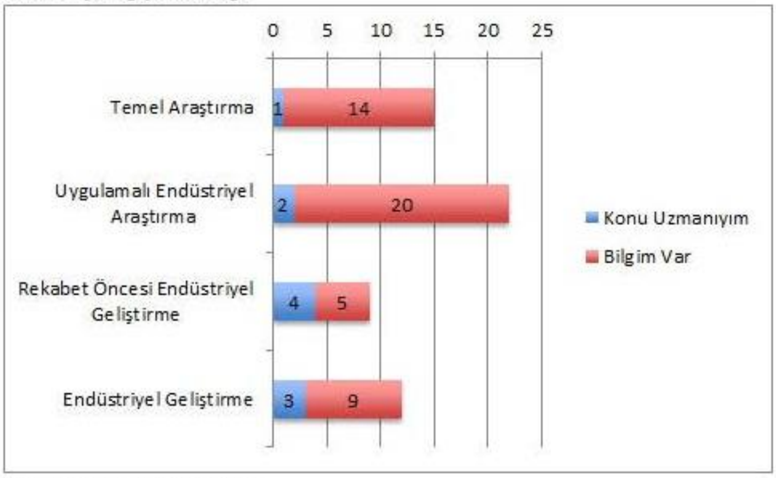
70. **14.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

71. **14.e: Başlangıç Yeteneği**

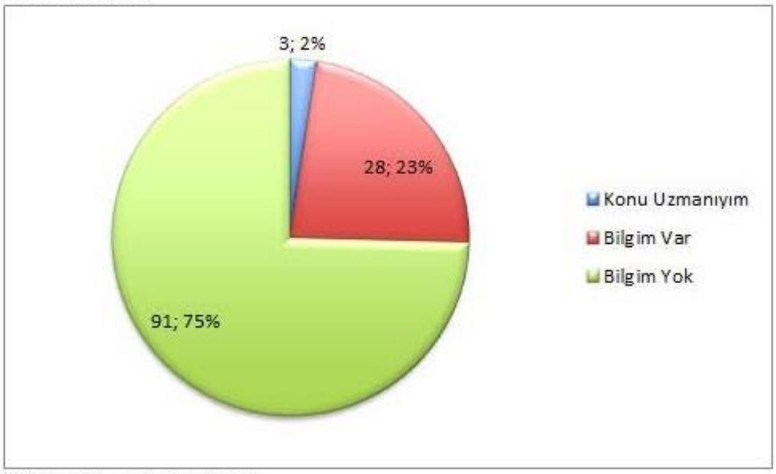


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

15: Frekansa göre yeniden yapılandırılabilen grafen tabanlı Terahertz Anten teknolojileri geliştirilmiştir.

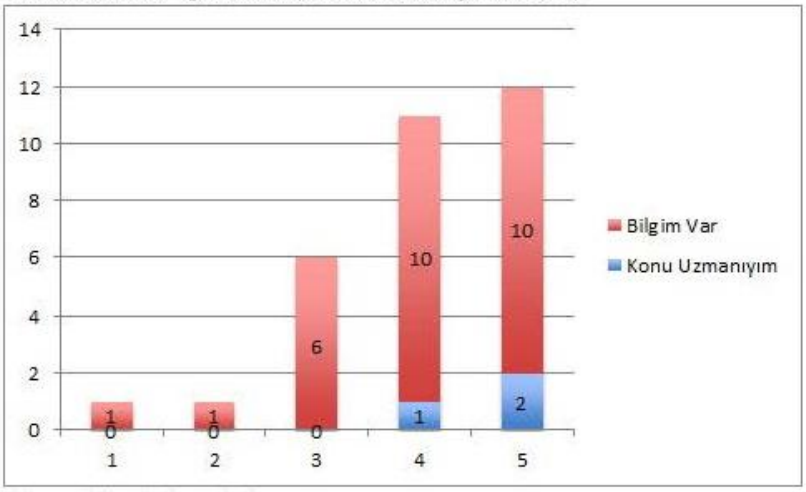
72. **15.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

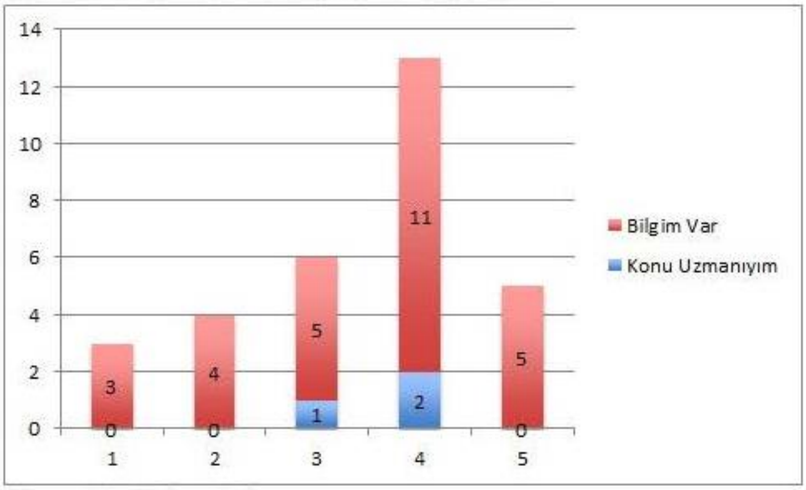
73. **15.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

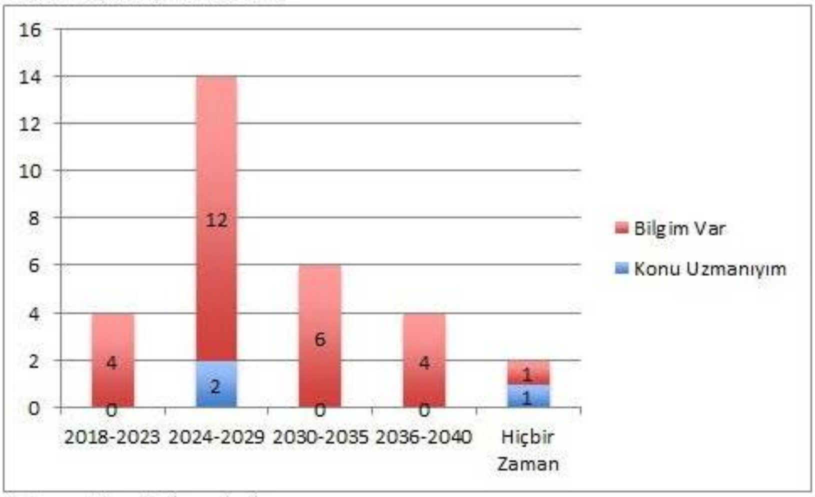
74. **15.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

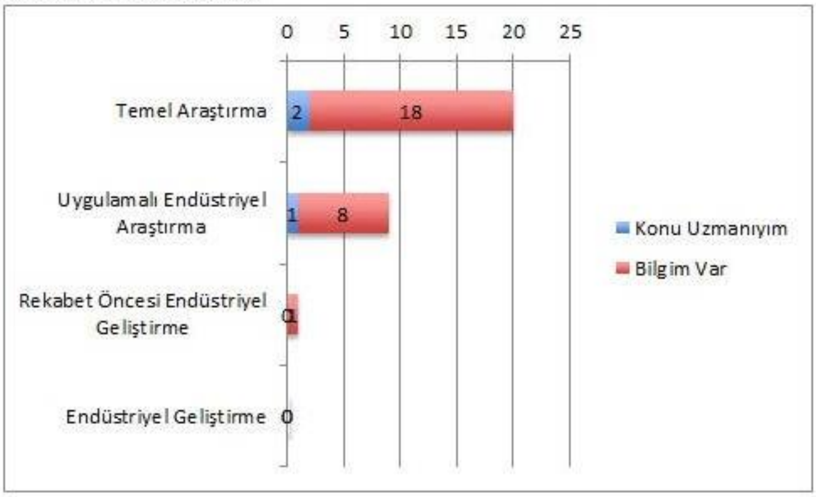
75. **15.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

76. **15.e: Başlangıç Yeteneği**

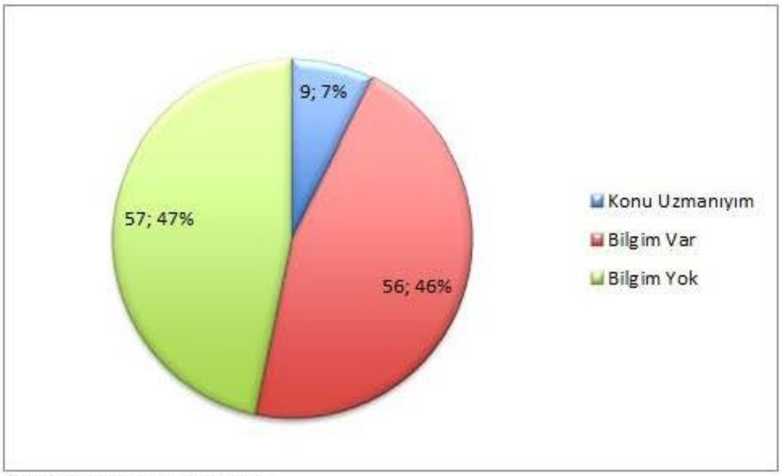


Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

16: Uydu ile İHA/SİHA/Uçak/Balon/Zeplin/Helikopter arasında açık alan optik kablosuz iletişim kullanılmaktadır.

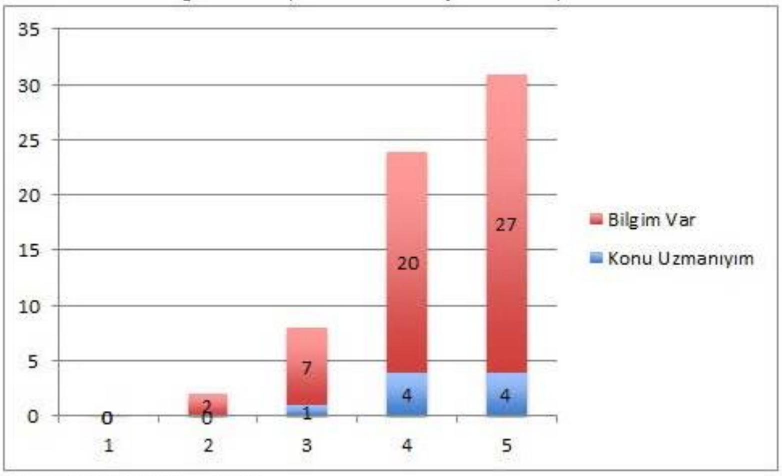
77. **16.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

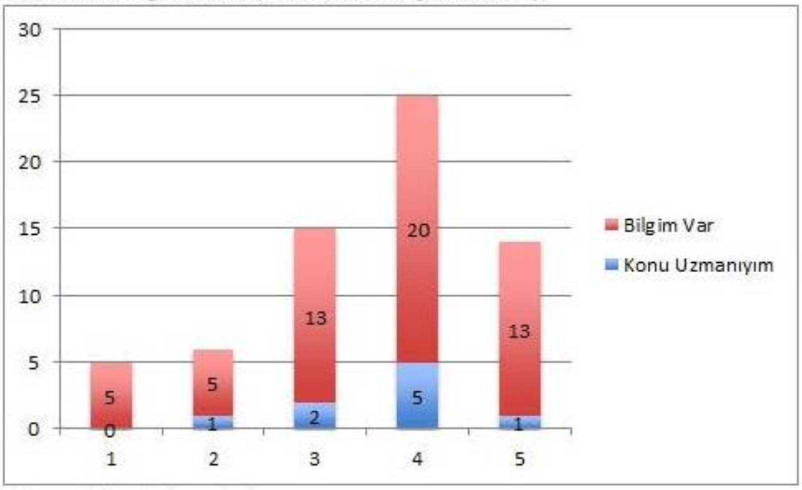
78. **16.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

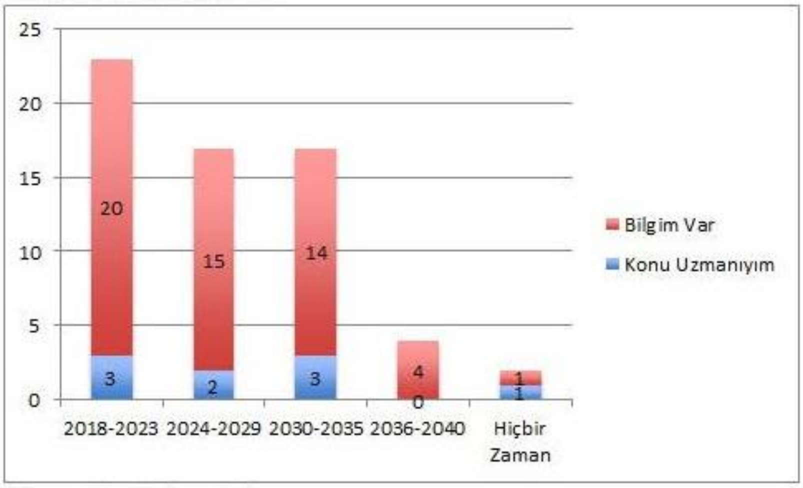
79. **16.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

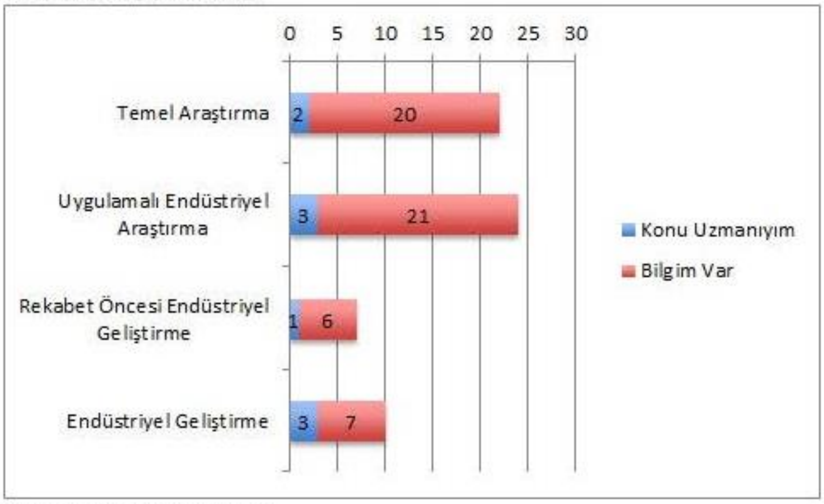
80. **16.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

81. **16.e: Başlangıç Yeteneği**

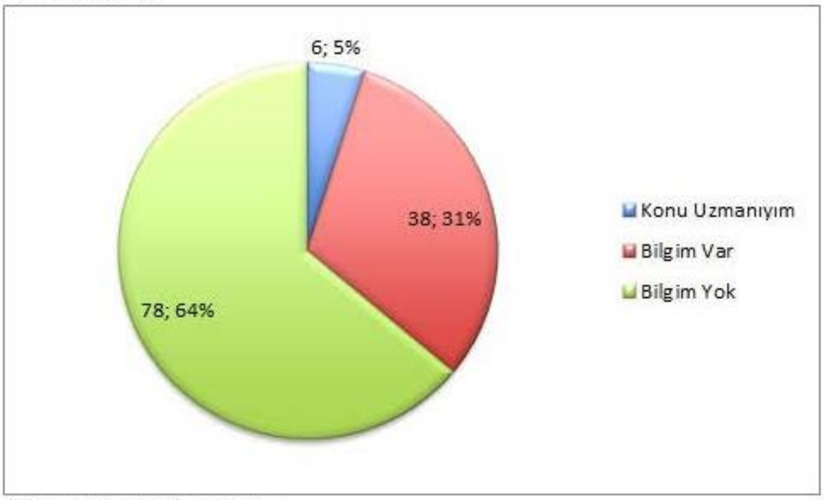


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

17: Sanallaştırılmış ağ fonksiyonları ile düşük güç tüketimli yazılım tabanlı ağ şebekeleri yaygın kullanılmaktadır.

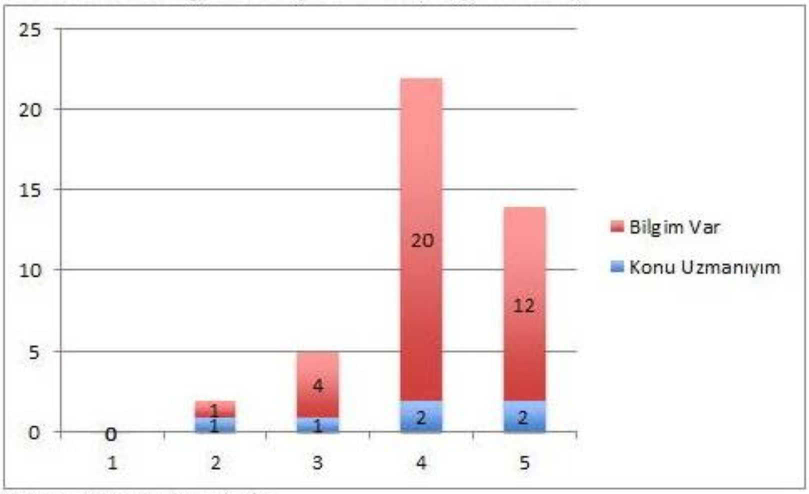
82. **17.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

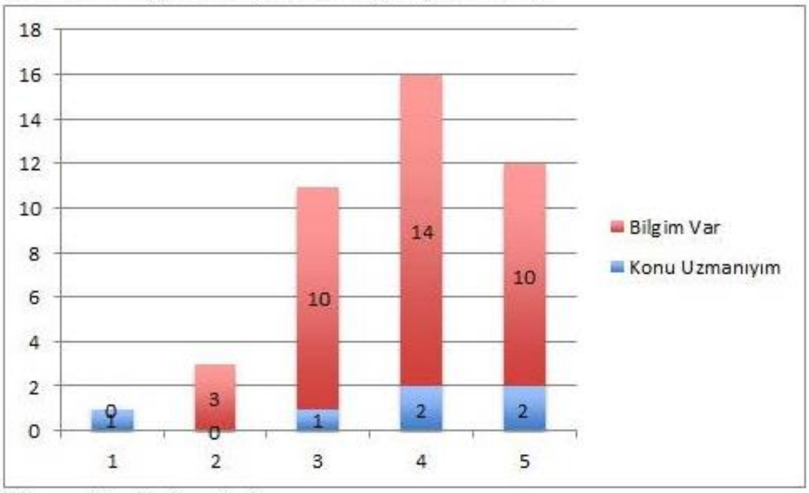
83. **17.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

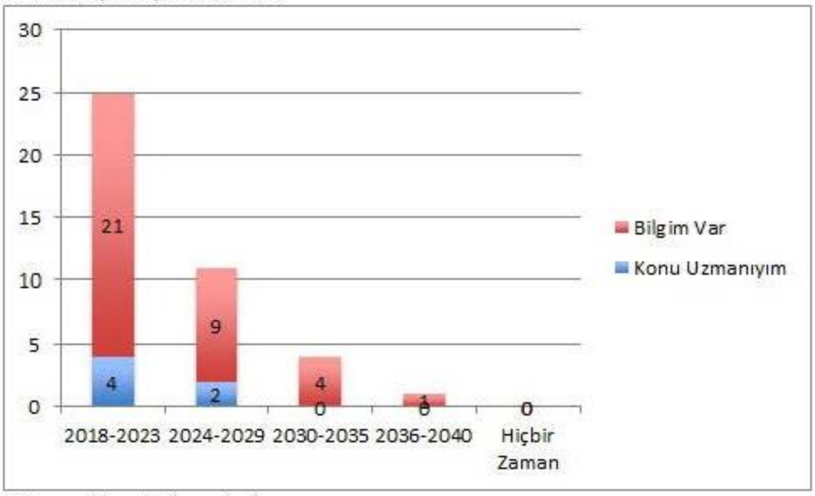
84. **17.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

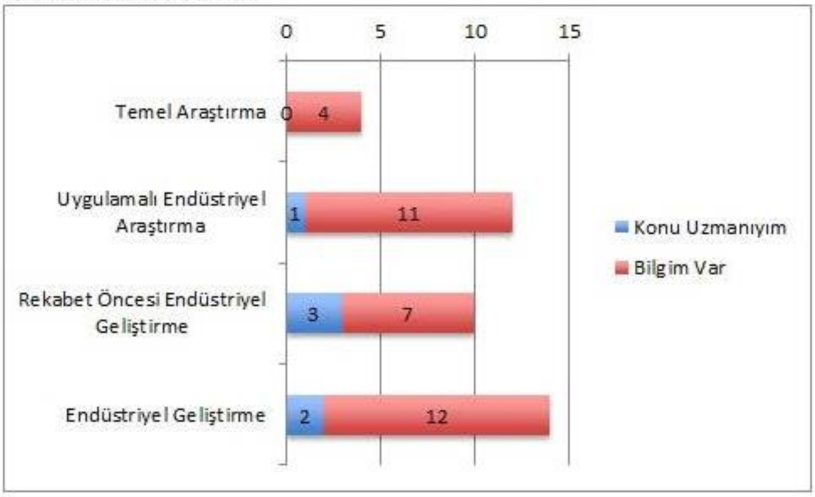
85. **17.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

86. **17.e: Başlangıç Yeteneği**

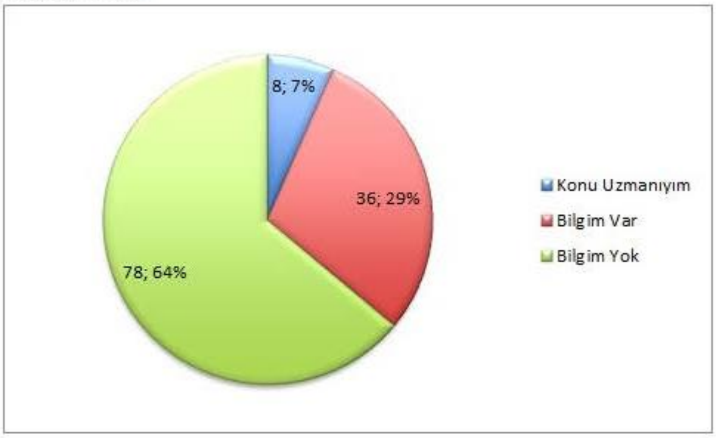


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

18: Optik hüzmenin hareketli platformlardan alıcıya güvenilir şekilde ulaşması için etkin tespit, izleme ve gösterme (Acquisition, Tarcking and Pointing- ATP) sistemleri kullanılmaktadır.

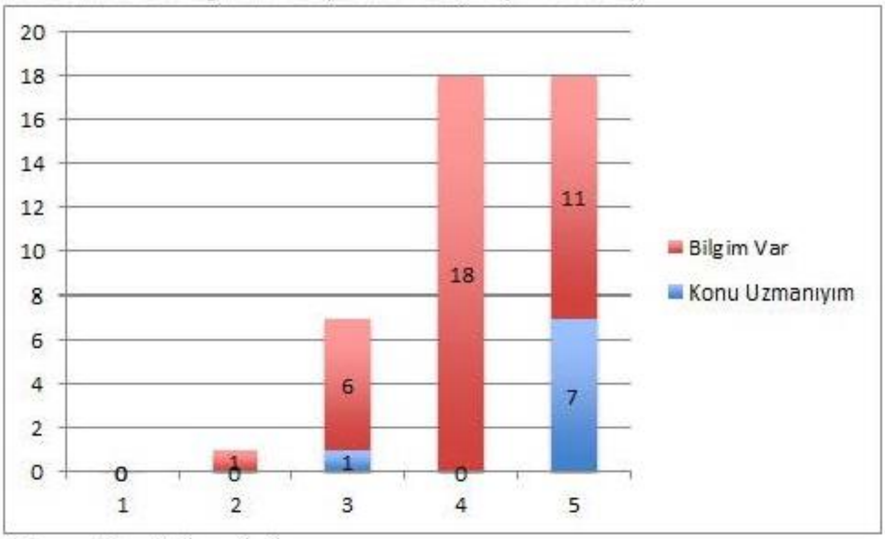
87. **18.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

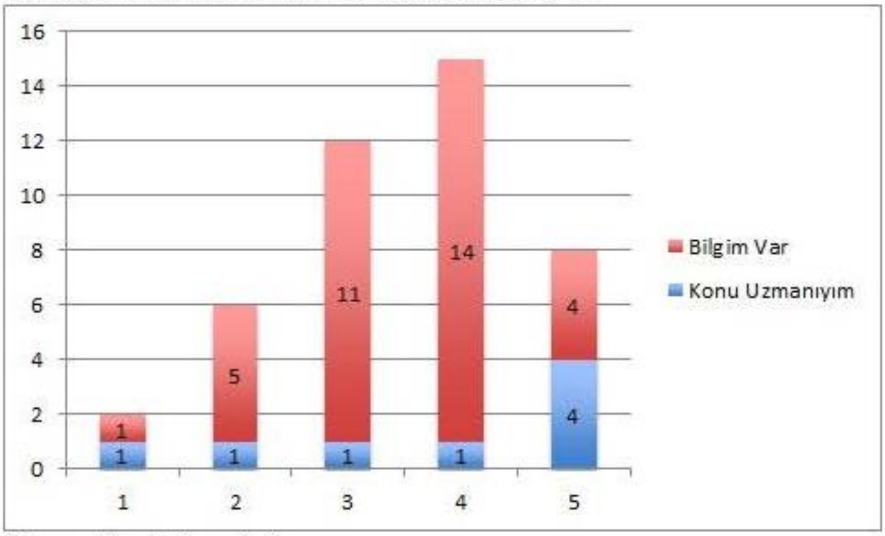
88. **18.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

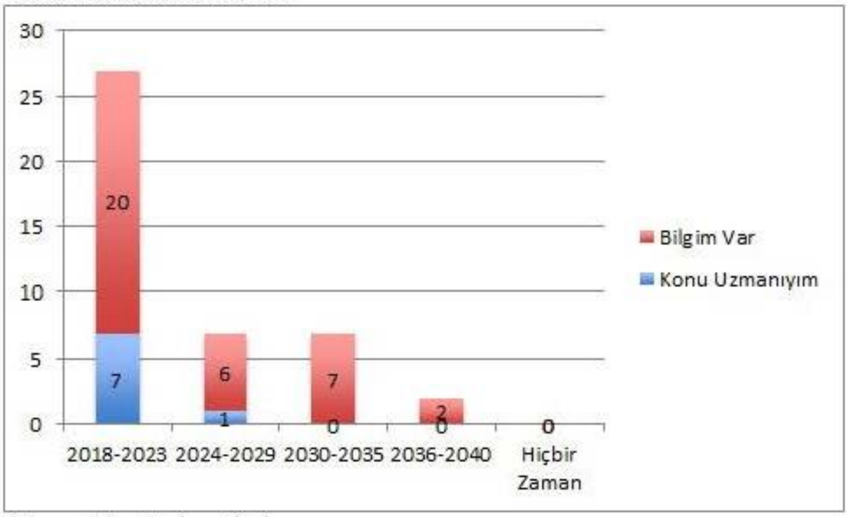
89. **18.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

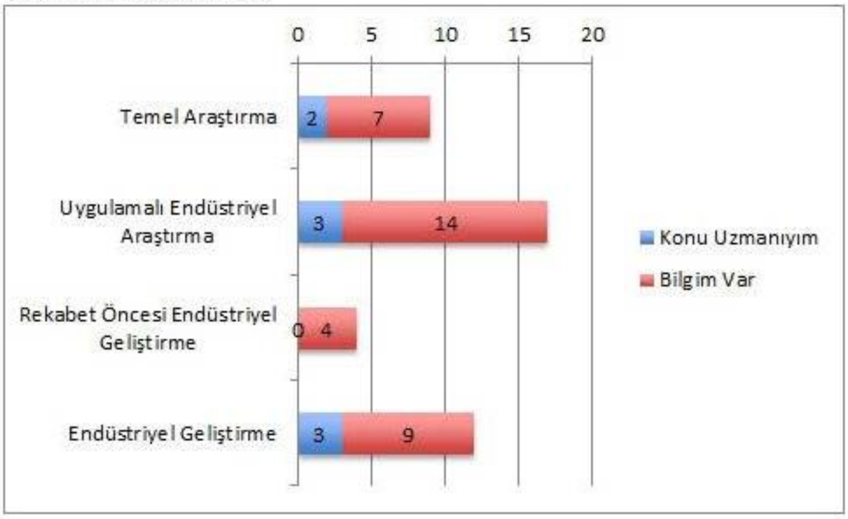
90. **18.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

91. **18.e: Başlangıç Yeteneği**

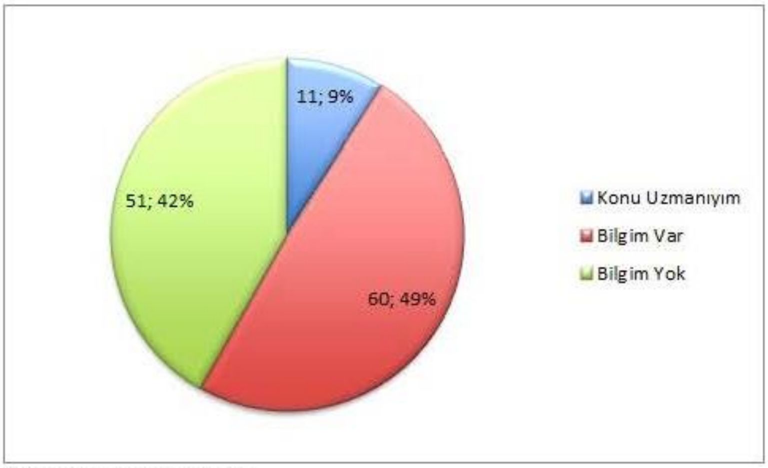


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

19: Dost Düşman Tanıma ve Tanıtma Sistemi (Identification Friend or Foe- IFF) uydu haberleşmesi aracılığı ile gerçeklenmiştir.

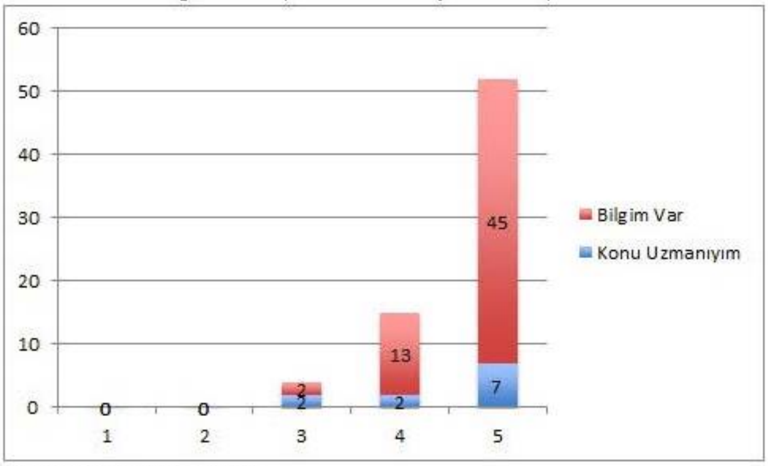
92. **19.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

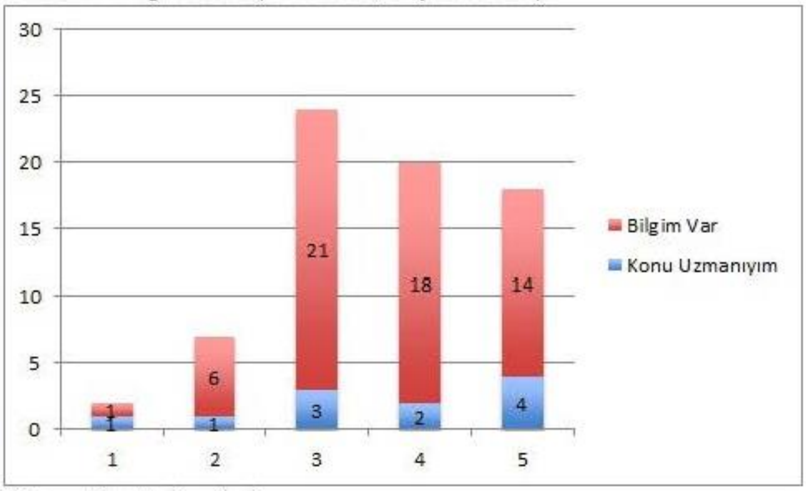
93. **19.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

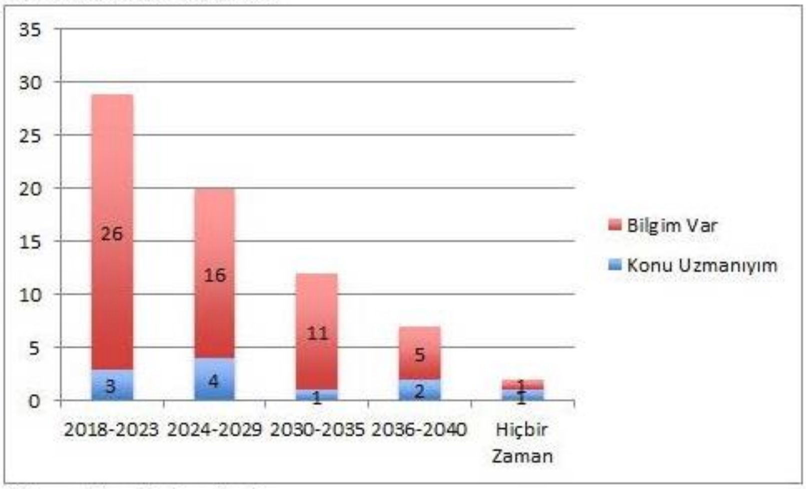
94. **19.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

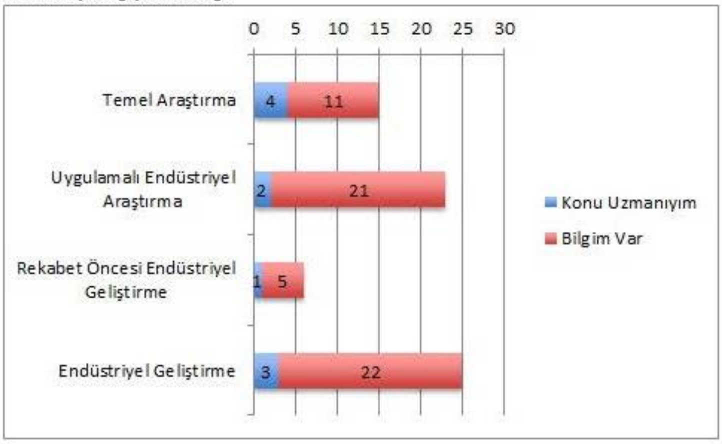
95. **19.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

96. **19.e: Başlangıç Yeteneği**

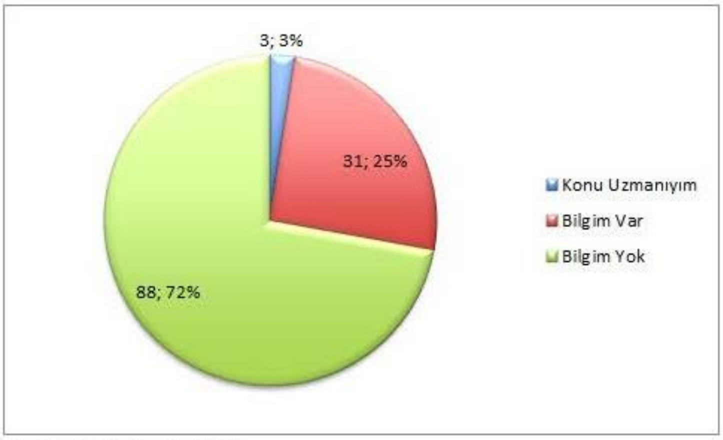


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

20: Radyo dalgalarının hüzmesini yönlendirebilen çoklu bant akıllı plazma antenleri geliştirilerek, %50'den fazla oranda geleneksel antenlerin yerine kullanılır hale gelmiştir.

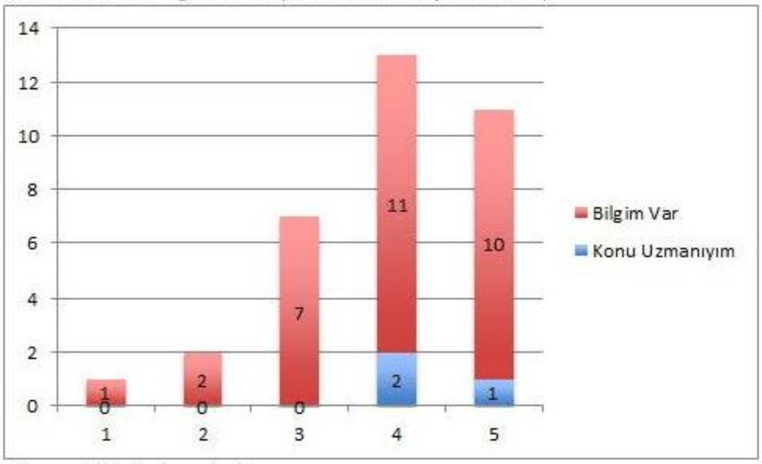
97. **20.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

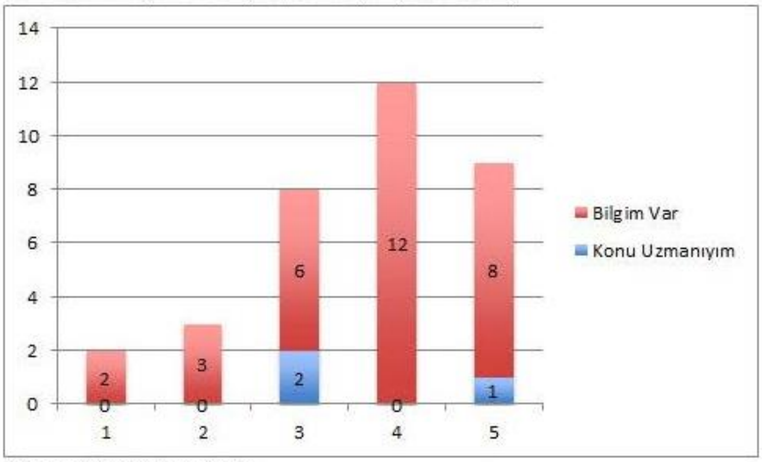
98. **20.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

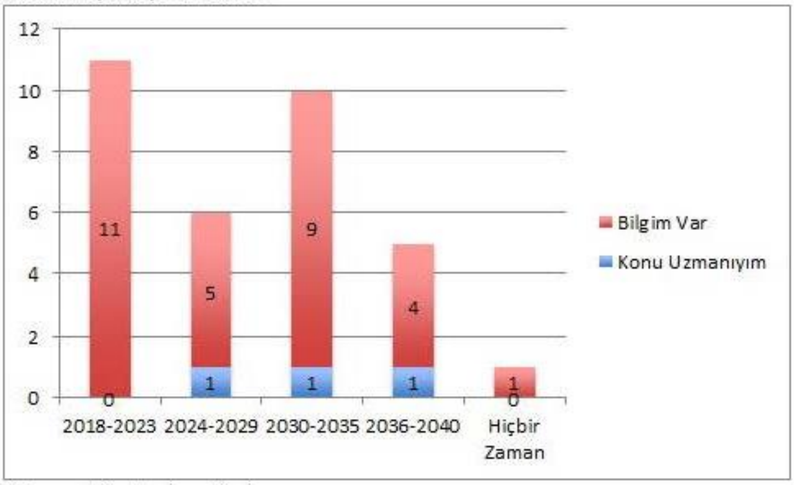
99. **20.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

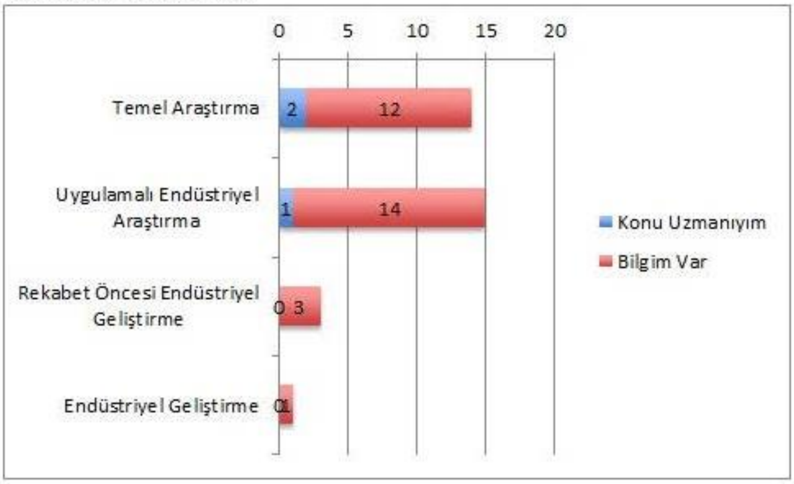
100. **20.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

101. **20.e: Başlangıç Yeteneği**

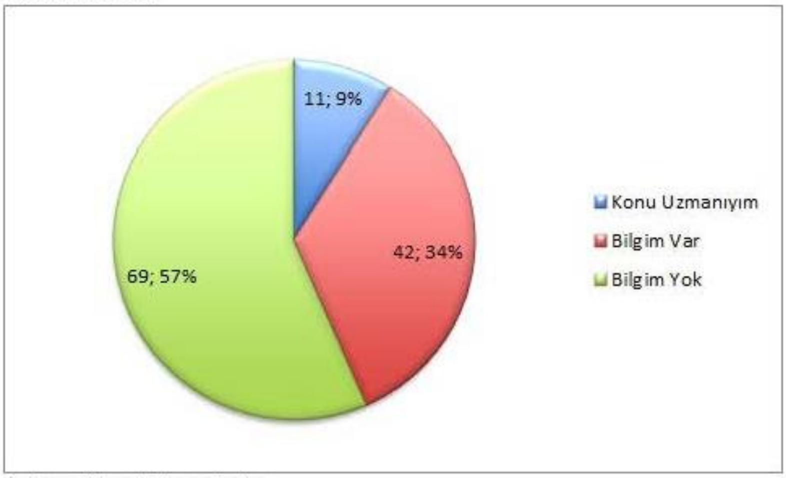


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

21: Uzayda LEO yörüngede internet uydu teknolojileri geliştirilmiş ve kullanıma alınmıştır.

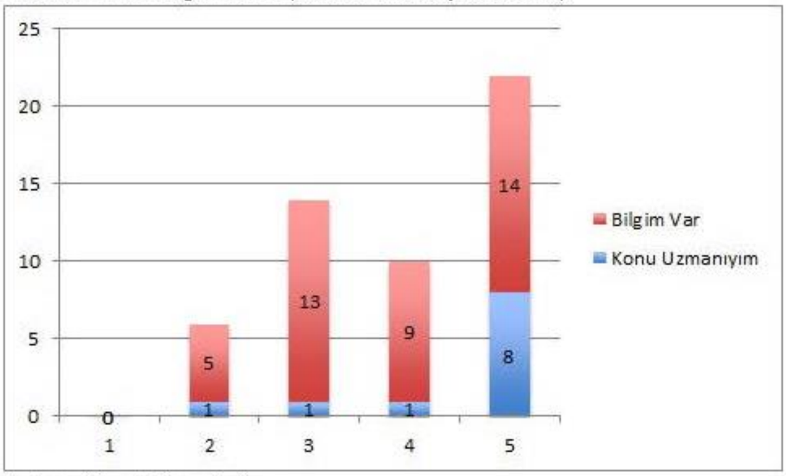
102. **21.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

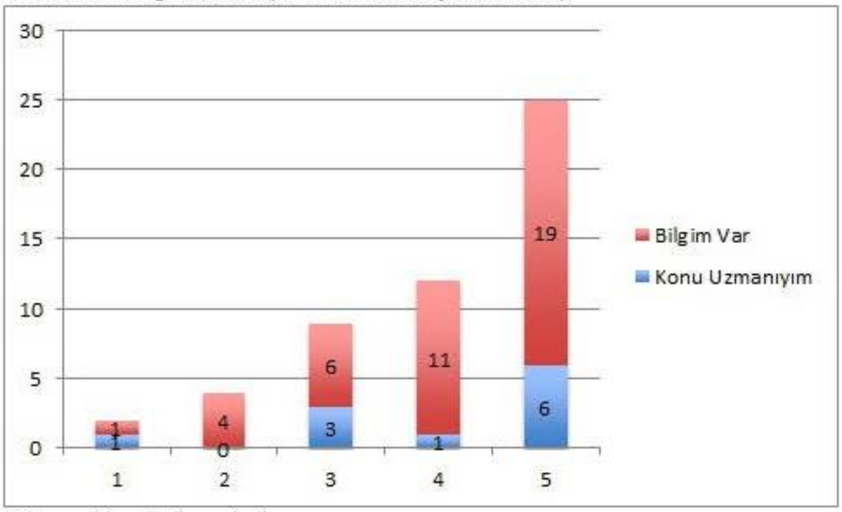
103. **21.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

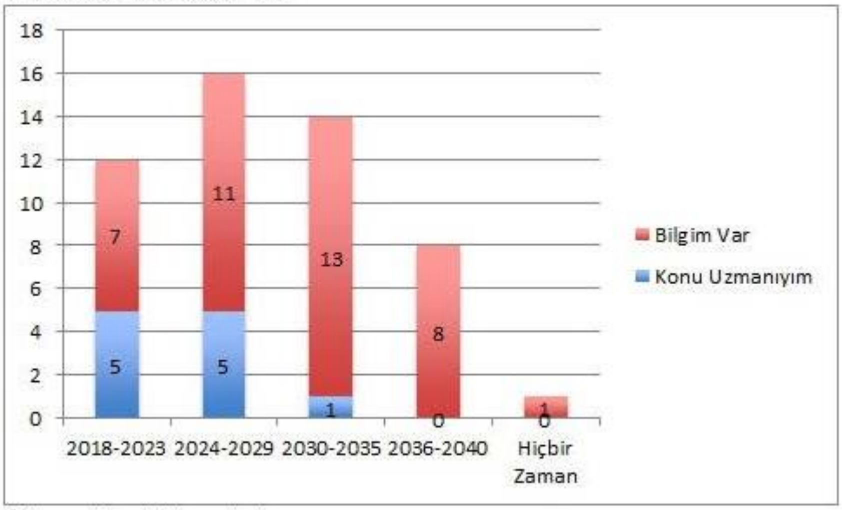
104. **21.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

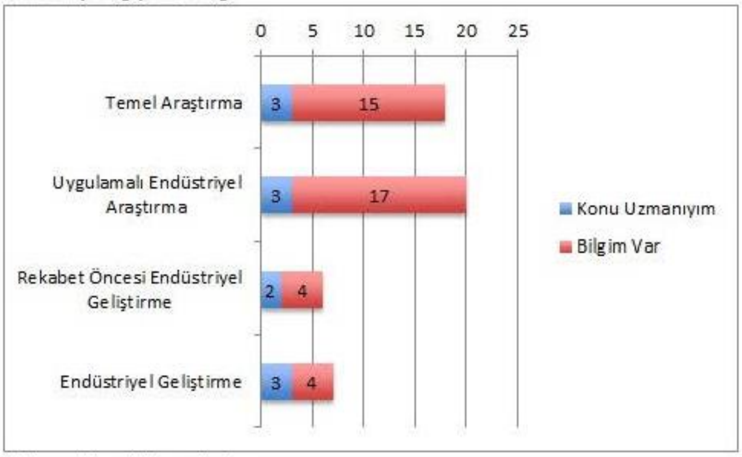
105. **21.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

106. **21.e: Başlangıç Yeteneği**

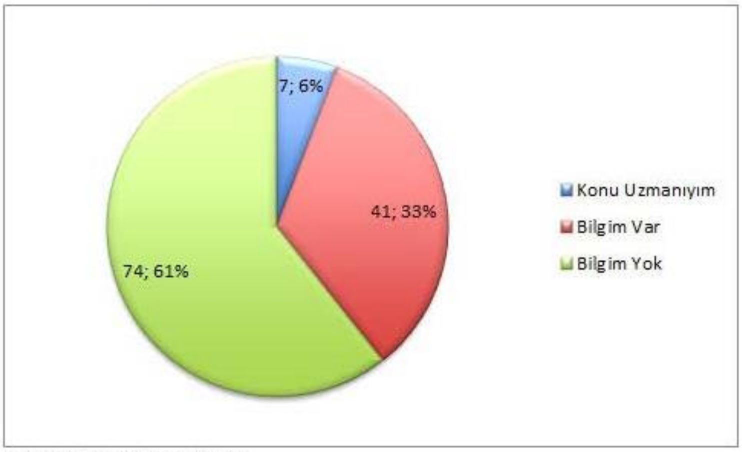


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

22: Uydular arası uzay tabanlı optik mesh-ağları kullanılmaktadır.

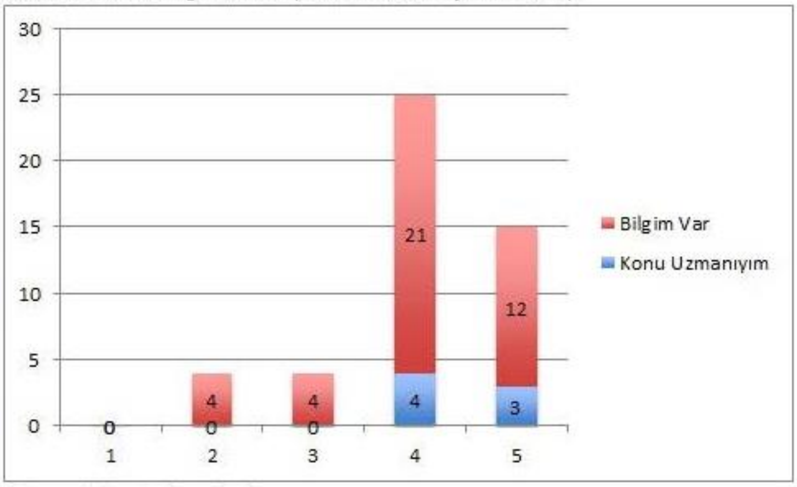
107. **22.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

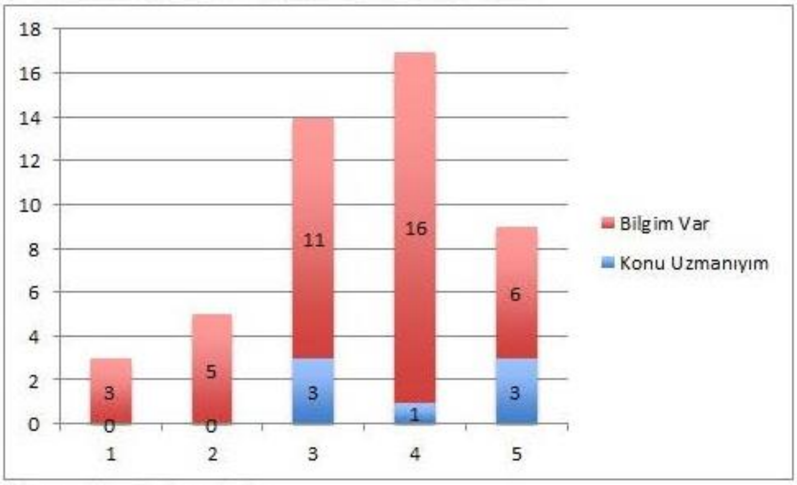
108. **22.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

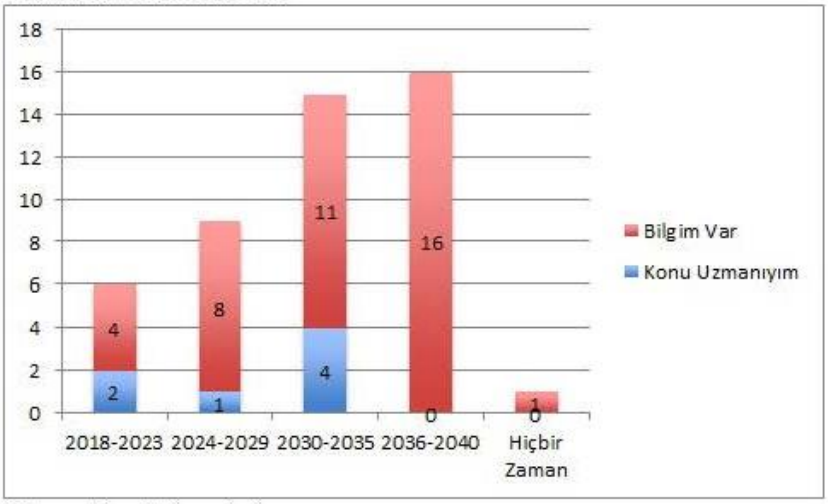
109. **22.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

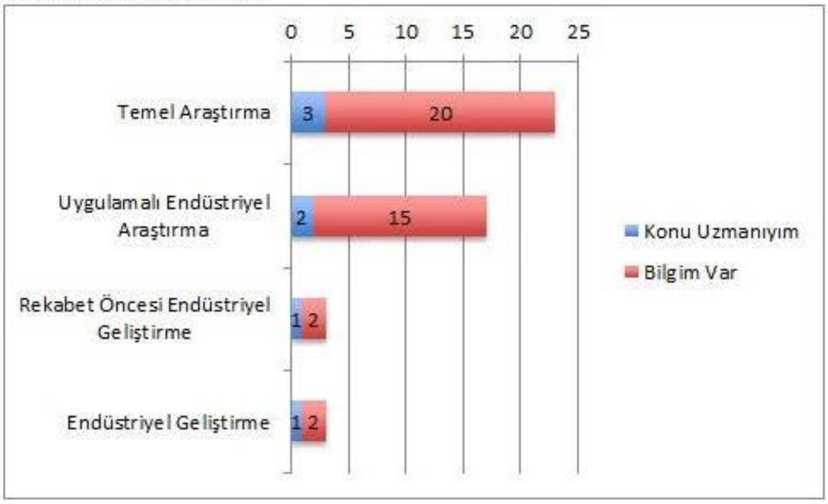
110. **22.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

111. **22.e: Başlangıç Yeteneği**

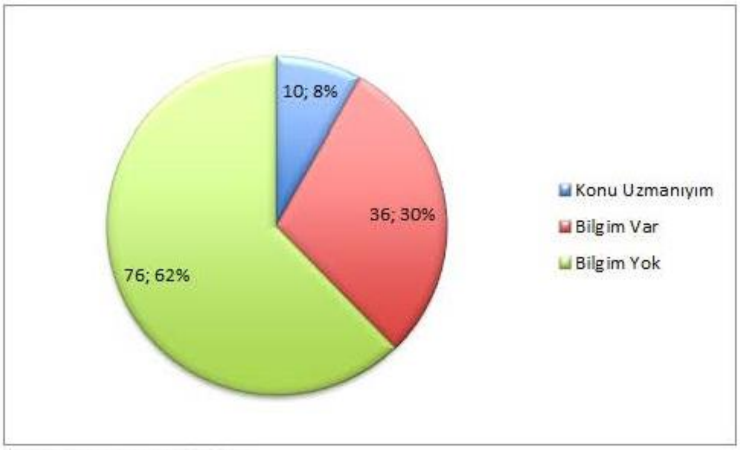


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

23: GEO yörüngede uydular arası haberleşme kapasitesine sahip çoklu bant uydu geliştirilmiştir.

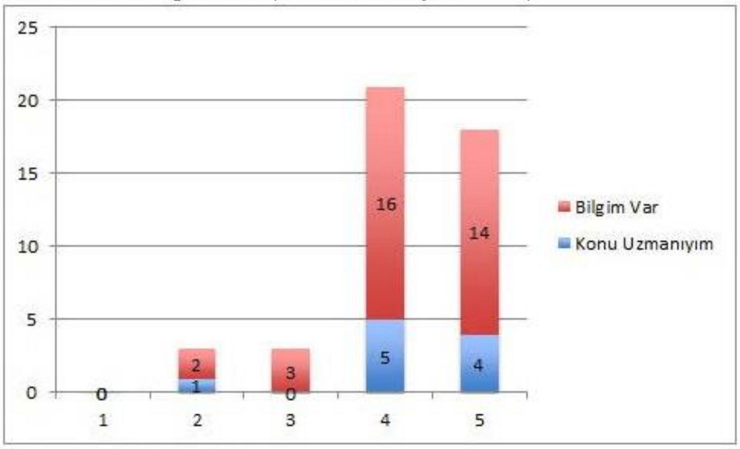
112. **23.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

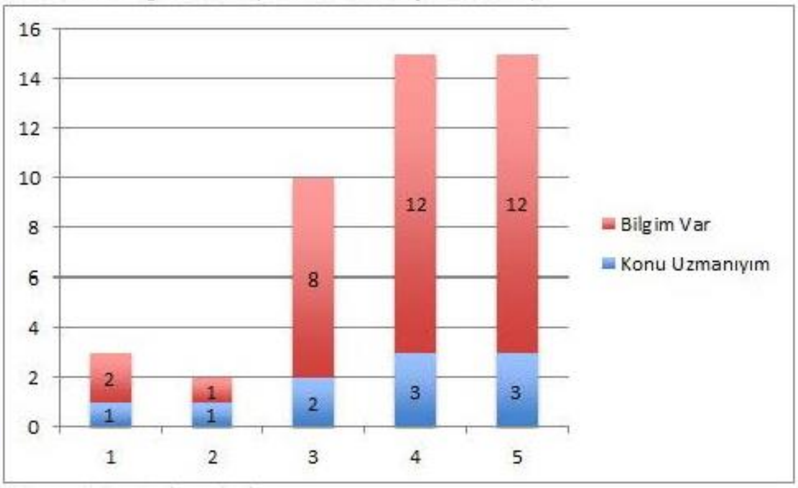
113. **23.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

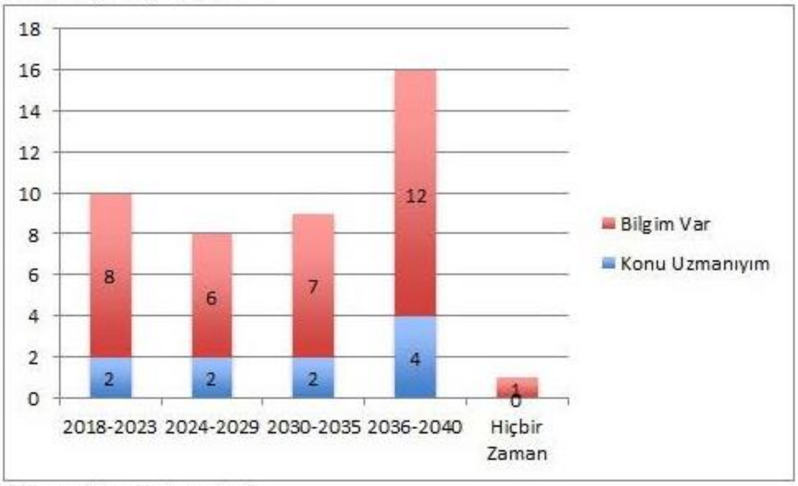
114. **23.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

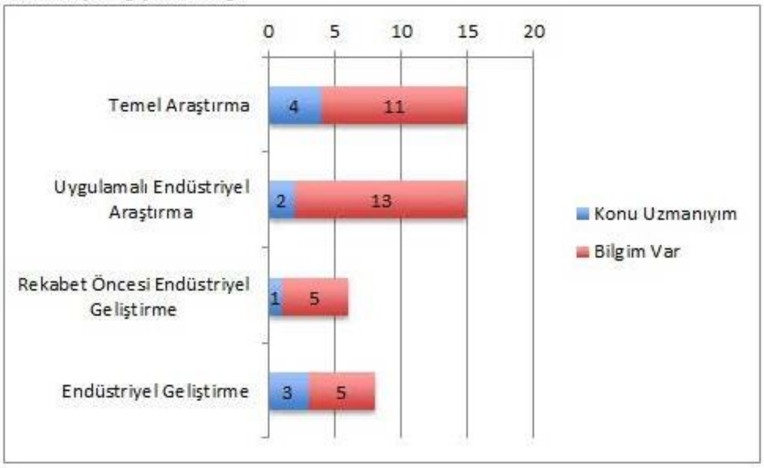
115. **23.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

116. **23.e: Başlangıç Yeteneği**

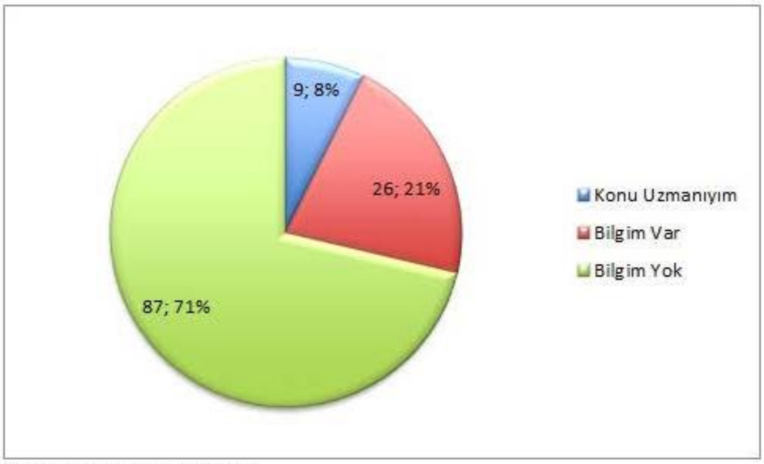


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

24: Yüksek verimli çoklu nokta hüzmeli (High Throughput Multi Spot Beam) uydu geliştirilip kullanıma alınmıştır.

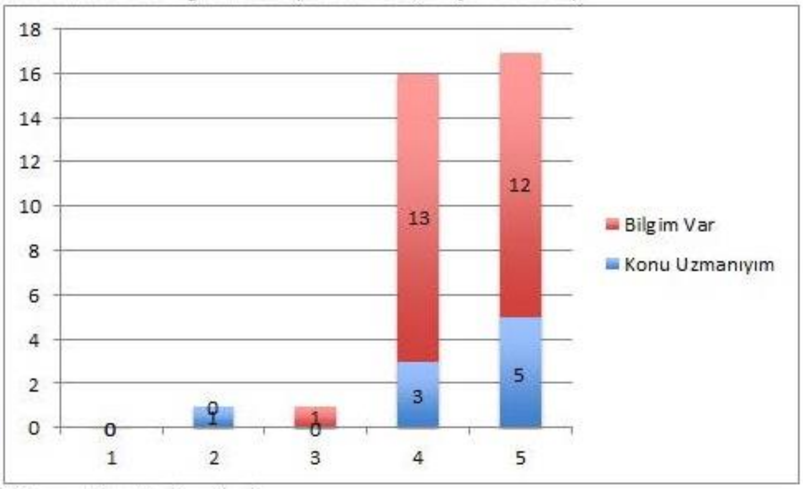
117. **24.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

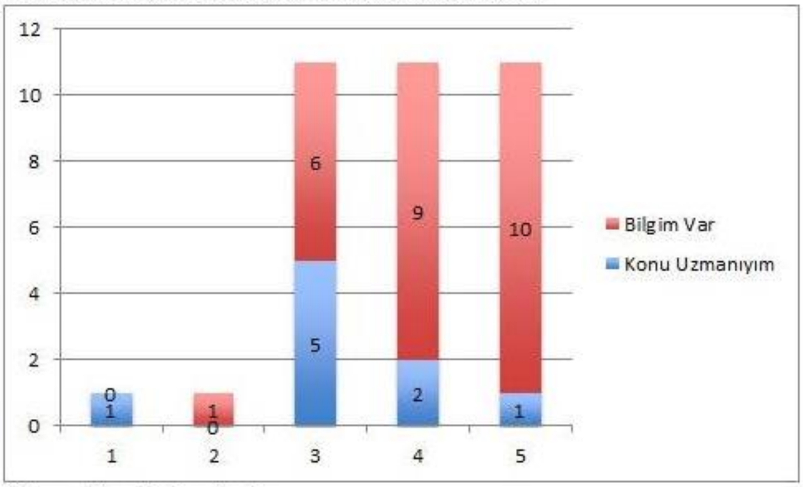
118. **24.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

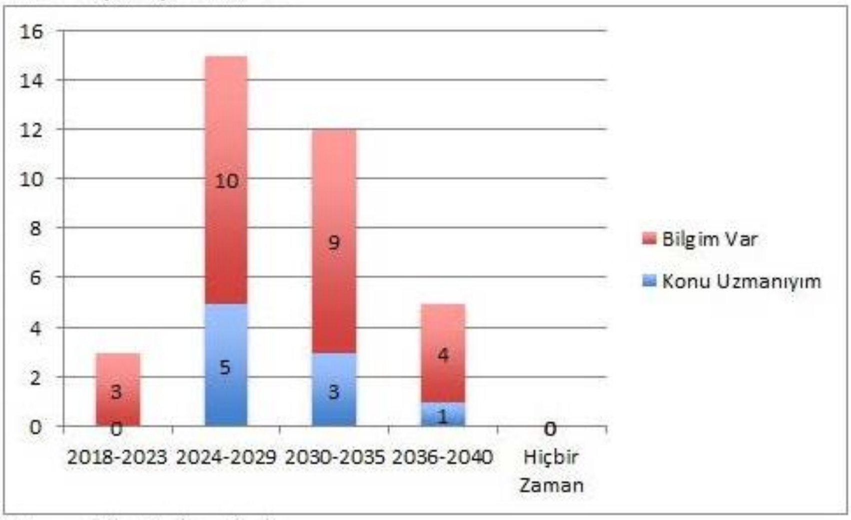
119. **24.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

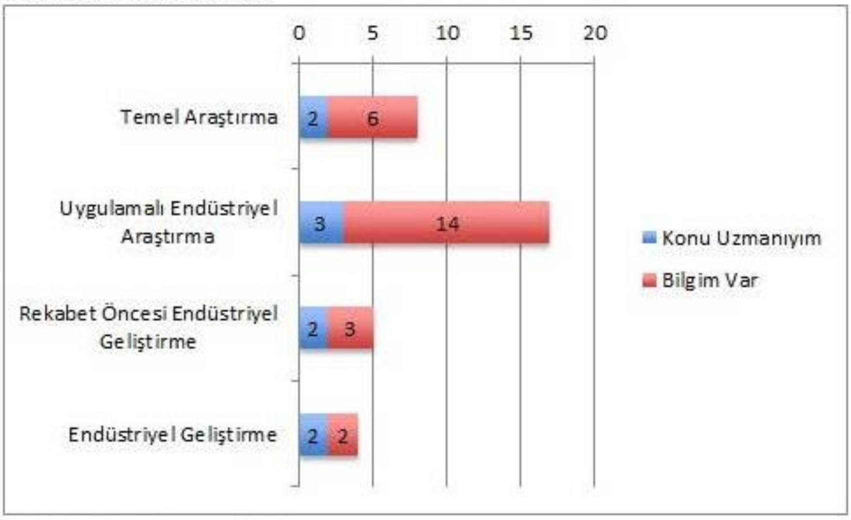
120. **24.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

121. **24.e: Başlangıç Yeteneği**

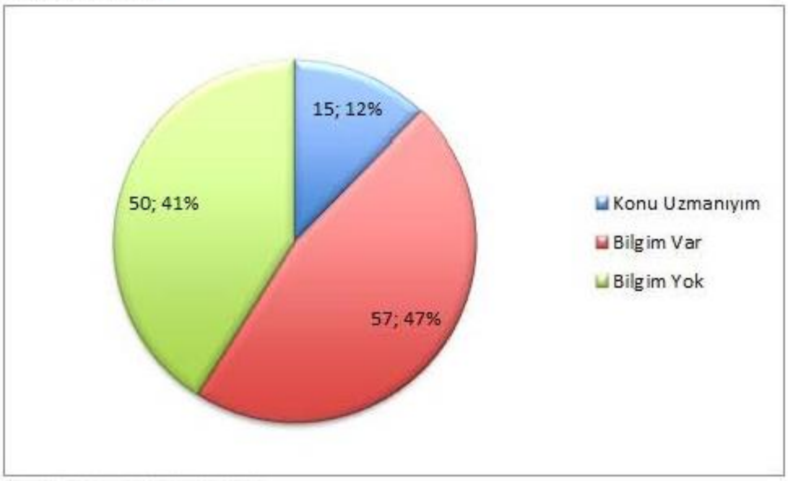


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

25: Ataletsel ölçerler (dönüölçer, ivmeölçer) tüm seviyelerde (stratejik, navigasyon, taktik) geliştirilip kullanıma alınmıştır.

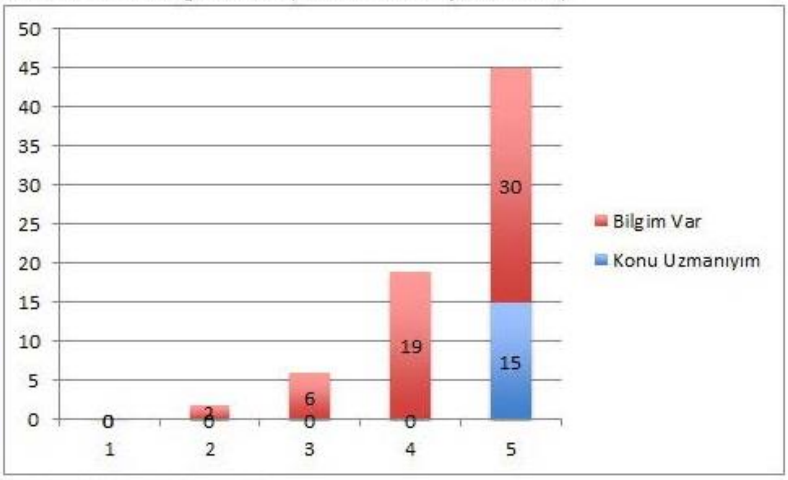
122. **25.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

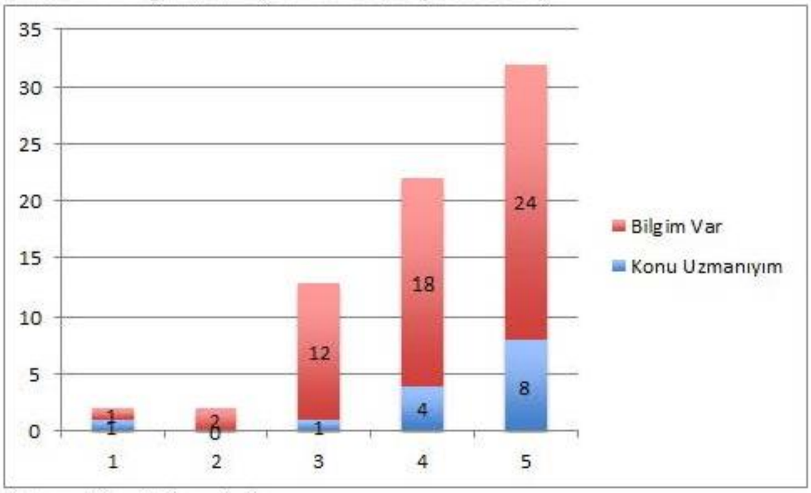
123. **25.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

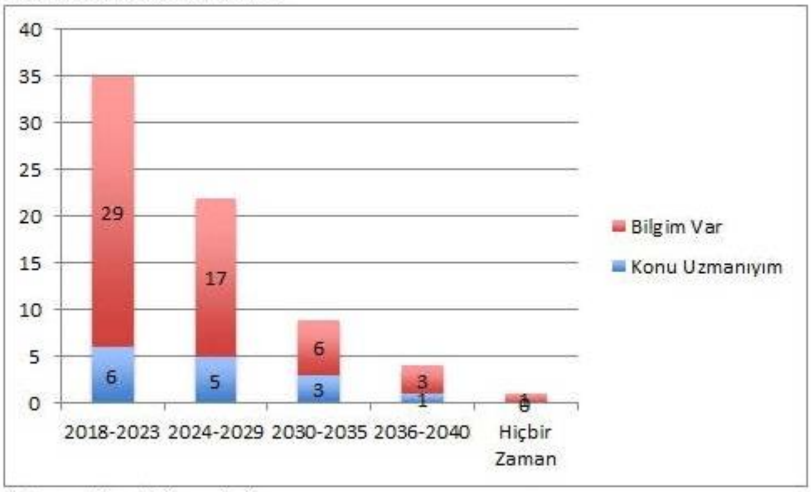
124. **25.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

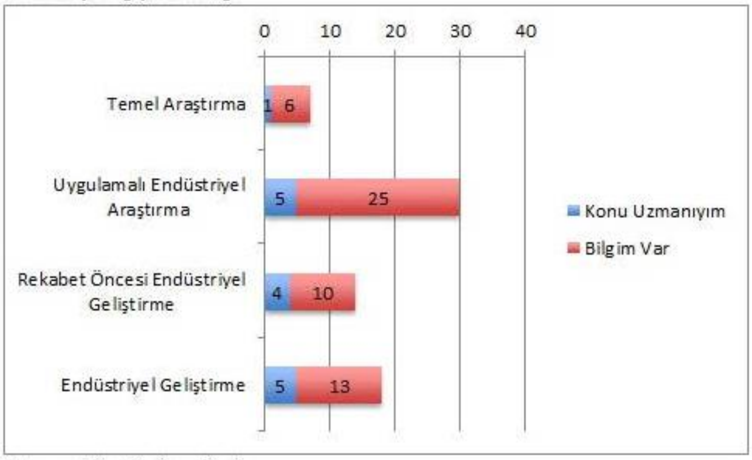
125. **25.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

126. **25.e: Başlangıç Yeteneği**

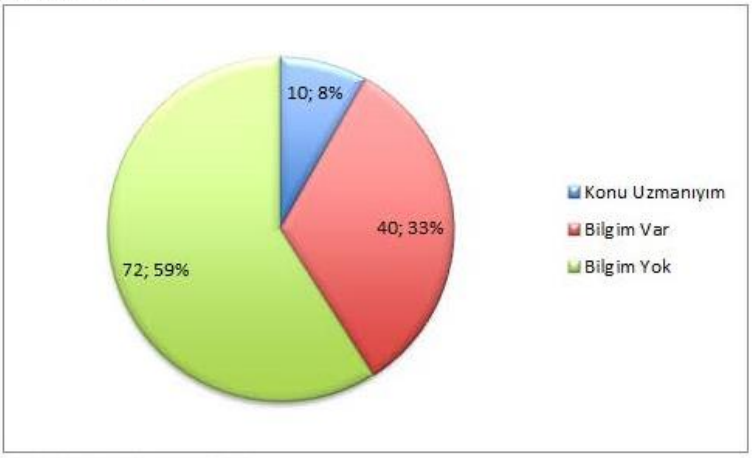


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

26: Uzay ve hava platformları için fiber optik tabanlı navigasyon sistemi geliştirilmiştir.

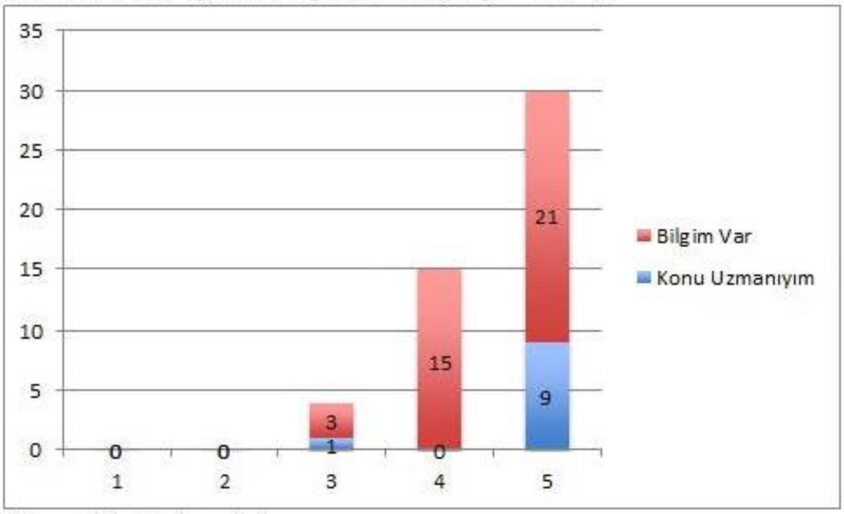
127. **26.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

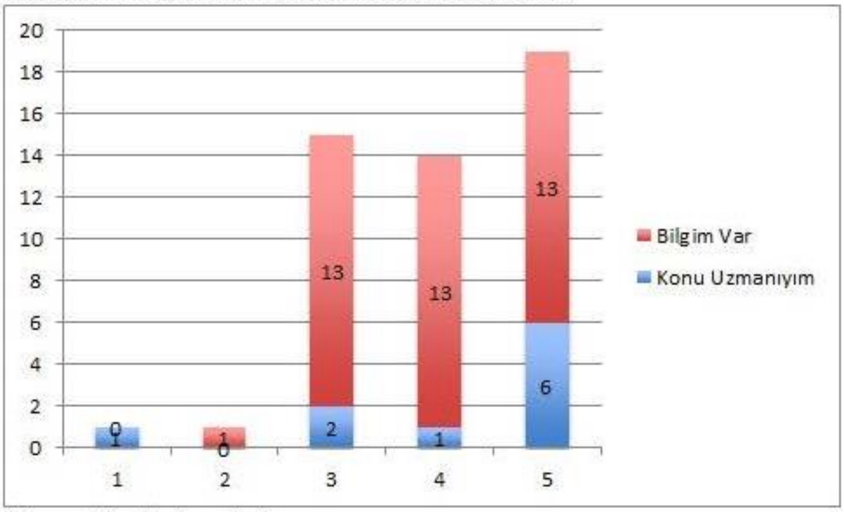
128. **26.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

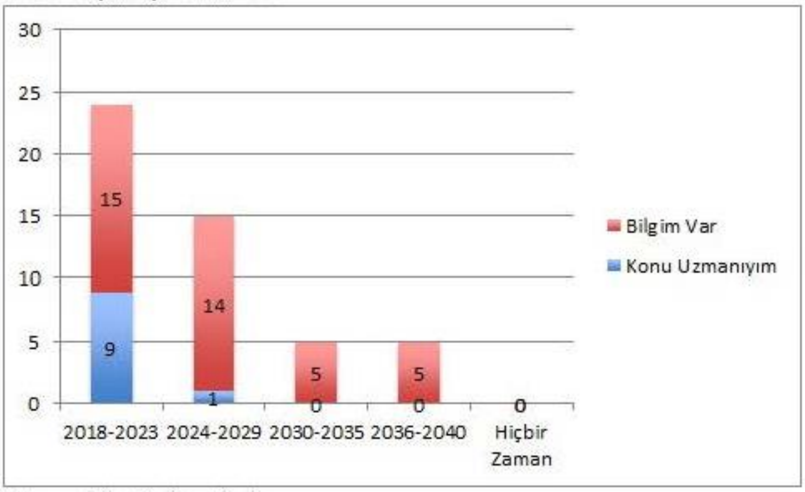
129. **26.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

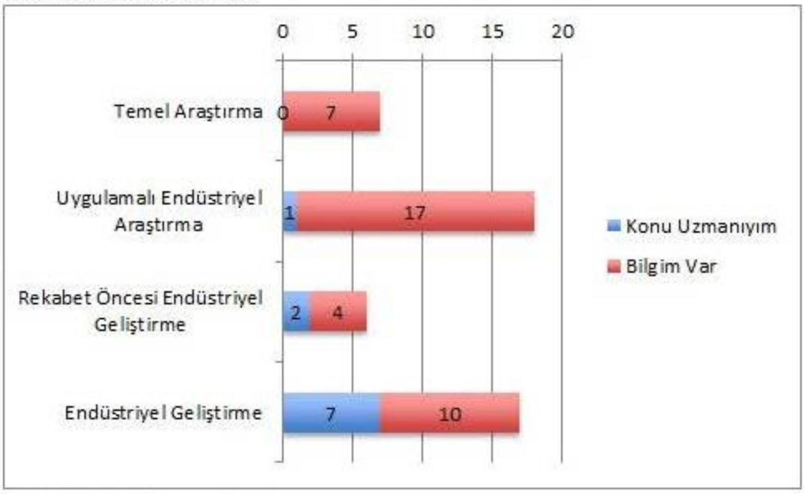
130. **26.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- 2018-2023
- 2024-2029
- 2030-2035
- 2036-2040
- Hiçbir Zaman

131. **26.e: Başlangıç Yeteneği**

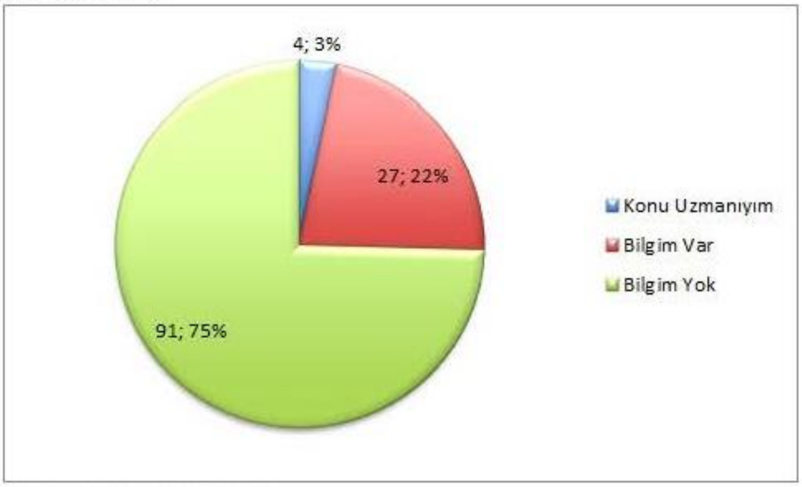


Yalnızca bir şıkkı işaretleyin.

- Temel Araştırma
- Uygulamalı Endüstriyel Araştırma
- Rekabet Öncesi Endüstriyel Geliştirme
- Endüstriyel Geliştirme

27: GaN tabanlı güç elemanı içeren modüllerde yüksek güç/yüksek verimlilik (>%50) hedeflerine geniş bant için erişilmiştir.

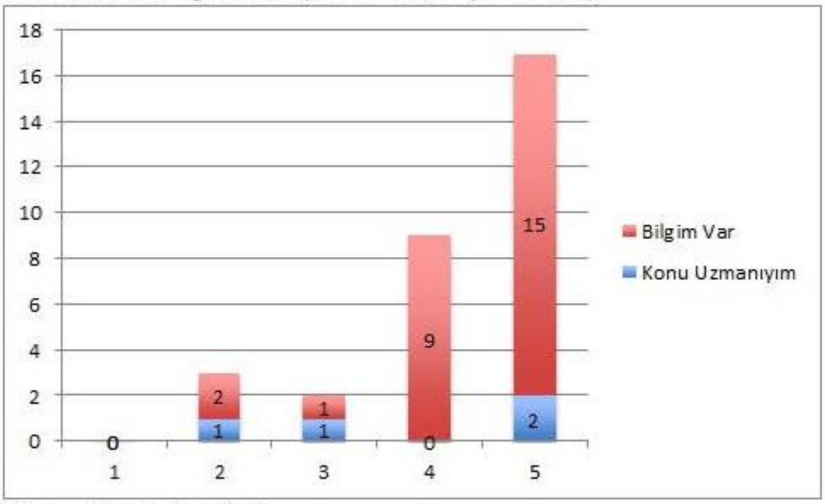
132. **27.a: Uzmanlık** *



Yalnızca bir şıkkı işaretleyin.

- Konu Uzmanıyım
- Bilgim Var
- Bilgim Yok

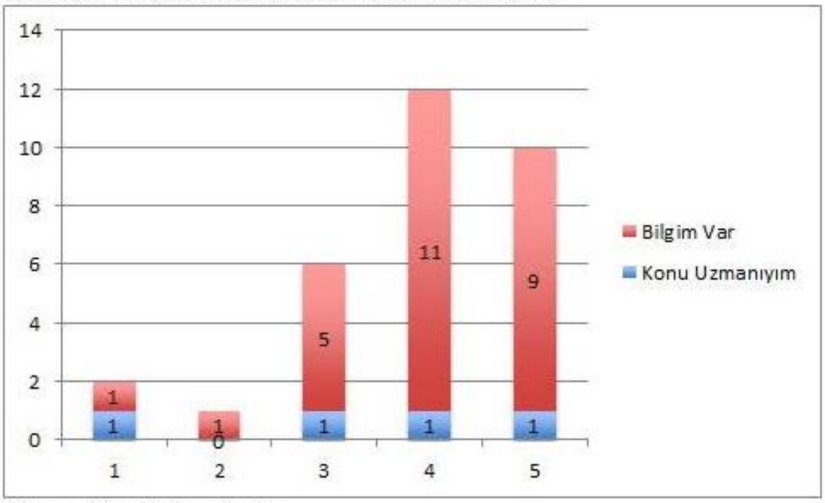
133. **27.b: Millî Güvenliğe Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

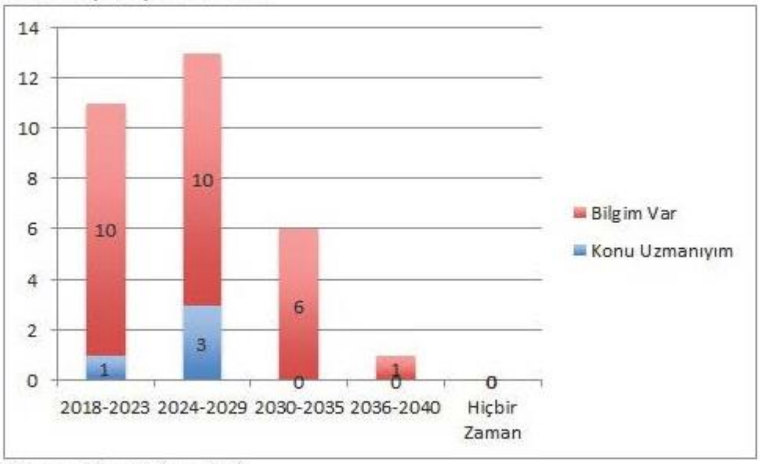
134. **27.c: Ekonomiye Katkısı (1: Önemsiz, 5: Çok Önemli)**



Yalnızca bir şıkkı işaretleyin.

- 1
- 2
- 3
- 4
- 5

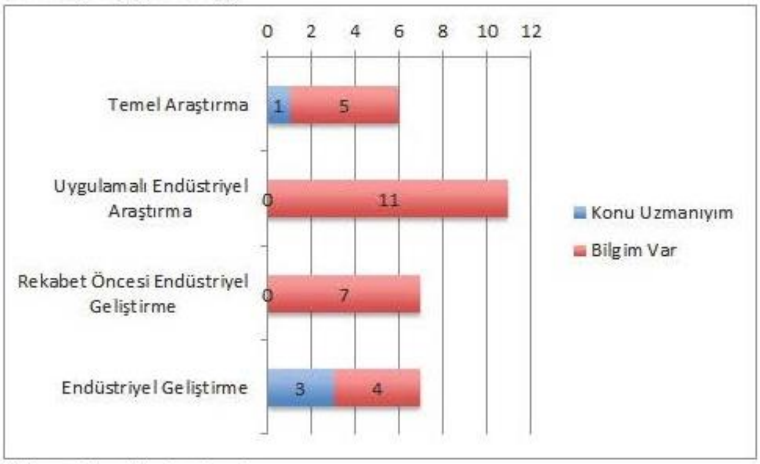
135. **27.d: Gerçekleşme Zamanı**



Yalnızca bir şıkkı işaretleyin.

- ◯ 2018-2023
- ◯ 2024-2029
- ◯ 2030-2035
- ◯ 2036-2040
- ◯ Hiçbir Zaman

136. **27.e: Başlangıç Yeteneği**



Yalnızca bir şıkkı işaretleyin.

- ◯ Temel Araştırma
- ◯ Uygulamalı Endüstriyel Araştırma
- ◯ Rekabet Öncesi Endüstriyel Geliştirme
- ◯ Endüstriyel Geliştirme

☐ Yanıtlarımın bir kopyasını bana gönder.

APPENDIX M CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name	: Yüksel, Nurdan
Nationality	: Turkish (TC)
Date and Place of Birth	: 14 January 1978, Ankara
Marital Status	: Married
Phone	: +90 312 592 18 76
Email	: yuksel.nurdan@metu.edu.tr

EDUCATION

Degree	Institution	Year of Graduation
MS	Hacettepe University Electrical Electronics Engineering	2000
BS	Hacettepe University Electrical Electronics Engineering	2003
High School	Bahçelievler Deneme Lisesi, Ankara	1995

WORK EXPERIENCE

Year	Place	Enrollment
2000- Present	ASELSAN Inc.	Leader Engineer

FOREIGN LANGUAGES

Advanced English, Upper Intermediate Italian.

PUBLICATIONS

1. Çifci, H., & Yüksel, N. (2018). Foresight 6.0: The New Generation of Technology Foresight. In *IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)* (pp. 1–5). Stuttgart.

2. Yüksel, N., & Çifci, H. (2017). A New Model for Technology Foresight: Foresight Periscope Model (FPM). In *International Conference on Engineering, Technology and Innovation* (pp. 807–817).

3. F. Arikan & N. Vural (2005) Simulation of Sea Clutter at Various Frequency Bands, Journal of Electromagnetic Waves and Applications, 19:4, 529-542.

HOBBIES

Playing Qanun, Gourmand

APPENDIX N TURKISH SUMMARY / TÜRKÇE ÖZET

Bugünün bilgi tabanındaki rekabet dünyasında, hava-uzay endüstrisi için teknolojik gelişmeler en temel ilkedir. Hava-uzay (aerospace) kavramının sözlük tanımı dünyanın atmosferini kapsayan uzay ve ötesidir. Hava-uzay endüstrisi, uçuş platformları gibi (balon, zeplin, uçak, füze, insansız hava araçları, uzay gemileri, uydular, uzaya iniş araçları, vb.) ana sistemlere; araştırma, geliştirme, işlem ve bakım çalışmalarına odaklanır. Hava-uzay endüstrisi, her alanda uluslararası ekonomik ve politik gücün belirleyicisi olduğu için, hükümetlerin ve kamu kurumlarının bu endüstrinin şekillenmesinde anahtar rol oynamaları kaçınılmazdır. Bu açıdan da dünyanın lider endüstrisi olarak hava-uzay endüstrisi bilim ve teknolojinin önünü açmaktadır. Hükümetler ve kamu kurumları, kendi ülkelerinin caydırıcılığını artırmak ve elektronik ürünlerin çifte kullanımını (askerî ve sivil) teşvik ederek ekonomik kazancı yükseltmek için savunma sektörlerini bir nevi zorlamaktadır. Bu nedenle, bazı ülkeler kendi teknoloji alt yapılarına ve araştırmaya yatırım yaparken ve ihracattan ekonomik olarak yararlanırken diğer ülkeler bu ülkelerden teknolojiyi, ürünleri ve servisleri satın alma yoluna gitmektedirler. İki durumda da, askeri harcamalar ülkelerin sahip oldukları bütçelerin büyük bir kısmını oluşturmaktadır. Yeni teknolojik gelişmeler, trendler ve tahsis edilmiş bütçeler savunma sanayinde askeri hava-uzay sistemlerinin baskın olacağının göstergesidir. Haberleşme teknolojilerinin, tüm askerî sistemlerin ara yüzünün merkezi olduğu düşünüldüğünde, hava-uzay haberleşme teknolojilerinin geleceğinin savunma sanayi için de uygun yöntemler ile kestirilmesi gereği öz kaynakların tahsisi ve yönetilmesi için çok önemlidir. Bilgi ve elektronik teknolojilerindeki hızlı değişiklikler sayesinde, savunma sanayinde Komuta, Kontrol, Bilgisayar, Haberleşme, İstihbarat, Keşif ve Gözetleme (Command, Control, Computer-Communication, Intelligence, Surveillance and Reconnaissance, C4ISR) sistemleri anahtar alt-sistemler haline gelmiştir. Hava, uzay, deniz ve kara platformları arasında ve platformlar içindeki akıllı alt sistemler arasında bilgiyi senkronize ve ağ tabanlı olarak taşıyan haberleşme alt yapısı; bilgiyi ileten ve alan alıcı- verici sistemlerindeki anten ve yükselteçler, ağ yapıları dahil akıllı mikroişlemciler vasıtasıyla programlama, kontrol etme, belirleme, analiz etme, karar verme ve komuta etme için paralel ve hızlı hesaplamadan sorumludur. Askeri uygulamalarda, gerekliliği ve öneminden dolayı C4ISR, bu askeri harcamaların ana kalemlerinden bir tanesidir. Bu sistemler haberleşme teknikleri ile birbirlerine bağlı olduklarından dolayı, bir ülkenin ordusu haberleşme sürecinin etkin, dinamik, güvenli ve emniyetli olmasına bağlıdır. Son zamanlarda, uyduların etkin ve yoğun kullanımı ve uzayda kolonileşme çalışmaları haberleşme açısından hava-uzay sistemlerini çok ön plana çıkarmaktadır. İnsansız hava araçlarının yaygınlaşması, ağ merkezli komuta ile askerî kuvvetlerin senkronize ve hızlı şekilde harekât ortamında kaynakları en etkin şekilde kullanarak strateji oluşturması haberleşme sisteminin hızına, güvenliğine ve güvenilirliğine bağlı hale gelmiştir. Hava-uzay platformlarının geniş kapsamlı menzile ve hızlı hareket kabiliyetine sahip olmaları ve deniz-kara platformlarını da kontrol edebilmeleri yeteneklerinden dolayı bu platformlardaki haberleşme sistemleri daha etkindir. Hava-uzay haberleşme konusunda kullanılabilecek ileri düzey teknikler; daha güvenli, daha hızlı, daha emniyetli ve bant genişliğini daha etkin kullanan ve birlikte çalışabilirliği artıracak şekilde geliştirilme eğilimindedir. Bundan dolayı pek çok ülke hava-uzay askeri haberleşme pazarında ciddi yatırımlar yapmaktadırlar. Son yıllarda hızla geliştirilen beşinci kuşak haberleşme teknolojisi (5G), nesnelerin interneti (Internet of Things, IoT), Büyük Veri (Big Data) ve Yapay Zeka (Artificial Intelligence) gibi Endüstri 4.0 (Industry 4.0) devriminin de altyapısı olan gelişmeler yeni teknoloji alanlarını da beraberinde getirmektedir. Bu bağlamda yeni frekans bantlarına ve bu bantlarda çalışacak cihazlar için yeni malzeme teknolojilerinin oluşturulmasına ihtiyaç duyulması, bant genişliğinin optimum şekilde tahsis edilerek spektrum verimliliğinin sağlanması, senkronizasyon ve şifrelemelerin etkin yapılabilmesi için sistemlerin ve temel teknolojilerin neler olabileceğinin önceden belirlenerek sistematik şekilde geliştirilmesi etkinlik açısından önemlidir. Bu sebeplerden dolayı, savunma sanayi gibi yatırımları ve riskleri çok büyük olan; sistem ömür devri uzun periyotlara yayılan ve en önemlisi uluslararası caydırıcılık ve güç getiren bir sanayi için ön planda olan uzay-hava haberleşme sistemlerindeki yatırım tutarları, şekilleri ve dağılımları çok daha önem kazanmaktadır. Belirtilen bu durumun varlığı da uzay-hava haberleşme teknolojileri alanında geleceği kestirmek açısından bir çalışma yapma gerekliliğini doğurmaktadır.

Türk Savunma Sanayii'nde devam eden ve planlanan projelere bakıldığında hava-uzay alanındaki projelerin yoğunluğu ve maliyet açısından baskınlığı dikkat çekmektedir. Araştırmacı tarafından yapılan literatür taramasında dünyada savunma sanayi için sadece hava-uzay haberleşme teknolojilerine yönelik hiçbir gelecek tahmini çalışmasına rastlanılmamıştır. Bu konudaki boşluğun doldurulması belirtilen proje yoğunluğundan dolayı Türk Savunma Sanayii için gerekli görülmüştür. Bu bağlamda araştırmacı, Türk Savunma Sanayii'nde 2040 yılı için öngörülen hava-uzay teknolojileri için tercih edilen stratejiye yönelik bir yol haritasını ortaya koymak üzere araştırma sorusunu belirlemiştir. Bu soruyu cevaplamak için alt sorular geliştirilerek, alt soruların adım adım cevaplanması ile bütüncül cevaba erişilmiştir. Temel motivasyon, geleceği keşfetmeye duyulan heves ve bu hevese yönelik uygulamaların daha önce araştırmacı tarafından tasarlanan modele göre yapılacak olmasıdır. Bu şekilde gerçekleştirilen uygulamanın, modelin çalışabilirliği ve eksikliklerinin keşfedilmesine yönelik araştırmacıdaki merağı da giderecek olması destekleyici motivasyonlardandır. Çalışmanın özgünlüğü, model tabanlı gerçeklenmesinden, metotlarının bir kısmının uygulamasının ve analizinin Türkiye'de bu tarz çalışmalar için ilk olmasından ve metotların uygulanış şeklinden kaynaklanmaktadır. Bu bağlamda, tezde detayları ile ortaya konulan çalışmanın kattığı değer, belirlenen konuda bir referans rehber olmasıdır.

Gelecek çok fazla değişkeni içinde barındırdığı için tahmin edilmesi çok güç bir kavramdır. Yine de insanoğlu varoluşundan beri geleceği tahmin etmeye çalışmıştır. Bunun altındaki sebep, geleceğe karşı hazırlıklı olma iç güdüsüdür. Birden fazla gelecek alternatifi vardır, ancak bunlardan sadece bir tanesi gerçekleşecek olan gelecektir. Gelecek tahmin edildiği zamanda var olmadığı ve kendisi ile ilgili herhangi bir tespit o anda denenemediği için öngörülmesi çok zordur. Bu derece zor bir kavramın tahmin edilebilmesi, disiplinler arası, çok disiplinli ve disiplinler üstü çalışmaları beraberinde getirir. İleriye bakmak anlamını çağrıştıran *Gelecek* kelimesinin aksine, *Gelecek Çalışmaları* geçmişe bakma ve şimdiki zamana bakmayı da içerir. Geleceğe bakışa yönelik çok çeşitli kavramlar kullanılmaktadır. Bunlar arasında *gelecek araştırmaları (futures research), gelecek çalışmaları (futures studies), gelecekçilik (futurism)* ve *gelecek bilimi (futurology)* öne çıkmaktadır. Bazı görüşlere göre, bilim nesnellik ve kesinliği ifade ettiği için belirsizliği barındıran gelecek için bilim demek uygun değildir. Ayrıca, bilim sayesinde geleceğin bilinebileceğini ima eden gelecekçilik kelimesi de uygun görülmemektedir. Bazı bilim insanları bu konuda farklı gelecekleri çağrıştıran, çoğul olan *Gelecekler (Futures)* kelimesini, bir kısmı da benzer mantıkla *Gelecekler Çalışmaları* ifadesini tercih etmektedir. Geniş bir profesyonel ve akademik camia tarafından yöntemleri ve araçları geliştirilmeye devam edilen *Gelecekler Çalışmaları* popüler bir çalışma alanı olarak karşımıza çıkmaktadır. Gelecekleri tahmin etmek ile ilgili olarak yapılan çalışmalar, *Gelecekler Çalışmaları*, her konuda yapılabilir. Bu konuların arasında, küreselleşen dünyada ekonominin ve gücün de en önemli temeli şeklinde ortaya çıkan *Teknoloji* kavramı en belirgin olarak seçilen konudur. Teknolojinin geleceği ile ilgili yapılan çalışmalar, teknoloji izleme, istihbarat, tahmin veya öngörü şeklinde birbirinden farklı amaçları olan ve işlevleri gerektiren çalışmalar olabilir. Bu çalışmalar arasında zaman içinde farklı kuşaklarda en fazla öne çıkanları tahmin (forecast) and öngörü (foresight) çalışmalarıdır. Bu çalışmalardan tahmin, tek bir geleceği daha az katılımcılı çalışmalar ile bugünden alınacak aktif tavıra çok fazla odaklanmadan kestirmeyi temel alırken, öngörü çalışmaları dinamik öğrenme tabanına dayanan çok katılımcılı olarak birden fazla geleceği ortaya çıkarmak ve bu geleceklere karşı bugünden alınacak aktif tavırları belirlemeyi içerir. Öngörü terimi ilk defa 1695 yılında Mr. Foresight olarak bir komedideki karakter olarak ortaya çıkmıştır. Anlamlı olarak ilk defa 1937 yılında Birleşik Devletler Ulusal Komitesinde kullanılmıştır. Gelecekleri kestirmek için, en sistematik şekilde öngörü çalışmaları 1970'li yıllarda Japonya'da gerçekleştirilen otuz yıllık periyotlar gibi uzun dönem için yapılan teknoloji öngörü çalışmalarıdır. Bu çalışmalar 1990'ların başından itibaren tüm dünyada yaygınlaşmaya başlamıştır. Bu araştırma konusunun temelinde yer alan öngörü tanımı araştırmacı tarafından, "organizasyondan uluslararası seviyeye kadar çeşitli kaynakları kullanmak suretiyle orta veya uzun vadeli gelecek stratejilerini gerçekleştirmek amacıyla teknolojik, ekonomik ve sosyal alanları tanımlayarak yatırım ve araştırmaları önceliklendirmek için doğru metodoloji kombinasyonlarıyla sistematik ve çok disiplinli bir süreçtir" şeklinde tanımlanmaktadır. Bu tanım daha sonraki paragraflarda açıklanacak olan model ile örtüşecek şekilde yapılmıştır. Öngörü zaman içinde amaçları, metotları ve kapsamı ile farklılaşarak evirilmiş ve kuşaklar şeklinde sınıflandırılmıştır. Bir öngörü çalışması farklı kuşakların özelliklerine aynı anda sahip olabilir. Kuşakları ardışık olarak düşünmek yanlıştır, aynı anda gerçekleştirilebilen özelliklere sahip olarak düşünmek gerekir. Literatürde beş öngörü kuşağı; odaklanma boyutları, katılımcı aktörleri, ekonomik temelleri ve prensiplerine göre tanımlanmış bulunmaktadır. Altıncı öngörü kuşağı da aynı çerçevede araştırmacı tarafından Foresight 6.0 olarak literatüre tanımlanmıştır. Belirtilen kuşak farklılıklarından ve evrimden dolayı öngörü konusunda ortak bir terminoloji oluşturmak aynı dili konuşmak açısından önemli olmuştur. Bu açıdan bakıldığında öngörü konusunda bazı çerçeveler tanımlamak işleyişi kolaylaştırmaktadır.

Gelecekler ile ilgili çalışmalardan biri olan öngörü, özellikle çerçevelere ve modellere dayalı olarak sistematik bir şekilde uygulandığında, geçmiş ve şimdiki durumu değerlendirerek farklı gelecekleri öngörmek için etkili bir araçtır. Bu araştırmada, 2017 yılında araştırmacı tarafından geliştirilen analojik yeni bir model olan *Öngörü Periskop Modeli (FPM),* Türk Savunma Sanayii'nde 2040 yılına kadar hava ve uzay haberleşme teknolojilerinin öngörü çalışması için temel olarak kullanılmıştır. Bu modelde, su yüzeyindeki herhangi bir hedefi aramak için su altında kullanılan periskop, herhangi bir konunun geleceğini kestirmek için, içinde bulunulan zamandaki çalışmalar ile gerçekleştirilen öngörü ile pek çok özelliği ile özdeşleştirilmiştir. Periskopun bir görüş menzilinin, açısının ve çözünürlüğünün olması öngörünün zaman ufku, kapsamı ve kapasitesi ile eşleştirilmiştir. Periskopun kullanılmasının eğitimli ve yetkinliği olan kullanıcılar tarafından gerçekleştirilmesi gereği, öngörünün de bu konuda deneyimli ve eğitimli uygulayıcılar tarafından yapılması gereğini yansıtmaktadır. Periskopun görevini yapabilmesi için kontrol ve kullanımı sağlayan temel bölümler suyun altındaki parçalarında yer almaktadır. Aynı şekilde öngörüde de, öngörü çalışmalarını belirleyen öz kaynaklar ve metodoloji bölümü yaşanılan zaman olan *Bugün'de* yer almaktadır. Bu sebeple deniz yüzeyi bugün ve gelecek arasındaki geçiş gölgesi olarak değerlendirilebilir. Periskopun görevini yapmasını sağlayan (hedefi yakalayan, çözünürlüğü ve menzili ayarlayan, hedefin ne olduğu ile ilgili kestirimler yaparak ona göre kararları veren) su altındaki bölümleri, tıpkı öngörünün *Gelecekler Stratejileri*'ni oluşturmak için kullanılan öz kaynaklar ve metodoloji bölümleri gibidir. Bu bölümler ne kadar etkin tasarlanmış ise verim de o kadar yüksek olacaktır. Bu verimi artırmak için, bu araştırma kapsamında yeni ve özgün bir algoritma, *Öngörü Metot Seçme Algoritması (FMSA)* geliştirilmiş ve FPM ile entegre edilmiştir. FPM'de, yine araştırmacı tarafından geliştirilen *Öngörü İşlevsel Çerçevesi (FFF)*, öngörünün işlevlerini her bir harfin bir işlevi ifade ettiği, kolaylıkla akılda kalan kısaltması *(FORESIGHT)* ile açıklamak için kullanılmıştır. FFF'yi oluşturmak için araştırmacı tarafından tüm öngörü nesilleri araştırılmış ve yorumlanmıştır. FPM'de öngörüyü modellemek için *Öz Kaynaklar, Metodoloji* ve *Gelecekler Stratejileri* olmak üzere üç katman tanımlanmıştır. Öz kaynaklar gelecek çalışmasını başlatmak ve şekillendirmek için öncelikle ele alınması gerektiğinden, bu bölüm periskop modelinin en alt kısmında yer almaktadır. Öz kaynaklar, somut (altyapı, finans ve insan kaynakları) ve somut olmayan (zaman; yapı, süreçler ve kültür; veri ve bilgi; bilim, teknoloji ve yenilikçilik yetenekleri) olmak üzere iki gruba ayrılır. Gruplandırılmış bu kaynaklar genel olarak organizasyonel, sektörel, ulusal ve uluslararası düzeylerde yer alır. Öz kaynakların bir üst seviyesinde, öz kaynaklara göre seçilen bir metodoloji bölümü yer alır. Metodolojide, uygun metotların seçimi ve bunların ilgili öz kaynaklara ve öngörü seviyesine uygun bir metodoloji oluşturmak için gerekli entegrasyonları oluşturulur. Bu tez çalışmasında öz kaynakların değerlendirilmesi ve öz kaynaklara göre metodolojinin oluşturulması FMSA ile yapılmaktadır. Burada ele alınan Türk Savunma Sanayii olan sektörel düzey, araştırmacı tarafından oluşturulan algoritmalar ile otomatik olarak sorulan sorular ve yine araştırmacı tarafından yapılan literatür taramasına göre verilen cevaplar kullanılarak değerlendirilmektedir. Cevaplar, araştırmacı tarafından belirlenen bazı kriterlere göre algoritma ile işlenir. Kriterler, metotları öz ve destekleyici metotlar olarak ayrıştırır ve çıktı olarak FFF'ye uygun sıralı bir biçimde bir metodoloji olarak önerilir. FFF'de işlevsel sistemin ana hatlarını çizmek için kullanılan FORESIGHT akronimi ile oluşturulan çerçevede aşağıda belirtilen işlevler gerçekleştirilmektedir. Bu işlevlerden biri uygun şekilde faaliyet göstermediğinde, tüm sistemin de uygun olarak işlerliğinden bahsedilemez. Önerilen FORESIGHT işlevsel çerçevesinde, *çerçeveleme*, *edinme*, *gözden geçirme*, *oluşturma*, *sentezleme*, *gösterme*, *rehberlik etme*, *yürütme* ve *takip* olarak isimlendirilen dokuz adet işlevsel blok bulunmaktadır. Çerçevede birbirini takip eden işlevler birbirleri ile bağlantılı ve birbirlerine bağımlıdırlar.

Bu bağlamda, FFF'deki işlevlerin açıklaması aşağıdaki gibidir:

*F*raming (Çerçeveleme): Öngörünün amacının, kapsamının, içeriğinin ve zaman ufkunun belirlenmesi görevlerini yerine getirme.
*O*btaining (Edinme): Veri ve bilginin toplanması, bir önceki çerçeveleme fonksiyonunda belirtilenler ile uyumlu şekilde katılımcıları bir araya getirme.
*R*eviewing (Gözden Geçirme): Günümüz ve geçmiş ile ilgili erişilen veri ve bilgi üzerinde fikir ve görüşleri paylaşma, özetleme ve işlenmeleri için analiz etme.
*E*stablishing (Oluşturma): Yaratılan bilgi ile gelecekler hakkında düşünme, zihinlerde olasılıkları canlandırma ve gelecekleri oluşturmak için alternatifleri hayal etme.
*S*ynthesizing (Sentezleme): Mevcut durum şartları ve kaynakları ile alternatif gelecekleri yorumlayıcı bir şekilde birleştirme. Tartışma, müzakere, kolaylaştırma ve çatışma çözümleme bu fonksiyonda yer almaktadır.
*I*llustrating (Gösterme): Olası gelecekleri işaret etme, vizyon oluşturma, raporlama, multimedya üzerinden yayma, sosyal medyada paylaşma.
*G*uiding (Rehberlik Etme): Uygulanacak eylemleri ve değişiklikleri tanımlama, bunları farklı geleceklere ulaşmak için sıralama, strateji geliştirme ve planlama.
*H*andling (Yürütme): Harekete geçme, değişiklikleri yapma ve uygulama problemlerini çözme.
*T*racking (Takip): Yürütmenin sonuçlarını ve neticelerini değerlendirme, öğrenme sürecine yönelik dersler çıkarma amacıyla analizler (ör.: etki analizi) yaparak öngörü sonucu yapılan faaliyetleri takip etme.

FFF'de her bir işlevde kullanılan metotlar, amaçları açısından birbirinden farklı olabilirler, ancak aynı metotlar farklı işlevlerin içinde de kullanılabilirler. Öngörü yaklaşımı da çerçevedeki işleyişin sırası açısından önemlidir. Normatif -geriye doğru- yapılan bir öngörü çalışmasında işlevler ve metotların sırası FFF'de belirtilenden daha farklı bir durum alabilir. Bu nedenle, yapılan bu çalışmada öngörü yaklaşımının da normatif veya keşfedici esaslı olduğu algoritmada sorgulanmaktadır. Öngörü yaklaşımı ve metotlar için araştırmacı tarafından belirlenen kriterler, Türk Savunma Sanayiinin öncelikleri göz önüne alınarak yapılmıştır. FPM'nin ikinci katmanında bulunan metodoloji kısmı için literatürdeki tüm öngörü metotlarının sınıflandırılması ve ele alınış biçimi incelenerek bir tablo olarak ortaya konmuştur. Buradaki amaç, hangi metotların hangi durumlarda kullanıldığı ve birbirleri ile nasıl bağlantılarının sağlanabileceğinin ortaya çıkarılması için bir alt yapı oluşturmaktır. Farklı metotlar belirli amaçlar için tutarlı ve bir ilişki kapsamında (neden-sonuç, girdi-çıktı, eş zamanlı vs.) bir araya getirildiğine metodoloji ortaya çıkmaktadır. Literatüre bakıldığında, öngörü metotları da araştırma metotları gibi genel olarak nicel, nitel ve yarı nicel olarak ayrıştırılmıştır. Farklı bilim insanları tarafından farklı bakış açıları ile ortaya konan ve öngörü metotlarının kriterlere göre sınıflandırılmasını içeren, araştırmacı tarafından araştırılarak oluşturulan *Tablo 5* literatür taraması açısından çok değerlidir. 866 durum çalışmasını içeren European Foresight Monitoring Network (EFMN) çalışmasının sonuçlarına göre, öngörü çalışmalarında nitel metotlar nicel metotlara göre hatalara daha açık olmalarına rağmen çok daha sık kullanılmıştır. Ancak, verilerin çok hızlı çoğalması ve elektronik ortamda veri işleme tekniklerinin yaygınlaşması sebebi ile nicel metotların da kullanımının artacağı kestirilmektedir. Ortak eğilim nicel ve nitel metotların uygun kombinasyonlar ile etkin şekilde birlikte kullanılmasıdır. Ancak bu metotların öngörüde birbirleri ile nasıl entegre edilebileceğine dair literatürde çok fazla çalışma bulunmamaktadır. Metotların paralel olarak aynı anda, ya da sıralı bir şekilde girdi-çıktı ilişkisi içinde çalıştırılması dışında, web tabanlı aynı anda çalıştırılabilecek ve analiz sonuçları ile revize olabilecek şekilde bir araya getirilmesi de ön plana çıkmaktadır. Bu bağlamda, FMSA algoritmasında girdiler Türk Savunma Sanayii ile ilgili olarak araştırmacının yine kendisinin belirlediği sorulara verdiği cevaplar bilgisayar programı ile girilmektedir. Aslında, sorular öngörü seviyesine göre pek çok paydaşın katılımı ile web ortamında girilerek analizi yapılarak belirlenecek düzeyde olursa etkinlik artacaktır. Sorulara verilen cevapların da aynı şekilde toplanması, web ortamında analizinin yapılması ve paylaşılması dinamik öğrenme sürecini de artırarak çok daha etkin metot önerilerinin ortaya çıkmasını sağlayacaktır. Şu anda geliştirilen FMSA algoritması prototip düzeyde olup, araştırmacı tarafından kapsamının dinamik öğrenmeye uygun ve çok katılımcılı uygulamalara açık, analiz yöntemlerinin de dahil edildiği kapsamlı bir hale getirilmesi planlanmaktadır. Literatürde öngörü yöntemlerinin birleştirilmesi dışında hangi yöntemlerin hangi durumlarda kullanılacağı ile ilgili çalışmalara bakıldığında, metot seçiminin öngörünün çerçevesi ile doğrudan bağlantılı olduğu görülmektedir. Öngörü çalışmasının amacı, kapsamı, bütçesi, insan kaynağı, gerçekleştirme zamanı, kapsayacağı zaman ufku, paydaşları ve uygulanacak öngörü seviyesindeki kurum ve kuruluşların yetenekleri metotların seçiminde etkin rol oynamaktadır. Öngörü çalışması farmakoloji gibi bilimsel araştırma odaklı konularda yapılacak ise literatür taraması, patent analizi, bibliyometri veya webometri gibi metotlar ön plana çıkarken, yenilik tabanlı konulardaki öngörülerde pazar araştırmaları, zayıf sinyal analizleri ve sürpriz kartlar da metotlara eklenmelidir. İletişim ve otomotiv gibi konularda yapılacak öngörü çalışmaları için, pazarın nabzını tutacak trend analizi ve ekstrapolasyon gibi metotlar ön plandadır. Maliyet, güvenlik ve gerçekleşme zamanı açısından riski büyük olan savunma sanayi gibi alanlarda mevcut durumun ortaya konması ile ilgili STEEPL, SOAR, SWOT gibi metotlar etkin şekilde kullanılmalıdır. Metotların uygulanmasında varsayımların açık şekilde ortaya konulması ve paylaşılması, doğrusal olmayan esnek modeller ile çalışılması etkinlik açısından önemlidir. Bu bağlamda FMSA modüler bir biçimde esnekliği sağlayacak şekilde geliştirilmiş ve metot seçiminde sonradan eklenebilecek kriterlere açık hale getirilmiştir. Literatürde öngörü konusundaki en geniş kapsamlı araştırma olan European Foresight Monitoring Network (EFMN) çalışmasına bakıldığında da literatür taraması, uzman panelleri ve senaryo oluşturma gibi bilgi üretme tabanlı metotlar ön plana çıkmaktadır. Bu durum da bilginin varlığının, erişilebilirliğinin ve kalitesinin öngörü çalışmalarındaki en temel kriter olduğunu ortaya koymaktadır. Özellikle bu araştırmanın konusu olan savunma sanayii gibi bilgi erişiminin ve paylaşılmasının zor olduğu alanlarda öngörü çalışmalarının metotlarının belirlenmesi *bilgi* kriterini en ön plana çıkarmaktadır. Yapılan bu çalışmada da istatistiki bilgilerin yeterli olmayışı, erişiminin zor olması ve paylaşılması zorluğu, metot seçiminde ilk kriter olarak kullanılmıştır.

FPM'nin en üst bölümünde yöntemlerin uygulamalarının sonuçlarına göre *Geleceklerin Stratejileri* belirlenir. Geleceklerin stratejilerinin oluşturulmasında kullanılan yöntemler de FMSA tarafından verilmektedir. Önceki yöntemlerle belirlenen durumları gösteren senaryolara göre; tutumlar, yani stratejiler ortaya konmaktadır. Bu araştırmada da belirtilen teknolojik konu için; öz kaynaklar FFF ile uyumlu olarak FMSA ile değerlendirilmiş, metodoloji ortaya konmuş ve metodolojinin uygulanması ile de farklı geleceklerin senaryoları belirlenmiştir.

Tercih edilen gelecek için de strateji ve yol haritası çizilmiştir. Tercih edilen geleceğin belirlenmesi de yine uygulanan metotlar ve metotların analizi ile sağlanmıştır.

Bu tezde araştırma metodolojisinin yaklaşımı olarak ontoloji ve epistemoloji anlamında hem *pozitivist,* hem de *yorumsamacı* yaklaşım kullanılmıştır. Ontolojiyi gerçekliğin doğası, epistemolojiyi de o gerçekliği tanımlamak için ortaya konan bilgi ve açıklayıcı kanı olarak ele aldığımızda; bilgi, araştırmacı ve doğa arasında ilişkiyi sağlayan olgudur. Bilginin elde edilmesi deneysel ve deneysel olmayan yöntemler ile gerçekleştirilir. Pozitivist yaklaşımda bilgi evrensel yasalara dayanan objektif ve tarafsız gerçekleştirilen deneyler ile nicel olarak elde edilirken, yorumsamacı yaklaşımda kişisel tecrübeler, duygular ve algılamalar ön plana çıkar ve nitel yöntemler baskın olarak kullanılır. Bu araştırma çalışmasındaki temel kavram olan *Gelecek* kavramının öngörüsünün hem bugünü ve geçmişi kavramak hem de geleceği kestirmek olduğunu düşündüğümüzde, her iki yaklaşımın da kullanılması kaçınılmazdır. Gelecek ile ilgili ortaya konan herhangi bir varsayımın o anda deneysel olarak gerçeklenmesi söz konusu değildir. Ayrıca, gelecek ile ilgili her değişkeni değerlendirmek de mümkün değildir. Bu durum *Gelecek* kavramının kısmî olmasını ifade etmektedir. Bu bağlamda Gelecekler Çalışmalar'ından biri olan öngörü geçmiş ve bugün için istatiksel verileri, test edilerek ortaya konmuş enformasyonu değerlendirir. Bu açıdan geçmiş ve günümüz için pozitivist yaklaşım daha baskındır. Geleceğin kestirilmesi için geçmişin ve bugünün açık bilgileri kullanılarak, örtük bilgilerin, algıların, yorumların ve hayal etme gücünün eklenmesi ile gelecek kestirilmeye çalışılır. Bu nedenle Gelecekler'in kestirilmesi yorumsamacı anlayışı daha baskın hale getirir. Araştırmanın metodolojisi, indükleyici akıl yürütme (inductive reasoning) tabanına göre tasarlanmıştır. Araştırma, gözlemler ve literatür taraması ile başlamış; çeşitli yöntemler ile örüntülere ve bütünsel çıkarımlara ulaşmaya çalışılmıştır. Gelecek kavramını keşfedebilmek, tanımlayabilmek ve açıklayabilmek için temel olarak araştırma *Nitel Araştırma* olarak yürütülmüştür. Veri toplama yöntemleri olarak yarı yapılandırılmış ya da açık uçlu soruların oylama ve anket ile toplanması esas olarak kullanılmıştır. Kullanılan bu metotların analizleri de verilerin hem nitel hem de nicel olarak değerlendirmesini içermiştir. Veriler nitel olarak araştırmacı tarafından yorumlanmış, gruplanmış ya da konuya dahil edilmemiştir. Ancak yorumlanan ve gruplanan verilere atanan değerler ve oylamalar matematiksel yöntemler ile sayısallaştırılarak değerlendirilmiştir. Belirtilen bu çerçevede araştırma metodolojisi, araştırmacı tarafından yapılan literatür taraması ile başlamış, paydaşların fikir ve görüşlerinin dahil edilmesi ile devam etmiş ve çeşitli kriterlere göre sayısallaştırılan verilerin uzmanlık seviyesi ile yorumlanması ile sonuçlandırılmıştır. Araştırma zaman periyoduna göre boylamsal araştırma, amacına göre uygulanan metotlar dahilinde hem keşfedici hem de tanımlayıcı niteliktedir. İlk uzman paneli için daha çok tanımlayıcı; ikinci uzman paneli için de keşfedici olarak tanımlanmaktadır. Çalışmada kullanılan metotlarda veri tipine göre nominal ve ordinal veriler elde edilmiştir. Veri kaynakları olarak birincil ve ikincil veri kaynaklarından faydalanılmıştır. Birincil veri kaynakları olarak uzman görüşleri, gözlemler ve anketler kullanılmış; ikincil veri kaynakları olarak da diğer araştırmacıların sonuçlarını içeren kaynaklardan yararlanılmıştır.

Türk Savunma Sanayii'nde 2040 yılına kadar Hava-Uzay Haberleşme Teknolojileri Öngörüsü için esas olarak model, yapılar ve algoritma kullanılmıştır. Bu konunun seçimindeki esas amaç, literatürde böyle özel bir alanda herhangi bir çalışma yapılmamış olmasıdır. Ayrıca, araştırmacı öngörü çalışmalarının hava-uzay teknolojileri yerine hava-uzay *haberleşme teknolojileri* gibi daha dar kapsamlı özel amaçlı bir konuda gerçekleştirildiğinde daha etkili olduğunu değerlendirmektedir. Bunun nedeni, araştırmacının akademik (elektrik-elektronik mühendisliği) ve profesyonel kariyerinin (Türk Savunma Sanayiinde mühendislik) çalışmanın daha etkin olmasını sağlamasıdır. Bu tezde verilmeyen, kazanılan dersler dikkate alındığında (araştırmacının gelecekteki bir başka çalışmasının konusu olarak planlanmaktadır), öngörü çalışmasını yürütenlerin yetkinliği, bilgi birikimi ve uzmanlığı, en az çalışmanın modeller üzerinde planlanması ve sistematik bir biçimde gerçekleştirilmesi kadar önemlidir. Öngörünün doğası katılımcı ve katılımcılarla öğrenme sürecini teşvik edici olduğundan, kısıtlı zaman ve bütçe içerisinde öngörü çalışmaları yürütmek ve baskın katılımcıların uzun konuşmasını önlemek için önceden hazırlanmış şablonlarla yöntemlerin açık bir şekilde açıklanmasını gerektirir. Bu nedenle, tüm bu yorumlar dikkate alınarak, modelin yöntemler ve alt yöntemler ile uygulanması aşağıdaki paragrafta verilmiştir.

FMSA'nın çıktıları öz yöntemler olarak *Literatür Taraması*, *Uzman Paneli*, *Delphi Anketi* ve *Yol Haritalama*; destek yöntemler olarak *STEEPL*, *SOAR*, *Trendler*, *Zayıf Sinyal*, *Sürpriz Kart Analizleri* ve *Senaryo Oluşturma* yöntemlerini önermiştir. Literatür taraması araştırmacı tarafından savunma sanayiinde hava-uzay haberleşme teknolojileri için olduğu kadar öngörü yöntemleri için de yapılmıştır. Bu tez çalışmasında yöntemler ve teknolojiler hakkında sunulan tüm şablonlar ve açıklamalar, uzman panellerinden önce literatür taraması ışığında hazırlanmıştır. İleride yürütülecek yöntemlerin uygulamalarına ışık tutmak amacıyla, araştırmacı tarafından tüm yöntemlerin analizleri yapılmıştır. Bütçe, zaman ve sponsor olmaması nedeniyle sadece iki uzman paneli gerçekleştirilmiştir. İlk uzman paneli SSB'de akademisyenler, savunma sanayiinde yer alan kamu ve özel kuruluşlar ile STK'lardan 44 katılımcı ve SSB'nin kısmi desteği ile gerçekleştirilmiştir. İlk uzman panelinin amacı, 2040 yılı için Türk Savunma Sanayiinde hava-uzay haberleşme teknolojilerinin geleceğinin öngörülmesi konusunda paydaşlar arasında farkındalık yaratmak olmuştur. Bu nedenle, ilk aşamada, havacılık ve uzay teknolojilerinin güncel durumunu belirlemek için *STEEPL*, *SOAR*, *Tek Kaynak*, *Trendler*, *Vizyon Oluşturma*, *Taksonomi için Ağırlık Kriterlerinin Önceliklendirilmesi*, *Taksonomi Uygulamalarında Sistem ve Destek Seviyesi Teknolojilerin Puanlanması* çalışmaları 2.5 saat içinde gerçekleştirilmiştir. Araştırmacı, çalışmanın amacını ve akışını açıkladıktan sonra (her bir yöntemin zamansal planı ile) önceden hazırladığı (kağıt ortamda) STEEPL ve SOAR şablonlarını, kendi fikirlerini eklemek ve tüm maddeleri oylamak üzere uzmanlara sunulmuştur. Tek kaynak çalışmasında uzmanlardan, Türkiye'nin tek kaynak olduğu teknolojileri yazmaları istenmiştir. Trend çalışması için katılımcıların şablona önceden yazılmış olan hava-uzay haberleşme teknolojilerindeki trendlerin oylama yoluyla değerlendirmesi istenmiştir. İlk panelde yer alan masalardaki uzmanların oturma düzeni, araştırmacı tarafından görevli oldukları kurumlara göre yapıldığından, 2040 yılı için savunma sanayiinde havacılık ve uzay haberleşme teknolojileri vizyonları bağımsız olarak toplanmıştır. Bu düzenleme, katılımcıların vizyon çalışmasını çok kısa sürede gerçekleştirmesi ve diğer yöntemlerin sonuçlarının analizi için de gerekli görülmüştür. Bu şekilde, araştırmacı analizlerde gruplar arasındaki farklılıkları görme şansına sahip olmuştur. Eklerdeki grafiklerde ve tezdeki metinlerde gruplar masa numarası ile tanımlanarak belirtilmiştir. Kriterlerin ağırlıklandırılması çalışmasında, araştırmacı tarafından önceden belirlenmiş kriterlerin uzmanlara açıklanmasından sonra, uzmanlardan kriterlerin öneminin ikili olarak karşılaştırılması istenmiştir. *Rekabet avantajı yaratmak* K1 olarak, *başka araştırma alanları oluşturmak* K2 olarak ve *ulusal güvenlik ihtiyaçlarını karşılamak* K3 olarak belirlenen kriterlerdir. Hava-uzay haberleşme taksonomisinde sistem ve destek teknolojilerle ilgili puanlama yapılan bir sonraki uygulamada, EDA ve NASA taksonomileri ve araştırmacının kendi yorumu (literatürde havacılık-uzay haberleşmeye özel bir taksonomi yoktur) esas alınarak araştırmacı tarafından oluşturulan taksonomi kullanılmıştır. Uzmanlar, teknolojilere her bir kriter için (0-10 arası) puanlama yapmıştır.

SSB'nin organizasyon değişimi nedeniyle yalnızca toplantı odası desteği verdiği ikinci uzman panelinde 19 katılımcı yer almıştır. Araştırmacı, katılımcılara ilk uzman paneli verilerinin analizi hakkında bilgi vermiş ve bu amaçla tasarladığı web sitesi aracılığıyla sonuçları katılımcılarla paylaşmıştır. İlk uzman panelinin analizi, ikinci uzman panelinin gerçekleştirilmesinden önce yapılmıştır. Uzmanların tüm cevapları, Excel'in uygun formülleri kullanılarak yapılan analizler ile her bir yöntem için yorumlanmış, gruplandırılmış, ağırlıklandırılmış ve düzenlenmiştir. Katılımcı ve masa (farklı gruplar) düzeylerine ait histogram ve önceliklendirilmiş ortalama grafikleri, ikinci uzman panelinden önce oluşturulmuş web sitesi aracılığıyla birinci ve ikinci uzman paneli katılımcıları ile paylaşılmıştır. Araştırmacı tarafından özgün olarak yapılan *Zayıf Sinyal Analizi*, histogram ve önceliklendirmelerin ortalamaları arasındaki farkların değerlendirilmesi ile gerçekleştirilmiştir. İkinci uzman panelinin amacı, hava-uzay haberleşme teknolojileri için araştırmacı tarafından *varsayımsal tespit* olarak tanımlanan *Delphi ifadelerinin* oluşturulmasıdır. İlk uzman panelinin analizi ile ortaya konulan hava-uzay haberleşme teknolojilerinin mevcut durumuna göre, ikinci panelde uzmanların önceden yazılmış olan (araştırmacı tarafından) havacılık ve uzay haberleşme teknolojileri ile ilgili Teknik Delphi ifadelerinin önceliklendirmesi beklenmiştir. Uzmanların kendi teknik Delphi İfadelerini de yazmaları istenmiştir. SEEPL Delphi İfadeleri için de aynı prosedür izlenmiştir. Delphi sorgulama soruları uzmanların görüşüne sunulmuş ve *Sürpriz Kart* çalışması yapılmıştır. Dört tip sürpriz kart olduğu ve bunların birbirinden farkları uzmanlara açıklanmış ve onlardan araştırmacı tarafından önceden hazırlanmış olan şablonun doldurulması istenmiştir.

Araştırmacı, uzmanlar tarafından değerlendirilerek gruplanan, karşılaştırma ve önceliklendirme yapılan Delphi ifadelerini analiz etmiştir. Delphi Anketi için, değerlendiricilerin anketi doldurma süresi ve sıkılma noktaları düşünülerek, 104 Delphi İfadesi'nden 27'si seçilmiştir. Delphi Anketi, Google Formlar'da oluşturulmuş ve ilk turda çevrim içi olarak 2120 katılımcıya gönderilmiştir. Tez çalışmasında ayrıntılı olarak açıklanan bazı sınırlamalar ve kısıtlar nedeniyle dört hafta içinde ilk tur anketi 120 katılımcı yanıtlamıştır. İkinci tur Delphi Anketi ilk turdaki katılımcılara kendi cevapları ve ilk turun analiz istatistiklerini içeren bir anket olarak gönderilmiştir. Bu kontrollü geri bildirimin amacı, katılımcıların genel fikirleri görmesi ve ihtiyaç duyarlarsa görüş birliğine varmak için cevaplarında değişiklik yapmalarına olanak sağlamaktır. Katılımcıların 34'ü cevaplarını değiştirmiş ve 120 katılımcının verdiği son cevaplara göre araştırmacı tarafından Delphi Anketi analizi yapılmıştır. İkinci uzman panelde oylanan ve oluşturulan SEEPL Delphi İfadeleri ankete tabi tutulmamış, analiz edilerek politika önerileri olarak strateji oluşturmada kullanılmıştır. Delphi anketi örneklem büyüklüğü, içerik geçerliliği, güvenilirliği ve görünüş geçerliliği açısından da değerlendirilmiştir. Anket belirli bir örnekleme gönderilmemiş Türkiye'deki tüm üniversitelerin ve savunma sanayinde elektronik haberleşme alanında ön plana çıkan akademisyenlerine ve uzmanlarına gönderildiği için tüm araştırma evrenini kapsamıştır. Delphi tekniğindeki Delphi İfadelerinin oluşturulması için oluşturulan uzman panellerinin büyüklüğü ve kalitesi literatürde verilen referanslar ile örtüşmektedir. Delphi çalışmalarının içeriği uzmanlar gibi birincil kaynaklara ve yayınlanmış literatüre dayandığı için, literatürde içerik geçerliliği yüksek yöntemlerden biri olarak değerlendirilmektedir. Delphi anketi de en az 2 aşamalı olarak gerçekleştirildiği ve kontrollü geri beslemeyi içerdiği için içerik geçerliliğini üst düzeye çıkaran bir araç olarak değerlendirilmektedir. Delphi ifadelerinin oluşturulmasında yaratıcının bilinmemesini temel alan yöntemler ile ön yargı, baskınlık, katılımcıların yüz yüze görüşmesinin önüne geçildiği için, ankette de yineleyici aşamaların olması güvenilirliği sağlamıştır. Görünüş geçerliliği, Delphi ifadelerinin belirlenmesinde kullanılan taslakların açık ve net olması, ayrıca araştırmacı tarafından açıklanması ile sağlanmıştır. Delphi anketinde de Delphi ifadeleri açık şekilde ortaya konmuş, belirsizlik yaratabilecek sorular yazılı olarak açıklanarak görünüş geçerliliği elde edilmiştir.

Türk Savunma Sanayiinde 2040 yılı için hava-uzay haberleşme teknolojileri yol haritasının oluşturulması, öncelikle gelecekler senaryolarının belirlenmesini gerektirmiştir. *Ulusal güvenliğe katkı, ulusal ekonomiye katkı* ve *gerçekleştirilme zamanı'* na göre yapılan Delphi anketi analizi sonucunda araştırmacı tarafından dört farklı senaryo oluşturulmuştur. Hızlı Senaryo olarak adlandırılan ilk senaryo, 2018-2023'ün gerçekleşme zamanında en yüksek puanlanan Delphi İfadelerini içermektedir. Kârlı Senaryo -ikinci senaryo-, ulusal ekonomiye ortalama katkı puanı (uzmanların aynı Delphi ifadesi için verdiği puanların ortalamaları) aynı kriterdeki tüm Delphi İfadeleri'nin ortalamasından daha yüksek Delphi İfadelerinden oluşturulmuştur. Tercih Edilen Senaryo, ulusal güvenliğe katkı kriterine göre belirlenmiştir. Tercih Edilen Senaryoda, ulusal güvenliğe ortalama katkı puanı aynı kriterdeki tüm Delphi İfadeleri'nin ortalamasının üzerinde olan Delphi İfadelerini içermektedir. Optimum Senaryo olan son senaryoda, ulusal güvenlik ve ulusal ekonomiye katkısı olan ve her iki kriterde de tüm Delphi İfadelerinin ortalamalarının üzerinde puanlanan Delphi İfadeleri kapsanmıştır. Strateji, -stratejinin eylemleri içerdiği gerçeğinden dolayı- araştırmacı tarafından başlangıç yeteneklerine göre şekillendirilmiştir. Bu nedenle ikinci uzman panelinde SEEPL analizinin sonuçları strateji oluşturmada kullanılmış ve değerlendirmelere göre oylanan ve puanlanan sosyal, ekonomik, çevresel, politik ve yasal faktörler politika önerilerine dahil edilmiştir. Aynı zamanda, uzmanlar tarafından oluşturulan ilave SEEPL faktörleri araştırmacı tarafından gruplandırılarak birleştirilmiş ve analiz edilmiştir. Ulusal güvenlik ihtiyaçlarını karşılama kriteri ilk uzman panelinde önceliklendirme kriterleri çalışmasının ağırlıklandırılmasında ilk sırada yer aldığından bu araştırmanın stratejisi Tercih Edilen Senaryo için belirlenmiştir. Tercih Edilen Strateji, Tercih Edilen Senaryo'sundaki Delphi ifadelerinin başlangıç yetenekleri dikkate alınarak oluşturulmuştur. Birçoğu uygulamalı araştırma aşamasında olduğundan, stratejideki politika önerileri gerekli gerçekleşme zamanı için bu koşul iyileştirilecek şekilde seçilmiştir. Son olarak, Türk Savunma Sanayiinde 2040 yılına kadar havacılık ve uzay haberleşme teknolojilerinin yol haritası ile stratejideki eylemler görsel olarak öngörü çalışmalarının dinamikliğini de içerecek şekilde gösterilmiştir. Tercih edilen senaryoda, Türk Savunma Sanayii'nde hava-uzay haberleşmede kuantum kripto teknolojilerinin kullanılır hale gelmesi 2030-2035 yılları arasında öngörülmüş şu andaki durumu temel araştırma düzeyinde değerlendirilmiştir. Hava ve uzay platformları akıllı bir ağ üzerinden haberleşebilme ve pozisyonel kodlarını iyonosferden kaynaklanan bozulmalara rağmen düzeltebilme ve bu sayede dar iletişim hüzmeleri kullanarak ağ yapısını gürbüz şekilde koruyabilme yeteneğine sahip olarak geliştirilmesi ancak 2024-2029 yılı için öngörülmüş ve şimdiki durumu uygulamalı araştırma olarak değerlendirilmiştir. Hava ve uzay platformları arasında güvenli iletişim, yüksek hızlı iletişim (>=100GB/sn) ve verimli iletişim (>1pJ/bit) sağlayan kodlama ve kod çözme teknolojileri kullanılması da 2024-2029 yılları için tahmin edilmiş, mevcut alt yapı da uygulamalı araştırma olarak değerlendirilmiştir. Hava platformları arasında orta-kısa menzilli, iki yönlü yüksek veri iletişimi sağlayan, birbirlerine kilitli dar hüzmeli Ad-Hoc (Electronic Counter Measure-ECM ve Low Probability of Intercept-LPI özellikli) hava tabanlı ağ oluşturulması, birinci uzman panelinde özellikle askerler için en öncelikli teknolojik gereklilik olarak çıkmasına rağmen gerçekleştirilme zamanı 2024-2029 olarak tahmin edilmiştir. Bu alt yapının henüz uygulamalı araştırma durumunda olması da -acil ihtiyaç olarak belirtildiği için- hızlandırılması gereken bir durumdur. Tercih edilen stratejide 2018-2023 aralığında gerçekleştirileceği kestirilen ve hepsi uygulamalı araştırma aşamasında olan yedi adet sistemden teknik detaylara girmemek için özet bölümünde bahsedilmeyecektir.

Bu araştırma, hem model tabanlı olması ve hem de pratik uygulamasının yapılmış olması yönüyle önemli bir araştırma olarak değerlendirilmektedir. Türk Savunma Sanayinde 2040 yılı Hava-Uzay Haberleşme Teknoloji Öngörüsü için yeni çerçeve ve kuşak da içeren yeni bir model ve yeni bir metot seçim algoritması birbirine entegre edilerek kullanılmıştır. Veri Analizi bölümünde ve eklerde, araştırmacının yorumlarıyla birlikte pek çok detay sunulmuş olduğundan araştırmanın konusuyla ilgili herhangi bir teknolojik sonuca burada değinilmemiştir. Savunma sanayiinin etkili kurumları tarafından bu araştırmanın teknik sonuçlarının ve pratik uygulamanın yeniden değerlendirilmesi ve kullanılması beklenmektedir. Bu şekilde, bu araştırmadan elde edilen zorlukların ve kazanılan derslerin, model ve uygulamayı iyileştirmek için ileride yapılacak çalışmalara ışık tutacağı değerlendirilmektedir. Çoğunlukla mikro ve makro faktörlerden etkilenen savunma sanayiinde geçerli ve genişletilmiş istatistiksel verilerin yetersiz olmasından dolayı, bu çalışmanın ana teması FPMA sonuçlarının da desteklediği gibi uzman görüşlerinin ve değerlendirmelerinin toplanması olarak tasarlanmıştır.

Öngörü çalışmaları etkin olabilmek için sahiplenme, bağlılık ve süreklilik gerektirmektedir. Bu nedenle öngörü seviyesine, konusuna ve kapsamına da bağlı olarak sahiplenici bir kuruluşun varlığı ve desteğinin olması önemlidir. Bu çalışmada böyle bir kurumun varlığının tam olarak sağlanamaması araştırmacının uzmanları bir araya getirmesinde zorluklar yaşaması belirgin bir kısıtlama olarak ortaya çıkmaktadır. Bu kısıtlama dahilinde bile ilk panelde hiçbir ekonomik destek veya teşvik almadan uzmanların katılımları ve konuyu kavramaları araştırmacı açısından cesaret verici olarak değerlendirilmektedir. Hava-uzay haberleşme teknolojilerinin mevcut durumunu belirlemek için gerçekleştirilen ilk uzman panelinde ilgili kurum ve kuruluşlardan gerekli katılımcıların aynı gün ve zamanda bir araya getirilmeleri araştırmacının yüksek eforu ile doğru orantılı olmuştur. İkinci panel ise tamamen teknik yeterlilik üzerine kurgulanmış ve katılımcılar bu doğrultuda davet edilmişlerdir. Bu panelde ilk panele göre katılımcı sayısının az olmasına rağmen teknolojik değerlendirme için gerekli teknik uzman sayısına ulaşıldığı değerlendirilmiş ve literatürdeki sayılar ile örtüşmüştür. Çalışmadaki zaman kısıtlaması da diğer bir kısıtlayıcı unsur olmuştur. Herhangi bir zaman kaybını önlemek için katılımcıların çalışacakları tüm dokümanlar ve taslaklar araştırmacı tarafından kağıt ortamında hazırlanıp panel başlamadan masalarında hazır hale getirilmiştir. Panelin başlamasıyla beraber araştırmacı, panelin zaman çizelgesini ve aktivitelerin açıklamalarını kısaca katılımcılara belirtmiştir. Bu şekilde kısıtlı zaman içinde, yazılı formatta veriler etkin ve verimli bir şekilde araştırmacı tarafından toplanmıştır. Ek olarak, Delphi Anketi için çok boyutlu matris oluşturarak tek pencerede 27 adet Delphi ifadesi için sorgulama yapabilen bir ticari sorgu program bulunamamıştır. Google Forms ve Survey Monkey'de de bu şekilde bir tasarım olanağı bulunmamaktadır. Aynı şekilde, araştırmacı tarafından bulunan Lime Survey programı da sadece çifte-matris olanağı sağladığı için yeterli olamamış, gerekli olan çoklu matris formu araştırmacı tarafından Excel Makro yazılımı ile geliştirilmiştir. Fakat geliştirilen makro programının bir çok web sunucu için reddedilme ihtimalinin yüksek olması ve anket kullanıcılarının bir uygulama programını bilgisayarlarında açmalarını tercih etmeyeceklerinin öngörülmesi tek pencerede gerçekleştirilen ve daha kolay değerlendirmeye imkan sağlayan bu programdan vazgeçilmesini zorunlu kılmıştır. Bu nedenle araştırmacı Delphi Anketini 27 sayfa olarak Google Formlar ara yüzünde hazırlayarak katılımcılara göndermiştir. Bu durumdan dolayı öngörü çalışmalarının temel metotlarından biri olan anket metotları için daha uygulanabilir alt yapıların geliştirilmesi önerilmektedir. Savunma sanayinin doğasının gereği olan *gizlilik* bu araştırma için bir başka kısıtlama olmuştur. Katılımcılar özellikle devam eden projeler ile ilgili bilgilerin bazılarını gizlilik gerekçesiyle paylaşamamışlar, bu durum da ankete katılım oranını etkilemiştir. Aslında bu çalışma için en önemli kısıtlama Türkiye'nin şu an içinden geçtiği küresel ve bölgesel sıkıntıların yansıması olmuştur. Bu süreçte insanların herhangi bir araştırmaya katılmasındaki isteksizlik hayal kırıklığı yaratmıştır.

Sonuç olarak, gelecekteki benzer çalışmalarda sahiplenici kurumların ve ekonomik desteklerin bulunması; paydaşlar için güven ortamının, bağlılık ve özverinin arttırılmasında en önemli rolü oynayacaktır. Öngörü çalışmalarının belirli zaman periyotlarında değerlendirilmesi ve etki analizlerinin yapılması çalışmaları daha faydalı hale getirecektir.

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Soyadı / Surname : Yüksel
Adı / Name : Nurdan
Bölümü / Department : Science and Technology Policy Studies

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