AN R&D ROADMAP FOR TURKISH DEFENSE INDUSTRY

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ABSTRACT

AN R&D ROADMAP FOR TURKISH DEFENSE INDUSTRY

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One of the worldwide leading sectors with the highest R&D resources allocation is the defense industry, which has recently been growing rapidly in Turkey. R&D projects require investments and extra costs depending on the type of business. Therefore, companies feel obliged to track their R&D activities strictly by carrying out a series of controls and measurements so as to reach the desired objectives and avoid any financial loss. However, performance measurement of defense R&D activities differ from country to country since each country have their own unique defense industry laws and regulations, issues regarding defense industry call for confidentiality, and there is a lack of unanimously accepted source of reference in the field of defense R&D. This study deals with R&D performance measurement methods and metrics in Turkish defense industry. In two different focus group interviews, an answer was sought to the question of *What should be the R&D and innovation vision of Turkish Defense Industry companies?*. In this way, technology evaluation criteria were weighted, and technology areas were ranked. Thereafter, a two-round Delphi survey relating to 19 Delphi statements about defense industry was carried out. As a result of this process, D.14 statement of *Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to*

simulate critical cues provided by real platforms came to the forefront, and what should be done by public and private enterprise to realize the corresponding question of this Delphi statement – D.14.8 – asking *The contribution of the issue mentioned in the Delphi statement to Turkey's science, technology, and innovation capacity* was identified as the roadmap through face-to-face interviews with relevant experts in the field.

Keywords: R&D Performance Metrics and Methods, The Delphi Method, Virtual and Augmented Reality, Manufacture Effective Simulators, Technology Roadmap

ÖZ

TÜRK SAVUNMA SANAYİİ İÇİN BİR AR-GE YOL HARİTASI

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Ar-Ge çerçevesinde dünya genelinde en fazla kaynak ayrılan sektörlerden biri de savunma sanayii sektörüdür. Türkiye' de de savunma sanayii sektörünün gelişimi hızlı bir şekilde devam etmektedir. Ar-Ge projeleri faaliyet alanına göre yatırım ve maliyet gerektirmektedir. Bu sebeple firmalar bu yatırımları yaparken zarar etmemek ve sonuç almak için bir dizi kontrol ve incelemeler yaparak Ar-Ge faaliyetlerinin durumunu takip etmelidirler. Ancak her ülkenin savunma sanayiine yönelik kanun ve mevzuatı farklı olduğundan, savunma sanayii konuları gizlilik barındırdığından Savunma sanayii Ar-Ge'si konusunda uluslararası verilerin tek ve yaygın olarak kabul gören bir kaynağın bulunmamasından dolayı savunma sanayii Ar-Ge faaliyetlerinin performans ölçümü ülkelere göre farklılık arz etmektedir. Bu tez çalışmasında Türkiye'de savunma sanayiine yönelik Ar-Ge faaliyetlerinin performans ölçümüne dair metrikler ve ölçüm yöntemlerinden bahsedildi. Ayrıca tez çalışmasında iki adet odak grup çalışması yapılarak *Türk Savunma Sanayii Firmalarının Ar-Ge ve inovasyon vizyonu ne olmalı?* sorusuna cevap arandı. Teknoloji değerlendirme kriterlerinin ağırlıklandırılması ve teknoloji alan sıralaması yapıldı. Sonrasında savunma sanayiine yönelik ortaya çıkan 19 adet Delphi cümlesiyle ilgili iki turlu Delphi anketi gerçekleştirildi. Anket neticesinde ön plana çıkan D.14 Delphi cümlesi: *Gerçek platformlardaki ayırt edici kritik karakteristik*

özellikleri simüle etmek için sanal gerçeklik teknikleri kullanılarak yerli simülatör sistem ve alt sistem teknolojileri üretilecektir ile ilgili D.14.8 sorusunu: Delfi cümlesindeki konunun *Türkiye'nin bilim teknoloji ve yenilik yeteneğine katkısı* gerçekleştirmek için 2023'e ve 2023-2028 yılları arasında kamu ve özel sektör tarafından yapılması gerekenler, ilgili teknik uzmanlarla yapılan yüz yüze görüşmeler de dikkate alınarak yol haritası olarak belirlendi.

Anahtar Kelimeler: Ar-Ge Performans Metrikleri ve Yöntemleri, Delphi Yöntemi, Sanal ve Artırılmış Gerçeklik, Etkili İmalat Simülatörleri, Teknoloji Yol Haritası

To my elder brother Ersan

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LIST OF ABBREVIATIONS

2D	2 dimension
3D	3 dimension
5G	Fifth Generation Mobile Communications Service
6D	6 dimension
AI	Artificial Intelligence
AR	Augmented Reality
BSC	Balanced Scorecard
CBK	Presidential Decree
GIS	Geographical Information Systems
GPU	Graphics Processing Unit
HUD	Heads up Display
ITAR	International Traffic in Arms Regulations
OECD	The Organization for Economic Co-operation and Development
PPL	Participial number
R&D	Research and Development
SIPRI	Stockholm Internatıonal Peace Research Instıtute
SLAM	Simultaneous Localization and Mapping
SSB	Presidency of Defense Industries
SSM	Undersecretariat of Defense Industries
TAF	Turkish Armed Forces
TTM	Trailing Twelve Months
TÜBİTAK	Scientific and Technological Research Council of Turkey
TÜİK	Turkish Statistical Institute
TÜSSİDE	Turkish Management Sciences Institute
UAV	Unmanned Aerial Vehicles
UI	User Interface
US	United States of America
USA	United States of America

UX	User Experience
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

Originated in England in the late 18th century, the Industrial revolution, also known as the First Industrial Revolution, refers to a transition in mode of production from man-made and animal-based to machinery-based (Yediyıldız, 1994). The continuous advancements in science and technology accompanying the Industrial Revolution paved the way for a great deal of inventions such as steam engines, telegram, telephone, electric lamp, railroads and fuel-powered 4-wheel cars. These technological inventions and scientific advancements brought about improvements in people's lives as well as in economy. With the invention of transistors in the 20th century, a lot more different and advanced technologies can be used today.

Scientific and technological progress is one of the foremost aspects of economical and societal enhancements, and policies in science and technology are used to determine the pace and direction of these improvements. Attaining the desired goals requires well-educated manpower along with the use of goal-oriented policies in research and development (henceforth R&D), industry, and education (Yılmaz, 2014). There is a connection between the worth of a country's exports and its level of development. Exporting high-quality, technological, and value-added products is essential to the economy of a country. Scientific and technological developments are necessary for a society to produce value added products, continue its competitive advantage, and enhance its people's welfare. In doing so, policies in science, technology, and industry should be aligned with the existing conditions in the country and its relative position in the world (Uzkurt, 2014) because these policies directly influence the welfare level of countries (Seyrek & Karakaya, 2008).

Transferring the gains obtained through scientific and technological advances into modes of production means developing new products and methods. In other words, any R&D expenditure is actually a form of investment, and profits to be gained out of such investment can indeed be more than the value of investment itself. R&D activities include collecting new technical data, developing production methods and processes, creating unique designs, lowering the product costs, and attempts to increase quality standards (Agir, 2010). In today's world, it is a necessity to produce inexpensive and high quality goods in order to be able to compete in international markets. Countries that manage to transfer scientific and technological knowledge into financial and societal benefits maintain a competitive advantage over others. In this sense, the proportion of a country's R&D expenses to its gross national expenditures is a significant indication of this advantage. Such figures as the number of people employed in R&D, patents obtained, scientific publications and citations, and the rate of high-tech products in the overall export volume are considered within the scope of R&D activities (Agir, 2010). R&D investments are regarded as indicators of competitive capacity and economic growth, and are, in the long run, the key components in increasing welfare and productivity (Korkmaz, 2010).

One of the leading industries all over the globe with the highest R&D investment is the defense industry. R&D in defense industry generally targets at developing and producing national weaponry, decreasing foreign dependency, increasing the market share through novel products, and realizing country's strategic objectives (Genç, 2013). Global defense expenditures experienced a rise of 45% between 1999 and 2008 (Genç, 2013).

Today, arms race among countries is continuing without slowing down, and expenses worldwide, particularly in defense industry, are increasing day by day. Table 1 below summarizes the data reported in Stockholm International Peace Research Institute (SIPRI) database regarding the regional distribution of military expenditures across the world and yearly change in percentage.

Table 1
World Military Expenditures in 2018

Region	Spending (in millions of US$)	Yearly Change (%)
Africa	40.6	-8.4
North Africa	22.2	-5.5
Sub-Saharan Africa	18.4	-11
America	735	4.4
Central America and the Caribbean	8.6	8.8
North America	670	4.4
South America	55.6	3.1
Asia and Oceania	507	3.3
Central and South Asia	85.9	4.2
East Asia	350	4.1
Oceania	29.1	-2.9
South East Asia	41.9	-0.8
Europe	364	1.4
Central Europe	28.3	12
Eastern Europe	69.5	-1.7
Western Europe	266	1.4
Middle East	no data available	no data available
World Total	1822	2.6

According to SIPRI data, Turkey's military spending in 2018 reached up to approximately 19 billion US$ following an increase of 24% compared to previous year[1]. Defense-based R&D activities in Turkey have gained considerable speed in recent years. These defense industry R&D activities have had a positive influence on finance and other industries. Needless to say, R&D activities play a key role in the development of countries. R&D is a costly process requiring certain amount of

[1] https://www.dw.com/tr/sipri-t%C3%BCrkiye-askeri-harcamalar%C4%B1-y%C3%BCzde-24-art%C4%B1rd%C4%B1/a-48523367 (accessed on 23.08.2019)

investment. Therefore, companies are to keep track of their R&D activities through continuous checks and investigations so that they will not lose money, and can secure positive gains. However, as each country has its own defense industry laws and regulations, issues of defense industry call for secrecy, and there is not a single, collectively agreed upon data source on defense industry R&D, countries differ in measuring the performance of R&D activities in defense industry (Gallart, 1999). Besides, since each R&D project and organization is unique, there are not common criteria to assess any R&D process (Temel, Kaplan, & Sonkaya, 2016). That's why the present study focuses on the performance measures and measurement methods of R&D activities in Turkish defense industry. Within this context, seeking an answer to the question of *What should be the R&D vision of Turkish Defense Industry Companies?*, the study aimed at weighting and ordering the technology evaluation criteria. Thereafter, a two-round Delphi survey on the 19 Delphi statements relating to defense industry was carried out. D.14 statement coming to the fore as a result of this process is as follows:

Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms. Related to this, in order to investigate the D.14.8 question asking *The contribution of the issue mentioned in the Delphi statement to Turkey's science, technology, and innovation capacity*, actions to be taken until 2023, and between 2023 and 2028 were identified based on face-to-face interviews with relevant technical experts.

This dissertation is composed of 7 chapters including the introduction. Chapter 2 gives a brief historical overview of Turkish Defense Industry, followed by information on the organizational structure, and the subsidiaries and affiliates of Presidency of Defense Industries – an operative institution in Turkish Defense Industry – defense industry support fund, defense industry executive committee, and the post-2006 period in defense industry. The chapter concludes by defining R&D, and mentioning its types and indicators of Turkey's R&D expenditures.

Chapter 3 reviews the related literature in R&D performance metrics, R&D performance measurement methods, and R&D in defense industry. The final part of the chapter presents a synopsis of all the reviewed articles.

Research methodology is detailed in Chapter 4 beginning with information on quantitative research, focus group, and survey techniques. Subsequently, different types of surveys, development of survey questions, the Delphi method, its steps, planning, and sample determination are explained. The chapter closes with step-by-step delineation of how to implement a two-round Delphi survey.

Chapter 5 includes a description of the data analysis process. Data was collected through 2 focus group interviews on different days, and a two-round Delphi survey. Weighting of the technology evaluation criteria was completed in the first focus group interview with the participation of 9 individuals from the academy and business world. As a result, the criterion of *Meeting National Security Requirements* occupied the first place.

Based on technology evaluation criteria, participants ranked 35 technology areas. Relying on the criteria of Meeting National Security Requirements, Competitive Advantage, and Creating Other Technology Areas, the rough drafts of the Delphi statements to be finalized in the second focus group interview and used in the Delphi survey were written.

The first focus group also included a vision study whereby participants were posed the question of *What should be the R&D and Innovation vision of Turkish Defense Industry companies?*, and were asked to form vision statements. Participants created two vision statements in two respects; one for Turkey, and one for companies. The first vision statement for the companies came out to be as follows:

To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies.

The second vision statement for Turkish defence industry:

To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands in international markets, and adopts space as a new living environment.

Additionally, strategic goals to achieve the targeted visions were identified to be used in Delphi studies.

The second focus group interview was conducted with 11 people from public enterprises, the academy, and the business world. Participants' opinions on the 10 Delphi statements to be used in the Delphi survey prepared in relation to the technology areas derived in the first focus group interview, and their Delphi propositions concerning the related technology areas were obtained. Consequently, together with these 10 Delphi statements, and the ones developed by the participants at the end of the second focus group interview, a total of 19 Delphi statements were formed to be used in the first and second rounds of the Delphi survey. Beneath each of these were added the following 9 questions for the Delphi survey participants:

- level of expertise,
- sufficiency of human resources in our country,
- level of core knowledge in our country,
- capacity of hard infrastructure (devices/equipment),
- skills the companies in our country have,
- date of execution
- contribution to Turkey's competitive power,
- contribution to Turkey' science, technology, and innovation capacity,
- contribution to energy efficiency and environmental awareness in Turkey.

The Delphi survey participants were sampled from people employed or experienced in defense industry. The first round of the Delphi survey was carried out online with 167 participants contacting a total of 30 institutions via phone and e-mail. 94 participants answered the survey questions. The second round of the Delphi survey

was again conducted online with these 94 participants, who were again contacted via phone and e-mail. 58 participants answered the questionnaire in the second round. As a result of the analysis run, the D.14.8 question asking *The contribution of the issue mentioned in the Delphi statement to Turkey's science, technology, and innovation capacity* which was posed in relation to the D.14 Delphi statement of *Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms* was ranked first.

Within the context of the D.14 Delphi statement specified as the targeted technological activity, following companies located in Ankara, and doing business in *virtual reality technologies* were identified. Chapter 6 includes face-to-face interviews with the technical staff of these companies.

- SİM-TEK (Sim-Tek Simulation and IT Company)
- BITES (Bites Aerospace and Defense Inc.)
- HAVELSAN (Avionics Industry Inc.)
- SİMSOFT (Simsoft Computer Technologies Ltd. Comp.)

In these interviews, participants were generally informed about what should be done in accordance with the targeted technological activity.

Finally, Chapter 7, the Conclusions and Discussion part, mentions the studies conducted for this dissertation, and the course of action that should be taken until 2023 and from 2023 to 2028 by the public, academy and private sector in order to reach the technology objective expressed in the D.14 Delphi statement.

CHAPTER 2

A BRIEF HISTORICAL REVIEW OF TURKISH DEFENSE INDUSTRY

Recently, Turkish defense industry has increasingly gained prominence both because of the current political and economic conditions in Turkey and because of the worldwide cyclical fluctuations. Defense industry is basically defined as the totality of all the industrial facilities that manufacture weaponry, equipment, and ammunition including, as well, their spare parts and accessories[2].

Yavuzyılmaz (2014) provides a more comprehensive definition describing it as the branch of industry which consists of organizations investing in the defense of a country by providing various services and manufacturing processes.

The history of Turkish defense industry dates back to the conquer of İstanbul by the Ottoman Empire. As the Ottoman Empire enlarged its borders in time, its economy, and correspondingly its war industry, grew, too. For instance, cannons used for beating the sieged castles, and vessels designed in shipyards for naval warfare can be considered as indicators of this development.

Bostan (2000) highlighted that within only one year after the loss of 190 vessels in the Battle of Lepanto on October 7, 1571, 250 vessels built mostly in İstanbul, Gallipoli, İzmit and Sinop shipyards, including also the ones in Varna, Silistra, Semndire, Burgas, Igneada, Vize, Ahyolu, Sozopol, Midye, Kefken, Bartin, Samsun, Biga, Gemlik, Rhodes, Alanya, Antalya and Sakarya joined Turkish naval forces on June 13, 1572.

[2]http://www.sasad.org.tr/uploaded/Turk-SS-Politikasi-ve-Stratejisi-%281998%29.pdf (accessed on 14.09.2018)

Early defense industry activities of the Ottoman period were also uttered by Öztuna (2017), who stated that the superiority of the Ottoman artillerymen continued for three centuries until 1700s, and cited Machiavelli's account of how the Turks defeated the Mamluk Sultan and the Shah of Iran using firearms.

The failure of the 1683 Siege of Vienne marked a period of regression in the Ottoman Empire (Turan, 1999). Thereafter, defense industry started to lose its prominence as a consequence of decline in activity across technology and economy, a process which lasted until the foundation of the Turkish Republic on October 29, 1923.

According to Önder (2005), all the enterprises and factories particularly in İstanbul, and in several other locations in Anatolia, were gathered under a centralized administration by the General Directorate of Military Factories. Some pioneering defense industry enterprises of the early republican period are outlined below[3]:

- 1924: Small arms and cannonball repair shops as well as cartridge factories were established in Ankara, and Gölcük Shipyard was built in Gölcük.
- 1925: The first private factory of Turkish defense industry was founded by Şakir Zümre in Haliç, İstanbul.
- 1926: Turkish Aircraft and Motor Incorporated Company was established.
- 1930s: Nuri Killigil Production Plants were constructed.
- 1940: A total of 24 NuD-36 trainer aircrafts were manufactured in Nuri Demirağ Aircraft Factory.
- 1944: NuD-38 airliner with 6 passenger capacity was manufactured.

Figure 1 and Figure 2 show the pictures of the aircraft factory established by Nuri Demirağ and the NuD-38 airliner manufactured again by Nuri Demirağ, respectively.

[3] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1 (accessed on 20.09.2018)

Figure 1 Aircraft Factory Established by Nuri Demirag[4]

Figure 2 Nu.D 38 Aircraft Produced by Nuri Demirag[5]

Eğilmez (2018) argued that the young Turkish Republic suffered from the heavy burden of Ottoman debts and the guarantee of not imposing tariffs on imports, which

[4] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1 (accessed on 20.09.2018)

[5] http://www.kokpit.aero/ilk-turk-yolcu-ucagi-nu.d.38 (accessed on 20.09.2018)

Turkey had guaranteed under the condition of the abolishment of capitulations by Lausanne Peace Treaty, and which ended later in 1929. In 1929, a great economic crisis, known as the Great Depression, began in America and penetrated the whole world. The depression pushed Turkey to enforce import restrictions, adopt an etatist policy, and develop national plans and programs in industrialization.

Kurt (2018) acclaims the period between 1923 and 1950 for the establishment of 5 factories in Aerospace, 13 in Weaponry and Ammunition, and 3 in Machine and Equipment industries as well as for the appearance of such entrepreneurs as Nuri DEMİRAĞ, Nuri KİLLİGİL and Şakir ZÜMRE. Önder (2005) stated that the aircraft factory set up by the Turkish Aeronautical Association manufactured trainer, ambulance and light transport aircrafts, and gliders in 1944, adding however that the aircraft factory established in 1943 by Nuri DEMİRAĞ had to be closed down owing to a lack of R&D and insufficient order volume.

Önder (2005) also remarked that during Gazi Mustafa Kemal Atatürk's reign, Turkey, with an awareness of the fact that defense industry could play a vital role in comprehensive development and industrialization, and exerting considerable amount of effort, knew how to make good use of the military, economic and political benefits offered by the defense industry.

Karakaş (2009) highlighted the contribution of the "Lend-Lease Act" of 1941, signed by the US President Roosevelt, which allowed transfer of 50 units of 155-mm. mortars, and 18500 tons of ammunition to Turkey through Britain. Turkey continued to receive military aid from the USA under the Truman Doctrine of 1947, and became a member state of NATO in 1952. Kurt (2017) asserted that although this membership enabled the Turkish Armed Forces (TAF) to integrate into the NATO systems, it impaired the ability of TAF to plan and direct the country's military activities.

Thereafter, military aids provided by America poured in with a view to increasing the capabilities of TAF against the Soviet Union, yet it was claimed that the

maintenance costs of these aids created an extra burden of 400 million TL on the budget[6].

1950 witnessed a reorganization of Turkey's defense industry enterprises when the state-subsidized Machinery and Chemical Industry Corporation was established in accordance with the Law No. 5591, and the General Directorate of Military Factories was transferred to this new organization (Köseoğlu, 2010). Önder (2005) enumerated the institutions handed over to the Machinery and Chemical Industry Corporation under the aforementioned law as such:

- Silahtarağa Cartridge Factory
- Bakırköy Gunpowder Factory
- Kayaş Detonator and Bullet Factory
- Mamak Gas Mask Factory
- Ankara Carpenter's Factory
- Ankara Armory
- Ankara Cartridge Factory
- Elmadağ Gunpowder and Explosives Factory
- All the factories, plantations and buildings in Kırıkkale

In the aftermath of Cyprus crisis in 1964, some allied nations imposed sanctions on the military equipment which they had supplied until then as they did not want Turkey to use this equipment in line with its interests[7]. Cyprus has always occupied a significant position for Turkey. As a matter fact, Atatürk had previously pointed to the vitality of Cyprus warning that Turkey's logistics routes would be blocked in case Cyprus was lost to an enemy state.

In 1974, Turkey launched the Cyprus Peace Operation, which was followed by an arms embargo on Turkey. The embargo substantiated the importance of a national

[6] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1 (accessed on 20.09.2018)

[7] https://www.tskgv.org.tr/contents/kurumsal/234 (accessed on 12.10.2018)

defense industry, which, in Turkey, had entered into a period of recession upon the Truman Doctrine and NATO membership. This, in turn, resulted in the establishment of such native corporations as TUSAŞ, HAVELSAN and Aydın A.Ş. for the Air Force, DİTAŞ and NETAŞ for the Navy, and ASPİLSAN and ASELSAN for the Army.

2.1. Presidency of Defense Industries

In accordance with the Law No. 3238 dated 1985, Defense Industry Development and Support Administration Office (SAGEB) was set up in order to improve defense industries, which was shortly after restructured as the Undersecretariat for Defense Industries (SSM) (Köseoğlu, 2010). Among the objectives of the Undersecretariat was to modernize the Turkish Armed Forces (SSM, 2011). The Law No. 3238 also aimed to reach the following goals[8]:

- To make maximum use of the existing opportunities
- To promote investments in advanced technology
- To cooperate with foreign companies in technology and gain their financial contribution
- To enable domestic production of all defense industry products by promoting R&D activities.

With the cabinet decision released on June 20, 1998, the primary goals for the defense industry infrastructure were specified, and the Principles of Turkish Defense Industry Policy and Strategy were articulated as such[9]:

- Accessible to both native and foreign private sectors
- A dynamic structure
- International competitiveness with increased export volume
- Ability to adapt to and produce new technologies

[8] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1(accessed on 15.10.2018)

[9] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1(accessed on 15.10.2018)

- Ability to respond quickly to changing technologies
- Cooperation of defense industries with allied nations
- Maximum use of existing opportunities, and avoidance of unnecessary investments
- Ability to produce equipment also for civil life

The Undersecretariat for Defense Industries became an affiliate of the Presidency of the Republic of Turkey in 2017, and, in accordance with the decree-law (KHK) no. 703 issued in 2018, was restructured under the name of Presidency of Defense Industries, which was assigned to[10]:

- Implement the decisions taken by Defense Industry Executive Committee
- Make contracts of the programs to be purchased on project basis
- Reorganize the national defense industry in line with emergent needs, and discover foreign capital and technology opportunities
- Develop financial modelling for procurement programs sticking to the existing financial resources
- Use, when necessary, both the public and private enterprises to meet the requirements
- Support the public and private investments
- Develop and produce prototypes of the required products, and determine the financial incentives
- Enter into project-based contracts covering user demands, and taking into consideration the technical and financial issues
- Monitor the exporting and off-set issues of the related products
- Grant and obtain loans, and set up companies should the need arise

2.1.1. Organization Chart of the Presidency of Defense Industries

On top of the organization is the President of Defense Industries. Affiliated to the President are 5 Vice Presidents under whom operate a total of 18 Departments and 7 Divisions.

[10] https://www.ssb.gov.tr/WebSite/contentlist.aspx?PageID=47&LangID=1(accessed on 15.10.2018)

2.1.2. Subsidiaries and Affiliates of the Presidency of Defense Industries

Defense Technologies Engineering and Trade Inc. (STM): The Presidency owns the 34% of the shares of STM, established in 1991 upon the decision of Defense Industry Executive Committee. Its main areas of business activity are system engineering, project management, and logistics support[11].

Teknopark İstanbul – İstanbul Technology Development Zone: Established on October 7, 1987 based on the decision taken by Defense Industry Executive Committee, Teknopark İstanbul aims at meeting advanced technology needs of the country promoting R&D activities and innovation. The Presidency of Defense Industries holds 45% of its shares[12].

Turkish Aerospace Industries Inc. (TUSAŞ-TAI): With 45.45% of its shares owned by the Presidency of Defense Industries, TAI was set up on June 23, 1973 with a view to reducing foreign dependency in defense industries[13].

Airport Management and Aeronautical Industries Inc. (HEAŞ): Its establishment rests upon the Advanced Technology Industrial Park and Airport Project commenced by Defense Industry Executive Committee in 1987. Operating today as Sabiha Gökçen Airport, and with 96.4% of its capital held by Presidency of Defense Industries, HEAŞ allots all its profit in order to meet the needs of the Turkish Armed Forces[14].

Defense Industry Technologies Inc. (SSTEK): Established with 100% equity shares of the Presidency of Defense Industries, SSTEK targets at forming partnerships with

[11] https://www.stm.com.tr/tr/hakkimizda/sirket-profili (accessed on 17.10.2018)

[12] https://teknoparkistanbul.com.tr/ortaklarimiz (accessed on 18.10.2018)

[13] https://www.tai.com.tr/kurumsal/hakkimizda (accessed on 18.10.2018)

[14] http://www.sgairport.com/kurumsal/tarihce (accessed on 18.10.2018)

to-be-established and already existing companies in order to manufacture advanced technology systems for defense industries[15].

Kazakhstan ASELSAN Engineering Limited Company (KAE): KAE was set up in 2011 so as to meet the military needs of Kazakhstan, and those of the neighboring countries[16].

2.1.3. Defense Industry Support Fund (SSDF)

Designed as an extra-budgetary body on the basis of the Law No.3238 Article 12, and under the supervision of the Central Bank, SSDF aims to meet the needs of Turkish Armed Forces. All its revenues are managed by the Presidency of Defense Industries. The Fund also covers the urgent requirements of the General Directorate of Security, and National Intelligence Agency (SSM, 2017).

2.1.4. Defense Industry Executive Committee

Defense Industry Executive Committee is the main decision making body of the Presidency of Defense Industries within the framework of the Law No. 3238. Chaired by the President of the Republic of Turkey, the managerial board of the Committee consists of the Vice President, the Minister of Interior, the Minister of National Defense, the Treasury and Finance Minister, the Commander of the Turkish Armed Forces, and the President of Defense Industries. The missions of the Committee, determined by the Presidential Decree (CBK, 2018) No. 7 issued about the organization of Presidency of Defense Industry are to:

- Take decisions targeted at the development of defense industries in line with the general strategies and principles.
- Take decisions, in line with the priorities set by the Ministry of Interior, about the domestic production and, when necessary, international procurement of

[15] http://www.sstek.com.tr/index.php?u=hakkimizda (accessed on 18.10.2018)

[16] https://www.kae.com.kz/en/about-company.html (accessed on 18.10.2018)

weaponry, machinery and equipment for the Turkish Armed Forces, the General Command of Gendarmerie, the Coast Guard Command, and the General Directorate of Security.

- Search for the opportunities whereby public and private sectors can set up production plants for defense industries using foreign capital and technologies, and take leading decisions inviting state participation in the process when the need arises.
- Give directions to the Presidency of Industries about carrying out R&D activities, producing prototypes, offering advance loans and financial incentives, and issuing purchase orders for the required weaponry, machinery and equipment.
- Take decisions relating to the exporting and off-set trading of relevant products.
- Establish coordination among defense industry organizations.
- Specify the conditions of use for defense industry support funds.
- Determine the amounts of funds to be designated for the development of human resources employed in defense industries, and develop payment ranges.

2.2. The Defense Industry From 2006 to Present

Turkish State Planning Organization, in its 9th Development Plan covering the 2007-2013 period, stated that foreign dependency continued to exist despite the promotion of domestic production in defense industry before 2007, thereby setting the objectives of secure and stable fulfillment of the demands in the defense industry through local resources, and having acquired the necessary technology, infrastructure and management capabilities, participating, to this end, in international cooperation activities in co-design, co-production, and collaborative R&D (DPT, 2006). Turkish defense industry continued its progress after 2006. However, as reported in the 10th Development Plan (2014-2018), although the rate of domestically manufactured defense industry products rose from 41.6% in 2007 to 54% in 2011, this relative increase still indicated the continuation of foreign dependency as this ratio ranged between 85% and 95% in developed countries(DPT,2013). The 10th Development Plan, therefore, accentuated the goal of increasing the ration of domestic production, and the amount of funds allotted to

R&D activities. The Presidency of Defense Industries, in its Strategic Plan for the 2017-2021 period, solidified its objectives as (SSM, 2017):

- Developing projects based on needs to emerge in defense and security
- Ensuring the growth of the defense industry by improving its capabilities
- Developing the relevant core and advanced technologies through national resources.

2.3. The Definition of Research and Development

Although the R&D perspective adopted throughout this dissertation is, by its very nature, based upon engineering and natural sciences, R&D studies are, as well, conducted in social sciences. This implies that there exists a multitude of R&D definitions in the literature. According to the most widely accepted definition provided by the Organization for Economic Cooperation and Development (OECD) in Frascati Manual 2002, Proposed Standard Practice for Surveys on Research and Experimental Development, R&D is defined as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2002). For a dictionary definition of the term, we can look up the official dictionary of the Turkish Language Association, where it is described as "in-depth research conducted by experts to ensure the influence, efficiency and development of a product or study" [17].

R&D is classified, according to area and type of activity, into three categories, which are basic research, applied research and experimental development.

Basic Research: Defined as "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view" (OECD, 2002, p. 29), basic research covers non-commercial R&D activities in such disciplines as

[17] http://www.tdk.gov.tr/index.php?option=com_gts&arama=gts&guid=TDK.GTS.5c0b8fac9d0c48.60081237 (accessed on 18.10.2018)

Physics, Chemistry and Biology in basic science, which are not expected to provide an immediate payoff in the form of a commercial product.

Basic research analyzes principles, structures and relationships in order to formulize and test scientific hypotheses, theories and laws. Having no direct commercial value, its findings are published in scientific journals, and sometimes may even be labelled as 'secret' for security concerns. It is usually done at universities, and, albeit scarcely, at state institutions. Scientists involved in this type of study are partially free in setting goals. Basic research is divided into two categories as pure and oriented. When basic research is directed towards a certain scientific discipline, it is referred to as oriented basic research, which is conducted to discover new practices in a certain area. While pure basic research is merely for increasing our existing knowledge, oriented basic research is for assisting policy makers in their quest for areas requiring strategic study. The study of the productivity, and the chemical and physical properties of a given polymerization reaction is basic research (Çakır, 2014).

Applied Research: Applied research is also an original quest for new knowledge, yet has a specific practical aim (OECD, 2002). Applied research involves evaluation of existing knowledge and its extensions to find solution to certain problems, and is carried out to determine either the possible uses of the findings of basic research or the new methods for reaching certain predetermined objectives. This type of research is mostly undertaken in the private business sector as a continuation of basic research. Its results are intended to be valid for a limited number of products, processes, systems or methods. The research results usually end up with a patent, yet may as well be kept secret at times. A study of the optimization process of a polymerization reaction for the production of polymers having specific physical or chemical properties is an example to applied research (Çakır, 2014).

Experimental Development: Experimental development refers to "systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already

produced or installed" (OECD, 2002, p. 29). For example, "scaling up" the process optimized under laboratory conditions, studying and assessing the potential production methods of the polymer, and any possible products to be developed out of this process is within the scope of experimental development (Çakır, 2014).

2.4. Indicators of R&D Expenditures in Turkey

R&D activities in defense industries are of paramount importance. Any increase in R&D activities in defense industries has an immediate positive influence on the development of the industry. Along with the products developed, scientific articles published, patents obtained, and exports of advanced technologies realized contribute greatly to defense industries. OECD specifies in its Frascati Manual, prepared as a methodological reference for R&D studies, various approaches to identifying the total amount of R&D spending by a country (TÜİK, 2018). According to the first of these ways, public and private institutions, universities, and non-profit private business organizations are initially given surveys to identify their R&D spending within the country. It is then possible to measure how much of this expense has been funded by the government. Nonetheless, this approach is time-consuming in terms of data-collection, and difficult to correlate with policies. As for the other method, finance-based measurement approach, governmental budget data is used to define the budgetary items for R&D support, or to predict the R&D specifications (TÜİK, 2018).

According to the TUİK data, the amount of direct R&D spending realized through central government budget reached up to 10.750 billion TL in 2017 with a 17.5% increase from the previous year, the totality of indirect R&D support in the form of tax deductions and exemptions was 2.872 billion TL (TÜİK, 2018). The proportion of direct R&D spending realized through central budget to gross national product (GDP) in 2017 was 0.34%, and its share within the central government budget was 1.4 %. According predictions based on startup budget allocations, the amount of startup funds to be allotted to R&D activities directly from central budget of 2018 came out to be 12.950 billion TL. Considering our socio-economic objectives, the

share of startup allocations of the central government budget for R&D in the defense industry was 28.5%. Figures 3 and 4 show a graphical distribution.

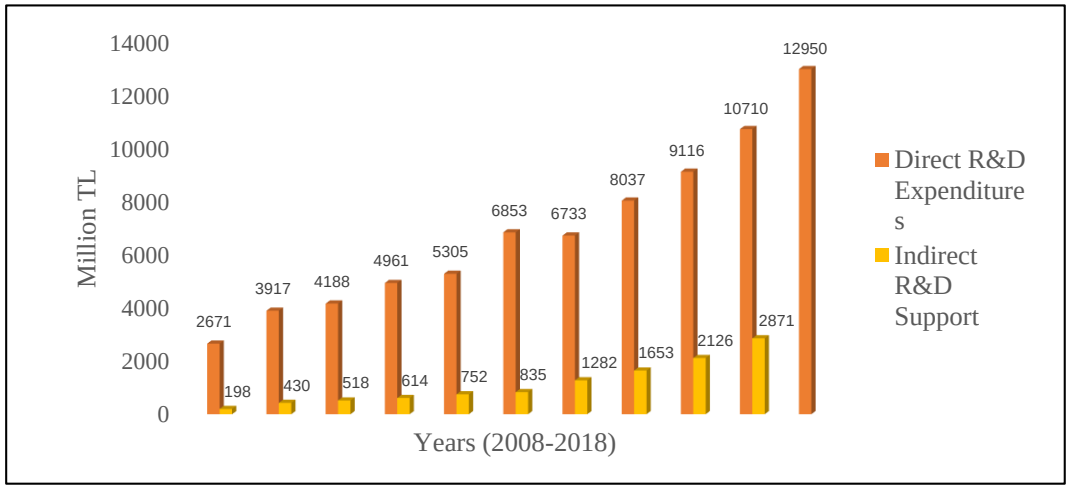


Figure 3 Direct R&D Allocations and Expenditures, and Indirect R&D Support from Central Government Budget (TÜİK, 2018)

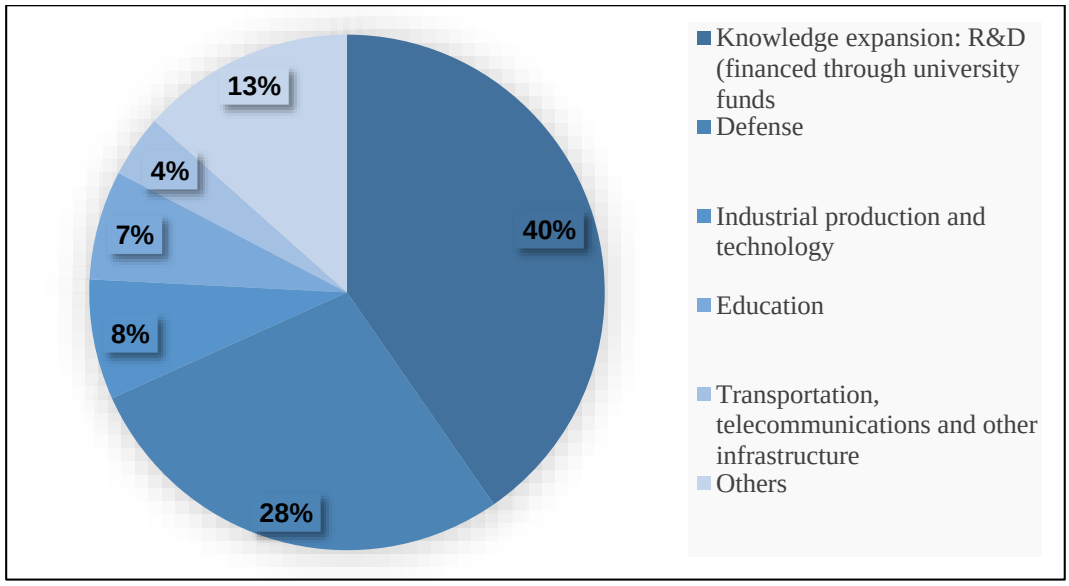


Figure 4 Socio-Economic Objectives 2018 (TÜİK, 2018)

CHAPTER 3

LITERATURE REVIEW

The related literature is reviewed under three sub-headings, which are:

1. R&D performance metrics
2. R&D performance measurement methods
3. R&D in defense industries

Under each sub-heading is given a synthesis of the reviewed publications, and the chapter concludes with a general discussion of all the work reviewed.

3.1. Studies on R&D Performance Metrics

This sub-heading reviews the literature on what should be the metrics for R&D performance measurement, discussing the findings of each relevant publication. To begin with, Chiesa, Frattini, Lazzarotti, Manzini and Troia (2008) mention the significant role of performance measurement in gaining and sustaining competitive advantage, adding also that the reports based on such measurements provide information for senior executives about their companies. Foremost among the issues evaded sharing in these reports is the financial business secrets. Chiesa et al. (2008) argue that performance measurement aims to:

- Regulate resource allocation, monitor project progress, and assess project profitability
- Provide motivation for the staff
- Help improve communication and coordination
- Help increase the extent of learning
- Help reduce the R&D risks and uncertainties

Having specified the goals, Chiesa et al. (2008) list the following as the units to implement performance measurement:

- Units in charge of R&D activities in a specific field of study or technological discipline
- Specific R&D units in each business unit
- Project teams
- Individuals

According to the researchers, these units should, in their R&D performance measurement, cover the dimensions below:

Input: The quantity and quality of current expenditures, investments, human resources, and technologies;

Process: Concept generation, project selection, and technology acquisition with respect to effectiveness and efficiency;

Output: Monitoring the R&D project in terms of actual results; e.g. patents, scientific publications, projects completed, and new products developed

Finally, Chiesa et al. (2008) bring to the fore the five contextual factors that should be taken into consideration in any performance measurement:

- The R&D strategy of the company
- The type of R&D organization
- The type of the R&D activities conducted (basic research and/or applied research and/or development) the corresponding level of risk
- The existing resources of time, money, human technology, and know-how needed for the implementation and use of performance measurement
- Company’s business area

Laliene and Ojanen (2015) emphasize the importance of selecting the most accurate indicators for a valid evaluation of efficiency and effectiveness while

assessing R&D activities at organizational level. R&D performance measurement, according to the article, consists of seven aspects and indicators corresponding to each.

1. Metrics: Resources, project management, human resources management, planning, search for and development of new technologies, outputs, and outcomes.
2. Activities to be measured: Selection of R&D type, Planning and managing the projects, Generating ideas for new product development, Maintaining the quality of R&D processes and methods, Motivating the technical staff, and as such setting interdisciplinary teams, Coordinating R&D and marketing activities, Transfer of technologies to production, Ensuring coordination between R&D and finance, Linking R&D to business schedules.
3. Measurement groups: Interaction and cost, internal R&D process, external R&D process.
4. System phases: Input, process, output/outcome
5. System phases: Input, output, throughput in process, output/outcome
6. Performance measurement group: New technologies and groundbreaking concepts, customer support, information storage, and outside recognition
7. System phases: Input, process, output, receivers/outputs

According to Laliene and Ojanen (2015), R&D processes are modelled as; *Input – Process – Output – Receiving System – Outcome*. Inputs are financial and nonfinancial resources, personnel, funds, tools, and data. Process is composed of basic research, applied research, and experimental development. Outputs are scientific and technological performance results. Receiving system consists of linkage and recipient components. While the former component includes business world, economic, and societal linkages of R&D, the latter is composed of R&D and business organizations, private and public institutions, and peoples. Finally, outcomes have internal and external perspectives. The internal perspective is the assessment of R&D outcomes within an organization whereas external perspective is the evaluation of R&D outcomes in terms of recipients.

Kulatunga, Amaratunga & Haigh (2006) argue that organizations are involved more in R&D activities due to changing customer demands, competitive capacities in domestic and international markets, and resource and financial constraints, which call for performance evaluation for managing, monitoring and controlling R&D activities. The researchers define performance measurement as the assessment of the efficiency and effectiveness of an organization's past activities by way of obtaining, collecting, sorting, analyzing, interpreting, and disseminating data. They additionally mention the contribution of performance measurement to R&D. Performance measurement enables managers to base their decisions on statistical data rather than personal assumptions. Performance measurement aims to direct employees' focus on company goals, provide business improvement, increase customer and employee satisfaction, enhance company reputation, increase productivity, and ensure continuous development in employee behaviors. To Kulatunga et al. (2006), performance measurement provides feedback for an organization to intervene, revise, and reengineer its business processes, lowering also the overhead expenses by 25%, and increasing the return on assets. The study mentions three performance indicators for R&D studies of 1970s, which are "strictly technical products (patents, technical publications or citations to technical publications), financial benefits that immerge from R&D (profits, sales), and judgements about the success of individual R&D projects" (Kulatunga et al., 2006, p. 364).

In 2000s, however, it is stressed in the article that a need arose for using financial as well as nonfinancial measures to obtain success in line with company aims and objectives. Performance measurement is considered to be composed of phases like input, output and outcome. Inputs are human resources, equipment and ideas, and outputs are patents, products and publications. Finally, growth in sales and reduced costs are outcomes. With respect to performance measures, the study specifies a multitude of metrics such as output quality, goal realization, percentage of project completion, amount of work done, customer satisfaction, customer acceptance, market share and sales objectives, education, qualified staff, coordination and feedback mechanisms, percentage of new product sales, product development costs, criteria for reaching strategic objectives.

According to Chiesa, Frattini, Lazzarotti and Manzini (2009), company managers were always interested in the contribution of R&D studies to business competition whereas with 1990s, changes in competition environment called for a need to apply various methods for assessing the value of R&D studies. R&D performance measures are influenced by company's R&D strategy, organizational structure, type of R&D, product development, accumulation of time, financial resources and knowledge, and type of industry company operates in. Decisions on resource allocation and investment selection, motivation employees to behave in accordance with company goals, facilitating information sharing by increasing human interaction, promoting learning as a means to data collection tool, reducing R&D risks and uncertainties, and acquiring new capabilities are enumerated as the aims of R&D performance measurement. Chiesa et al. (2009) accentuate, however, that evaluation of performance metrics should be undertaken separately for each R&D type on account of the unique properties of R&D activities, projects carried out, basic technological changes, and differing strategic objectives. The study specifies four performance dimensions:

1. Financial performances of the investments in R&D activities based on return on investment.
2. Performance of R&D activities in weighing up market orientation prioritizing customer needs.
3. Time and cost performance of R&D activities to increase the efficiency of R&D processes.
4. Capability performance related to organizational and individual creativity.

Finally, below are the performance indicators Chiesa et al. (2009) presented under six headings in their study:

R&D processes: People's satisfaction, resource consumption targets, attaining the development goals, costs, respect to development, temporal milestones

R&D operations: Respect to work, procedures, objectives achieved, costs, and agreed milestones

Innovation capability: Delivery capacity and providing the desired outputs

Orientation: Competencies aimed to acquire, important areas, and growing potentials

Efficiency of R&D processes: Following the agreed milestones

Financial perspective: Profitability of completed R&D projects

Lee, Park, & Choi (2009) ascribe the allocation of considerable amount of resources to R&D to the very fact that it is a driving force in international competition. Therefore, there exists a compelling need to measure the performance of R&D projects so that these resources can be utilized in the most effective way possible. Such measurements help take informed decisions on what R&D projects to continue, and which ones to terminate.

Lee et al. (2009) highlight the difficulty of comparing national R&D projects to one another as each might have dissimilar outputs, pinpointing also the paucity of a common agreement on what should be the universally accepted inputs and outputs of R&D projects. It is stated in the article that evaluation of large-scale R&D programs in respect to their primary objectives can be realized by looking into R&D project outputs. The inputs specified in the study are in two perspectives; financial input is the totality of resources allocated to the project, and human resource input is the number of researchers holding a PhD. As for the outputs, the article includes the number of scientific and technical publications in Science Citation Index (SCI), the number of patents obtained from national and international patent offices, and MA-PhD degrees earned as part of the project.

To Chiesa, Frattini, Lazzarotti, & Manzini (2008), R&D is a process whose performance needs to be monitored measured in order for companies to be able to continue their competitive advantage. It is rather difficult, however, to measure this performance in the presence of non-quantitative and intangible factors influencing the success. In such cases, it is prescribed to define the administrative

and organizational data. With an attempt to unearth the performance measurement in their study Chiesa et al. (2008) first divide the business into two dimensions, and then list the relevant metrics under them.

The first dimension is composed of service efficiency, capacity to acquire new technologies and competencies, following the service costs planned, on time delivery of the service to customers, the quality of customer relations, and the level of external prestige.

The second dimension include the qualifications of the newly discovered and optimized target customers, capacity to acquire new technologies and competencies, licenses and partnership opportunities discovered, capability to develop coordination with external institutions, and the level of external prestige.

The metrics defined under these dimensions in the study are; average customer satisfaction, appropriateness of the technologies/expertise acquired to international standards, time required to acquire new technologies/competencies, average service-cost difference, percentage of projects competed on time, frequency of interactions with customers, number of citations to company researchers' scientific publications, rate of new customers to targeted numbers, number of provisional/declared partners, percentage of fully satisfied partners.

Kobe and Bodmer (2002) studied the controlling practices in R&D performance measurement under four topics, which are strategic controlling in R&D, controlling of R&D projects, controlling of the innovation process, and cultural aspects. In their study, focusing mainly on R&D controlling practices, they argue that although companies employ strategy, process and innovation controlling, carry out studies for improving their R&D programs, and systematically implement multi-project controlling, only few companies conduct project performance evaluation based on predetermined criteria.

According to Kobe and Bodmer (2002), while companies use IT tools successfully for controlling purposes, they also monitor the technology developments and

performances of their external partners. Additionally, companies analyze specific idea generation, assessment of technological developments, success rate of innovation projects, product cycle times, and success rate of innovations in the market.

Suomola and Jamsen (2003) claim that the dimensions and multifaceted effects of R&D studies could not be assessed with sufficient criteria, and underline the insufficient use of performance measures in R&D management.

The success of performance measurement, they assert, depends upon selecting the right metrics having operationalized the construct of success. Discussing the performance measurement in R&D management in the case of Finland, the study identified the criteria of evaluation under four headings.

1. Customer view: product performance, product quality, the extent to which the product can respond to customer needs as compared to competitors, how much after sales support is provided.
2. Shareholder view: Does R&D result in a profitable business? Is there an acceptable rate of business growth? How much does it contribute to competition?
3. R&D view: Use of strategic resources, improvement in competencies, learning.
4. Supply chain view: Cost effectiveness, marketing time, design, availability of sales, availability of delivery chains and related infrastructures.

Besides these criteria, Suomola and Jamsen (2003) categorized the metrics used in their study into 14, which were time, sales or revenue, R&D costs, customer satisfaction measures, profitability, costs of supply chain, efficiency, innovation, product's producibility, volume-based R&D measures, personnel, strategic, combination of profitability and sales or costs, other.

Hauser and Zettelmeyer (1997) formed their performance metrics by integrating different categories and perspectives used in R&D performance measurement. Table 2 shows the metrics and categories.

Table 2
Metrics by Different Categories (Hauser & Zettelmeyer, 1997)

Category	Metric
Strategic Goals	Competitive responses
Quality / Value	Quality of the research Peer review of research Benchmarking comparable research activities Value of top 5 deliverables Gate success of concepts Percent of goal fulfillment Yield = [(quality x opportunity x relevance x leverage)/overhead] x consistency of focus
People	Managerial involvement
Process	Productivity Timely response Deliverables delivered Fulfillment of technical specifications Time for completion Speed of getting technology into new products Time to market Time of response to customer problems
Customer	Relevance Customer satisfaction Service quality (customer measure) Number of customers who found faults
Revenues / Costs	Revenue of new product in 3 years/R&D cost Percent revenues derived from 3-5-year-old products Gross margin on new products Economic value added Break even after release Cost of committing further Overhead cost of research

Werner and Souder (1997a) believe selection of appropriate metrics for R&D performance measurement depends on the comprehensiveness of measurement, type of R&D, and user needs. Some quantitative and objective data required, according to the study, in this process are number of scientists employed in companies, total R&D expenditures, value of investments in research equipment, costs reduced, number of new products released, comparison of planned and actual project costs, milestones met on time, number of patents and licenses relative to R&D expenditures, scientific publications released and number of citations to

these, project status reports, and, in terms of software R&D, number of lines coded accurately.

The article also mentions the accord among marketing, production, technology transfer process, business strategies, and technology with respect to R&D activities.

Werner and Souder (1997b), in another study, compare the practices of R&D performance measurement in America and Germany. They conclude that while German managers only take into account input metrics, American managers quantitative output metrics.

The study reports that issues favored most by American managers are number of patents obtained, total quality management, cost/time ratio, and audits. Furthermore, number patents per scientist, scientific publications, aspects requiring commercial secrecy, rate of return on investment, rates of new product recognition, profitability of R&D investment on new products, employees' self-evaluations, and external evaluations by co-workers are presented as the metrics deployed by American managers.

German companies, on the other hand, take R&D inputs as metrics, some of which are money spent annually for R&D personnel, annual investments in R&D activities, and rate of scientists per employee. Finally, German managers assess the success of their projects by time spent and costs incurred, milestones met on time, customer satisfaction data, data obtained through industrial partnerships or other partners, and comparison of project data with previous projects.

Molnar (2011) investigates R&D performance measurement building up two models. The Quantitative Measurement Model stands on the four pillars of "R&D performance, input performance, process performance and output performance" whereas "R&D efficiency, input efficiency, process efficiency, and output efficiency" make up the core of the Qualitative Measurement Model.

3.2. Studies on R&D Performance Measurement Methods

Ojanen and Voula (2003) aimed to review the methods for R&D performance evaluation. They assert that dimensions relating to R&D activities and R&D personnel tax the performance analysis heavily, which, considering also the amount of resources invested in it, compels R&D projects to prove profitability and significance of R&D to companies. As a direct corollary to this, products derived from R&D projects should be able to compete with other products of the company. Ojanen and Voula (2003) classified measurement dimensions as R&D performance measurement level, type of R&D, and phase of R&D process. The study accentuates the Balanced Scorecard (BSC) approach, arguing that it is an approach driving forward strategy and vision, and integrating different performance measures. BSC is a management tool that enables an organization to transform its missions and strategies into a meaningful and testable performance measures (Ölcer, 2005). Ojanen and Voula (2003) present a BSC based classification of performance measures. The targets and metrics are shown in Table 3.

Table 3
Performance Measures as Categorized by the Principles of BSC

Financial perspective objectives	Metrics
Survive	Present Value of R&D accomplishments / R&D expenditure
Succeed	Percentage of sales from new products
Prosper	Market share gained due to R&D
Customer perspective objectives	
High customer satisfaction	Score on customer satisfaction audit
Anticipation of internal and external customers' needs	Percentage of customer driven projects
High level of design for manufacture	Engineering hours on projects / engineering hours on projects and troubleshooting
R&D hit rate	Percentage of projects terminated before implementation

Table 3 *(cont'd)*

Financial perspective objectives	Metrics
Internal business perspective objectives	
Productivity	Hours spent on projects / total hours of R&D
Speed to market	Current t.t.m. / reference t.t.m.
Technology/ design re-use	Rate of re-use of standard design/proven technology
Reliable delivery of outputs	Sum of revised project duration / sum of planned duration
Quality of output	
Innovation and learning perspective objectives	
Technology leadership	Number of patentable discoveries per $ spent on R&D
Long term focus	Percentage of budget spent internally and externally on basic and applied research
High absorptive capacity	Percentage of projects in co-operation with a third party
Learning organization	Percentage of project evaluation ideas applied in new projects

Describing how companies can integrate BSC into their R&D performance measurement processes, Parisi and Rossi (2015) delineated BSC in four perspectives; financial, customer, competence, and people. They elaborated on existing measurement systems, claiming that they are result-oriented, only address financial issues, and hence prove insufficient for the management problems product designers and developers experience. The researchers further added that performance measurement should support the general strategy of a company as project and innovation strategies influence the overall success of a project. According to Parisi and Rossi (2015), learning and growth perspective, with its measurement dimensions of "number of patent awarded, strategic skill coverage ratio by competency category, and percentage of product ideas approved for stage" can be employed as performance metrics to measure the internal processes affecting customer satisfaction. Cost, quality, time, innovativeness, contribution to profit are

the five categories presented in the article for defining performance measures. Contribution to profit is explained as the data obtained as a result of the other four.

Parisi and Rossi (2015) also form a one to one correspondence between BSC perspective and these categories such that quality, cost and time, innovativeness, and contribution to profit are aligned with customer perspective, internal processes perspective, innovation and learning perspective, and financial perspective, respectively. Finally, it is argued that controllers of performance measurement activities partake in planning, controlling, and decision-making processes as regular members of the managerial board.

Tan and Rasli (2011) discuss performance measurement within the context of new product development (NPD). Being competitive and ensuring sustainable growth necessitate investment in new products together with R&D, a compelling reason to assess NPD performance, which is "a measure of the time required to introduce a new product to the market, the level of product quality and the response from customers" (Tan & Rasli, 2011, p. 194). NPD process consists of "concurrent engineering (CE) and multiple feedback loops". The article defines seven CE constructs, which are "top-down CE approach, interface with customers, formation of CE team, continuity of CE team, CE technique and tools application, early involvement of subcontractors and vendors, and corporate focus on continuous improvement and lessons learned" (Tan & Rasli, 2011, p. 195). Moreover, the study, adopting a holistic point of view, identifies measures for NPD performance on five levels; product, customer acceptance, market, financial, and timing.

Zizlavsky (2014) focuses on the implementation of BSC in small and medium-scaled enterprises as a strategic management control system. Management control is defined as the process by which managers find resources and use these resources effectively and efficiently so as to reach organizational objectives. Some important performance measurement methods given in the article are Performance Measurement Matrix, Performance Pyramid, Integrated Performance Measurement Systems, Performance Prism, Data Envelope Analysis, Quantum Performance

Measurement or Productivity Measurement, and Enhancement System. BSC is fore fronted as the most renowned model.

Ascribing success of a business model to a thorough understanding of innovation processes, Zizlavsky (2014) recommends implementing BSC, a process classification relying on the value chain, and covering all the critical processes throughout the company. These processes are innovation, operational, and post-sale services. During innovation process, research and development of new products in line with changing customer needs is planned. Operational process is for the production and supply of new products and services. Post-sale services help to gain competitive advantage. By means of this model, as argued in the article, it is highly possible to achieve a swift transition from strategic to process level. BSC measurement is composed of four balanced perspectives; financial, customer, internal business processes, and potential (learning and development). Zizlavsky (2014) also outlines five main rules to create a strategy-focused organization using BSC:

- Translate the strategy into operational terms using balanced scorecards and strategy maps;
- Align the organization to the strategy by cascading the highest-level scorecard to strategic business units, support departments, and external partners;
- Make strategy everyone's job with initiatives to create strategic awareness and by using personal scorecards with related incentives;
- Make strategy a continual process by linking budgets to strategy, implementing a process for learning and adapting firm strategy; and
- Mobilize leadership change to a strategic management system.

Kim and Oh (2002) maintain that in the absence of an effective performance measurement system, R&D companies will have difficulty motivating their staff. The presence of a fair performance measurement system, however, will provide behavioral and qualitative suggestions in terms of leadership and mentorship for young employees, bottom-up evaluations of leaders by their employees, and horizontal evaluations of managers by R&D managers and/or that of colleagues one

another. Kim and Oh (2002) shaped their research model asking the questions of by whom and what criteria should performance be measured. Answers to the former were self, peer, boss, subordinate, R&D center chief, and customer. Answers to the latter were market-oriented, R&D project-specific, technological capacity, behavioral capacity of the R&D researcher. The study aimed to measure the R&D performance creating an optimal integration of these two questions, and adding onto this the fairness perception of R&D personnel.

To Spano, Sarto, Caldareli and Vigano (2016) an efficient measurement should comprise a multi-dimensional approach assessing financial or nonfinancial indicators, and prospective measures. In their study, they used an innovation-based BSC approach with its four dimensions of economic and financial, shareholder, internal processes, and learning and growth in order to improve performance measurement. BSC measures performances relying on strategies applied, and, unlike other measurement systems, enables transformation of nonstrategic and intangible objectives into operational measures that should be monitored to increase performance.

Santos, Lucianetti and Bourne (2012) specify the purpose of implementing performance measurement systems by organizations as facilitating their strategy practices, and increasing their performances. Expanding on contemporary performance systems (CPS), the article outlines the consequences of CPS in three categories: People's behavior (employees' actions, reactions, and motivations), organizational capabilities (competitive advantage, strategic alignment, and organizational learning), and performance consequences (company performance, management performance, and team performance). Traditional budgeting systems or activity-based costing systems cannot be considered as CPM systems due to their focus on financial issues. Santos et al. (2012) report the consequences of CMS implementation in companies on the basis of following measures:

Consequences for people's behavior: Strategic focus, internal and external coordination, cooperation and participation, motivation, citizenship behaviors, role understanding and job satisfaction in terms of mission, responsibility and authority,

decision-making, learning and self-monitoring, leadership and culture, satisfaction, perceptions of subjectivity, justice and trust, biases, and conflicts and tensions.

Consequences for organizational capabilities: Strategy processes (alignment, development, implementation, and review), communication, strategic capabilities, management practices, and corporate control.

Consequences for performance: organizational and business unit performance, team performance, management performance, and inter-firm performance.

Deen and Vossensteyn (2006) argue that R&D outputs in the Netherlands are mostly based on citation counts in national and university indexes, patents, financing, and expending. Outputs on ministry level are the rate of innovative companies awarded patents within the last three years, number of patents per million people in workforce in Europe, results derived from customer satisfaction questionnaires, number of organizations cooperating with national technological research center upon receiving government grants, and number of organizations cooperating with research centers and universities. Finally, the article categorically presents the research performance criteria used by Dutch universities as quality (international recognition and potential of innovativeness), productivity (scientific outputs), appropriateness (scientific and socio-economic effects), agility (flexibility, management, and leadership).

Hall and Mairesse (2009) hold that European Union countries carry out less R&D activities than the USA. They attribute this to increasing costs and lack of R&D demands. The study embraces growth in market value, profits to shareholders, percentage of gross profit margin, percentage of operating margin, operating revenue increase, sales growth, and amortization of R&D as financial returns of R&D investments.

Farkas and Gonda (2012) deal with more comprehensive effects of R&D. They assert that globalizing nature of increasing economic crises and population problems bring about environmental problems. Performance measurement of R&D

investments are deemed to be critical for fighting against these problems. R&D investments are also presumed to contribute significantly to success in such issues as high growth rate, increasing competitive power and national wealth, growth in business assets, and increase in payment and career opportunities. As regards productivity in R&D investments, it is associated with the input-output ratio.

Karlsson, Trygg and Elfström (2004) predicate the need to measure productivity on the fact that companies are obliged to maintain sustainable increase in R&D efficiency should they aspire to continue their competitiveness. They recommend measuring each R&D activity separately after specifying the expected outputs, and designing a measurement system accordingly. Concepts like time, authenticity, depth of organization and knowledge have become more of an issue because by measuring these, a system can be controlled, and thus development studies can be carried out. Among the measurement dimensions used in R&D studies, according to the article, are product development, environment, life cycle cost, safety, and availability with the focus being on process development, product support based on increasing in-house productivity, production, and marketing. The purpose in doing so is to ensure an increase in quality and flexibility, and a decrease in cost and lead time.

Peng, Hu and Xin (2012) attempted in their study to measure the performances of engineers employed in R&D, arguing that performance measurement of engineers could be different from that of other R&D personnel. The study used performance indicators of morality, ability, diligence, and performance. They designed a four-layered performance evaluation system. On the layer of personal qualities were level of knowledge, ability to learn, innovation, and problem-solving. The second layer, team spirit, included the indicators of communication, team loyalty, spirit of cooperation, and confidentiality. Work responsibility, motivation, and discipline were evaluated under the layer of work attitude. The fourth layer of work performance aimed to assess the studies published, number of projects, role of work performance in the project, completion of the project progress, and temporary production tasks.

Marques, Gourc and Lauras (2010) delved into a different aspect of performance evaluation systems, decision making processes. In their viewpoint, the widely-used criteria of cost, time, and quality do not suffice alone for performance evaluation of product and service development projects, which call for decision support mechanisms. Decision support necessitates ability to represent the decision maker's perspective, and evaluate the current progress of the project. Managers are in need of decision support, particularly in complex projects, due mainly to large volumes of data. The model proposed in the article helps reduce such complexities. A decision making activity in the context of project development, according to Marques et al. (2010), consists of success criteria as defined in senior management's project objectives, the volume of data in the project, and project manager's point of view and the value s/he attaches to each piece of information and element in the project. The size of the project, the number of departments involved in the project, the number and type of the stakeholders involved, the scope of contracts, the organizational structure, integration of different functions, key people in the organization, and competent project managers play a vital role in this process. It is especially emphasized in the article that creating a universally-accepted measurement criteria in project performance evaluation is a far-fetched objective.

The dimensions Marques et al. (2010) grounded their evaluation on were relevance (sufficiency of tools in achieving desired objectives), efficiency (proper use of resources), and effectiveness (the extent to which project activities can produce desired results). Finally, they defined nine knowledge areas that should be covered in project management; integration, scope, time, cost, quality, human resource, communication, risk, and procurement.

Defining innovation as the successful adoption of new ideas in product and service development, business processes and models, and technology, Dewangan and Godse (2014) discuss performance measurement in respect to innovation whereby they offer a process-based system for innovation performance measurement. They believe companies ought to measure the performance of their innovation attempts in order to ensure efficiency of their investments. According to them, traditionally-used key performance indicators of an organization – return on investment,

estimated time of return, productivity, cycle times, and operational efficiency – are mostly financial, yet in innovation measurement nonfinancial dimensions come to play, too. Performance prism, performance pyramid, and BSC are some of the performance measurement systems. Dewangan and Godse (2014) pinpoint the requirements for new product development as a decent organizational innovation strategy; communication; diagnosis, control and correction; resource allocation; evaluation of employees; incentives, and improvements.

In their article, Dewangan and Godse (2014) draw attention to the use of strategy, technology management, and information management areas along with BSC. Furthermore, they recommend reference to such issues as providing resources for innovation, acquiring leadership, systems and means, technology transfer and acquisition, market orientation, and networking. The guidelines they tap into in their study dictate that performance measurement needs to:

- be multi-dimensional, and integrate financial and nonfinancial elements,
- ensure a step-by-step measurement of performance, and accommodate an innovation-based process,
- be able to meet the needs of integral and external shareholders,
- comprise causal relationships between financial measures (e.g. customer relations, process effects, and employee capabilities) and nonfinancial measures,
- be easy to implement

Lee, Park and Kim (2013) investigated performance measurement of public R&D processes by developing a new BSC framework, which, they argue, should produce success factors in an organization, link them to management strategies, and measure organizational performance through four perspectives; financial, customer, internal business processes, and learning and growth. Having identified the vision and mission of the organization, they identified a BSC framework, which was adapted as R&D performance perspective (R&D output and effectiveness), energy industry perspective (the advancements and technology commercialization in energy industry), R&D process perspective (input resource and R&D efficiency),

infrastructure perspective (combination of innovation and learning). The researchers finally adapted the performance indicators to be:

- Effects of R&D results on the advancement of related industry,
- Financial performance originating from the commercialization of R&D results,
- Achievement of R&D objectives,
- Management effects on R&D efficiency,
- Ratio of resources used in the original plan,
- Development costs,
- R&D utilization system,
- Researcher exchange programs,
- Public relations of R&D results,
- Number of people with MA and PhD,
- Manpower development projects within the related R&D area

3.3. Studies on R&D in Defense Industries

For nations and companies, ensuring sustainable competitive advantage and economic growth depends largely on the extent to which they can produce, manipulate, and disseminate scientific and technological knowledge (Jacobsson & Philipson, 1996). The study conducted in Switzerland, where company, sector, and nation-wide data is accessible as R&D data is regularly stored, used patent and R&D data as technological data. However, since the data is stored in a generic sense, the size and features of the technology utilized in the company and sector might be neglected. The article maintains that data loss is indispensable if small-sized firms refrain from sharing their data. The authors further emphasize that patent should be pioneering and new, be commercially feasible, and offer solutions to users. They additionally point out the strength of the indicators in Swedish metallic and mechanical industries.

Gallart (1999) highlighted the steady increase in R&D activities in defense industries, remarking, however, on the need to define defense R&D for carrying out quantitative analysis. This may be a challenging task as it has become increasingly

difficult for OECD to define the boundary between what is military and what is civilian as regards R&D activities, and due to the paucity of uniform and unanimous data set in the field of defense R&D. To make matters worse, each country has their own laws regulating defense R&D activities. The article also underlines that the only stable source of data offering nation-wide comparable data is OECD, yet its definitions of defense R&D may cause misleading estimates. It is particularly significant in defense industries to define clearly what is R&D and what is not.

To Gallart (1999), although prototyping, testing, and engineering studies are embraced as experimental development in the Frascati manual, the reproduction of a prototype for defense purposes cannot be considered as an R&D activity. This creates a confusion as to whether or not investments in defense industry should be accepted as R&D. Moreover, specifications developed by governments to determine their R&D budget do not comply with the Frascati manual. According to SIPRI, one of the two accepted organizations along with OECD in defense R&D, R&D activities funded by defense agents in a country, and all the government-funded R&D activities carried out for manufacturing weaponry to serve military or civilian defense are regarded as defense R&D (Gallart, 1999).

Chakrabarti and Anyanwu (1993) pointed out the contribution of defense R&D to the development of new computer technologies in the USA. In return, electronics, computer, conductor, and aviation industries have played key roles in the development of defense industries. Defense R&D expenditures created a demand for goods and services by civilian industries. There is a relationship between defense R&D and civilian economy in terms of the following aspects:

- Conducting basic and applied research as defense R&D,
- Technology transfer from defense industries to civilian industries,
- Defense spending as part of defense policies,
- Conversion of defense facilities to serve for civil uses when necessary

Defense R&D activities trigger an increase in the number of patents obtained, which positively influence the development of technical skills. Besides, the technological

needs of governments promoted an increase in R&D investments, and hence in technological innovations (Cakrabarti & Antanwu, 1993).

Defense R&D, to Hartley (2006), means an improvement in military capabilities through use of new technologies rather than an increase in the number of weapons. Scientists employed in defense R&D, and utilization of R&D outputs in civilian industries affect the economic progress in a country. Such conclusions are based on existing defense R&D data like the share of defense spending in GNP, and the rate of government-funded military and nonmilitary R&D, which can be obtained from OECD Main Science and Technology Indicators, and SIPRI yearbooks (Hartley, 2006).

Peled (2001), too, underscores the role of defense R&D in a country's technological and economic development in the case of Israel. As stated in the study, in Israel defense industry covers 25% of the whole industrial production, and 20% of employment. It is further stressed that most defense R&D, and advanced technology practices are performed and funded by private sector in the country. Thus, investment in defense R&D, Peled (2001) argues, contributes to advanced technology, economic progress, and development of technology, scientific knowledge and workforce, which indicates that defense R&D is a driving force for such development. Finally, the article underlines the strong ties with universities within the context of defense R&D.

3.4. Reflections on the Reviewed Literature

The literature reviewed revealed that there is not a template of metrics for performance measurement of R&D projects. Therefore, each project should be evaluated distinctively specifying unique metrics in line with goals set. However, it is possible to derive from the literature the following generalizable set of metrics in R&D performance evaluation:

- Current expenditures,
- Investments,

- Financial and nonfinancial resources,
- Rate of cost reductions,
- Sales and rate of objectives achieved,
- Comparison of planned and actual project costs,
- Money spent for R&D personnel,
- Quantity and quality of human resources and technologies,
- Employee motivation,
- New technologies and groundbreaking concepts,
- MA and PhD theses conducted as part of the project,
- Number of patents awarded by national and international patent offices,
- Scientific publications released,
- Number of citations to scientific publications,
- Encouraging employees to collect data,
- Performance capability in organizational and individual creativity,
- Data acquired and its usability,
- Idea generation, project selection and technology acquisition in terms of efficiency and effectiveness,
- Quality of the equipment used,
- Quantity and quality of the projects successfully completed,
- Project on-time completion rate,
- Reduction of risks and uncertainties in the project,
- New products developed and their quality,
- Success rate of innovation projects,
- Market success of innovative products,
- R&D project's contribution to growth and competition,
- Success in achieving strategic objectives of the organization,
- Percentage of customer-oriented projects,
- Rate of market recognition,
- Ability to cooperate with other organizations,
- Number and success rate of provisional/declared partnerships,
- Customer satisfaction rates,

- After sales support,
- Availability of supply chains and infrastructure,
- Presence of active feedback mechanisms

The literature abounds in suggestions for why and how performance should be measured. Some of the methods used are Performance Measurement Matrix, Performance Pyramid, Integrated Performance Measurement Systems, Performance Prism, Data Envelope Analysis, Quantum Performance Measurement, and BSC. Apparently, BSC, which measures performance based on organizational strategies, and ensures, unlike other measurement systems, transformation of strategic objectives and intangible outcomes into operational measures to maintain increase in performance, has proved to be the most widely used approach in R&D performance measurement. By means of BSC, also undertaken as a strategic management control system in companies, a meaningful measurement of an organization's mission and strategy can be realized. BSC measurement is mostly built on four measurement dimensions (financial perspective objectives, customer perspective objectives, internal business perspective objectives, and innovation and learning perspective objectives), various metrics related to each.

Development of countries and companies sustaining their competitive advantages in today's increasingly globalized world depends upon generating manipulating and disseminating scientific and technological knowledge. In this respect, R&D investments in defense industries are of paramount importance for countries. Storing company, sector and nation-wide data, and sharing such data for functional purposes is highly valuable in terms of getting a full grasp of the extent of their progress. Unfortunately, however, there is not a uniform and unanimous data source in defense R&D. One reason for this is the disparity in defense industry regulations of each country. OECD stands alone as the only data source offering nation-wide comparable data concerning defense R&D. Nonetheless, the literature reviewed particularly demonstrates that OECD definitions of R&D in defense industries could cause misleading estimates. This directs related parties to SIPRI, another generally accepted reference source in defense R&D.

An inevitable corollary of countries' need for technological innovation is a rise in their R&D investments. Development and products derived from defense R&D provide militaries with technological superiority. Defense R&D projects can trigger progress in nonmilitary areas, as well. In the USA, for instance, such projects paved the way for developments in IT, which, in turn, enabled electronics, computer, semiconductor, and aviation industries to gain ground. Needless to say, then, that investments in defense R&D represent the development of civilian sectors, contributing, hence, to improvements in economy, technology, scientific knowledge, and workforce.

CHAPTER 4

METHODOLOGY

This chapter sets forth the research methodology adopted in this study. After elaborating on qualitative research methods, focus group and survey techniques, the chapter concludes with information regarding Delphi survey.

Any research is a quest for collecting data on a given topic (Çokluk, Yılmaz, & Oğuz, 2011). Change and transformations in social, cultural, economic, and political fields over the years have resulted in shifts in science, too. While studies in natural sciences can be traced back to ancient times, social sciences have only been shaped from the 20th century onward. Research methods in social sciences are basically classified as qualitative and quantitative (Bir, 1999).

4.1. Qualitative Research

Conducted mainly for eliminating research complexities, qualitative research is an interpretive and multi-methodological approach focusing on specific issues (Coşkun, Altunışık, Bayraktaroğlu, & Yıldırım, 2004). Qualitative researchers look into a topic in its natural setting. Thus, each research topic signifies a distinct value depending on unique understandings of different individuals. Such data collection tools as interviews, visual texts, and personal narratives used in qualitative research help define significant moments and meanings in people's lives (Coşkun et al., 2004). Relying on this viewpoint, we can deduce that qualitative research is an approach offering findings without referring to statistical rules and numerical data. According to (Coşkun et al., 2004), qualitative research consists of data, analytical or interpretive procedures, and written or oral reports. Data is generally collected through questionnaires, observations, and interviews. Procedures are used to reach

findings. Written or oral reports can be published in scientific articles or theses, or presented in conferences (Coşkun et al., 2004).

Conducted for collecting data, and developing hypotheses or theories related to a specific discipline, qualitative research is also defined as a research undertaking in which data is not numerical (Punch, 2011). Since it is mostly engaged in phenomena, and is sensitive to processes, personal experiences, and the local, a qualitative researcher desires to get closer to the research topic to digest its depth and complexity (Punch, 2011).

Qualitative research samples are relatively small, yet sampling is based on theoretical evaluations. Data in qualitative research is generally not pre-structured. Besides, as qualitative data is holistic and rich in content, it enables researchers to investigate complex social phenomena. Thanks to its flexibility, qualitative research can be used in a wide array of disciplines. This flexibility enables easy shifts in later stages of the research. Qualitative methods are the best means of deriving insights from participants' comments on the research topic (Punch, 2011).

In another definition, qualitative research is described as an approach that helps uncover certain problems or issues holistically in its natural setting using techniques like observation, interview, and document analysis (Yıldırım, 1999). It attempts to investigate and grasp social phenomena within their natural environment. Social phenomena are not stable, and are subject to continuous change in time, so they are not universal.

The most frequently used techniques for studying this change are observations and interviews. The foremost advantage of qualitative research is that it provides an in-depth analysis and vivid picture of an issue through the perspectives of related parties. A qualitative researcher collects data about settings, processes, and perceptions. Settings comprise social, cultural, and demographic characteristics. Processes are sets of data revealing what has happened throughout the research, and perceptions cover research participants' opinions. These data sets are obtained

through analysis of interviews, observations, and written documents (Yıldırım, 1999).

Finally, qualitative research is a method attempting to unearth the reasons behind social realities and human behaviors through such techniques as interviews, observations, and document analysis. Qualitative data is analyzed via inductive methods.

Discussing the purposes and characteristics of qualitative research, Böke (2014), states that qualitative research;

- aims at understanding participants' behaviors, and the reasons and background behind these behaviors,
- enables researchers to deeply investigate and interpret behaviors of a small sample rather than a superficial analysis of large samples and numeric data,
- is flexible enough to reshape the research design based on emerging data,
- helps figure out the processes phenomena and relationships go through,
- offers an understanding of the how and why of reasons and results, and what processes are in play.

4.2. Focus Group Technique

After deciding on a research topic, the next step is collecting data through suitable techniques. This decision is grounded on data collection process, research topic, and methodology. Focus groups, observations, and surveys are three of the techniques used in data collection processes (Beisenbayeva, 2017).

Focus groups have been in use since 1920s. The influence of training and propaganda used in the course of World War II on soldiers, for example, were assessed by means of focus group technique. Over years, the technique has been utilized in some other disciplines like marketing, anthropology, communications, politics, medical sciences, and psychology (Coşkun et al., 2004).

While conducting focus groups, both in-depth interviews and observations can be used. Focus groups can be made up of people with similar as well as different backgrounds or characteristics. Once focus group discussions are directed by a moderator, who is responsible for ensuring a non-threatening setting where participants can freely express their opinions, and smooth flow of discussions (Coşkun et al., 2004).

Focus group interviews last for approximately 1-3 hours with typically 8-12 people. Moderators are supposed to remain neutral without interfering with any respondents' comments. Besides, moderator should act as an observer, be polite to the whole group, and empathize with them. A successful moderator is expected to invite more participants to partake in discussions by encouraging them (Coşkun et al., 2004). During discussions, participants interact with each other, which allows for elicitation of diverse opinions on research topic. Focus groups are characteristically open-ended, and interview forms are used during discussions.

In another source, focus group technique is claimed to have emerged as a result of people's social interactions (Böke, 2014). In designing focus groups, first of all a research topic is identified, and then participants and interview location are selected. Sampling is done purposefully so that people competent on the research topic can be involved. Questions and related sub-topics should be specified in advance. By asking open-ended questions, all the participants should be encouraged to contribute to discussions (Böke, 2014). In groups with participants familiar to one another, moderators should especially be wary of those who might potentially suppress others, and thus inhibit participation.

Focus group interviews can make significant contribution to research studies. A notable characteristics of the technique is that it facilitates elicitation of data that is otherwise hard to obtain through group interactions. Such interactions allow room for expression of participants' opinions and perceptions. Focus interviews are not costly, and can provide flexible and detailed data in the form of written records of group interactions. Focus group interviews can be used in both in qualitative and quantitative research (Punch, 2011).

4.3. Survey

Survey is a data collection tool designed to obtain responses to questions ordered and structured in advance. Questions should be prepared in accordance with research needs and expected answers. Otherwise, the validity and reliability of the survey would be questionable. Steps in conducting surveys are specifying a research topic, sampling, designing a questionnaire, testing the reliability of the questionnaire, preparing a cover page, delivering the survey, and implementing the survey follow-up steps (Coşkun et al., 2004).

Survey method has been used by newspaper editors, politicians, marketing experts, and a wide array of institutions apart from social sciences. It owes this popularity to its versatility, generalizability stemming from large sample sizes, and cost-efficient structure enabling data collection in a relatively short period of time with minimum financial resources. Survey research has reached today's modern framework in early and mid-20th century (Böke, 2014).

4.3.1. Survey Types

Surveys can broadly be categorized as traditional and modern surveying techniques. In traditional techniques, mode of survey delivery plays a role in this categorization. If questionnaires are delivered to respondents through mail, fax, or by hand, this type of survey is called a self-administered survey. If the researcher contacts respondent via phone, or face-to-face to fill out the questionnaire, the survey type is named as researcher-administered survey. Examples of modern surveying techniques are questionnaires delivered online or by e-mail.

This mode of delivery enables researchers save speed, time, and cost. Today, with a wide range of benefits they offer to researchers, online surveys have gained enormous popularity. Questionnaires delivered through e-mail require participants to respond in a given time whereas in online questionnaires, participants can go online and respond to questions 24/7. Figure 5 demonstrates different survey types.

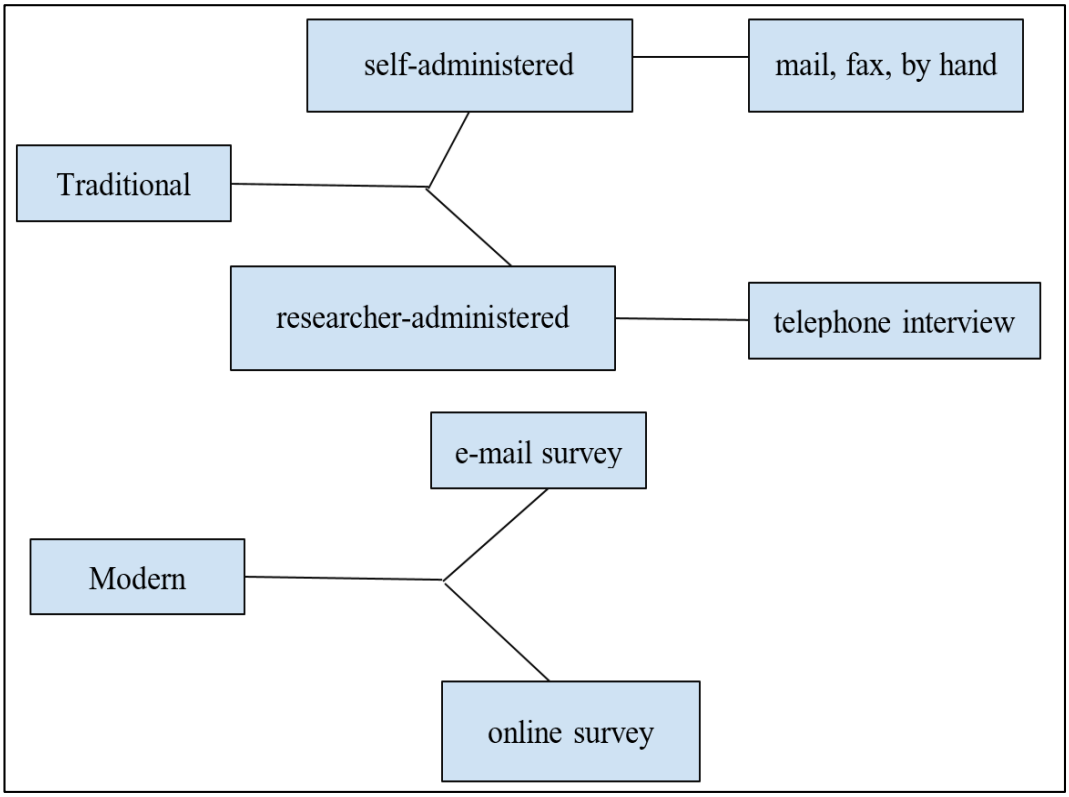


Figure 5 Types of Surveys (Coşkun et al., 2004)

4.3.2. Writing Survey Questions

Depending on the type data a researcher wants to elicit, survey questions can have different response formats. While respondents are sometimes requested to make a choice between "yes" or "no", at other times expected responses may indicate differing levels of preference like "totally agree" or "partially agree". There are basically two question types. Closed-ended questions, e.g. Did you graduate from your school in 2008? require answers as simple as a "yes" or "no". Open-ended questions, on the other hand, invite respondents to freely provide a response. Open-ended questions may elicit unexpected responses, which can potentially expand the scope of data.

However, they are more time-consuming, and might as well create problems in data analysis (Büyüköztürk, 2005). An example to open-ended question type is "What are the problems encountered in the production of national simulator systems?"

Based on response formats, a survey can consist of rank ordering, dichotomous, multiple-choice, and rating scale questions. Rank ordering questions request respondents to rank the given answer options as in "Rank your favorite flowers on a scale of 1 to 5". In closed-ended questions, such as "Do you have an automobile?", respondents are expected to choose between "yes" or "no" options. Alternatively, respondents can be asked to mark the most suitable answer out of the alternatives given. For instance, participants are to pick one of the choices of "Monday, Tuesday, Wednesday, Thursday, Friday" when they are posed the question of "On which week day would you like to ride a bike?". Rating scale items present respondents a range of options indicating their degree of agreement/disagreement. Take, for example, the question of "How do you find the food service offered by your institution?". Participants are to make their preference on the given scale of "Very bad, Bad, No opinion, Good, Very good" for such a question.

In social sciences, rating scales are data collection tools used for assessing, identifying qualifications, classifying, and providing more information about a product, service, process, skill, or performance. Likert scale, a non-comparative rating scale, is one the most widely used scales. Likert scales signify respondents' degree of agreement/disagreement or approval/disapproval concerning a given idea or activity. Below are response options classically used in 5-point Likert Scale. Researchers can also use 7-, 9-, or even 11-point scales (Böke, 2014):

"1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly agree"

4.4. The Delphi Method

The Delphi method was named after the town of "Delphi", where an oracle lived in ancient Greece. The method has been undertaken for over a half century in military, medical, and educational disciplines. It was developed in 1950 by Norman Dalkey and Olaf Helmer of the RAND Corporation to make predictions on military issues (Şahin, 2001). Researchers may experience clash of ideas while offering alternative solutions regarding the research topic. The Delphi technique is a means of consensus building that helps eliminate such clashes using meticulously constructed surveys

instead of face-to-face interviews (Gençtürk & Akbaş, 2013). Although the technique is highly suitable for the collection of qualitative data, it is a well-structured process that can utilize qualitative, quantitative, and mixed methods (Skulmoski, Hartman, & Krahn, 2007).

Junior, Vasconcellos, Guedes, Guedes, & Costa (2018) stated that the Delphi method is particularly useful in understanding problems, opportunities and solutions, developing forecasts about a problem, and investigating complex problems that call for expert opinions albeit lacking the rigor in testing and quantitative analyses. This method should especially be undertaken to prevent dominant groups from influencing other participants' opinions while taking political or emotional decisions (Şahin, 2001).

The Delphi method is characterized by anonymity of the participants, statistical analysis, and controlled feedback. Anonymity is the foremost feature of the Delphi technique. Anonymous participation allows for aggregation of opinions on the research topic by preventing unconditioned acceptance of the dominant, well-respected, and well-known group members' opinions. Anonymity can additionally avert a possible misassumption of dominant individuals that their opinions are questionable.

Controlled feedback allows for comparison of statistical analysis of responses elicited through round by round survey administration. Thus, consensus can be reached as data collected in each round is feedback to the next rounds (Şahin, 2001). Even though the number of rounds is mostly limited to two or three, a Delphi survey can have 2-10 rounds (Day & Bobeva, 2005).

4.4.1. Stages of the Delphi Implementation

The Delphi technique is composed of successive questionnaires (Gençtürk & Akbaş, 2013). Below are the stages followed for iterative administration of the technique.

4.4.1.1. Planning

During the planning stage, the purpose and the variables of the study are identified, and the Delphi statements are developed. The Delphi statements should be clear enough for all the participants to understand easily (Melander, Dubois, Hedvall, & Lind, 2019).

4.4.1.2. Participant Recruitment

Participants, usually referred to as a panel of experts, should be recruited among people who are knowledgeable and experienced in the area of interest. It is highly important that the individuals sampled for the study have expertise in the research topic, and can contribute profoundly to the study (Şahin, 2001). Furthermore, they should be willing to participate, have sufficient time, and possess effective communication skills (Skulmoski, Hartman, & Krahn, 2007).

Subsequently, researchers should decide on a sample size taking into account various relevant factors. If homogeneity is desired, sample size can vary between 10 and 15, and in cases of mixed groups, several hundreds of participants may be required.

The disadvantage with the heterogeneous groups is that they make it difficult to collect data, reach a consensus, and carry out analyses. With a large sample size, above a certain limit, data collection and analysis might turn into a cumbersome process (Skulmoski et al., 2007).

4.4.1.3. Delphi Survey Round I

The first round is expected to collect participant experts' technological forecasts concerning the issues worded in the Delphi statements, and elicit opinions about their effects on certain areas. Questions for each Delphi statement aim to measure level of expertise, current situation, feasibility, date of execution, and contribution to the country. Table 4 displays these questions and answer options.

Table 4
Sub-Questions and Answer Options for Delphi Statements(Adapted from Çakır, 2016)

Topics	Sub-questions	Answer Options
Level of expertise	Participant's expertise	1. None 2. Moderate 3. High
Existing situation	1. Sufficiency of human resources 2. Level of core knowledge 3. Hard infrastructure 4. Company capabilities	1. None 2. Low 3. Moderate 4. Strong 5. No opinion
Feasibility		1. Impossible 2. Very difficult 3. Difficult 4. Possible 5. Easy
Date of execution		1. 2018-2023 2. 2023-2028 3. 2028-2033 4. 2033-2038 5. Impossible
Contribution to the country (competitive advantage, science, technology and innovation capacity, environmental awareness and energy efficiency, gross value added, quality of life)		1. No contribution 2. Little contribution 3. Fair contribution 4. High contribution 5. Negative contribution

An example of questions and answer options for a Delphi statement are given in Table 5 below. The information in the table is designed for the D.1 Delphi statement, which is; Smart materials with programmable features are to be manufactured for the use of defense industries.

They are to be formed to fit the environment where they will be used, and be reshaped when necessary. These materials are not to be disposable, but reusable and reprogrammable.

Table 5
Sub-Questions and Answer Options for a Sample Delphi Statement

D.1.1	Participant's level of expertise about the Delphi statement	1. None	2. Moderate	3. High		
D.1.2.	Sufficiency of human resources in our country about the Delphi statement	1. None	2. Low	3. Moderate	4. Strong	5.No opinion
D.1.3.	Level of core knowledge in our country about the Delphi statement	1. None	2. Low	3. Moderate	4. Strong	5.No opinion
D.1.4.	Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement	1. None	2. Low	3. Moderate	4. Strong	5.No opinion
D.1.5.	Company capabilities in our country about the Delphi statement	1. None	2. Low	3. Moderate	4. Strong	5.No opinion
D.1.6.	Date of execution	1. Before 2023	2. Between 2023-2028	3. After 2028	4. Never	
D.1.7.	Contribution of the issue in the Delphi statement to Turkey's competitive power	1. Negative	2.None	3. Little	4. Fair	5.High
D.1.8.	Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity	1. Negative	2.None	3. Little	4. Fair	5.High
D.1.9.	Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey	1. Negative	2.None	3. Little	4. Fair	5.High

The first round of the Delphi survey commences upon the delivery of the questionnaire to participants, who are now expected to respond in a given period of time. Responses are analyzed, significant points are jotted down, and the round is finished. Next is the preparation stage for the second round.

4.4.1.4. Delphi Survey Round II

Analyzed data from the first round is represented in a graph or table. Notes in the form of graphs, tables, or images showing responses for each Delphi statement and participants' self-reports are inserted into the second round questionnaire if possible; if not, responses to the first round are emailed to participants. They can thus see their and all others' responses, which gives them the chance to revise their responses. Participants are posed the same questions in this round, too. They are left free to either change the responses they provided in the first round or skip the questions and end the questionnaire. Figure 6 displays the distribution of the first round responses for the D.1.1 Delphi statement of Level of participants' expertise about the Delphi statement:

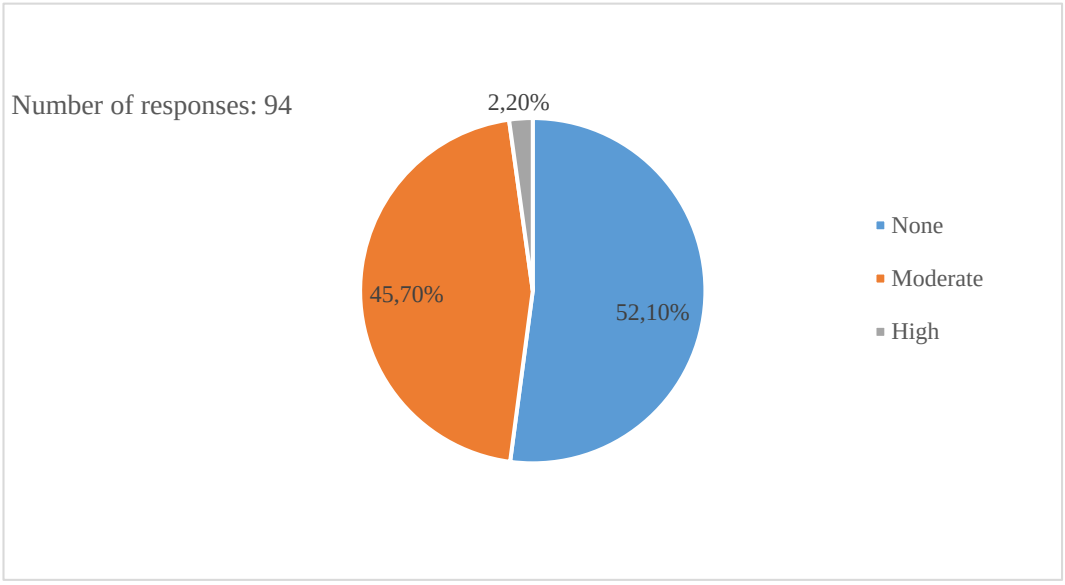


Figure 6 Distribution of Responses to the Delphi Statement

Participants are again expected to respond to the second round questionnaire within a given period of time. Once the round is over, a similar analysis process is carried out.

CHAPTER 5

DATA ANALYSIS

In this study, data was collected through two focus group interviews and a two-round Delphi survey. This chapter is dedicated to the investigation of the data collected via these two tools.

5.1. The First Focus Group

Technology Development Foundation of Turkey hosted the first focus group implementation on February 23, 2018 between 13:30 and 18:00 with the participation of nine experts from different academic, public, and private business institutions.

Participants were divided into two groups composed of five in one and four in the other, and each group was seated around a table. Table 6 below shows the number of participants from each institution.

Table 6
First Focus Group Participants

Institution	Participants
Middle East Technical University (METU)	1
Çankaya University	1
METU Teknokent Management Company	1
METU MEMS Center	1
Presidency of Defense Industries	1
ASELSAN	1
ATEL Technology and Defense Industry Inc.	1
BNBC International Engineering and Consultancy Inc.	2

Participants grouped and seated as demonstrated in Figure 7 followed the schedule detailed in Table 7.

Figure 7 First Focus Group

Table 7
First Focus Group Implementation Schedule

Time	Activity
13:30-13:45	Opening
13:45-14:15	Weighting of the technology evaluation criteria
14:15-15:15	Evaluation of the technology areas
15:15-15:30	Break
15:30-16:30	Vision study
16:30-18:00	Participants' speeches

The first focus group was implemented in two phases. First of all, for the purpose of *Weighting of the Technology Evaluation Criteria*, participants were asked to rank from 1 to 5 the predetermined criteria (competitive advantage, creating other technology areas, and meeting national security requirements) and the ones they added. Sample evaluation form used at this phase is illustrated in Figure 8.

The reason why these exemplary criteria are proposed is one of the main objectives of the defense industry to respond to national defense needs. In addition, the defense industry sector can consist of public and private companies.

Companies must have different technologies in order to survive. In addition, the fact that these technologies will pave the way for other technological developments will enable companies to expand their field of activity with new technological gains.

23.02.2018

Table No:

Name & Surname:

WEIGHTING OF THE TECHNOLOGY EVALUATION CRITERIA

No.	Technology Criteria	Rank*
1	Competitive Advantage	
2	Creating Other Technology Areas	
3	Meeting National Security Requirements	
	Other Criteria To Be Added	
4		
5		
6		
7		
8		
9		

(*) Ranking will be done between "1", the lowest, and "5", the highest.

Figure 8 Technology Evaluation Criteria Weighting Form

Together with the ones added by participants, a total of 19 criteria were identified. These criteria and the rankings assigned by participants are in Table 8 and some technology criteria are not rated so these are shown with zero.

Table 8
Technology Criteria and Rankings Assigned by Participants

Technology Criteria	Ranking
Competitive Advantage	34
Creating Other Technology Areas	16
Meeting National Security Requirements	38
Providing High Added Value	3
Creating Asymmetric Effect	5
Being National	3
Creating New Markets/Customers	3
Short Product Realization Periods	1
Convenience in Forming Combinations with Existing Technologies	0
Creating a Striking Impact	5
Reducing Costs	4
Creating Employment	1
Added Value to Customers	2
Addressing Market Needs	4
Ratio of Being Domestic And National	3
Sustainable Technologies	1
Being a Critical Technology	3
Difficulty in International Procurement	1
Opportunities for International Cooperation	0
19 Technology Criteria	Total: 127

Next, weighted scores were calculated dividing the rank assigned for each criterion by the total ranking score, as shown in Table 9 below.

Table 9
Weighting of Technology Criteria

Technology Criteria	Weighted Scores
Competitive Advantage	34/127=0.267
Creating Other Technology Areas	16/127=0.125
Meeting National Security Requirements	38/127=0.299
Providing High Added Value	3/127=0.02
Creating Asymmetric Effect	5/127=0.039
Being National	3/127=0.023
Creating New Markets/Customers	3/127=0.023
Short Product Realization Periods	1/127=0.007
Convenience in Forming Combinations with Existing Technologies	0/127=0
Creating a Striking Impact	5/127=0.039
Reducing Costs	4/127=0.031
Creating Employment	1/127=0.007
Added Value to Customers	2/127=0.015
Addressing Market Needs	4/127=0.031
Ratio of Being Domestic And National	3/127=0.023
Sustainable Technologies	1/127=0.007
Being a Critical Technology	3/127=0.023
Difficulty in International Procurement	1/127=0.007
Opportunities for International Cooperation	0/127=0
19 Technology Criteria	Total: 127

As can be seen in Table 9, the first three places were occupied by *Meeting National Security Requirements, Competitive Advantage, and Creating Other Technology areas* with scores of 0.299, 0.267, and 0.125, respectively.

Afterwards, participants, based on the aforementioned technology evaluation criteria, assigned rankings for 35 technology areas stated in the Taxonomy of

Defense Industry Technologies – Glossary of Terms and Abbreviations (SSB, 2017) published by Department of R&D and Technology Management under Presidency of Defense Industries. For a sample form (Appendix A) and data regarding the rankings, see Appendix B.

Relying on the technology areas and rankings shown in Appendix B, first drafts of the Delphi statements addressing the technology evaluation criteria that occupied the first three places in the above evaluation (Meeting National Security Requirements, Competitive Advantage, and Creating Other Technology). Final drafts of these statements will be written in the course of second focus group to be used in the Delphi survey. Related details are presented under 5.2. The Second Focus Group heading.

During the first focus group, a vision study was conducted. The vision study was conducted through in-tray exercise technique (TÜSSİDE, 2004). Groups divided as table-1 and table-2 were delivered A3 paper sheets as trays. Each participant was requested to note down their rough opinions on post-its and stick them on these sheets, which they then passed onto the person on their right. This process continued until all possible opinions were elicited.

On the basis of relevance, the opinions were then merged to identify topic titles. These titles were ranked from 1 to 5, and thus constructed the *Vision Statement*. The question directed to both groups for generating ideas in the process of vision development was What should be the R&D and innovation vision of Turkish defense industry companies?

The group at table-1 considered the question in terms of the companies, and constructed the vision statement of To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies. In Tables 10 and 11 are the ideas generated and the topic titles ranked by the first group seated at table-1 and the meaning of "line (-)" has never scored.

Table 10
First Group's Vision Statements and Topic Titles

Table 1- Vision statement: *To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies*	
Asymmetric	2 Points
Cannot be copied	2 Points
Able to create mutual interdependence	-
Focuses on issues able to create striking (surprise) effect	-
Strong	-
Able to adapt to technological transformations	4 Points
Responsive	-
Knows what technology to select	-
Possesses technology management skills	-
Keeps up with new technology	-
Possesses latest technologies	-
Able to integrate different technologies	-
Develops cooperation for critical technologies	-
Informatics	1 Point
Capitalizes on materials science	1 Point
Focused on practices in robotics	-
Distributed	-
Develops and supports human resources needed	1 Point
Able to create new markets	5 Points
Competitive	-
Globally competitive	-
Adopts dual-use practices	-
Cost effective	-
Import substitution	5 Points
Attends to national and regional needs	-
National	-

Table 10 *(cont'd)*

Table 1- Vision statement: *To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies*	
Meets national needs	-
Handles products failing to comply with ITAR	-
Low maintenance	-
Focused on product management rather than marketing	-

Table 11
Scored Topic Titles in the First Group's Vision Statement

Topic titles	Ranking
Import substitution	5 Points
Able to create new markets	5 Points
Able to adapt to technological transformations	4 Points
Cannot be copied	2 Points
Asymmetric	2 Points
Develops and supports human resources needed	1 Point
Capitalizes on materials science	1 Point
Informatics	1 Point

The second group (table-2) members were asked to answer the same question (*What should be the R&D and innovation vision of Turkish defense industry companies*?) specific to Turkey, not companies. The vision statement they suggested was:

To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands in international markets, and adopts space as a new living environment. Tables 12 and 13 show the ideas generated, and ranked titles by the second group and the meaning of "line (-)" has never scored.

Table 12
Second Group's Vision Statement and Topic Titles

Table 2- Vision statement: *To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands in international markets, and adopts space as a new living environment*	
National (Domestic and national)	4 Points
Original	-
Domestic and national	-
Possesses sustainable technologies (Sustainable and reproducible)	3 Points
Sustainable and reproducible	-
Engages in basic technologies	3 Points
Core technology (Able to develop design technologies)	1 Point
Basic technology	-
Able to develop design technologies	-
Innovative	3 Points
Able to provide process innovation (Adopts "space" as a new living environment)	2 points
Increase in the number of triadic patents	-
Adopts "space" as a new living environment	-
Can be transformed into product (Marketable, Can be transformed into product)	1 Point
Able to release marketable products	-
Can realize (trigger) multidisciplinary studies (e.g. biotechnology)	2 Points
Relies on merit-based workforce	1 Point
Quick design	-
Based on energy use and efficiency	1 Point

Table 12 *(cont'd)*

Table 2- Vision statement: *To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands in international markets, and adopts space as a new living environment*	
Brands in international markets	2 Points
International	-
Provides remedy to a problem/suffering of the country and humanity	-
Addresses market needs	-
Matches national strategy serving national security	1 Point
Capitalizes on strategic objectives	-
Provides dual usability	-
Provides diversity	-
Supports integrated concepts	-

Table 13
Scored Topic Titles in the Second Group's Vision Statement

Topic titles	Ranking
Domestic and national	4 Points
Sustainable and reproducible	3 Points
Engages in basic technologies	3 Points
Innovative	3 Points
Adopts "space" as a new living environment	2 Points
Can realize (trigger) multidisciplinary studies (e.g. biotechnology)	2 Points
Brands in international markets	2 Points
Able to develop design technologies	1 Point
Marketable, can be transformed into product	1 Point
Relies on merit-based workforce	1 Point
Based on energy use and efficiency	1 Point
Matches national strategy serving national security	1 Point

Consequently, in the vision study, the two groups were requested to provide two answers – one for companies, and one for Turkey – to the question of *What should be the R&D and innovation vision of Turkish defense industry companies?*

The vision statement constructed for companies was *To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies*; and the one suggested for Turkey was *To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands in international markets, and adopts space as a new living environment*.

Thus, based on this vision study, strategic objectives to be used in the Delphi implementation were identified. Below are the objectives specified for the first vision statement:

1st Strategic Objective: To be internationally competitive
2nd Strategic Objective: To produce technologies that can meet country's needs
3rd Strategic Objective: To be able to import products and services

Strategic objectives for the second vision statement are as follow:

1st Strategic Objective: To be able to sustain basic technologies
2nd Strategic Objective: To conduct multidisciplinary studies
3rd Strategic Objective: To be innovative, and brand in international markets

5.2. The Second Focus Group

Similarly, the Kıvılcım hall of Technology Development Foundation of Turkey hosted the second focus group implementation on April 27, 2018 between 14:00 and 18:00 with the participation of 11 experts from different academic, public, and private business institutions. Participants were divided into three groups. Table 14 shows the number of participants from each institution.

Table 14
Second Focus Group Participants

Institution	Participants
Presidency of Defense Industries	2
Scientific and Technological Research Council of Turkey (TUBITAK)	1
METU	1
Gazi University	1
Çankaya University	1
Turkish Aerospace Industries Inc. (TAI)	1
ASELSAN	1
HAVELSAN Inc.	2
Sim-Tek Simulation and IT Company	1

Participants grouped and seated as demonstrated in Figure 7 followed the schedule detailed in Table 15.

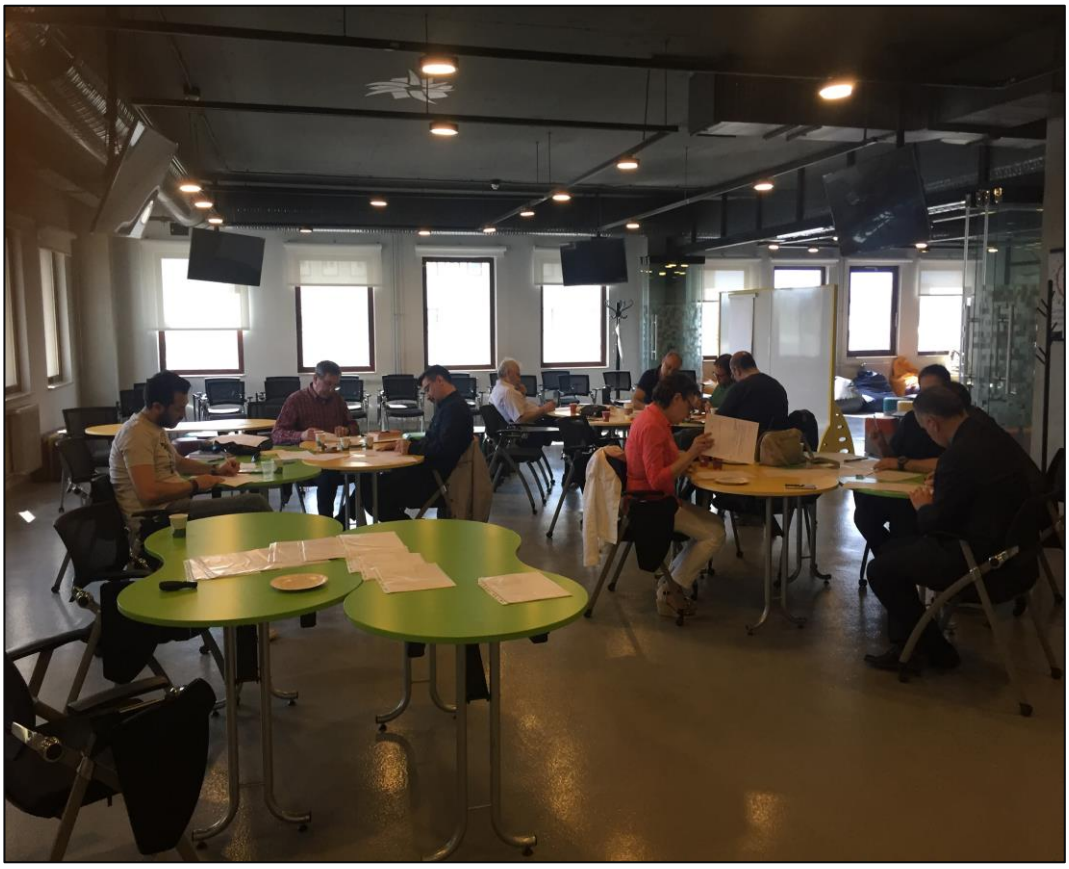


Figure 9 Second Focus Group

Table 15
Second Focus Group Implementation Schedule

Time	Activity
14:00-14:30	Briefing on the 1st Focus Group Results and the Delphi Method
14:30-16:00	Developing the Final Draft of the Delphi Questionnaire and the Final Draft of the 5 Delphi Statements
16:00-16:15	Break
16:15-17:15	Developing the Final Draft of the 5 Delphi Statements
17:15-18:00	Comments and Suggestions

The second focus group study was carried out in two phases. The first part of the study commenced with a short briefing on the Delphi method. Next, participants' opinions regarding the first set of 5 Delphi statements addressing the technology areas identified in the first focus group were elicited. They were also asked to provide their own Delphi propositions addressing the related technology areas. Finally, each of the three groups developed a separate Delphi proposition all the group members agreed upon. Table 16 shows the technology areas.

Table 16
Technology Areas

Technology Areas
1. Structural & Smart Materials & Structural Mechanics
2. Electronic Materials Technology
3. Propulsion and Powerplants
4. Sensor Systems
5. Integrated Platforms
6. Weapons Systems
7. Electronic, Electrical & Electromechanical Device Technology
8. Energetic Materials and Plasma Technology
9. Simulators, Trainers and Synthetic Environments
10. Computing Technologies and Mathematical Techniques

In the second part of the study, participants' opinions about the second set of 5 Delphi statements, and their own Delphi propositions referring to the related

technology areas were obtained. The overall purpose in both parts of the second focus group was to finalize the Delphi statements to be used in the Delphi questionnaire. During this process, the Taxonomy of Defense Industry Technologies – Glossary of Terms and Abbreviations was used as a reference (SSB, 2017). In Table 17 below are the 10 Delphi statements the participants worked on, and the Delphi propositions for the related technology areas.

Table 17
Delphi Propositions for the Related Technology Areas

Technology areas	Delphi propositions
Structural & Smart Materials & Structural Mechanics	Within the next five years, brand new structural ceramic materials are to be developed and manufactured to be used for the practices in armor and aero engine systems.
Electronic Materials Technology	Low-cost thermal detectors are to be domestically manufactured and exported.
Propulsion and Powerplants	Technologies that will provide increased resistance of gas tribunes to effects of sand/salt ingestion are to be developed.
Sensor Systems	Domestic antenna systems to detect and track visible/invisible sea surface and air targets are to be developed.
Integrated Platforms	Underwater platforms and weapons systems that are dependent on international procurement in terms of such features as speed, balance, strength, stealth, self-defending, sustainability, war power, and life lengthening are to be domestically manufactured.
Weapons Systems	Within the next five years, system technologies that direct the electromagnetic energy to target, focus it on target, and create destructive or nondestructive damage on target are to be designed.
Electronic, Electrical & Electromechanical Device Technology	For use in defense systems, Li-ion batteries of different shapes and sizes are to be domestically manufactured and exported.
Energetic Materials and Plasma Technology	Environmentally-friendly technologies for the disposal of new propellants at the end of their service life are to be developed.
Simulators, Trainers and Synthetic Environments	Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate the critical cues provided by the real platforms.
Computing Technologies and Mathematical Techniques	Certification, verification, and accreditation of airworthiness software for air platforms are to be national and internationally valid.

5.3. Delphi Questionnaire – First Round

Together with the 10 Delphi statements participants in the second focus group study carried out on Friday of April 27, 2018 were asked to assess, and the ones proposed by participants at the end of the study, a total of 19 Delphi statements were developed to be used in the first and second round of the Delphi questionnaire. Under these were inserted nine questions covering the following topic titles:

- level of expertise,
- sufficiency of human resources in our country,
- level of core knowledge in our country,
- capacity of hard infrastructure (devices/equipment),
- skills the companies in our country have,
- date of execution
- contribution to Turkey's competitive power,
- contribution to Turkey' science, technology, and innovation capacity,
- contribution to energy efficiency and environmental awareness in Turkey

For the questionnaire form, 19 Delphi statements used in the questionnaire, and the related questions and their answer options, see Appendix C. It includes a total of 171 questions to be pose to the participants.

5.3.1. Participant Recruitment for the Delphi Questionnaire

As the research topic and the questions relate to defense industries, participants needed to be sampled from defense industries, too. To this end, Department of Industrialization under Presidency of Defense Industries was contacted to demand a list of contact details of the companies in Ankara that conduct R&D studies, and can participate in the questionnaire. The presidency provided the contact information of seven companies with R&D units which had been accredited to make an industrial competency inventory of defense industry companies, detect and improve their level of competencies within the framework of Industrial Competency Assessment and Support Program (EYDEP). In addition to these companies, experts from Havelsan,

Aselsan, TAI, and Roketsan – affiliated companies of the Turkish Armed Forces Foundation – universities, public institutions, and other defense industry organizations were recruited as participants. Below are the 30 organizations participants were recruited from.

1. TTAF Defense Industries and Commerce Inc.
2. Fotoniks Military Electronics and Electro-Optics Company
3. GalenTech
4. Esen System Integration and Engineering Company
5. Ayduo Electronics Inc.
6. Manas Energy Management
7. Bilplas Inc.
8. BITES Defense and Aerospace Technologies Inc.
9. Scientific and Technological Research Council of Turkey (TUBITAK)
10. Stc Electronics
11. FNSS Defense Systems
12. SDT Space and Defense Technologies
13. Türksat Company
14. Turkish Armed Forces
15. Meteksan Defense
16. MZS Energy
17. EMTEKNO Electronics
18. Presidency of Defense Industries
19. Gazi University
20. Middle East Technical University
21. Ankara University
22. Innovera Informatics Technologies
23. Digitest Electronics
24. Vodafone Türkiye
25. ENOVAS Engineering
26. ATLAS Unmanned Systems
27. Koç Information and Defense Industries
28. ATEL Technology and Defense Industry Inc.

29. CS-TECH
30. ICterra Information and Communication Technologies

The first Delphi round was designed online using a survey form in “Google Forms”. Using an online delivery mode brought about advantages in terms of time and ease of reaching participants. 167 individuals from the aforementioned 30 organizations were contacted via email and phone, asked to partake in the first round questionnaire on https://docs.google.com/forms/d/e/1FAIpQLSe8TUerIB_QWJXN2wap9mSCiz9sTHIIBUZLG2KGiT96rxEcGw/viewform?usp=sf_link.

First response was received on June 22, 2018, and the questionnaire ended on July 6, 2018. Throughout this process, all the 167 participants were repeatedly reminded to respond to the questionnaire by contacting them through email and/or phone. 94 of the participants completed the questionnaire. Figure 10 and Figure 11 are the screenshots of the home page of the questionnaire, and the total number of participants that answered the questions, respectively.

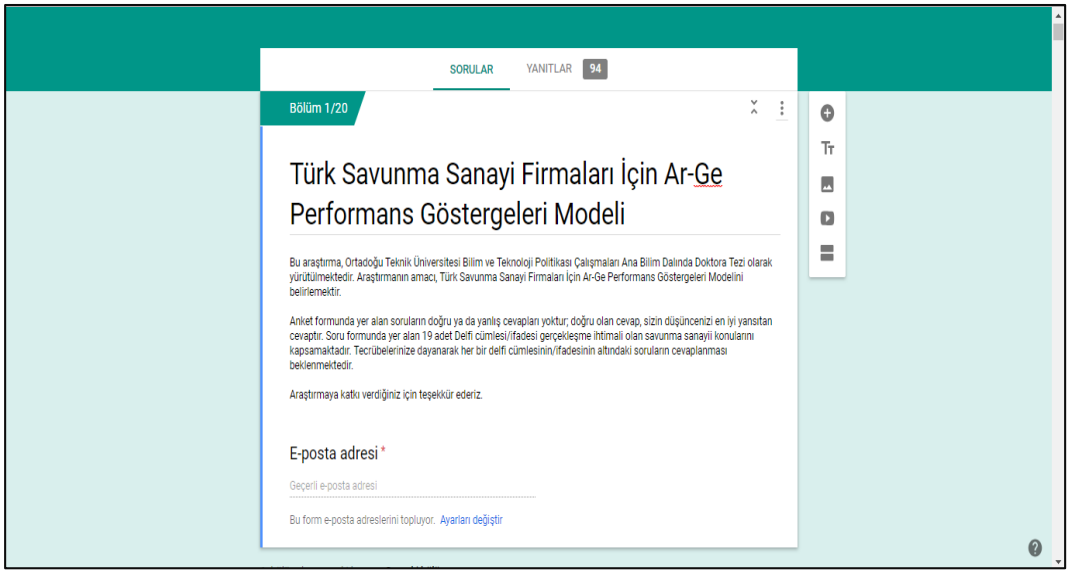


Figure 10 The First Delphi Round Home Page

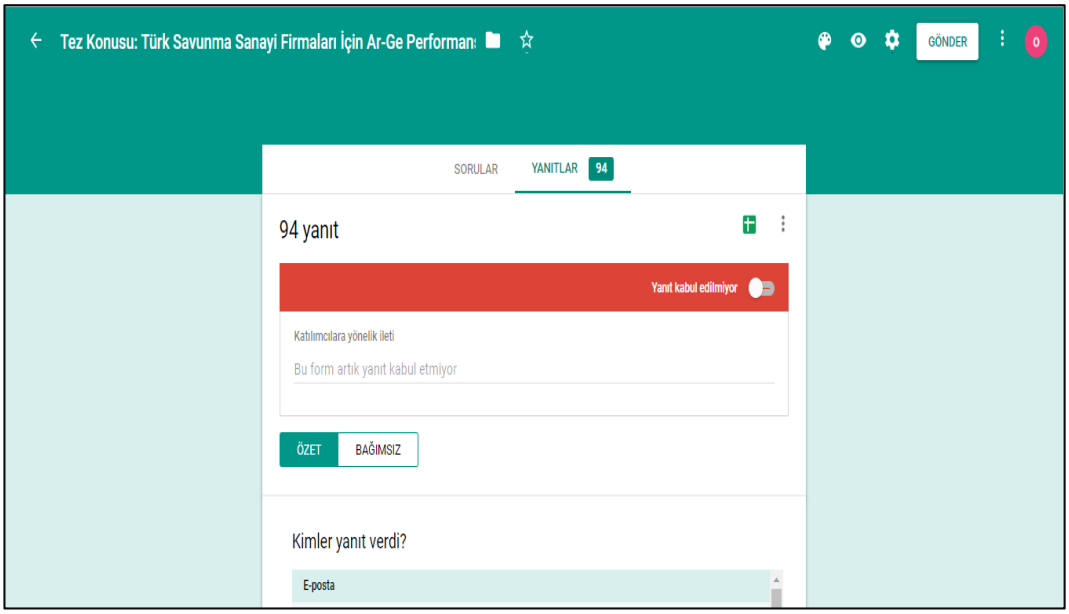


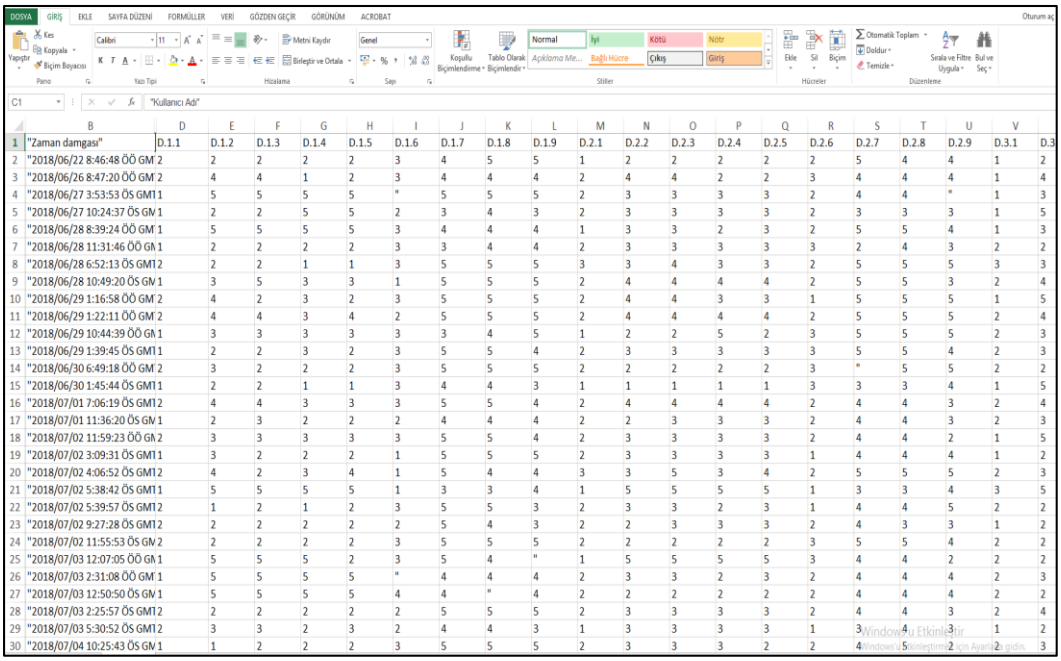
Figure 11 Number of Responses to the First Delphi Round Questionnaire

5.3.2. Analysis of the Responses to the First Round Delphi Questionnaire

94 respondents' answers were extracted from "Google Forms" as a "csv" file. This file extension was converted into "tsv" to be able to process the data in Microsoft Excel. The "tsv" file was then opened in Excel, and using comma function the text data was converted into cells. The data was thus made analyzable. The data was analyzed and assessed following the steps below:

1. Responses were assigned numeric values between 1 and 5 according to the answer options. (=PARÇAAL(Sayfa1!D2;2;1))
2. Then, weighted scores for each response (=EĞERSAY(D2:D85;"1")), frequency distributions in groups of 10 (=EĞERSAY(D2:D11;"1")), and response densities in groups of 10, 30, 60, 80 and 90 (=TOPLA(D126)/10) were calculated. After these calculations, responses were represented graphically. Procedures after this step were done together with the second tour of the Delphi questionnaire. These analyses were run using Microsoft Excel VBA and Microsoft Excel Formula.

Figure 12 demonstrates the numeric data of the responses to the first Delphi round questionnaire.



	B	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	"Zaman damgası"	D.1.1	D.1.2	D.1.3	D.1.4	D.1.5	D.1.6	D.1.7	D.1.8	D.1.9	D.2.1	D.2.2	D.2.3	D.2.4	D.2.5	D.2.6	D.2.7	D.2.8	D.2.9	D.3.1	D.3
2	"2018/06/22 8:46:48 ÖÖ GM	2	2	2	2	2	3	4	5	5	1	2	2	2	2	2	5	4	4	1	2
3	"2018/06/26 8:47:20 ÖÖ GM	2	4	4	1	2	3	4	4	4	2	4	4	2	2	3	4	4	4	1	4
4	"2018/06/27 3:53:53 ÖS GM	1	5	5	5	5	"	5	5	5	2	3	3	3	3	2	4	4	"	1	3
5	"2018/06/27 10:24:37 ÖS GN	1	2	2	5	5	2	3	4	3	2	3	3	3	3	2	3	3	3	1	5
6	"2018/06/28 8:39:24 ÖÖ GM	1	5	5	5	5	3	4	4	4	1	3	3	2	3	2	5	5	4	1	3
7	"2018/06/28 11:31:46 ÖÖ GN	1	2	2	2	2	3	3	4	4	2	3	3	3	3	3	2	4	3	2	2
8	"2018/06/28 6:52:13 ÖS GM	2	2	2	1	1	3	5	5	5	3	3	4	3	3	2	5	5	5	3	3
9	"2018/06/28 10:49:20 ÖS GN	1	3	5	3	3	1	5	5	5	2	4	4	4	4	2	5	5	3	2	4
10	"2018/06/29 1:16:58 ÖÖ GM	2	4	2	3	2	3	5	5	5	2	4	4	3	3	1	5	5	5	1	5
11	"2018/06/29 1:22:11 ÖÖ GM	2	4	4	3	4	2	5	5	5	2	4	4	4	4	2	5	5	5	2	4
12	"2018/06/29 10:44:39 ÖÖ GN	1	3	3	3	3	3	3	4	5	1	2	2	5	2	3	5	5	5	2	3
13	"2018/06/29 1:39:45 ÖS GM	1	2	2	3	2	3	5	5	4	2	3	3	3	3	3	5	5	4	2	3
14	"2018/06/30 6:49:18 ÖÖ GM	2	3	2	2	2	3	5	5	5	2	2	2	2	2	3	"	5	5	2	2
15	"2018/06/30 1:45:44 ÖS GM	1	2	2	1	1	3	4	4	3	1	1	1	1	1	3	3	3	4	1	5
16	"2018/07/01 7:06:19 ÖS GM	2	4	4	3	3	3	5	5	4	2	4	4	4	4	2	4	4	3	2	4
17	"2018/07/01 11:36:20 ÖS GN	1	2	3	2	2	2	4	4	4	2	2	3	3	3	2	4	4	3	2	3
18	"2018/07/02 11:59:23 ÖÖ GN	2	3	3	3	3	3	5	5	4	2	3	3	3	3	2	4	4	2	1	5
19	"2018/07/02 3:09:31 ÖS GM	1	3	2	2	2	1	5	5	5	2	3	3	3	3	1	4	4	4	1	2
20	"2018/07/02 4:06:52 ÖS GM	2	4	2	3	4	1	5	4	4	3	3	5	3	4	2	5	5	5	2	3
21	"2018/07/02 5:38:42 ÖS GM	1	5	5	5	5	1	3	3	4	1	5	5	5	5	1	3	3	4	3	5
22	"2018/07/02 5:39:57 ÖS GM	2	1	2	1	2	3	5	5	3	2	3	3	2	3	1	4	4	5	2	2
23	"2018/07/02 9:27:28 ÖS GM	2	2	2	2	2	2	5	4	3	2	2	3	3	3	2	4	3	3	1	2
24	"2018/07/02 11:55:53 ÖS GN	2	2	2	2	2	3	5	5	5	2	2	2	2	2	3	5	5	4	2	2
25	"2018/07/03 12:07:05 ÖÖ GN	1	5	5	5	2	3	5	4	"	1	5	5	5	5	3	4	4	2	2	2
26	"2018/07/03 2:31:08 ÖÖ GM	1	5	5	5	5	"	4	4	4	2	3	3	2	3	2	4	4	4	2	3
27	"2018/07/03 12:50:50 ÖS GN	1	5	5	5	5	4	4	"	4	2	2	2	2	2	2	4	4	4	2	2
28	"2018/07/03 2:25:57 ÖS GM	2	2	2	2	2	2	5	5	5	2	3	3	3	3	2	4	4	3	2	4
29	"2018/07/03 5:30:52 ÖS GM	2	3	3	2	3	2	4	4	3	1	3	3	3	3	1	3	4	3	1	2
30	"2018/07/04 10:25:43 ÖS GN	1	1	2	2	2	3	5	5	5	2	3	3	3	2	2	4	5	2	2	3

Figure 12 Responses to the First Delphi Round Questionnaire

Answer options of the D.1.1 question addressing the D.1.1 Delphi statement were coded as “None-1”, “Moderate-2”, and “High-3”. Number of responses was calculated for each answer option when the number of respondents reached 10, 20, 30, 40, 50, 70, 80, and 90. These values can be seen in Table 18. Also Table 19 shows the weighted means for each answer in groups of 10, 30, 60, 80, and 90.

Table 18
Distribution of Responses to D.1.1 Question

D-1.1 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	5	6	4	6	5	4	5	4	9
2	5	4	6	4	5	4	4	6	1
3	0	0	0	0	0	2	0	0	0
Left unanswered	0	0	0	0	0	0	1	0	0

Table 19
Weighted Means of Responses to D.1.1 Question

D-1.1 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.50000	0.50000	0.50000	0.48750	0.53333
2	0.50000	0.50000	0.46667	0.47500	0.43333
3	0.00000	0.00000	0.03333	0.02500	0.02222

A graphical representation of the weighted means of the responses to the D.1.1 question is seen in Figure 13.

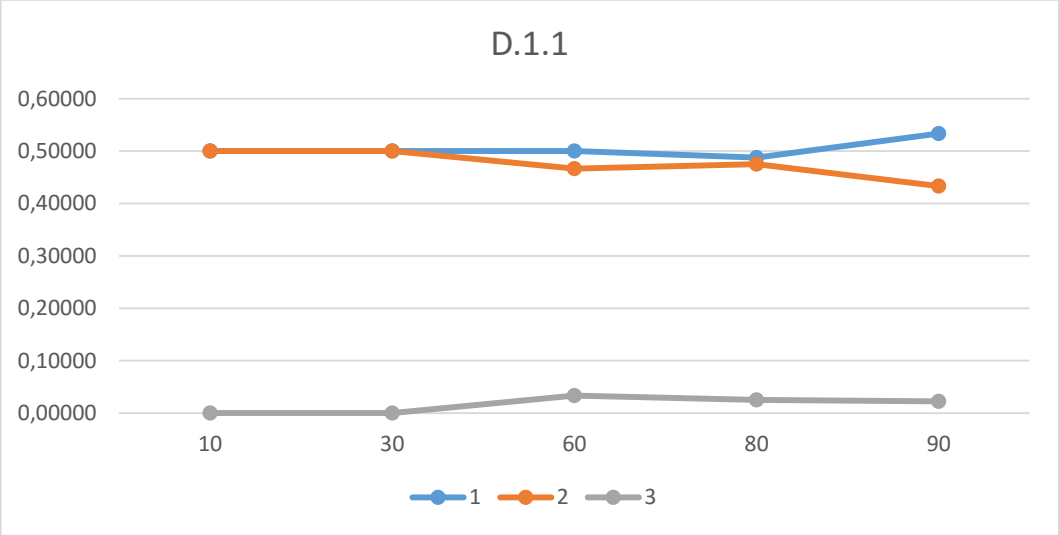


Figure 13 Weighted Means for D.1.1 Question

Answer options of the D.4.6 question addressing the D.4.6 Delphi statement were coded as “Before 2023-1”, “Between 2023 and 2028-2”, “After 2028-3”, and “Never-4”. Number of responses was calculated for each answer option when the number of respondents reached 10, 20, 30, 40, 50, 70, 80, and 90. These values can be seen in Table 20 below, and Table 21 shows the weighted means for each answer in groups of 10, 30, 60, 80, and 90. Besides, a graphical representation of the weighted means of the responses to the D.4.6 question is given in Figure 14.

Table 20
Distribution of Responses to D.4.6 Question

D-4.6 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	2	0	1	0	0	0	0	0
2	3	1	1	2	2	5	3	2	3
3	5	6	5	4	8	2	5	5	6
4	1	1	3	0	0	2	1	1	0
Left unanswered	1	0	1	3	0	1	1	2	1

Table 21
Weighted Means of Responses to D.4.6 Question

D-4.6 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.06667	0.05000	0.03750	0.03333
2	0.30000	0.16667	0.23333	0.23750	0.24444
3	0.50000	0.53333	0.50000	0.50000	0.51111
4	0.10000	0.16667	0.11667	0.11250	0.10000

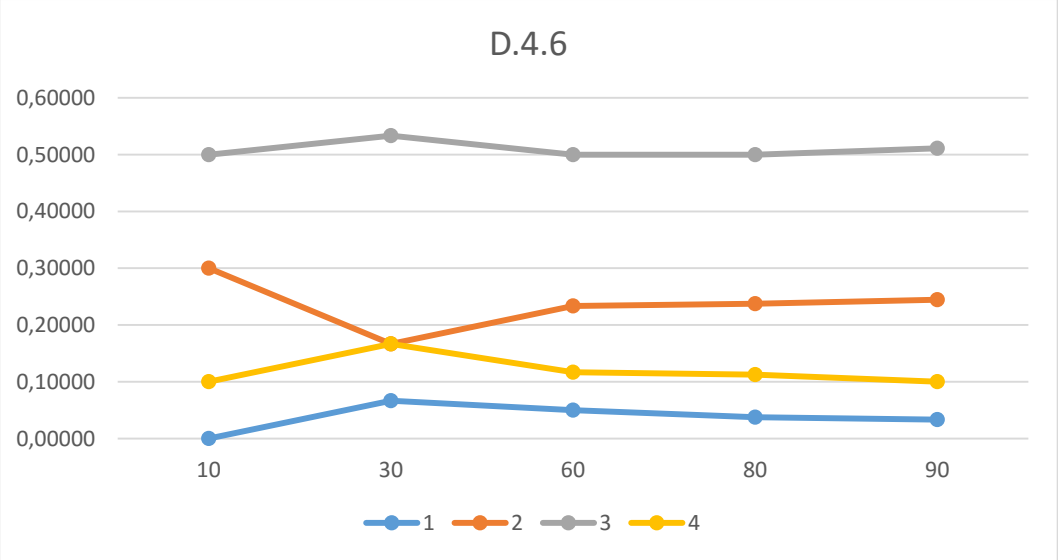


Figure 14 Weighted Means for D.4.6 Question

Answer options of the D.15.3 question addressing the D.15.3 Delphi statement were coded as “None-1”, “Low-2”, “Moderate-3”, “Strong-4”, and “No opinion-5”. Number of responses was calculated for each answer option when the number of respondents reached 10, 20, 30, 40, 50, 70, 80, and 90. These values can be seen in Table 22 below, and Table 23 shows the weighted means for each answer in groups of 10, 30, 60, 80, and 90. Figure 15 shows the graphic of these weighted means.

Table 22
Distribution of Responses to D.15.3 Question

D-15.3 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	0	0	1	0	1	0	0	0
2	2	0	0	2	4	3	1	1	3
3	1	5	6	4	4	3	3	5	2
4	6	4	2	3	0	0	5	2	4
5	0	1	0	0	2	3	0	2	1
Left unanswered	1	0	2	0	0	0	1	0	0

Table 23
Weighted Means of Responses to D.15.3 Question

D-15.3 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.00000	0.03333	0.02500	0.02222
2	0.20000	0.06667	0.18333	0.16250	0.17778
3	0.10000	0.40000	0.38333	0.38750	0.36667
4	0.60000	0.40000	0.25000	0.27500	0.28889
5	0.00000	0.03333	0.10000	0.10000	0.10000

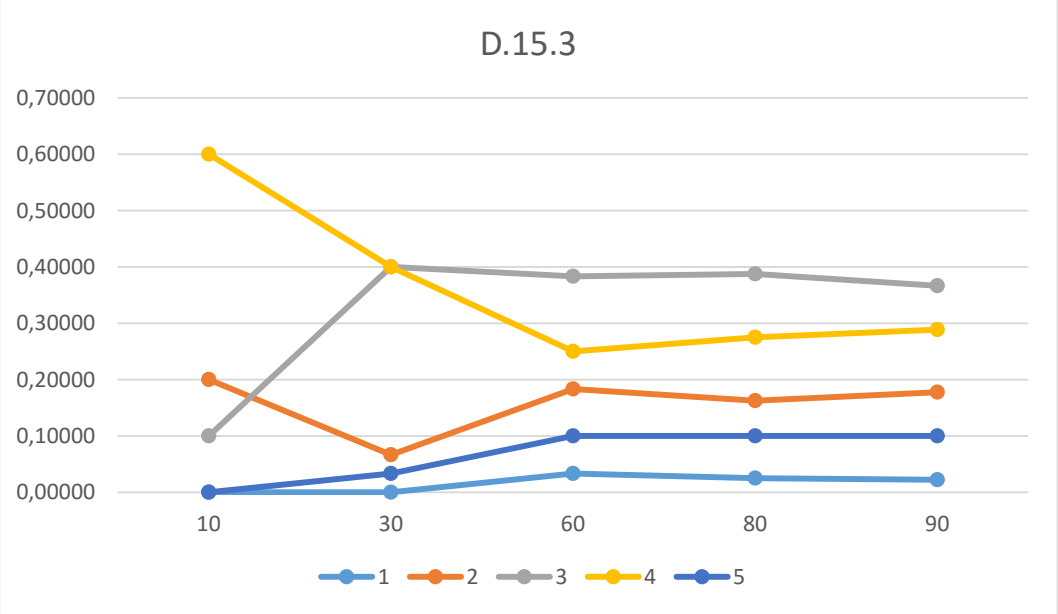


Figure 15 Weighted Means for D.15.3 Question

Answer options of the D.11.5 question addressing the D.11.5 Delphi statement were coded as "None-1", "Low-2", "Moderate-3", "Strong-4", and "No opinion-5". Number of responses was calculated for each answer option when the number of respondents reached 10, 20, 30, 40, 50, 70, 80, and 90. These values can be seen in Table 24, and Table 25 shows the weighted means for each answer in groups of 10, 30, 60, 80, and 90. Figure 16 shows the graphic of these weighted means.

Table 24
Distribution of Responses to D.11.5 Question

D-11.5 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	0	0	2	0	0	0	1	0
2	2	2	2	1	4	1	1	1	3
3	4	6	6	3	2	6	6	6	2
4	1	0	0	3	1	3	2	1	1
5	1	2	0	1	3	0	0	1	4
Left unanswered	2	0	2	0	0	0	1	0	0

Table 25
Weighted Means of Responses to D.11.5 Question

D-11.5 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.00000	0.03333	0.03750	0.03333
2	0.20000	0.20000	0.20000	0.17500	0.18889
3	0.40000	0.53333	0.45000	0.48750	0.45556
4	0.10000	0.03333	0.13333	0.13750	0.13333
5	0.10000	0.10000	0.11667	0.10000	0.13333

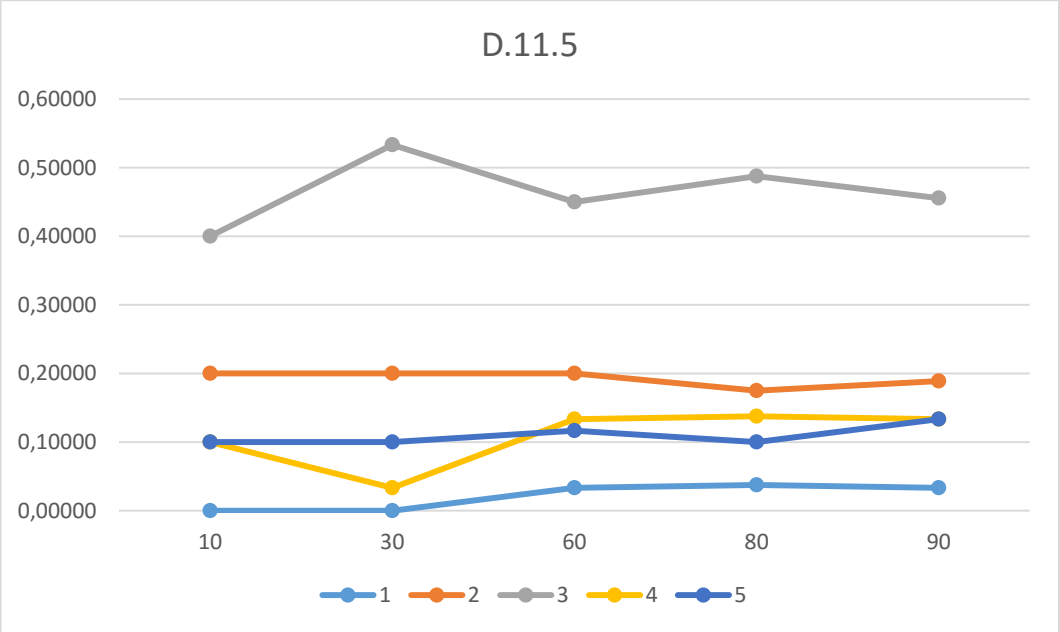


Figure 16 Weighted Means for D.11.5 Question

Relying on the data summarized in the relevant tables and figures above, it can be concluded that 90 would be a sufficient number of participants in the first round Delphi questionnaire since weighted means for 90 participants reach saturation point, which implies data from more than 90 will not add to the significance of results. Therefore, the first round Delphi questionnaire was ended at this point.

The Delphi statements that existed D.1.1, D.4.6, D.15.3 and D.11.5 in tables and graphics are randomly selected from 19 Delphi statements. The aim is to determine where the first round of Delphi questionnaire will be terminated.

When the answers given for the D.1.1 Delphi statement question are examined, the average answer for the “None-1” option is 0.5 when the number of participants is 10, 0.5 when 30 people, 0.5 when 60 people, 0.48 when 80 people, and 0.53 when 90 people.

For the "Moderate-2" option, the average answer is 0.5 when the number of participants is 10, 0.5 when 30 people, 0.46 when 60 people, 0.47 when 80 people and 0.43 when 90 people.

For the “High-3” option, the average answer is 0.0 when the number of participants is 10, 0.0 when 30 people, 0.03 when 60 people, 0.02 when 80 people and 0.02 when 90 people. As a result, the average answers are seen to be around certain values when the number of participants starts with 10 and reaches 90.

Therefore, when the number of participants reaches 90, we can stop Questionnaire. Similar results are obtained when similar comparison is made in D.4.6, D.15.3 and D.11.5 Delphi statements questions.

5.4. Delphi Questionnaire – Second Round

The second Delphi round commenced in mid-July, 2018. The questionnaire was again designed online using Google Forms, and was delivered at https://docs.google.com/forms/d/e/1FAIpQLSfgW4dF4brlLJ5IPWVnYegywh7biT5ODMW6Rc1hQBfKpNH4A/viewform?usp=sf_link web link.

The 94 respondents of the first round were invited to respond to the questionnaire via email and phone. As participants’ responses to the first round questionnaire could not be inserted in the second round due mainly to the limitations of “Google Forms”, each participant was emailed a pdf document – as in Figure 17 – showing their responses to the first round questions.

D.1.1 Participant's level of expertise about the Delphi statement	2. Moderate
D.1.2. Sufficiency of human resources in our country about the Delphi statement	1. None
D.1.3. Level of core knowledge in our country about the Delphi statement	1. None
D.1.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement	1. None
D.1.5. Company capabilities in our country about the Delphi statement	1. None
D.1.6. Date of execution	3. After 2028
D.1.7. Contribution of the issue in the Delphi statement to Turkey's competitive power	3. Little
D.1.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity	4. Fair
D.1.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey	5. High
D.2.1 Participant's level of expertise about the Delphi statement	3. High
D.2.2. Sufficiency of human resources in our country about the Delphi statement	2. Little
D.2.3. Level of core knowledge in our country about the Delphi statement	3. Moderate
D.2.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement	2. Little
D.2.5. Company capabilities in our country about the Delphi statement	2. Little
D.2.6. Date of execution	2. Between 2023 and 2028
D.2.7. Contribution of the issue in the Delphi statement to Turkey's competitive power	4. Fair
D.2.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity	5. High
D.2.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey	3. Little
D.3.1 Participant's level of expertise about the Delphi statement	2. Moderate
D.3.2. Sufficiency of human resources in our country about the Delphi statement	2. Little
D.3.3. Level of core knowledge in our country about the Delphi statement	2. Little
D.3.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement	2. Little

Figure 17 Sample pdf Document of 1st Round Responses Emailed to Participants

Participants were additionally provided graphics representing the distributions of their first round responses (Figure 18). Thus they had a chance to compare their responses to the first round questionnaire with general distributions, and revise their answers in the second round.

Questions in the second Delphi round were exactly the same as those in the first round, as prescribed by the Delphi method itself.

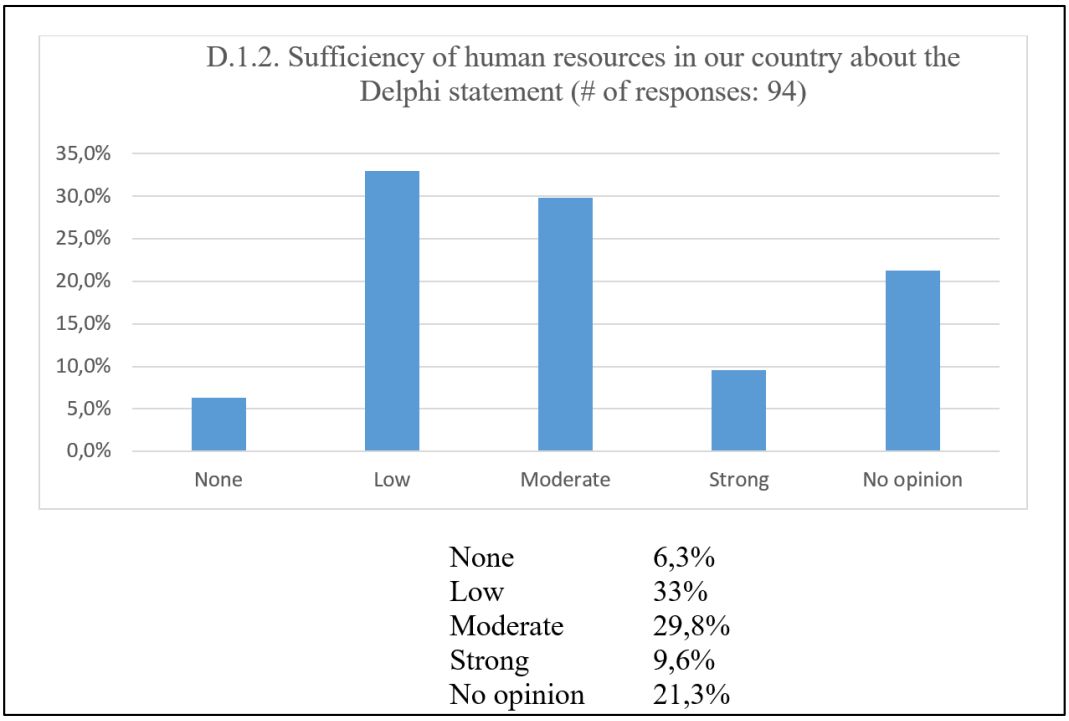


Figure 18 Distribution of Responses to D.1.2. Question in the 1st Round

The second round finished on October 25, 2018. A total of 58 participants responded to the questionnaire in this round.

5.4.1. Analysis of the Responses to the Second Round Delphi Questionnaire

58 out of 94 participants responded to the second round questionnaire. While 34 of these participants changed their responses, the other respondents preferred to make no change in their first round answers.

The responses of 58 participants were extracted form “Google Forms” as “cvs” extension, which was then converted into “tsv” file to be able to process the data in Microsoft Excel. The “tsv” file was next opened in Excel, and using comma function the text data was converted into cells, thus lending itself for statistical analysis. The data was analyzed and assessed following the steps below:

1. Responses were assigned numeric values between 1 and 5 according to the answer options. (=PARÇAAL(Sayfa1!D2;2;1))

2. Then, weighted scores for each response (=EĞERSAY(D2:D85;"1")), frequency distributions in groups of 10 (=EĞERSAY(D2:D11;"1")), and response densities in groups of 10, 30, 60, 80 and 90 (=TOPLA(D126)/10) were calculated. After these calculations, responses were represented graphically.
3. Final results were obtained by analyzing the responses to both rounds together for each participant (=EĞER(Sayfa1!B2=""; Sayfa2!B2;Sayfa1!B2))(survey2 document)

These analyses were run using Microsoft Excel VBA and Microsoft Excel Formula. Figure 19 demonstrates the raw data regarding the responses to the second Delphi round questionnaire.

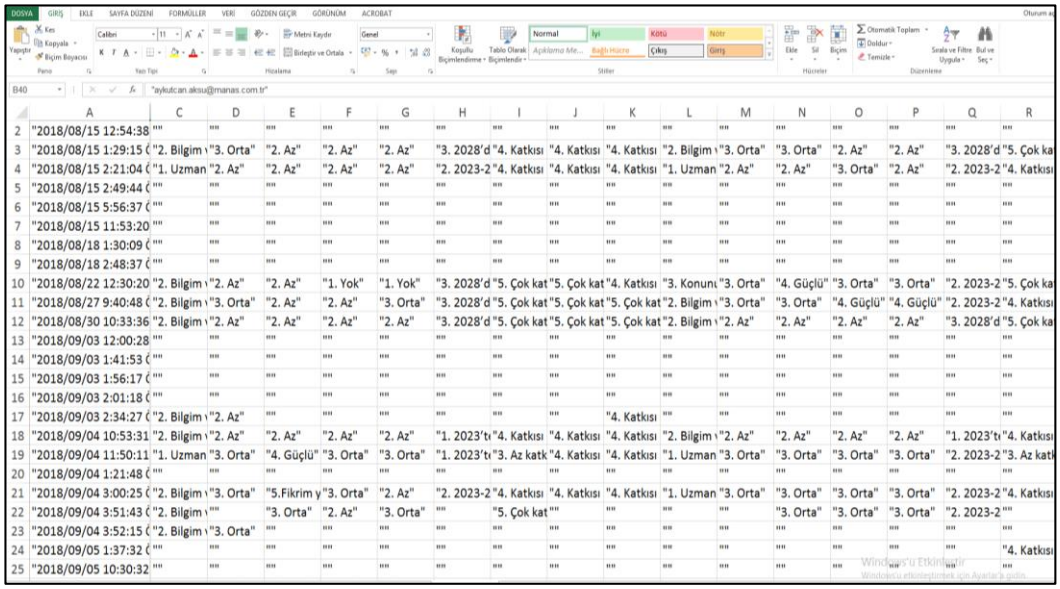


Figure 19 Raw Data of Responses to the 2nd Round Delphi Questionnaire

5.5. Combined Analysis of the Responses to Both Rounds

Upon completion of the second round, responses were combined with those from the first round. In the second round of Delphi questionnaire, 58 people out of 94 who responded to the first questionnaire returned by participating. 34 of these 58 people changed their responses to the questions of Delphi sentences.

These changes were recorded in the responses of the relevant participants, and the remaining 24 people didn't change their responses because they didn't make any changes in their answers. As a result, some participants were able to revise their responses to the first round questionnaire, and provide more calculated answers.

Thus, final results of the Delphi survey were obtained, and analyses were run on the basis of this data. Obtained through the combined analysis of both rounds, the distribution and the weighted means of the responses to D.1.1, D.4.6, D.15.3 and D.11.5 questions are summarized below.

D.1.1 Analysis:

Table 26
Distribution of Responses to D.1.1 Question After the Combined Analysis of Two Delphi Rounds

D-1.1 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	4	6	4	6	5	2	5	4	9
2	6	4	6	3	5	7	4	6	1
3	0	0	0	1	0	1	0	0	0

Table 27
Weighted Means of Responses to D.1.1 Question After the Combined Analysis of Two Delphi Rounds

D-1.1 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.40000	0.46667	0.45000	0.45000	0.50000
2	0.60000	0.53333	0.51667	0.51250	0.46667
3	0.00000	0.00000	0.03333	0.02500	0.02222

Weighted means of the responses to D.1.1. question are also represented in Figure 20 below.

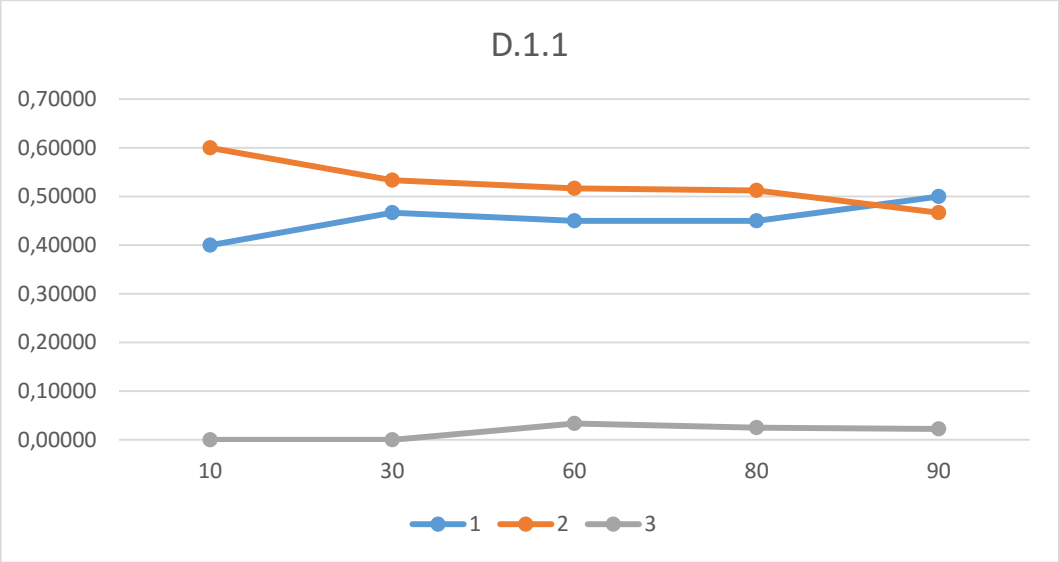


Figure 20 Weighted Means for D.1.1 Question After the Combined Analysis of Two Delphi Rounds

D.4.6 Analysis:

Table 28
Distribution of Responses to D.4.6 Question After the Combined Analysis of Two Delphi Rounds

D-4.6 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	1	0	1	1	0	0	0	0
2	3	1	1	2	1	5	3	2	3
3	5	7	5	4	8	3	5	6	6
4	1	1	3	0	0	1	1	1	0

Table 29
Weighted Means of Responses to D.4.6 Question After the Combined Analysis of Two Delphi Rounds

D-4.6 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.03333	0.05000	0.03750	0.03333
2	0.30000	0.16667	0.21667	0.22500	0.23333
3	0.50000	0.56667	0.53333	0.53750	0.54444
4	0.10000	0.16667	0.10000	0.10000	0.08889

Weighted means of the responses to D.4.6. question are also represented in Figure 21 below.

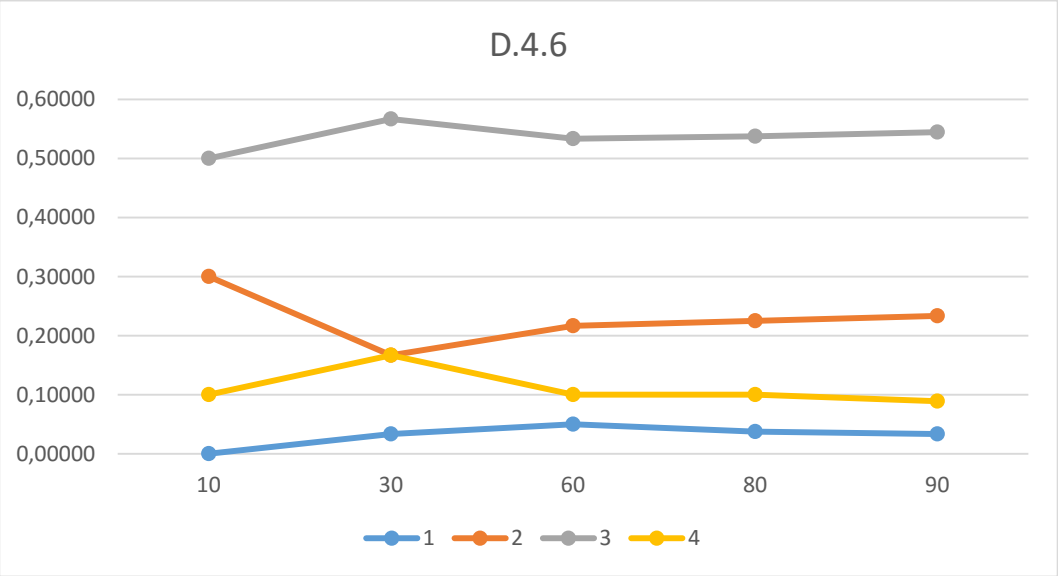


Figure 21 Weighted Means for D.4.6 question After the Combined Analysis of Two Delphi Rounds

D.15.3 Analysis:

Table 30
Distribution of Responses to D.15.3 Question After the Combined Analysis of Two Delphi Rounds

D-15.3 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	1	0	0	0	0	0	0	0
2	2	0	0	4	6	3	1	1	3
3	1	5	6	3	2	4	3	5	2
4	6	4	2	3	0	0	5	2	4
5	0	0	0	0	2	3	0	2	1

Table 31
Weighted Means of Responses to D.15.3 Question After the Combined Analysis of Two Delphi Rounds

D-15.3 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.03333	0.01667	0.01250	0.01111
2	0.20000	0.06667	0.25000	0.21250	0.22222
3	0.10000	0.40000	0.35000	0.36250	0.34444
4	0.60000	0.40000	0.25000	0.27500	0.28889
5	0.00000	0.00000	0.08333	0.08750	0.08889

Weighted means of the responses to D.15.3. question are also represented in Figure 21 below.

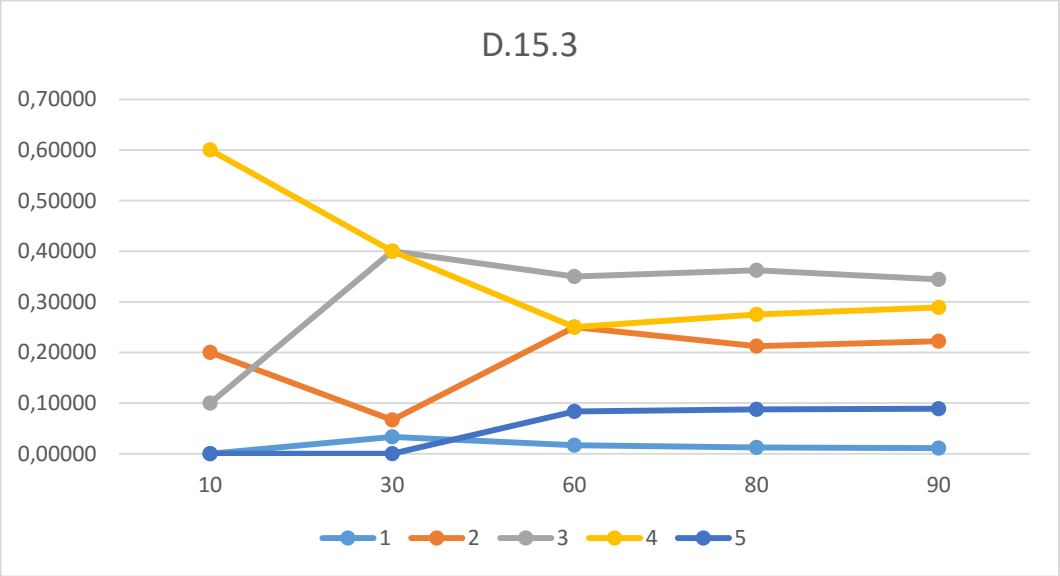


Figure 22 Weighted Means for D.15.3 question After the Combined Analysis of Two Delphi Rounds

D.11.5 Analysis:

Table 32
Distribution of Responses to D.11.5 Question After the Combined Analysis of Two Delphi Rounds

D-11.5 answer options	0-10 ppl.	11-20 ppl.	21-30 ppl.	31-40 ppl.	41-50 ppl.	51-60 ppl.	61-70 ppl.	71-80 ppl.	81-90 ppl.
1	0	0	0	2	0	0	0	1	0
2	2	2	2	1	4	1	1	1	3
3	5	7	6	4	1	8	6	6	2
4	1	0	0	2	1	1	2	1	1
5	1	1	0	1	4	0	0	1	4

Table 33
Weighted Means of Responses to D.11.5 Question After the Combined Analysis of Two Delphi Rounds

D-11.5 answer options	10 ppl.	30 ppl.	60 ppl.	80 ppl.	90 ppl.
1	0.00000	0.00000	0.03333	0.03750	0.03333
2	0.20000	0.20000	0.20000	0.17500	0.18889
3	0.50000	0.60000	0.51667	0.53750	0.50000
4	0.10000	0.03333	0.08333	0.10000	0.10000
5	0.10000	0.06667	0.11667	0.10000	0.13333

Weighted means of the responses to D.11.5. question are also represented in Figure 23 below.

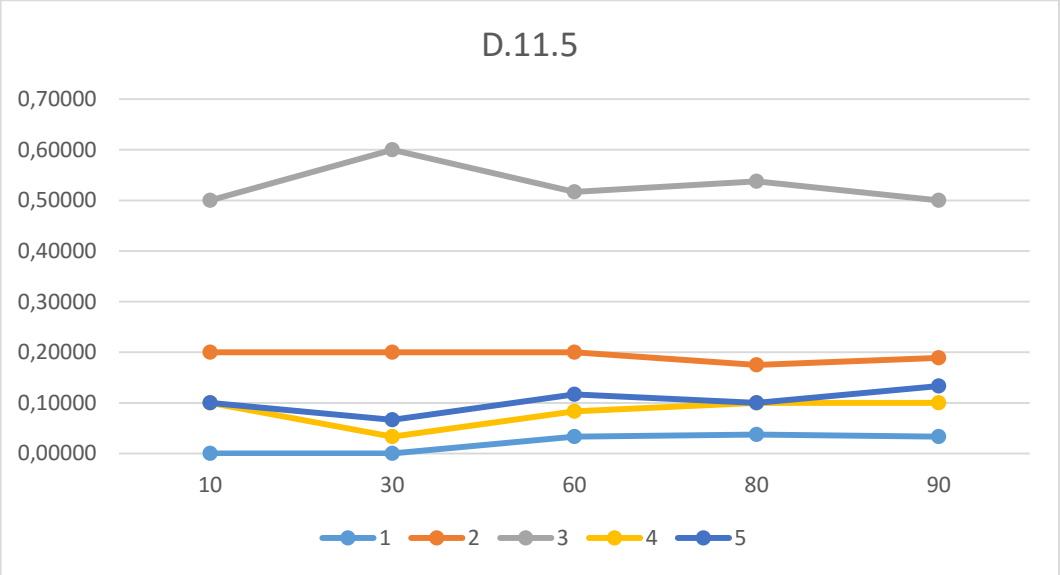


Figure 23 Weighted Means for D.11.5 Question After the Combined Analysis of Two Delphi Rounds

5.5.1. Analysis of each Delphi Statement in Terms of Date of Execution for Participants With "High" Level of Expertise

Distribution of responses from participants who selected the option of "High" for level of expertise with respect to the three options for date of execution ("before 2023", "between 2023 and 2028", and "after 2028") is shown in Table 34. Table demonstrates the responses from participants with "high" level of expertise to date of execution for each Delphi statement.

Table 34
Distribution of the Execution Dates of Delphi Statements Selected by Participants with "High" Level of Expertise

Delphi Questions	1. Number of participants who selected "Before 2023"	2. Number of participants who selected "Between 2023 and 2028	3. Number of participants who selected "After 2028"
D1.1.	2	0	0
D2.1.	1	7	1
D3.1.	1	2	0
D4.1.	0	1	1

Table 34 *(cont'd)*

Delphi Questions	1. Number of participants who selected “Before 2023”	2. Number of participants who selected “Between 2023 and 2028	3. Number of participants who selected “After 2028”
D5.1.	1	1	1
D6.1.	1	6	1
D7.1.	1	1	0
D8.1.	2	5	1
D9.1.	3	2	0
D10.1.	1	0	0
D11.1.	4	2	0
D12.1.	12	11	1
D13.1.	0	0	0
D14.1.	17	8	0
D15.1.	14	6	0
D16.1.	12	7	0
D17.1.	0	2	6
D18.1.	10	9	0
D19.1.	0	0	0

Figure 24 below shows a graphical representation of the same data in Table 34.

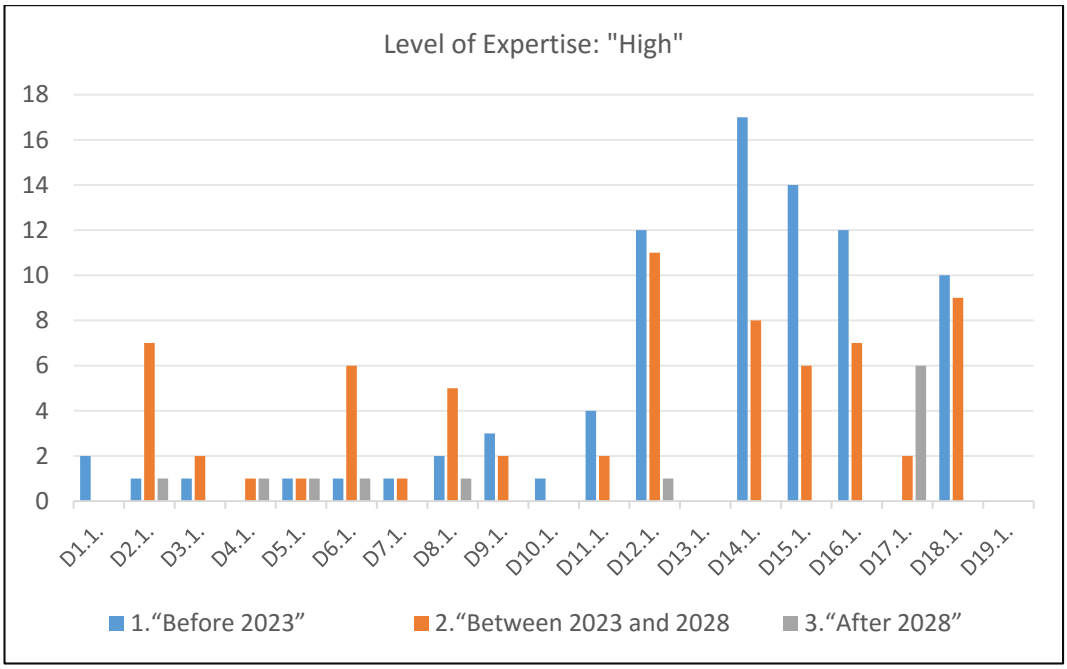


Figure 24 Graphical Representation of Execution Dates Selected by Participants With "High" Level of Expertise

While the vertical axis shows the number of participants, the horizontal axis indicates the dates specified by participants with "High" level of expertise.

5.5.2. Analysis of Each Delphi Statement in Terms of Date of Execution for Participants With "Moderate" Level of Expertise

Distribution of responses from participants who selected the option of "Moderate" for level of expertise with respect to the three options for date of execution ("before 2023", "between 2023 and 2028", and "after 2028") is shown in Table 35.

Table 35
Distribution of the Execution Dates of Delphi Statements Selected by Participants With "Moderate" Level of Expertise

Delphi Questions	1. Number of participants who selected "Before 2023"	2. Number of participants who selected "Between 2023 and 2028	3. Number of participants who selected "After 2028"
D1.1.	5	20	18
D2.1.	12	33	14

Table 35 *(cont'd)*

Delphi Questions	1. Number of participants who selected “Before 2023”	2. Number of participants who selected “Between 2023 and 2028	3. Number of participants who selected “After 2028”
D3.1.	13	14	15
D4.1.	2	5	12
D5.1.	3	8	16
D6.1.	9	14	10
D7.1.	9	21	8
D8.1.	18	17	14
D9.1.	8	16	15
D10.1.	11	24	15
D11.1.	19	19	13
D12.1.	21	17	8
D13.1.	1	2	3
D14.1.	21	14	10
D15.1.	19	22	8
D16.1.	23	20	9
D17.1.	2	10	19
D18.1.	13	19	6
D19.1.	7	15	8

Figure 25 below shows a graphical representation of the same data in Table 35.

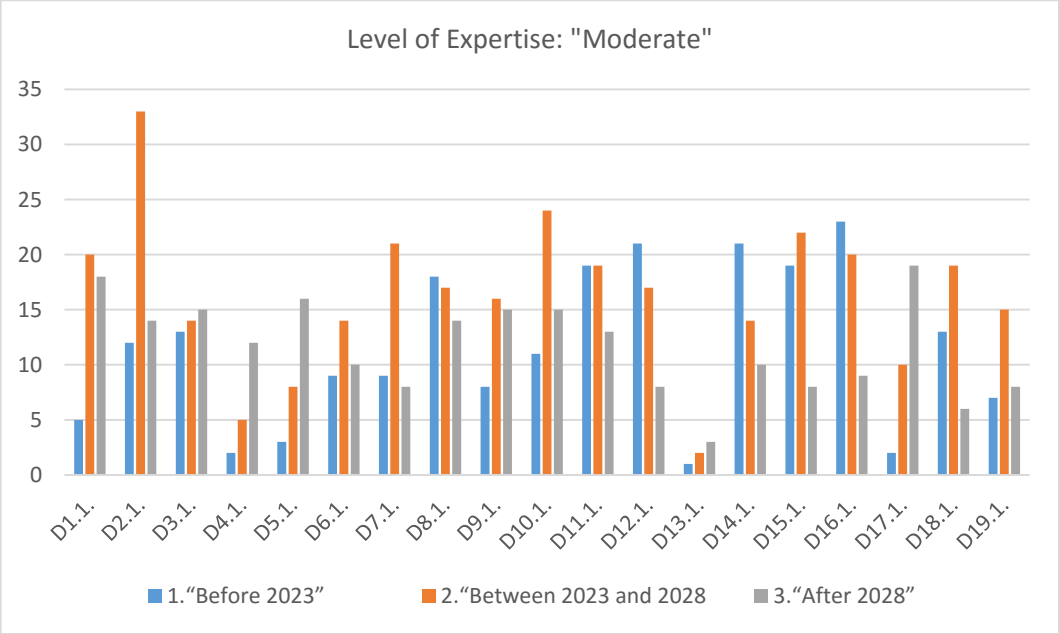


Figure 25 Graphical Representation of Execution Dates Selected by Participants With “Moderate” Level of Expertise

While the vertical axis shows the number of participants, the horizontal axis indicates the dates specified by participants with “Moderate” level of expertise.

5.5.3. Analysis of Each Delphi Statement in Terms of Date of Execution for Participants With “None” Level of Expertise

Distribution of responses from participants who selected the option of “None” for level of expertise with respect to the three options for date of execution (“before 2023”, “between 2023 and 2028”, and “after 2028”) is shown in Table 36.

Table 36
Distribution of the Execution Dates of Delphi Statements Selected by Participants With “None” Level of Expertise

Delphi Questions	1. Number of participants who selected “Before 2023”	2. Number of participants who selected “Between 2023 and 2028	3. Number of participants who selected “After 2028”
D1.1.	9	15	13
D2.1.	5	10	7

Table 36 *(cont'd)*

Delphi Questions	1. Number of participants who selected “Before 2023”	2. Number of participants who selected “Between 2023 and 2028	3. Number of participants who selected “After 2028”
D3.1.	7	23	11
D4.1.	1	16	38
D5.1.	3	11	37
D6.1.	9	23	11
D7.1.	6	19	18
D8.1.	4	7	14
D9.1.	6	11	22
D10.1.	4	14	18
D11.1.	3	12	17
D12.1.	1	2	14
D13.1.	1	14	47
D14.1.	3	7	8
D15.1.	4	3	10
D16.1.	4	7	5
D17.1.	0	2	37
D18.1.	7	12	7
D19.1.	4	22	21

Figure 26 below shows a graphical representation of the same data in Table 36.

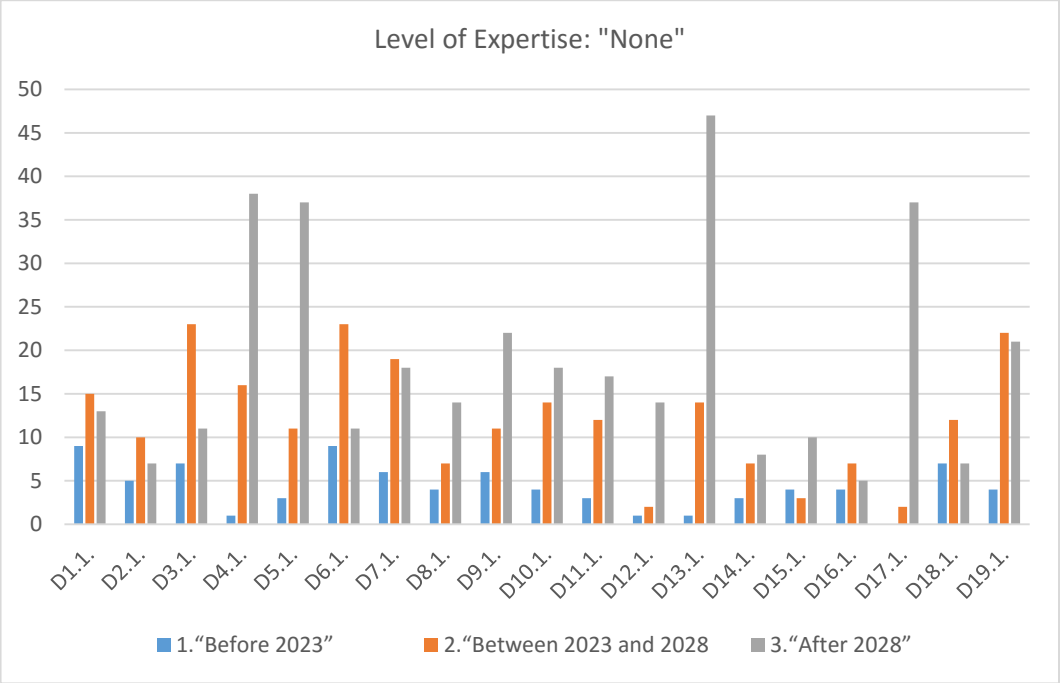


Figure 26 Graphical Representation of Execution Dates Selected by Participants With “None” Level of Expertise

While the vertical axis shows the number of participants, the horizontal axis indicates the dates specified by participants with “None” level of expertise.

As a result of these data, the related Delphi statement, which defines itself as “High-3 ”, “Moderate-2” and “None-1” and that “before 2023”, When the answers of the participants who marked the options “Between 2023 and 2028" and “After 2028” will be examined, the question of the D.14.1 Delphi statement introduced itself as “ High-3” and it is seen that it was brought to the fore by those who were said to have realized it first. This question is followed by questions D.15.1 and D.16.1 respectively.

The question of D.16.1 Delphi statement was put forward by those who defined themselves as “Moderate-2” and said that the related Delphi statement would take place before 2023. D.14.1 and D.15.1 Delphi statement questions followed this statement.

Finally, the question of D.1.1 Delphi statement was ranked as first by the participants who stated that the relevant Delphi statement, which defines itself as

"None-1" will take place before 2023. This was followed by questions D.3.1 and D.18.1 respectively. Statements that those who identify themselves as experts in Delphi surveys and take place in a shorter period of time are important. For this reason, D.14 Delphi statement related to D.14.1 Delphi question is worth examining.

5.5.4. Analysis of Each Delphi Statement in Terms of Date of Execution in Combination With Contribution to "Turkey's competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

The contribution of each Delphi statement to Turkey's "competitive power", "science, technology and innovation capacity", and "environmental awareness and energy efficiency" were analyzed in terms of date of execution.

Answer options for date of execution were marked as "Before 2023-1", "Between 2023 and 2028-2", and "After 2028-3". Coding for contribution to Turkey's "competitive power", "science, technology and innovation capacity", and "environmental awareness and energy efficiency" were "Little-3, "Fair-4", and "High-5". Distribution of responses for each Delphi statement is given in subsequent tables.

5.5.4.1. Preferential Questions for Delphi Statements

Answers marked for D1.7, D1.8 and D1.9 questions addressing the D.1 Delphi statement were "Little-3, "Fair-4", and "High-5". Numeric data regarding the interaction of these responses with the date of execution is given in Table 37.

For example, for the D.1.7 question (Contribution of the issue in the Delphi statement to Turkey's competitive power), only one of those who marked "Little-3", eight of those who marked "Fair-4", and seven of those who marked "High-5" selected "Before 2023-1" option for the date of execution. Other relevant results are shown in Table 37.

Table 37
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.1 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.1	1. Number of participants who selected "Before 2023"	2. Number of participants who selected "Between 2023 and 2028	3. Number of participants who selected "After 2028"
D.1.7 -> 3	1	2	2
D.1.7 -> 4	8	19	15
D.1.7 -> 5	7	14	14
D.1.8 -> 3	1	1	0
D.1.8 -> 4	8	23	16
D.1.8 -> 5	7	11	15
D.1.9 -> 3	2	6	2
D.1.9 -> 4	7	18	17
D.1.9 -> 5	6	10	10

The criterion for each Delphi statement is to make high contribution to Turkey's *competitive power, science, technology and innovation capacity*, and *environmental awareness and energy efficiency* within the shortest time possible, i.e. before 2023. Accordingly, data in Table 37 above was reorganized as in Table 38 below.

Table 38
Preferential Questions for D.1 Delphi Statement

D.1	1. Number of participants who selected "Before 2023"	2. Number of participants who selected "Between 2023 and 2028	3. Number of participants who selected "After 2028"
D.1.7 -> 5	7	14	14
D.1.8 -> 5	7	11	15
D.1.9 -> 5	6	10	10

A combined analysis of "Before 2023-1" and "High-5" responses was run using the data in the above table to identify the Preferential questions in the data. Results of this analysis are in the table 39.

Table 39
Preferential Question for D.1 Delphi Statement

D.1	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.1.7 -> 5	7	16	**23**
D.1.8 -> 5	7	16	**23**
D.1.9 -> 5	6	15	21

The totals in the table are the additions of number of responses at the intersection of "Before 2023-1" – "High-5", and "Before 2023-1" – sum of "Little-3", "Fair-4", "High-5". This was done as;

7+16= 23 for D.1.7 -> 5,
7+16= 23 for D.1.8 -> 5, and
6+15= 21 for D.1.9 -> 5.

As a result, D.1.7 and D.1.8. questions proved to be Preferential with 23 points each. These calculations were applied to other Delphi statements, too. Data related to saliency in other Delphi statements is presented in subsequent tables.

5.5.4.2. Preferential Questions for D.2 Delphi Statement

Table 40
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.2 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.2	Before 2023	Between 2023 and 2028	After 2028
D.2.7 -> 3	0	5	2
D.2.7 -> 4	11	32	11

Table 40 *(cont'd)*

D.2	Before 2023	Between 2023 and 2028	After 2028
D.2.7 -> 5	7	14	6
D.2.8 -> 3	0	6	2
D.2.8 -> 4	12	28	12
D.2.8 -> 5	6	17	7
D.2.9 -> 3	3	14	3
D.2.9 -> 4	10	20	11
D.2.9 -> 5	4	11	4

Table 41
Preferential Questions for D.2 Delphi Statement

D.2	1. Number of participants who selected “Before 2023”	2. Number of participants who selected “Between 2023 and 2028	3. Number of participants who selected “After 2028”
D.2.7 -> 5	7	14	6
D.2.8 -> 5	6	17	7
D.2.9 -> 5	4	11	4

Table 42
Preferential Question for D.2 Delphi Statement

D.2	“Before 2023-1” – “High-5” intersection	“Before 2023-1” – Total of “Little-3”, “Fair-4”, “High-5” intersection	Total
D.2.7 -> 5	7	18	**25**
D.2.8 -> 5	6	18	24
D.2.9 -> 5	4	17	21

As 7+18= 25 for D.2.7 -> 5, D.2.7. question, with 25 points, proved to be Preferential for D.2 Delphi statement.

5.5.4.3. Preferential Questions for D.3 Delphi Statement

Table 43
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.3 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.3	Before 2023	Between 2023 and 2028	After 2028
D.3.7 -> 3	0	5	2
D.3.7 -> 4	11	32	11
D.3.7 -> 5	7	14	6
D.3.8 -> 3	0	6	2
D.3.8 -> 4	12	28	12
D.3.8 -> 5	6	17	7
D.3.9 -> 3	3	14	3
D.3.9 -> 4	10	20	11
D.3.9 -> 5	4	11	4

Table 44
Preferential Questions for D.3 Delphi Statement

D.3	Before 2023	Between 2023 and 2028	After 2028
D.3.7 -> 5	7	13	8
D.3.8 -> 5	6	11	7
D.3.9 -> 5	3	6	4

Table 45
Preferential Question for D.3 Delphi Statement

D.3	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.3.7 -> 5	7	21	**28**
D.3.8 -> 5	6	21	27
D.3.9 -> 5	3	16	19

As 7+21= 28 for D.3.7 -> 5, D.3.7. question, with 28 points, proved to be Preferential for D.3 Delphi statement.

5.5.4.4. Preferential Questions for D.4 Delphi Statement

Table 46
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.4 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.4	Before 2023	Between 2023 and 2028	After 2028
D.4.7 -> 3	1	3	4
D.4.7 -> 4	1	7	26
D.4.7 -> 5	1	12	21
D.4.8 -> 3	1	2	5
D.4.8 -> 4	1	9	26
D.4.8 -> 5	1	11	20
D.4.9 -> 3	1	7	12
D.4.9 -> 4	1	5	20
D.4.9 -> 5	1	8	9

Table 47
Preferential Questions for D.4 Delphi Statement

D.4	Before 2023	Between 2023 and 2028	After 2028
D.4.7 -> 5	1	12	21
D.4.8 -> 5	1	11	20
D.4.9 -> 5	1	8	9

Table 48
Preferential Question for D.4 Delphi Statement

D.4	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.4.7 -> 5	1	3	**4**
D.4.8 -> 5	1	3	**4**
D.4.9 -> 5	1	3	**4**

As 1+3= 4 for D.4.7 -> 5, D.4.8 -> 5, and D.4.9 -> 5, D.4.7, D.4.8, and D.4.9 questions, with 4 points each, proved to be Preferential for D.4 Delphi statement.

5.5.4.5. Preferential Questions for D.5 Delphi Statement

Table 49
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.5 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.5	Before 2023	Between 2023 and 2028	After 2028
D.5.7 -> 3	1	0	7
D.5.7 -> 4	2	16	32
D.5.7 -> 5	4	4	15
D.5.8 -> 3	1	0	6
D.5.8 -> 4	2	16	28
D.5.8 -> 5	4	5	19
D.5.9 -> 3	0	4	14
D.5.9 -> 4	2	11	21
D.5.9 -> 5	3	3	8

Table 50
Preferential Questions for D.5 Delphi Statement

D.5	Before 2023	Between 2023 and 2028	After 2028
D.5.7 -> 5	4	4	15
D.5.8 -> 5	4	5	19
D.5.9 -> 5	3	3	8

Table 51
Preferential Question for D.5 Delphi Statement

D.5	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.5.7 -> 5	4	7	**11**
D.5.8 -> 5	4	7	**11**
D.5.9 -> 5	3	5	8

As 4+7= 11 for D.5.7 -> 5 and D.5.8 -> 5, D.5.7 and D.5.8 questions, with 11 points each, proved to be Preferential for D.5 Delphi statement.

5.5.4.6. Preferential Questions for D.6 Delphi Statement

Table 52
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.6 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.6	Before 2023	Between 2023 and 2028	After 2028
D.6.7 -> 3	2	0	1
D.6.7 -> 4	7	31	12
D.6.7 -> 5	10	12	7
D.6.8 -> 3	2	0	2
D.6.8 -> 4	7	29	13

Table 52 *(cont'd)*

D.6	Before 2023	Between 2023 and 2028	After 2028
D.6.8 -> 5	10	14	7
D.6.9 -> 3	6	14	6
D.6.9 -> 4	2	15	5
D.6.9 -> 5	6	5	4

Table 53
Preferential Questions for D.6 Delphi Statement

D.6	Before 2023	Between 2023 and 2028	After 2028
D.6.7 -> 5	10	12	7
D.6.8 -> 5	10	14	7
D.6.9 -> 5	6	5	4

Table 54
Preferential Question for D.6 Delphi Statement

D.6	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.6.7 -> 5	10	19	**29**
D.6.8 -> 5	10	19	**29**
D.6.9 -> 5	6	14	20

As 10+19= 29 for D.6.7 -> 5 and D.6.8 -> 5, D.6.7 and D.6.8 questions, with 29 points each, proved to be Preferential for D.6 Delphi statement.

5.5.4.7. Preferential Questions for D.7 Delphi Statement

Table 55
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.7 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.7	Before 2023	Between 2023 and 2028	After 2028
D.7.7 -> 3	1	1	6
D.7.7 -> 4	8	20	14
D.7.7 -> 5	7	21	6
D.7.8 -> 3	1	2	7
D.7.8 -> 4	8	23	13
D.7.8 -> 5	7	17	6
D.7.9 -> 3	2	14	7
D.7.9 -> 4	4	13	9
D.7.9 -> 5	2	6	3

Table 56
Preferential Questions for D.7 Delphi Statement

D.7	Before 2023	Between 2023 and 2028	After 2028
D.7.7 -> 5	7	21	6
D.7.8 -> 5	7	17	6
D.7.9 -> 5	2	6	3

Table 57
Preferential Question for D.7 Delphi Statement

D.7	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.7.7 -> 5	7	16	**23**
D.7.8 -> 5	7	16	**23**
D.7.9 -> 5	2	8	10

As 7+16= 23 for D.7.7 -> 5 and D.7.8 -> 5, D.7.7 and D.7.8 questions, with 23 points each, proved to be Preferential for D.7 Delphi statement.

5.5.4.8. Preferential Questions for D.8 Delphi Statement

Table 58
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.8 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.8	Before 2023	Between 2023 and 2028	After 2028
D.8.7 -> 3	1	1	1
D.8.7 -> 4	10	11	10
D.8.7 -> 5	13	17	19
D.8.8 -> 3	1	1	2
D.8.8 -> 4	11	10	11
D.8.8 -> 5	12	18	17
D.8.9 -> 3	5	5	8
D.8.9 -> 4	9	13	12
D.8.9 -> 5	5	6	6

Table 59
Preferential Questions for D.8 Delphi Statement

D.8	Before 2023	Between 2023 and 2028	After 2028
D.8.7 -> 5	13	17	19
D.8.8 -> 5	12	18	17
D.8.9 -> 5	5	6	6

Table 60
Preferential Question for D.8 Delphi Statement

D.8	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.8.7 -> 5	13	24	**37**
D.8.8 -> 5	12	24	26
D.8.9 -> 5	5	19	24

As 13+24= 27 for D.8.7 -> 5, D.8.7 question, with 37 points, proved to be Preferential for D.8 Delphi statement.

5.5.4.9. Preferential Questions for D.9 Delphi Statement

Table 61
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.9 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.9	Before 2023	Between 2023 and 2028	After 2028
D.9.7 -> 3	2	0	6
D.9.7 -> 4	7	15	17
D.9.7 -> 5	8	13	13
D.9.8 -> 3	0	0	6
D.9.8 -> 4	10	13	18
D.9.8 -> 5	7	15	13
D.9.9 -> 3	3	10	9
D.9.9 -> 4	5	7	13
D.9.9 -> 5	4	5	9

Table 62
Preferential Questions for D.9 Delphi Statement

D.9	Before 2023	Between 2023 and 2028	After 2028
D.9.7 -> 5	8	13	13
D.9.8 -> 5	7	15	13
D.9.9 -> 5	4	5	9

Table 63
Preferential Question for D.9 Delphi Statement

D.9	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.9.7 -> 5	8	17	**25**
D.9.8 -> 5	7	17	24
D.9.9 -> 5	4	12	16

As 8+17= 25 for D.9.7 -> 5, D.9.7 question, with 25 points, proved to be Preferential for D.9 Delphi statement.

5.5.4.10. Preferential Questions for D.10 Delphi Statement

Table 64
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.10 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.10	Before 2023	Between 2023 and 2028	After 2028
D.10.7 -> 3	4	3	5
D.10.7 -> 4	7	20	14
D.10.7 -> 5	5	16	13
D.10.8 -> 3	3	0	1

Table 64 *(cont'd)*

D.10	Before 2023	Between 2023 and 2028	After 2028
D.10.8 -> 4	7	21	17
D.10.8 -> 5	5	18	14
D.10.9 -> 3	3	5	7
D.10.9 -> 4	3	14	7
D.10.9 -> 5	4	13	4

Table 65
Preferential Questions for D.10 Delphi Statement

D.10	Before 2023	Between 2023 and 2028	After 2028
D.10.7 -> 5	5	16	13
D.10.8 -> 5	5	18	14
D.10.9 -> 5	4	13	4

Table 66
Preferential Question for D.10 Delphi Statement

D.10	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.10.7 -> 5	5	16	**21**
D.10.8 -> 5	5	15	20
D.10.9 -> 5	4	10	14

As 5+16= 21 for D.10.7 -> 5, D.10.7 question, with 21 points, proved to be Preferential for D.10 Delphi statement.

5.5.4.11. Preferential Questions for D.11 Delphi Statement

Table 67
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.11 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.11	Before 2023	Between 2023 and 2028	After 2028
D.11.7 -> 3	1	0	1
D.11.7 -> 4	11	11	12
D.11.7 -> 5	14	23	37
D.11.8 -> 3	1	1	1
D.11.8 -> 4	11	14	10
D.11.8 -> 5	13	19	19
D.11.9 -> 3	1	1	1
D.11.9 -> 4	5	8	6
D.11.9 -> 5	20	25	23

Table 68
Preferential Questions for D.11 Delphi Statement

D.11	Before 2023	Between 2023 and 2028	After 2028
D.11.7 -> 5	14	23	17
D.11.8 -> 5	13	19	19
D.11.9 -> 5	20	25	23

Table 69
Preferential Question for D.11 Delphi Statement

D.11	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.11.7 -> 5	14	26	40
D.11.8 -> 5	13	25	38
D.11.9 -> 5	20	26	**46**

As 20+26= 46 for D.11.9 -> 5, D.11.9 question, with 46 points, proved to be Preferential for D.11 Delphi statement.

5.5.4.12. Preferential Questions for D.12 Delphi Statement

Table 70
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.12 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.12	Before 2023	Between 2023 and 2028	After 2028
D.12.7 -> 3	0	0	4
D.12.7 -> 4	17	18	10
D.12.7 -> 5	17	12	8
D.12.8 -> 3	1	1	5
D.12.8 -> 4	14	15	8
D.12.8 -> 5	19	14	11
D.12.9 -> 3	8	4	9
D.12.9 -> 4	6	13	5
D.12.9 -> 5	15	7	6

Table 71
Preferential Questions for D.12 Delphi Statement

D.12	Before 2023	Between 2023 and 2028	After 2028
D.12.7 -> 5	17	12	8
D.12.8 -> 5	19	14	11
D.12.9 -> 5	15	7	6

Table 72
Preferential Question for D.12 Delphi Statement

D.12	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.12.7 -> 5	17	34	51
D.12.8 -> 5	19	34	**53**
D.12.9 -> 5	15	29	44

As 19+34= 53 for D.12.8 -> 5, D.12.8 question, with 53 points, proved to be Preferential for D.12 Delphi statement.

5.5.4.13. Preferential Questions for D.13 Delphi Statement

Table 73
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.13 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.13	Before 2023	Between 2023 and 2028	After 2028
D.13.7 -> 3	0	1	11
D.13.7 -> 4	2	12	27
D.13.7 -> 5	0	3	12
D.13.8 -> 3	0	1	11
D.13.8 -> 4	2	11	26
D.13.8 -> 5	0	4	14
D.13.9 -> 3	0	4	13
D.13.9 -> 4	2	9	22
D.13.9 -> 5	0	2	8

Table 74
Preferential Questions for D.13 Delphi Statement

D.13	Before 2023	Between 2023 and 2028	After 2028
D.13.7 -> 5	0	3	12
D.13.8 -> 5	0	4	14
D.13.9 -> 5	0	2	8

Table 75
Preferential Question for D.13 Delphi Statement

D.13	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.13.7 -> 5	0	2	**2**
D.13.8 -> 5	0	2	**2**
D.13.9 -> 5	0	2	**2**

As 0+2= 2 for D.13.7 -> 5, D.13.8 -> 5, and D.13.9 -> 5, D.13.7, D.13.8, and D.13.9 questions, with 2 points each, proved to be Preferential for D.13 Delphi statement.

5.5.4.14. Preferential Questions for D.14 Delphi Statement

Table 76
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.14 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.14	Before 2023	Between 2023 and 2028	After 2028
D.14.7 -> 3	6	4	5
D.14.7 -> 4	20	17	8
D.14.7 -> 5	15	9	4
D.14.8 -> 3	7	3	4
D.14.8 -> 4	15	17	10

Table 76 *(cont'd)*

D.14	Before 2023	Between 2023 and 2028	After 2028
D.14.8 -> 5	19	10	3
D.14.9 -> 3	13	12	1
D.14.9 -> 4	9	11	7
D.14.9 -> 5	13	7	3

Table 77
Preferential Questions for D.14 Delphi Statement

D.14	Before 2023	Between 2023 and 2028	After 2028
D.14.7 -> 5	15	9	4
D.14.8 -> 5	19	10	3
D.14.9 -> 5	13	7	3

Table 78
Preferential Question for D.14 Delphi Statement

D.14	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.14.7 -> 5	15	41	56
D.14.8 -> 5	19	41	**60**
D.14.9 -> 5	13	35	48

As 19+41= 60 for D.14.8 -> 5, D.14.8 question, with 60 points, proved to be Preferential for D.14 Delphi statement.

5.5.4.15. Preferential Questions for D.15 Delphi Statement

Table 79
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.15 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.15	Before 2023	Between 2023 and 2028	After 2028
D.15.7 -> 3	6	1	4
D.15.7 -> 4	16	18	8
D.15.7 -> 5	15	12	6
D.15.8 -> 3	5	1	3
D.15.8 -> 4	15	18	10
D.15.8 -> 5	17	12	6
D.15.9 -> 3	14	8	2
D.15.9 -> 4	9	11	6
D.15.9 -> 5	11	10	6

Table 80
Preferential Questions for D.15 Delphi Statement

D.15	Before 2023	Between 2023 and 2028	After 2028
D.15.7 -> 5	15	12	6
D.15.8 -> 5	17	12	6
D.15.9 -> 5	11	10	6

Table 81
Preferential Question for D.15 Delphi Statement

D.15	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.15.7 -> 5	15	37	52
D.15.8 -> 5	17	37	**54**
D.15.9 -> 5	11	34	45

As 17+37= 54 for D.15.8 -> 5, D.15.8 question, with 54 points, proved to be Preferential for D.15 Delphi statement.

5.5.4.16. Preferential Questions for D.16 Delphi Statement

Table 82
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.16 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.16	Before 2023	Between 2023 and 2028	After 2028
D.16.7 -> 3	4	5	2
D.16.7 -> 4	23	16	8
D.16.7 -> 5	12	13	4
D.16.8 -> 3	2	5	2
D.16.8 -> 4	25	18	9
D.16.8 -> 5	12	11	4
D.16.9 -> 3	10	12	0
D.16.9 -> 4	11	10	5
D.16.9 -> 5	10	8	5

Table 83
Preferential Questions for D.16 Delphi Statement

D.16	Before 2023	Between 2023 and 2028	After 2028
D.16.7 -> 5	12	13	4
D.16.8 -> 5	12	11	4
D.16.9 -> 5	10	8	5

Table 84
Preferential Question for D.16 Delphi Statement

D.16	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.16.7 -> 5	12	39	**51**
D.16.8 -> 5	12	39	**51**
D.16.9 -> 5	10	31	41

As 12+19= 51 for D.16.7 -> 5 and D.16.8 -> 5, D.16.7 and D.16.8 questions, with 51 points each, proved to be Preferential for D.16 Delphi statement.

5.5.4.17. Preferential Questions for D.17 Delphi Statement

Table 85
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.17 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.17	Before 2023	Between 2023 and 2028	After 2028
D.17.7 -> 3	0	1	9
D.17.7 -> 4	1	9	19
D.17.7 -> 5	1	4	33
D.17.8 -> 3	0	0	8
D.17.8 -> 4	1	8	19
D.17.8 -> 5	1	6	36
D.17.9 -> 3	2	4	18
D.17.9 -> 4	1	2	11
D.17.9 -> 5	1	4	18

Table 86
Preferential Questions for D.17 Delphi Statement

D.17	Before 2023	Between 2023 and 2028	After 2028
D.17.7 -> 5	1	4	33
D.17.8 -> 5	1	6	36
D.17.9 -> 5	1	4	18

Table 87
Preferential Question for D.17 Delphi Statement

D.17	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.17.7 -> 5	1	2	**3**
D.17.8 -> 5	1	2	**3**
D.17.9 -> 5	1	2	**3**

As 1+2= 3 for D.17.7 -> 5, D.17.8 -> 5, and D.17.9-> 5, D.17.7 and D.17.8, and D.17.9 questions, with 3 points each, proved to be Preferential for D.17 Delphi statement.

5.5.4.18. Preferential Questions for D.18 Delphi Statement

Table 88
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.18 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.18	Before 2023	Between 2023 and 2028	After 2028
D.18.7 -> 3	2	4	3
D.18.7 -> 4	15	17	5
D.18.7 -> 5	12	19	4
D.18.8 -> 3	6	6	5
D.18.8 -> 4	11	15	3

Table 88 *(cont'd)*

D.18	Before 2023	Between 2023 and 2028	After 2028
D.18.8 -> 5	12	19	5
D.18.9 -> 3	9	8	2
D.18.9 -> 4	4	13	1
D.18.9 -> 5	7	9	3

Table 89
Preferential Questions for D.18 Delphi Statement

D.18	Before 2023	Between 2023 and 2028	After 2028
D.18.7 -> 5	12	19	4
D.18.8 -> 5	12	19	5
D.18.9 -> 5	7	9	3

Table 90
Preferential Question for D.18 Delphi Statement

D.18	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.18.7 -> 5	12	29	**41**
D.18.8 -> 5	12	29	**41**
D.18.9 -> 5	7	20	27

As 12+29= 41 for D.18.7 -> 5 and D.18.8 -> 5, D.18.7 and D.18.8 questions, with 41 points each, proved to be Preferential for D.18 Delphi statement.

5.5.4.19. Preferential Questions for D.19 Delphi Statement

Table 91
Combined Analysis of Responses to Date of Execution and Responses to Contribution of D.19 Delphi Statement to Turkey's "Competitive Power", "Science, Technology and Innovation Capacity", and "Environmental Awareness and Energy Efficiency"

D.19	Before 2023	Between 2023 and 2028	After 2028
D.19.7 -> 3	0	1	4
D.19.7 -> 4	7	21	13
D.19.7 -> 5	4	15	13
D.19.8 -> 3	0	1	3
D.19.8 -> 4	6	18	14
D.19.8 -> 5	5	18	13
D.19.9 -> 3	0	6	9
D.19.9 -> 4	3	6	4
D.19.9 -> 5	2	11	5

Table 92
Preferential Questions for D.19 Delphi Statement

D.19	Before 2023	Between 2023 and 2028	After 2028
D.19.7 -> 5	4	15	13
D.19.8 -> 5	5	18	13
D.19.9 -> 5	2	11	5

Table 93
Preferential Question for D.19 Delphi Statement

D.19	"Before 2023-1" – "High-5" intersection	"Before 2023-1" – Total of "Little-3", "Fair-4", "High-5" intersection	Total
D.19.7 -> 5	4	11	15
D.19.8 -> 5	5	11	**16**
D.19.9 -> 5	2	5	7

As 5+11= 16 for D.19.8 -> 5, D.19.8 question, with 16 points, proved to be Preferential for D.19 Delphi statement.

5.5.4.20. Preferential Question Among All Delphi Statements

The data presented above is the numeric representation of participants' point-assigned responses to the questions relating to Delphi statements. Tables on preceding pages have demonstrated the most Preferential questions for each Delphi statement by adding these points assigned by respondents. The most Preferential question among all is the one that got the highest score. Looking into all the Preferential questions and their total points, as Table 91 below outlines, will reveal the most Preferential question; i.e., the one that got the highest score.

Table 94
Total Points for Each Delphi Question

Question Number	Points Received
D.1.7-D.1.8	23
D.2.7	25
D.3.7	28
D.4.7-8-9	4
D.5.7-D.5.8	11
D.6.7-D.6.8	29
D.7.7-D.7.8	23
D.8.7	37
D.9.7	25
D.10.7	21
D.11.9	46
D.12.8	53
D.13.7-8-9	2
D.14.8	**60**
D.15.8	54

Table 94 *(cont'd)*

Question Number	Points Received
D.16.7-8	51
D.17.7-8-9	3
D.18.7-8	41
D.19.8	16

As can be seen in Table 94, D.14.8 (Contribution of the issue in the Delphi statement to *Turkey's science, technology, and innovation capacity*) proved to be the most Preferential question. The Delphi statement it addressed was Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

CHAPTER 6

FACE-TO-FACE INTERVIEWS

In this part of the study, D.14 Delphi statement of Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms, which addressed the most Preferential question titled D.14.8, was specified as a technological objective. Additionally, the purpose here was to map out the trajectory as to what should be done by different shareholders in defense industries to reach this objective. To this end, face-to-face interviews with experts from the following Ankara-based companies, which have business activities in virtual reality technologies, were conducted between March and May 2019.

- SIM-TEK (Sim-Tek Simulation and IT Company)
- BITES (Bites Aerospace and Defense Inc.)
- HAVELSAN (Avionics Industry Inc.)
- SIMSOFT (Simsoft Computer Technologies Ltd. Comp.)

Interview questions were answered by 1 expert from SIM-TEK, 1 expert from BITES, 2 experts from HAVELSAN, and 2 experts from SIMSOFT. The questions posed to these experts are detailed below.

6.1. Questions Used in Face-to-Face Interviews

D.14 Delphi statement was identified as the Targeted Technological Activity. Next, following questions addressing the realization of this target were prepared, and participants technical experts were requested to reply to these questions in face-to-face interviews.

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms needed for the targeted technological activity?

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Below are exact quotations of the answers to these questions provided by the participant experts from each company.

6.2. Answers from SIM-TEK Company

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms needed for the targeted technological activity?

Answer 1: Military land vehicles, air vehicles, ships, submarines, weapons, missiles, launch pads, unmanned aerial vehicles (UAV), armed UAVs. Ease of designing virtual reality simulations for a land and air vehicle will not be the same. Simulations of these platforms bill be difficult depending on their complexities.

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: Everything to be used on platforms could be critical; parts, materials, software, or models not domestically manufactured previously.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: While designing a platform, there should be a three-dimensional (3D) model of each part. Virtual reality techniques can, through such processes as manufacturing blueprints of platforms with complex structures, and control of assembly-disassembly compatibility, offer a chance for pre-evaluation prior to actual production. Using virtual reality, user-friendly, color-compatible, and user-accessible products and parts can be designed, and by this way, projections and verifications can be offered for both engineers and end users.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: Any system can be simulated. For instance, systems that can simulate the dockage process of a ship can be designed. Modeling environments for the subsystems of all the platforms or their production can be simulated. Physical or dynamic simulation or simulators of each system can be developed. Parts can be simulated, or there can be training simulations.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5:

1. Game engines
-Graphics engines
2. Geographic information systems
-Mapping systems
3. Software technologies
-Software project execution technologies
-Software integration technologies
-Real-time software technologies
4. 3D modeling technologies
-Virtual reality headsets
-Sensor technologies
-Wearable sensor technologies

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 6: University students can be funneled into gaming, modeling, and simulation fields. 'OpenGL' course should be compulsory for these students. Currently, many of the students apply for a job without taking this course. In the universities, modeling and graphic programs should be extended to the game world, and master and doctoral programs should be increased in these areas.

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 7: TUBITAK-supported PhD programs should be promoted. TUBITAK should be more flexible in project supports they offer. For example, a project application should not be rejected because ethics committee approval, or another requirement related to project support application is missing. They can be flexible about such issues, and give applicants additional time. This gives applicants a chance to reevaluate their application documents. Presidency of Defense Industries should be in continuous contact with defense companies. Project competitions should be organized, and leading companies should be rewarded.

6.3. Answers from BITES Inc.

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms needed for the targeted technological activity?

Answer 1: This questions can be answered in two respects.

1. Existing Land/Air/Naval platforms with foreign origin
- F16, T38, KT-1, CN 235, C-130, A400M aircrafts,
- Blackhawk, Seahawk, Cougar, Chinook helicopters
- Leo 2A4 Tanks,
- Armored Combat Vehicles (ACV) and Armored Personnel Carriers (APC)

2. Existing Land/Air/Naval platforms developed with domestic/national resources
- National Combat Aircraft (MMU), HURKUS (Aircraft Development and Serial Production Project) B-C aircrafts
- T-625 Gökbey, ATAK, ATAK-2 helicopters

- ALTAY Tank,
- Multi-purpose Tactical-wheeled Armored Vehicles, Pars 6X6, 4X4, Tulpar (a tracked armored battle tank), Weapons Carriers, Ejder Yalçın (an armored combat vehicle)
- New and original ship projects like LHD (Multi-purpose Amphibious Assault Ship), LST (Amphibious Ship), MİLGEM (National Ship), New original ship projects such as TF2000

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: If I need to answer this question with the above approach, I can say simulators and sub-systems for Land/Air/Naval platforms are similar in many respects. Therefore, technologies to be manufactured will serve the needs of Land/Air/Naval simulators.

For instance, products like training station, end-of-activity analysis software, and tactical environment software are common needs of all platforms. Or hardware-wise, intercom, audio systems, visual systems can be used in all of them with some slight changes.

However, on-ship simulations are different. They differ radically according to the behaviors Land/Air/Naval platforms, and hence should be designed separately for each platform. The on-ship simulation you should develop for MİLGEM, for example, will be different from that for LHD. Our country has the technological infrastructure necessary for such activities, and there is no need for additional investments.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: Beginning with early 2000s, our domestic companies have invested largely in virtual reality technologies, and evolved into a position to compete with world giants with the volumes of their exports. Companies like HAVELSAN and BITES are successfully continuing their projects. Projects for almost all the platforms mentioned in the first question have either been completed or are still continuing.

However, while we were improving in virtual reality technologies, another trend – augmented reality technologies – gained ground. There have been considerable amounts of investments in this new trend since 2009. Therefore, our country should focus more on this technology. At this point, I need to elaborate a little on augmented reality. Virtual Reality – VR is a combination of several working concepts and tools that make us feel as if we were in a virtual universe.

Today's smart phones and tablets as well as VR headsets are based on these concepts. VR headsets can, for the time being, show us another virtual reality, make us hear virtual sounds, and enable us to move virtual objects.

The idea of creating illusions in human perceptions developing VR headsets was first introduced in 1965 by Ivan Sutherland in Bell Labs in the USA. In one of his published articles, he signified everything necessary to create virtual reality that is as real as the reality itself. The most remarkable issue mentioned in the article was the necessity to improve in display technologies. He argued that when VR completed its technological evolution, it would be able to improve the existing reality, or offer us an entirely different reality.

As for Augmented Reality – AR, the real world and the computer-generated virtual world are blended, enabling us to interact with the digital (virtual) world without being detached from the real world.

The first use of such technologies appeared in displays mounted on fighter jet pilots' helmets. Thanks to this device, pilots were able to reach all the information they needed without having to move their eyes away from their targets. These helmets

could not be used in other fields for a long time due to their weight, volume, and cost. In 2000s, new products of the same type were designed for use in industrial practices, yet desired results could not be reached as the display and sensor technologies of the time were not ripe enough (e.g. The Nomad VR display designed by Microvision).

Another noteworthy AR practice of the recent decade is windshield heads-up displays. With this technology, information on car dashboards can be projected on windshield, and be seen without needing to wear a headset. Sensors and computers started to shrink and become more functional in 2000s thanks to advances in microelectronic, micromechanical, and micro optic technologies. Today's new smart phones based on human-computer interaction emerged as a result of these technologies, too. Likewise, wearable devices became smarter and smaller in the shape of eye glasses. The first example of such devices is Google Glass manufactured by Google.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: Considering the answer to the previous questions, I can say our country has achieved a considerable success in VR technologies. Now our priority should be improvements in AR technologies in coordination with those in many other countries in the world. The first step should be manufacturing a national AR headset. Besides, there should be AR-specialized studies in such technology areas as Image Processing, Sensor Fusion, Video Management, Image Compression, Image Transfer, and SLAM Algorithms. In terms of the "how" part of the question, R&D activities and product projects supported by TUBITAK and Presidency of Defense Industries can accelerate the development of this technology.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5: Our country has reached to a certain point in terms of VR technologies. Now our priority should be improvements in AR technologies in coordination with those in many other countries in the world. With this in mind, studies in designing domestic and national AR headset should commence.

Besides, there should be AR-specialized studies in such technology areas as Image Processing, Sensor Fusion, Video Management, Image Compression, Image Transfer, and SLAM Algorithms. Supported from TUBITAK and Presidency of Defense Industries can accelerate the development of this technology.

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 6: For this purpose, urgent action is needed by 2023 because AR will soon be utilized more commonly in military and civilian areas on account of the increasing use of 5G technology both in military and, more importantly, in civilian areas in our country and in the world. In this regard, we should prevent our country from turning into a tech dump, as it once used to be.

Therefore, R&D projects targeted at using AR technologies in military not civilian areas should immediately be started. To this end, TUBITAK should invite related parties to launch R&D projects for the development of national software and hardware. Moreover, Presidency of Defense Industries should start projects to find out ways of using already existing domestically and nationally designed platforms in our military.

Besides, our Ministry of Industry and Technology should encourage businesses to manufacture AR headsets by incorporating such enterprise into incentive programs.

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 7: These days, world technology giants like Google, Microsoft, and Magic Leap have focused on AR technologies. Currently, such aviation companies as Boeing, Lockheed, and Airbus, as well as leading defense industry companies like raytheon and BAE systems have increased their investments in AR technologies, and added this technology onto their existing products.

As a result, if we want to have a say in this growing technology field, we should situate ourselves as a country not procuring, but exporting products of AR technologies. If we launch such projects before it is too late, we are sure to reap the fruits of our investments between 2023 and 2028. By the way, the market size of AR technology is expected to rise up to 50 billion US dollar within the next 10 years. Therefore, we should gather momentum in this software-based technology.

6.4. Answers from HAVELSAN – 1

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms needed for the targeted technological activity?

Answer 1: Military land vehicles, air vehicles, ships, submarines, on-the-job training systems (machine training for technicians), and providing alarms by producing map information on real platforms through AR technologies.

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: Costs can be reduced using VR. Costs and risks are minimized by using AR for fixing system errors. Non-spatial architectural designs and components can be created through VR.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: Use of interaction with haptic systems for module reconstruction, 3D modelling, creating realistic colors, using real satellite and special-effect images, and ensuring tactile feeling.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: VR can be used in training systems of all platforms, on-the-job training systems, and in medicine; e.g. in surgical training systems for brain surgeries.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5: Game engines, haptic devices, mathematical modeling, optimization techniques (graphics optimization), user interface and user experience (UI/UX), 3D modeling, computer science, software development methods, geographical information systems (GIS), graphics processing units (GPU), and image and video processing techniques.

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 6: Universities should offer VR courses aimed at addressing defense industry needs. TUBITAK can invite related parties to carry out projects on special VR-related issues. MA and PhD theses dedicated to VR can be investigated to detect potential areas VR can be used. SSB can organize VR workshops, and plan how to utilize existing experiences in other areas.

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 7: SSB can support the establishment of new VR-focused companies, help these companies streamline their processes and products, and contribute to improvements in VR hardware by making national production of such hardware as VR headset obligatory.

6.5. Answers from HAVELSAN – 2

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms with respect to the targeted technological activity?

Answer 1:

- Space technologies
- Flight systems and technologies
- Weapons systems and technologies
- Land vehicle systems and technologies
- Naval vehicle systems and technologies
- Health technologies
- Art
- Designing
- Architecture
- Construction
- Education

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: Physical laws valid in land, air, and naval systems are the most critical cues. The main objective of simulation systems developed for these platforms is to transport the real environment into the virtual. Critical cues in design, architecture, and design are for visualizing a task in its 3d real dimensions, as if you were actually in it rather than on a computer screen. Thus, possible design errors, and related corrections can be detected in advance, which can, in turn, hinder some extra costs. As for the use in education, learning through audio-visual and practical means can enhance the level of learning, rendering it more interesting, as well.

Finally, for space technologies, environments that cannot be created on earth can be formed by means of VR. These environments can be developed using not only visual but also other senses. Thus, tests of newly developed space technologies, and training of the personnel can be performed in these environments.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: If a virtual environment is to be used, then a VR headset can be used. To increase interactions with the virtual environment, controllers in VR headset pack can be used. Also with hand trackers or VR gloves, this interaction can be rendered more realistic.

Depending on the VR scenarios, in cases when user's body needs to be closely tracked, trackers like Kinect and the like, or tracker clothing can be used (If you want to measure the knee room when you are in a car in VR, leg positions need to be specified accurately). Haptic clothing can be used to increase the reality of virtual environments. Devices such as Omni walker and the like can ensure unlimited mobility in VR experiences. Using mobile platforms in air, land and naval systems and technologies, real physical laws can be transmitted into VR.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: Domestic simulators in HAVELSAN can be given as an example. Additionally, there are many VR simulators designed several Turkish companies, but they are not advertised well. These can be further developed.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5:

- Game programming and development
- Game engines
- Computer graphics
- Image tracking and e-mobility infrastructures
- Physics for transfer of physical reality into VR

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answers 6 and 7: (The respondent gave a general answer covering these two questions)

Today VR technologies are high-cost technologies. Considering also the exchange differences springing from economic conditions in our country, access to VR technologies can be achieved only through various large enterprises.

In such technologies, manufacturing a product and marketing it is another difficulty. Companies in this business design VR products for advertorial purposes, or for private affairs of some other companies. Even if there are any companies developing products tailored for end users, the number is very limited. That is mostly because there are only a few people to purchase and use VR products as end users, which cuts down the number and type of VR products.

As well-known, military technologies are generally ahead of those used by the general public. Thanks to the financial power of military technologies, VR technologies can be used in the military.

As my summary of VR and its marketing areas indicates, the most serious problem is access to VR devices. As long as there are incentives regarding accessibility issue, people and companies designing and developing VR products will double in number. What's more, as use of VR technologies at home increases, people will line up for designing products in this technology. The biggest problem is accessibility. If we are to do something, we need to do something addressing this issue.

6.6. Answers from SIMSOFT – 1

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms with respect to the targeted technological activity?

Answer 1: Platforms in aviation, aerospace, and defense, which are critical with high-cost hardware, where technicians carry out a lot of disassemble-assemble tasks, and which require strict tracking of malfunctions.

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: It is indispensable to use them in systems in aviation, aerospace, and defense, where there is a high risk of malfunction or damage during disassembling or general operation of the systems.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: Real-world environment, augmented reality, augmented virtuality, and virtual reality. These can be achieved by developing 3D models of systems as close to reality as possible, or by creating environments identical to them.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: There is a need develop VR headsets and devices. Plus, there should be sensors and mobile platforms to better simulate reality.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5: We need to be able to manufacture VR headsets and wearable devices as well as sensors.

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 6: R&D directed for generating technology, particularly new technologies, requires considerable amounts of investments. In developing countries, including us, small-size enterprises should be supported so they can produce and sustain such technologies. Moreover, users (needers), researchers (universities), and businesspeople (manufacturers) should be brought together, and projects and supports should be given to technology parks as part of a much larger production plan.

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 7: In Turkey, companies cannot make R&D investments for a long time. They should grow into a stand-alone organization. What's more, needed technology areas can be mapped out, and thus a firm infrastructure can be built.

6.7. Answers from SIMSOFT – 2

Targeted Technological Activity: Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms.

Question 1: What are the real platforms with respect to the targeted technological activity?

Answer 1: This can be a simulator for any device. No matter how well the device simulators can be, as virtual environments block any external sense, their use in dangerous environments can especially be more useful than that in hardware training.

Question 2: What are the critical cues provided by real platforms with respect to the targeted technological activity?

Answer 2: Maybe dangerous environmental conditions where device simulators are used.

Question 3: What are the virtual reality techniques to be used on these platforms with respect to the targeted technological activity, and how should they be manufactured?

Answer 3: A realistic virtual image generated by an advanced image generator using quality 3D models.

Question 4: What are the domestic simulator systems and sub-systems with respect to the targeted technological activity, and how should they be manufactured?

Answer 4: Domestic image generators, 2D and 6D mobile e-platforms, and high-performance simulator engines are areas that should be worked on separately.

Question 5: What are the primary technology areas and sub-technology areas with respect to the targeted technological activity?

Answer 5: VR hardware (headsets, sensors etc.)

Question 6: What do you think should be done until 2023 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 6: All device simulators should be developed through state-funded projects, and apart from government procurement of products manufactured out of such projects, they should be provided with international marketing supports. Production of simulators for defense industry devices should be made obligatory, or at least be encouraged.

Question 7: What do you think should be done between 2023 and 2028 to realize the targeted technological activity? What are your policy recommendations? (Legal regulations, TUBITAK support, university-industry cooperation, etc.)

Answer 7: We should spread the use of simulator systems by giving or selling a simulator system along with all the devices we export.

CHAPTER 7

CONCLUSIONS

7.1. Summary and Analysis of Results

The study was conducted using two data collection tools; two focus group interviews followed by a 2-round Delphi questionnaire. The first focus group interview was implemented at the Technology Development Foundation of Turkey on February 23, 2018 between 13:30 and 18:00 with the participation of nine experts from different academic, public, and private business institutions. The focus group was carried out in two parts. In the first part, for the purpose of *Weighting of the Technology Evaluation Criteria*, participants were asked to rank from 1 to 5 the predetermined criteria (competitive advantage, creating other technology areas, and meeting national security requirements) and the ones they added.

Although the criteria of Sustainable Technologies and Creating Employment were assigned 1 point each, they are still very important issues to be considered. Sustainability of technologies to be invested in will ensure uninterrupted existence in that technology area. This will, thus, directly contribute to the other criterion – creating employment. As a matter of fact, these two are inextricably intertwined. Manufacturing, and economic development as its by-product will lead to increase in employment, which will, in turn, bring social prosperity.

Based on the points assigned in weighting process, the first three technology criteria came out to be *Meeting National Security Requirements*, *Competitive Advantage, and Creating Other Technology areas* with points of 0.299, 0.267, and 0.125, respectively. Next, participants, relying on the technology evaluation criteria determined in the previous part, assigned rankings for 35 technology areas listed in the Taxonomy of Defense Industry Technologies – Glossary of Terms and

Abbreviations published by Department of R&D and Technology Management under Presidency of Defense Industries. According to the technology areas and rankings assigned in this part, first drafts of the Delphi statements addressing the first three criteria (Meeting National Security Requirements, Competitive Advantage, and Creating Other Technology). Final drafts of these statements were written in the course of second focus group to be used in the Delphi survey.

A vision study was carried out in the second part of the first focus group interviews. Participants were asked to suggest vision statements answering the question of *What should be the R&D and Innovation vision of Turkish Defense Industry companies?*. The method known as in-tray exercise was used in this process. In this technique, groups divided as table-1 and table-1 were delivered A3 paper sheets as trays. Each participant wrote the first relevant ideas on post-its within a reasonable time period, and stuck them on this sheet. The tray was then passed onto the next participant on the right. This process continued until all the pertinent opinion were elicited. These opinions were then merged under a various topic titles according to relevance to one another. Ranking the titles from 1, the lowest, and 5, the highest, the *Vision Statement* was written.

Table-1 answered the question in terms of companies, and formed the vision statement of *To be an internationally competitive company that can, in accordance with the country's needs, and using technologies we are focused on and competent in, freely export products and services, and manage our own technologies.* Vision means identifying the future objectives of individuals, societies, companies, and countries. The most critical issue for companies is to address the needs of the country. Their investments should serve this purpose. They should stand out in their field of business activity, and be able to export those technologies they have expertise in without being dependent on any preoccupations. By this means, they ought to improve themselves competing with others in the market.

Table-2 answered the same question for Turkey, and produced the vision statement of *To create a domestic and national defense industry that provides sustainability for basic technologies, carries out multi-disciplinary studies, innovates and brands*

in international markets, and adopts space as a new living environment. For the benefit of Turkish defense industry, technologies developed in the country must be sustainable. This is a prerequisite to continuous development. Level of development rises through cooperation of multidisciplinary areas. This cooperation ensures betterment in practices, processes, technologies, and hence, in performances. This having said, Turkey needs world-famous trademarks in R&D and innovation. By means of such trademarks, Turkish companies should have a say in international markets. Recently, it has become imperative to do space studies, as well, which is known to trigger the development of countless new technologies.

At the end of this part of the study, strategic objectives for both vision statements to be used in the Delphi study were identified as follow:

Strategic objectives for the first vision statement:

1st Strategic Objective: To be internationally competitive
2nd Strategic Objective: To produce technologies that can meet country's needs
3rd Strategic Objective: To be able to import products and services
Strategic objectives for the second vision statement:
1st Strategic Objective: To be able to sustain basic technologies
2nd Strategic Objective: To conduct multidisciplinary studies
3rd Strategic Objective: To be innovative, and brand in international markets

The second focus group interviews were conducted in the Kıvılcım hall of Technology Development Foundation of Turkey on April 27, 2018 between 14:00 and 18:00 with the participation of 11 experts from different academic, public, and private business institutions. Participants were divided into three groups, and the study was again carried out in two parts.

In the first part, after a short briefing on the Delphi method, participants were asked to comment on the first set of 5 Delphi statements addressing the technology areas identified in the first focus group. They were also asked to provide their own Delphi

propositions addressing the related technology areas. Besides, each of the groups was requested to provide a separate Delphi proposition.

A similar procedure was applied in the second part, too. Participants provided their comments on the second set of 5 Delphi statements to be used in Delphi questionnaire, and developed their own Delphi propositions regarding the related technology areas. This concluded the second focus group study.

At the end of the second focus group interview, together with the 10 Delphi statements participants worked on, and their propositions, a total of 19 Delphi statements were obtained to be used in the first and second rounds of the Delphi questionnaire. Under these statements, nine questions covering the below topic titles were added.

- level of expertise,
- sufficiency of human resources in our country,
- level of core knowledge in our country,
- capacity of hard infrastructure (devices/equipment),
- skills the companies in our country have,
- date of execution
- contribution to Turkey's competitive power,
- contribution to Turkey' science, technology, and innovation capacity,
- contribution to energy efficiency and environmental awareness in Turkey

In today's fast globalizing world, it is of paramount significance for countries and companies to be able to compete, generate science, technology and innovation, have environmental awareness, and reduce energy costs. Otherwise, it will be utterly challenging for them to subsist in the future.

Delphi Round I was designed online using "Google Forms". Through email and phone, 167 employees from different organizations were contacted, and asked to participate in the first round questionnaire on the given website. The first response came on June 22, 2018. The first round ended on July 6, 2018, until when participants were repeatedly contacted via email and phone to request their responses to the questionnaire. At the end, 94 responses were received.

The second Delphi round started around the middle of July 2018. The questionnaire was once again delivered online using "Google Forms". The 94 participants, who had responded to the first round questionnaire, were invited, through email and phone, to partake in the second round questionnaire. A pdf document showing the first round responses was emailed to each participant. Graphics representing the distributions of all the responses in the first round were inserted in the second round questionnaire. Thus, participants were provided with the chance to compare and change their responses to the first round questionnaire. The second round ended on October 25, 2018. The number of participants responding to this round was 58. At the end of the second round, each participant's responses to both rounds were evaluated together, and thus the data collection process was concluded. Calculations and comparisons of this data were made using Microsoft Excel VBA and Excel Formula functions.

As a result of these data, the related Delphi statement, which defines itself as "High-3", "Moderate-2" and "None-1" and that "Before 2023", When the answers of the participants who marked the options "Between 2023 and 2028" and "After 2028" will be examined, the question of the D.14.1 Delphi statement introduced itself as "High-3" and it is seen that it was brought to the fore by those who were said to have realized it first. This question is followed by questions D.15.1 and D.16.1 respectively. The question of D.16.1 Delphi statement was put forward by those who defined themselves as "Moderate-2" and said that the related Delphi statement would take place before 2023. D.14.1 and D.15.1 Delphi statement questions followed this statement. Finally, the question of D.1.1 Delphi statement was ranked as first by the participants who stated that the relevant Delphi statement, which defines itself as "None-1" will take place before 2023. This was followed by questions D.3.1 and D.18.1 respectively. Statements that those who identify themselves as experts in Delphi surveys and take place in a shorter period of time are important. For this reason, D.14 Delphi statement related to D.14.1 Delphi question is worth examining.

After the Delphi rounds, each Delphi statement was analyzed in terms of their contribution to Turkey's *competitive power*, *science, technology and innovation capacity*, and *environmental awareness and energy efficiency*. During these analyses,

as date of execution for Delphi statements, the recent period until 2023, and the 5-year period between 2023 and 2028 were selected.

Each Delphi statement was directed to the participants with answer options of “Before 2023-1”, “Between 2023 and 2028-2”, and “After 2028-3” for date of execution; and “Little-3, “Fair-4”, and “High-5” for contribution to Turkey’s “competitive power”, “science, technology and innovation capacity”, and “environmental awareness and energy efficiency”. Reponses to questions regarding each Delphi statement were transferred into numeric data using the points assigned to each, which helped rank the questions. As a result, D.14.8 question got the highest points (60), D.15.8 question with 54 points became the second, and next came the questions D.16.7 and D.16.8 with 51 points each. The questions with the lowest points (2) were D.13.7, D.13.8, and D.13.9.

The purpose, afterwards, was to identify technological objectives to outline a roadmap of what should be done regarding the D.14 Delphi statement of Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms, which addressed the highest scoring D.14.8 question. In so doing, technical experts of the following Ankara-based companies, which carry on business in VR, were interviewed.

- SİM-TEK (Sim-Tek Simulation and IT Company)
- BITES (Bites Aerospace and Defense Inc.)
- HAVELSAN (Avionics Industry Inc.)
- SİMSOFT (Simsoft Computer Technologies Ltd. Comp.)

In these interviews, the D.14 Delphi statement was specified as the Targeted Technological Activity. Questions regarding the realization of this target were prepared and posed to the expert in face-to-face interviews. Now, based on the results we obtained from face-to-face interviews, we present a roadmap and our policy recommendations as regards the D.14 Delphi statement. A similar process can be applied to other Delphi statements, as well.

7.2. A Roadmap and Policy Recommendations for the Targeted Technological Activity of D.14 Delphi Statement

It is doubtless that VR, and its follow-up, AR technologies are, in the forthcoming years, bound to permeate every realm of our lives, communications, gaming and entertainment, transportation and tourism, sports, education and training, healthcare, retail trade, automotive industry, marketing, advertising, and defense industries. As VR and AR technologies become more widespread, fifth generation mobile communications service (5G), which will lower data signaling rate below 1 ms (millisecond), and artificial intelligence should be added to them.

Artificial intelligence is the software technology that enables computers, controllable robots, and machines to do human-like tasks centralizing on such human abilities as thinking and reasoning. This recent technology makes it possible to develop algorithmic thinking. For instance, a product or a topic you look for on a search engine will appear again as an advert or suggestion next time you are online. That means your habits or interests are analyzed by thinking algorithms. Another example is smart robots, which can be used in tertiary sector and warfare systems by means of artificial intelligence technology. Apparently, then, it is inevitable that artificial intelligence will be used in many distinct areas including agriculture, tourism, defense industry, education, and healthcare.

As a result of increase in data signaling rate with the advent of 5G, VR and AR technologies are forecast to have covered up to several million US dollars of market share by 2025. Within this framework, guidelines for the technological objective of "Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate critical cues provided by real platforms" were identified considering also the answers obtained from face-to-face interviews with related experts.

In defense industries, VR practices can be used in land, air and naval platforms, missiles and launch pads, weapons systems, unmanned aerial systems, and on-the-job training systems to attain enhanced sense perception. A physical or dynamic simulation or simulator can be developed for each of these systems. Platform training and on-the-job

training systems are widely used. As for ease of application, the less complex platforms are, the less complex their simulations will be. Non-spatial architectural environments and elements can be simulated using VR. Therefore, design faults and necessary adaptations could be detected in advance, and pre-emptive measures can be taken for later uses. An example to this is space technologies. Environments that are impossible to create on earth can be simulated through VR technology with sense perceptions added, as well. While designing platforms with complex structures using VR, potential system faults can be pre-detected and fixed since VR allows for product assembly-disassembly processes providing a realistic virtual image created through an advanced image generator. Thus, VR brings about considerable advantages in terms of cost and risk reduction. These opportunities provide great convenience for both engineers and end users.

Using virtual reality, user-friendly, color-compatible, and user-accessible products and parts can be designed. Haptic interaction technique can be used to get tactile feeling. In the area of VR, manufacturing VR headsets, wearable products and sensors is of vital importance. Use of VR and AR headsets is expected to spread out. Take "Google Glass" by Google as an example. Hand trackers or VR gloves can help render virtual environments more realistic. Using tools like Omni walker, users can be made abler to move, gaining unlimited mobility in virtual environments. When needed, user's body can be closely tracked with devices such Kinect and the like. If you aim to acquire tactile feeling in virtual environments, this can be achieved through more sensors, 2D and 6D mobile e-platforms, and high-performance simulation engines. Having said these, it is noteworthy that parts, materials, software, and models not domestically manufactured are extremely critical.

Within this framework, studies into following technology areas and systems are needed.

1. Game engines
- Graphics engines
2. Geographic information systems
- Mapping systems
3. Software technologies
- Software project execution technologies

- Software integration technologies
- Real-time software technologies

4. 3D modeling technologies

- Virtual reality headsets
- Sensor technologies
- Wearable sensor technologies

5. Image processing

- Video management
- Image Compression and Image transfer

6. Optimization techniques

- Graphics processing techniques
- User interface and user experience (UI/UX)

Below are some policy recommendations for universities, TUBITAK, Presidency of Defense Industries, and Ministry of Industry and Technology in order to be able to realize the targeted technological activity first by 2023, and then by 2023-2028 period:

1. Recommendations for universities: University students should be guided through gaming and modelling simulations. To this end, courses like "openGL" should be offered as required courses. Modelling for the gaming industry, and graphic design software should be used by students in a more widespread manner, and relevant courses should be offered at universities. MA and PhD programs in the fields of gaming, modelling and simulation should be opened and popularized. University students should be provided with job shadowing opportunities in companies working on VR.
2. Recommendations for TUBITAK: Military and non-military R&D projects should be started. For this purpose, companies should be invited to engage in projects targeted at meeting the national software and hardware needs in VR.
3. Recommendations for Presidency of Defense Industries: Presidency of Defense Industries should organize workshops dedicated to VR, and sketch how to transfer experiences in this area to other related areas, and, through such workshops, human resource capability should be enhanced. Testing, verification, and evaluation standards for VR technologies should be identified. Defense industry

companies should be obligated or encouraged to manufacture simulators for the defense industry devices they manufacture. Besides that, the Presidency should provide international marketing support working in coordination with the related state institutions. Finally, an information repository of VR should be built out of experiences of relevant companies.

4. Recommendations for Ministry of Industry and Technology: The Ministry should incorporate end user products including primarily VR and AR headset into the incentive program. In the business of technology production, university – industry cooperation should be built, and technology parks should be supported extensively. Regular meetings should be organized with all the stakeholders in the sector.

Recommendations for the 2023-2028 period:

1. Recommendations for universities: Project contests on VR should be organized. Coding education should be rendered more widespread through cooperation with the Ministry of National Education. As part of academy – industry cooperation, joint projects with companies doing business in VR should be carried out.
2. Recommendations for TUBITAK: PhD programs in VR should be supported. Besides, TUBITAK should be as flexible as possible in its project support programs, and extend project completion deadlines.
3. Recommendations for Presidency of Defense Industries: Project contests for encouraging related companies should be organized, establishment of organizations engaged in VR technologies should be supported, and structures bringing VR companies together should be formed. Companies should be guided in areas that demand special expertise in VR. National production of the hardware of VR headsets should be planned in coordination with the relevant parties. Furthermore, the Presidency should promote the use of simulator systems by enabling companies to give or sell the simulators of the devices they export. Companies should be assisted in improving maintenance and life cycles of their VR products. Companies should be granted financial support in attending international VR fairs. Finally, the Presidency should work in coordination with embassies to advertise VR products of Turkish companies.

4. Recommendations for Ministry of Industry and Technology: Companies to invest in R&D in VR should be granted funds and tax privileges. Domestic products should be promoted by laws, and import volumes should be lowered. International property rights, and patent rights of domestic and national products should be protected, and preventive measures should be taken against problems to be faced in exporting these products. The Ministry should also contribute to the development and dissemination of national VR trademarks. Finally, these companies should be supported for their contribution to export.

In accordance with these recommendations, the roadmap for realizing the targeted technological activity associated with the D.14 Delphi statement by 2023 and 2023-2028 period is represented in Tables 95 and 96 below.

Table 95
Issues to be Realized for the Targeted Technological Activity Until 2023

Universities	• Universities are to offer openGL as a required course. • Universities are to offer more modelling and graphic programming courses. • Universities are to offer MA and PhD programs in VR. • Internships should be provided to university students in companies operating in virtual reality.
TUBITAK	• Civil and military R & D projects should be initiated. • Invited R & D projects should be initiated for the needs of national software and hardware on virtual reality.
Presidency of Defense Industries	• Workshops for virtual reality should be organized and the use of experience in other fields should be planned. • Trainings to be provided should increase human resource capabilities. • Standards for testing, verification and evaluation of virtual reality should be established. • Simulator production should be made compulsory or encouraged for the defense industry vehicles produced. • Marketing support should be provided for the foreign countries in coordination with the relevant public institutions. • In case of need for virtual reality, an information pool should be created in which the capabilities of the relevant companies can be applied.
Ministry of Industry and Technology:	• It should include in the incentive program the production of end-user products, Virtual reality and augmented reality headset. • Technology production should be realized in techno-parks within the scope of university-industry cooperation in the field of virtual reality. • Regular meetings should be held with sector stakeholders.

Table 96
Issues to be Realized for the Targeted Technological Activity Between 2023-2028

Universities	• Award-winning project competitions should be organized for students in terms of virtual reality. • Coding education should be expanded in cooperation with the Ministry of National Education. • Within the scope of university-industry cooperation, joint project studies should be carried out with companies operating in virtual reality.
TUBITAK	• PhD programs on virtual reality should be supported. • In projects, companies should be treated as flexible as possible. Thus, the completion of projects should be ensured.
Presidency of Defense Industries	• Competition projects that encourage companies should be organized. • The establishment of companies working on virtual reality should be supported and platforms should be established where such companies are brought together. • Companies should be directed to areas where special expertise in virtual reality is required. • Planning should be done together with the related institutions for national production of virtual reality headset. • Exported from Turkey about every platform beside simulator systems should be given or sold. • Virtual reality products produced by companies should be successful in subjects such as maintenance and life cycle. • Participation of companies in foreign fairs on virtual reality should be supported financially. • In the promotion of the products, coordinated works should be carried out with the embassies located in Turkey and abroad.
Ministry of Industry and Technology:	• Financial and tax support should be provided to companies that will invest in R & D in terms of virtual reality. • Use of domestic products should be encouraged by law and imports should be reduced. • Intellectual property and patent rights of domestic and national products should be protected. • Measures should be taken to solve the problems that may occur in the export of products. • The emergence of national brands on virtual reality should be supported and contributed to the spread of the world. • Companies should be supported for their contribution to exports due to their projects abroad.

Consequently, VR is a fast-growing technology, yet we have only recently started to use it for defense industry purposes. It is indispensable, in the forthcoming years, to accumulate considerable amounts of financial income by exporting VR products as we develop more in VR software and hardware. Within this scope, academy, private business enterprises, and public institutions should work in coordination,

and, utilizing this technology, develop products that will become world's leading brands.

As regards the actions to be taken in the immediate future, there should be investments in AR technology, which is considered as a follow-up to VR. AR technologies will be used in many diverse spheres of life particularly including defense industries. It will be possible to use these technologies together with the fast-developing 5G and artificial intelligence practices of these days. Therefore, we should invest, carry out projects, and start production in these developing technologies in order to enhance the level of social prosperity, and ensure economic growth.

REFERENCES

Agir, H. (2010). Türkiye ile Güney Kore'de bilim ve teknoloji politikalarının karşılaştırması. *Bilgi Ekonomisi ve Yönetim Dergisi,* 5(2), 43-55.

Beisenbayeva, L. (2017). *Examining scientific research competencies of graduate students studying in the field of education and educational sciences in Kazakhstan and Turkey*. PhD. Thesis, Gazi University, Ankara.

Bir, A. A. (Ed.). (1999). *Sosyal Bilimlerde Araştırma Yöntemleri.* Anadolu Üniversitesi Yayınları No: 1081.

Bostan, I. (2000). İnebahtı deniz savaşı. *Türkiye Diyanet Vakfı İslam Ansiklopedisi, 22*, 287-289. Retrieved from https://cdn.islamansiklopedisi.org.tr/dosya/22/C22007389.pdf.

Böke, K. (Ed.). (2014). *Sosyal Bilimlerde Araştırma Yöntemleri* (5. ed.). İstanbul: Alfa Yayıncılık.

Büyüköztürk, Ş. (2005). Anket geliştirme. *Türk Eğitim Bilimleri Dergisi, 3*(2), 133-151.

Cakrabarti, A. K., & Antanwu, C. L. (1993). Defense R&D, technology, and economic performance: A longitudinal analysis of the US experience. *IEEE Transactions on Engineering Management, 40*(2), 136-145.

Chiesa, V., Frattini, F., & Manzini, V. (2009). Performance measurement of research and development activities. *European Journal of Innovation Management, 12*(1), 26-61.

Chiesa, V., Frattini, F., Lazzarotti, V., & Manzini, R. (2008). Designing a performance measurement system for the research activities: A reference framework and an empirical study. *Journal of Engineering and Technology Management, 25*(3), 213-226.

Chiesa, V., Frattini, F., Lazzarotti, V., Manzini, R., & Troja, I. (2009). An exploratory study on R&D performance measurement practices: A survey of

Italian R&D intensive firms. *International Journal of Innovation Management*(13), 65-104.

Coşkun, R., Altunışık, R., Bayraktaroğlu, S., & Yıldırım, E. (2004). *Sosyal Bilimlerde Araştırma Yöntemleri SPSS Uygulamalı.* Sakarya Yayıncılık.

Çakır, S. (2014). *AR-GE ve İnovasyon (Yenilik) Ders Notları.* Ankara.

Çakır, S. (2016). Delphi sorgulaması. *SB-6302 Teknolojik Araştırma Yöntemleri Ders Notları*. Savunma BİlimleriEnstitüsü.

Çokluk, Ö., Yılmaz, K., & Oğuz, E. (2011). Nitel bir görüşme yöntemi: Odak grup görüşmesi. *Kuramsal Eğitimbilim , 4*(1), 95-107.

Day, J., & Bobeva, M. (2005). A generic toolkit for the successful management of Delphi studies. *The Electronic Journal of Business Methodology, 3*(2), 103-116.

Deen, J., & Vossensteyn, H. (2006). *Measuring performance of applied R&D: A study into performance measurement of applied R&D in the Netherlands and some other countries.* Report for the Center for Science and Technology Studies (CEST).

Dewangen, V., & Godse, M. (2014). Towards a holistic enterprise innovation performance measurement system. *Technovation, 34*, 536-545.

Dölkeleş, B. (2014). *Kıbrıs barış harekatı sonrasında ABD'nin uyguladığı silah ambargosu ve türk savunma sanayiine etkileri.* Yüksek Lisans Tezi.

DPT. (2006). *Türkiye Cumhuriyeti Başbakanlık Devlet Planlama Teşkilatı Dokuzuncu Kalkınma Planı.* Ankara: DPT.

DPT. (2013). *Türkiye Cumhuriyeti Başbakanlık Devlet Planlama Teşkilatı Onuncu Kalkınma Planı.* Ankara: DPT.

Eğilmez, M. (2018). *Değişim Sürecinde Türkiye* (1 ed.). İstanbul: Remzi Kitabevi.

Farkas, M. F., & Gonda, G. (2012). Necessity and difficulty of R&D performance measurement. *International Journal of Economics and Finance Studies, 4*(2), 129-138.

Gallart, J. M. (1999). Measuring defence R&D: A note on problems and shortcomings. *Scientometrics, 45*(1), 3-16.

Genç, Y. K. (2013). Savunma sanayiinde Ar-GE. *Türkiye Cumhuriyeti Bilim, Sanayi ve Teknoloji Bakanlığı 3. Sanayi Şurası.*

Gençtürk, E., & Akbaş, Y. (2013). Defining social studies teacher education geography standards: An implication of Delphi technique. *Gazi University Journal of Gazi Education Faculty, 33*(2), 335-353.

Gündoğan, E. (2002). *AB ve Kıbrıs: Bugünü ve Geleceği* (1. ed.). İstanbul: Gündoğan Yayınları.

Hall, B. H., & Mairesse, J. (2009). Measuring corporate R&D returns. *Researchgate*. Retrieved from https://www.researchgate.net/publication/255571173.

Hartley, K. (2006). Defense R&D: Data issues. *Defence and Peace Economics, 17*(3), 169-175.

Hauser, J., & Zettelmeyer, F. (1997). Metrics to Evaluate R, D&E. *Reserach-Technology Management, 40*(4), 32-38.

Jacobsson, S., & Philipson, J. (1996). Sweden's technological profile: What can R&D and patents tell and what do they fail to tell us? *Technovation, 26*(5), 245-253.

Junior, J. A., Vasconcellos, E., Guedes, L. V., Guedes, L. F., & Costa, M. (2018). Technology roadmapping: A methodological proposition to refine Delphi results. *Technological Forecasting and Social Change, 126*(C), 194-206.

Karakaş, N. (2009). Amerikan "ödünç verme ve kiralama" yardımlarında Türkiye. *Tarih İncelemeleri Dergisi, 1*(24).

Karlsson, M., Trygg, L., & Elfström, B. O. (2004). Measuring R&D productivity: Complementing the picture by focusing on research activities. *Technovation, 24*, 179-186.

Kim, B., & Oh, H. (2002). An effective R&D performance measurement system: Survey of Korean R&D researchers. *Omega The International Journal of Management Science, 30*, 19-31.

Kobe, C., & Bodmer, C. (2002). Performance measurement and controlling in R&D actual needs and successful practices. *Proceedings of the 9th International Product Development Management Conference,* (pp. 457-467).

Korkmaz, S. (2010). Türkiye'de AR-GE yatırımları ve ekonomik büyüme arasındaki ilişkinin var modeli ile analizi. *Journal of Yasar University, 20*(5), 3320-3330.

Köseoğlu, A. M. (2010). *Milli savunma sanayiinde yeniden yapılanma ve sosyal politikalara etkisi.* Doktora Tezi, Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü, İzmir.

Kulatunga, U., Amaratunga, D., & Haigh, R. (2006). Performance measurement of research and development: A literature review. *1st International CIB Endorsed METU Postgraduate Conference: Built Environment & Information Technologies,* (pp. 361-376). Ankara.

Kurt, Ç. (2017). Between define autarky and dependency: The dynamics of Turkish defense industrialization. *Defence Studies, 17*(3), 260-281.

Kurt, E. (2018). *Türk savunma sanayii tarihine mikro yaklaşim: Savunma sanayii işletmelerine dair bir envanter ve dönemselleştirme çalişmasi (1836-2018).* Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi Sosyal Bilimler Ensitüsü, İstanbul.

Laliene, R., & Ojanen, V. (2015). R&D performance measurement: A process perspective revisited. *Proceedings of the 2015 IEEM*, 971-975.

Lee, D. J., Park, S. J., & Kim, K. T. (2013). A development of key performance indicators for the public R&D of energy technology using balanced scorecard approach. *Proceedings of the World Congress on Engineering and Computer Science, 2.*

Lee, H., Park, Y., & Choi, H. (2009). Comparative evaluation of performance of national R&D programs with heterogeneous objectives: A DEA approach. *European Journal of Operational Research, 196*, 847-855.

Marques, G., Gourc, D., & Lauras, M. (2010). Multi-criteria performance analysis for decision making in project management. *International Journal of Project Management, 29*, 1057-1069.

Melander, L., Dubois, A., Hedvall, K., & Lind, F. (2019). Future goods transport in Sweden 2050: Using a Delphi-based scenario analysis. *Technological Forecasting & Social Change, 138,* 178-189.

Molnar, L. (2011). Research and development activity matrix – New conception in the performance evaluation of research and development. *Club of Economics in Miscolc TMP, 7*(2), 29-37.

OECD. (2002). *Frascati Manual 2002 Proposed Standard Practice for Surveys on Research and Experimental Development.* Paris: OECD Publishing.

Ojanen, V., & Voula, O. (2003). Categorizing the measures and evaluation methods of R&D performance: A state-of the art review on R&D performance analysis. *Telecom Business Research Center Lappeenranta Working Papers, 16*.

Ölcer, F. (2005). Dengeli stratejik performans ölçüm ve yönetim sistemi'nin (balanced scorecard) tasarımı ve uygulanması. *Amme İdare Dergisi, 38*(2), 89-134.

Önder, A. (2005). *Türk savunma sanayii tarihinde Makine ve Kimya Endüstri Kurumunun yeri.* Doktora Tezi, Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü , Ankara.

Öztuna, Y. (2017). *Osmanlı Devleti Tarihi- Medeniyet Tarihi* (Vol. 2). Ötüken Neşriyat.

Parisi, C., & Rossi, P. (2015). Strategic performance measurement of research and development: A case study. *The International Journal of Business & Management, 3*(12), 322-330.

Peled, D. (2001). Defense R&D and economic growth in Israel: A research agenda. *Science, Technology and the Economy Program.* Haifa: Tehnion-Israel Institute of Technology.

Peng, P., Barnes, M., Wang, C. C., Wang, W., Swanson, L., Dardick, W., & Tao, S. (2017). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin, 144,* 48-76.

Peng, X. M., Hu, Z. X., & Xin, D. (2012). Modeling of engineering R&D staff performance appraisal model based on fuzzy comprehensive evaluation. *Systems Engineering, 4*, 236-242.

Punch, K. F. (2011). *Sosyal Araştırmalara Giriş Nicel ve Nitel Yaklaşımlar* (3. ed.). (B. Dursun, H. B. Arslan, & Z. Akyüz, Trans.) Siyasal Kitabevi.

Santos, M. F., Lucianetti, L., & Bourne, M. (2012). Contemporary performance measurement systems: A review of their consequences and a framework for research. *Management Accounting Research, 23*, 79-119.

Savunma Sanayi Başkanlığı Hakkında Cumhurbaşkanlığı Kararnamesi Sayı 7 Madde 6 (1). (2018). Retrieved October 17, 2018, from mevzuat.gov.tr: https://www.mevzuat.gov.tr/MevzuatMetin/19.5.7.pdf.

Seyrek, I., & Karakaya, M. (2008). Teknoloji politikaları ve Türkiye: Bir inceleme. *Sosyal Ekonomik Araştırmalar Dergisi, 8*(15), 53-79.

SIPRI Yearbook 2019 . (2019). Stockholm International Peace Research Institute (SIPRI).

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education, 6*(1), 1-21.

Spano, R., Sarto, F., Caldarelli, A., & Vigano, R. (2016). Innovation & performance measurement: An adapted balanced scorecard. *International Journal of Business and Management, 11*(6), 194-204.

SSB. (2017). *Savunma Sanayii Teknoloji Taksonomisi-Kısaltmalar ve Terimler Sözlüğü.* Savunma Sanayii Başkanlığı.

SSM. (2011). *Savunma Sanayii Müsteşarlığı Teknoloji Yönetim Stratejisi 2011-2016.*

SSM. (2017). *Savunma Sanayii Müsteşarlığı Stratejik Planı 2017-2021.*

Suomola, P., & Jamsen, M. (2003). Performance measurement in Finnish industrial R&D management. *The Finnish Journal of Business Economics (now Nordic Journal of Business), 4*(3), 474-494.

Şahin, A. E. (2001). Eğitim araştırmalarında delphi tekniği ve kullanımı. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 215-220.

Tan, O. K., & Rasli, A. (2011). Prediction of new product development (NPD) performance in research and development (R&D) company. *3rd International Conference on Advanced Management Science IPEDR, 19,* 192-200.

Temel, M. A., Kaplan, T., & Sonkaya, Y. (2016). Büyük ölçekli firmalar için Ar-Ge performans ölçümü metriklerinin belirlenmesi. *SAVTEK (Savunma Teknolojileri Kongresi).*

Turan, M. (1999). II. Viyana muhasarası: Osmanlı Devletinde siyasi, idari ve askeri çözülme. *Osmanlı Tarihi Araştırmalar Merkezi Dergisi*, (9), 389-431.

TÜİK. (2018). Genel açıklamalar. *Türkiye İstatistik Kurumu Merkezi Yönetim Bütçesinden Araştırma Geliştirme Faaliyetleri İçin Ayrılan Ödenek ve Harcamalar Bülteni*, (27742).

TÜSSİDE. (2004). *Ortak Akıl Platformu Paydaş Toplantısı - I Raporu.* TUBİTAK.

UNESCO UIS. (2017, September). Literacy rates continue to rise from one generation to the next. *UIS Fact Sheet No. 45*. UNESCO Institute for Statistics. Retrieved from http://uis.unesco.org/sites/default/files/documents/fs45-literacy-rates-continue-rise-generation-to-next-en-2017_0.pdf.

Unsworth, N., Fukuda, K., Awh, E., & Vogel, E. K. (2014). Working memory and fluid intelligence: Capacity, attention control, and secondary memory retrieval. *Cognitive Psychology, 71*, 1-26.

Uzkurt, C. (2014). Kalkınmada Anahtar: Verimlilik. *Türkiye Cumhuriyeti Bilim, Sanayi ve Teknoloji Bakanlığı*, (301), 8-14.

Werner, B., & Souder, W. (1997). Measuring R&D performance-State of the art. *Research-Technology Management, 40*(2), 34-42.

Werner, B., & Souder, W. (1997). Measuring R&D performance-U.S. and German practices. *Research-Technology Management, 40*(3), 28-32.

Yavuzyılmaz, Ö. (2014). *Türk savunma sanayiinde teknoloji tedarik stratejilerini belirlemeye yönelik bir model önerisi.* Doktora Tezi, Kara Harp Okulu Savunma Bilimleri Enstitüsü, Ankara.

Yediyıldız, B. (1994). *Tarih* (Vol. 2). İstanbul: Türkiye Cumhuriyeti Milli Eğitim Bakanlığı Yayınları.

Yıldırım, A. (1999). Nitel araştırma yöntemlerinin temel özellikleri ve eğitim araştırmalarındaki yeri ve önemi. *Eğitim ve Bilim, 23*(112), 7-17.

Yılmaz, A. (2014). Kalkınmada Anahtar: Verimlilik. *Türkiye Cumhuriyeti Bilim, Sanayi ve Teknoloji Bakanlığı Yayını*, (301), 1-7.

Zizlavsky, O. (2014). The balanced scorecard: Innovative performance measurement and management control system. *Journal of Technology Management Innovation*, *9*(3), 210-222.

APPENDICES

A. EVALUATION FORM FOR TECHNOLOGY AREAS

23.02.2018

Table No:

Name & Surname:

EVALUATION OF TECHNOLOGY AREAS

NO.	TECHNOLOGY AREAS	P1	P2	P3
1	Structural & Smart Materials & Structural Mechanics			
2	Signature Related Materials			
3	Electronic Materials Technology			
4	Photonic/Optical Materials & Device Technology			
5	Electronic, Electrical & Electromechanical Device Technology			
6	Energetic Materials and Plasma Technology			
7	Chemical, Biological & Medical Materials			
8	Computing Technologies & Mathematical Techniques			
9	Information and Signal Processing Technology			
10	Human Sciences			
11	Operating Environment Technology			
12	Mechanical, Thermal & Fluid- Related Technologies & Devices			
13	Cyber Security Operations			
14	Lethality and Platform Protection			
15	Propulsion and Powerplants			
16	Design Technologies for Platforms and Weapons			
17	Electronic Warfare and Directed Energy Technologies			
18	Signature Control and Signature Reduction			
19	Sensor Systems			
20	Guidance and Control Systems for Weapons and Platforms			
21	Simulators, Trainers and Synthetic Environments			

22	Integrated Systems Technology			
23	Communications and CIS-related Technologies			
24	Personnel Protection Systems			
25	Smart Manufacturing Systems			
26	Cyber Security Solutions			
27	Defense Analysis			
28	Integrated Platforms			
29	Weapons			
30	Installations and Facilities			
31	Equipped Personnel			
32	Miscellaneous Defense Functions and Policy Support			
33	Battlespace Information			
34	Business Processes			
35	Weapons Systems			
36	Other (.....)			
37	Other (.....)			
38	Other (.....)			
39	Other (.....)			
40	Other(.....)			

B. RANKINGS ASSIGNED BY PARTICIPANTS

Participant-1	
Competitive Advantage (5) points	1. Structural & Smart Materials & Structural Mechanics 2. Electronic Materials Technology 3. Propulsion and Powerplants 4. Guidance and Control Systems for Weapons and Platforms 5. Integrated Platforms 6. Weapons 7. Weapons Systems 8. Photonic/Optical Materials & Device Technology 9. Electronic, Electrical & Electromechanical Device Technology 10. Energetic Materials and Plasma Technology
Meeting National Security Requirements (4) points	1.Battlespace Information 2.Weapons Systems 3.Defense Analysis 4.Weapons 5.Guidance and Control Systems for Weapons and Platforms 6. Simulators, Trainers and Synthetic Environments 7. Communications and CIS-related Technologies 8. Personnel Protection Systems 9. Computing Technologies & Mathematical Techniques 10. Information and Signal Processing Technology
Being a Critical Technology (3) points	1.Energetic Materials and Plasma Technology 2.Electronic Materials Technology 3.Photonic/Optical Materials & Device Technology 4.Electronic, Electrical & Electromechanical Device Technology 5. Chemical, Biological & Medical Materials 6. Electronic Warfare and Directed Energy Technologies 7.Sensor Systems 8. Guidance and Control Systems for Weapons and Platforms 9. Simulators, Trainers and Synthetic Environments 10. Integrated Systems Technology

Participant-2	
Meeting National Security Requirements (5) points	1. Propulsion and Powerplants 2. Structural & Smart Materials & Structural Mechanics 3. Signature Related Materials 4. Signature Control and Signature Reduction 5. Electronic Materials Technology 6. Photonic/Optical Materials & Device Technology 7. Energetic Materials and Plasma Technology 8. Information and Signal Processing Technology 9. Lethality and Platform Protection 10. Design Technologies for Platforms and Weapons
Competitive Advantage (4) points	1. Structural & Smart Materials & Structural Mechanics 2. Signature Related Materials 3. Electronic Materials Technology 4. Photonic/Optical Materials & Device Technology. 5. Electronic, Electrical & Electromechanical Device Technology 6. Energetic Materials and Plasma Technology 7. Chemical, Biological & Medical Materials 8. Computing Technologies & Mathematical Techniques 9. Information and Signal Processing Technology 10. Mechanical, Thermal & Fluid- Related Technologies & Devices
Creating New Markets/Customers (3) points	1. Signature Related Materials 2. Structural & Smart Materials & Structural Mechanics 3. Electronic Materials Technology 4. Photonic/Optical Materials & Device Technology 5. Signature Control and Signature Reduction 6. Information and Signal Processing Technology 7. Electronic, Electrical & Electromechanical Device Technology 8. Energetic Materials and Plasma Technology 9. Mechanical, Thermal & Fluid- Related Technologies & Devices 10. Lethality and Platform Protection

Participant-3	
Creating a Striking Impact (5) points	1. Computing Technologies & Mathematical Techniques 2. Structural & Smart Materials & Structural Mechanics 3. Photonic/Optical Materials & Device Technology. 4. Energetic Materials and Plasma Technology 5. Sensor Systems 6. Information and Signal Processing Technology 7. Electronic, Electrical & Electromechanical Device Technology 8. Simulators, Trainers and Synthetic Environments 9. Defense Analysis 10. Integrated Platforms
Meeting National Security Requirements (4) points	1. Cyber Security Operations 2. Electronic Warfare and Directed Energy Technologies 3. Signature Control and Signature Reduction 4. Signature Related Materials 5. Sensor Systems 6. Communications and CIS-related Technologies 7. Cyber Security Solutions 8.Defense Analysis 9.Integrated Platforms 10. Lethality and Platform Protection
Competitive Advantage (3) points	1. Computing Technologies & Mathematical Techniques 2. Information and Signal Processing Technology 3. Human Sciences 4. Mechanical, Thermal & Fluid- Related Technologies & Devices 5. Design Technologies for Platforms and Weapons 6. Smart Manufacturing Systems 7. Installations and Facilities 8. Miscellaneous Defense Functions and Policy Support 9. Business Processes 10. Electronic Materials Technology

Participant-4	
Meeting National Security Requirements (5) points	1. Electronic Warfare and Directed Energy Technologies 2. Guidance and Control Systems for Weapons and Platforms 3. Signature Related Materials 4. Battlespace Information 5. Cyber Security Operations 6. Sensor Systems 7. Communications and CIS-related Technologies 8. Personnel Protection Systems 9. Weapons 10. Equipped Personnel
Reducing Costs (4) points	1. Electronic Materials Technology 2. Structural & Smart Materials & Structural Mechanics 3. Electronic Warfare and Directed Energy Technologies 4. Electronic, Electrical & Electromechanical Device Technology 5. Information and Signal Processing Technology 6. Mechanical, Thermal & Fluid- Related Technologies & Devices 7. Propulsion and Powerplants 8. Design Technologies for Platforms and Weapons
Competitive Advantage (3) points	1. Business Processes 2. Defense Analysis 3. Electronic Materials Technology 4. Miscellaneous Defense Functions and Policy Support 5. Integrated Systems Technology 6. Equipped Personnel 7. Structural & Smart Materials & Structural Mechanics 8. Electronic, Electrical & Electromechanical Device Technology

Participant-5	
Meeting National Security Requirements (4) points	1.Weapons Systems 2.Weapons 3. Cyber Security Solutions 4. Electronic Warfare and Directed Energy Technologies 5. Design Technologies for Platforms and Weapons 6. Communications and CIS-related Technologies 7. Personnel Protection Systems 8. Information and Signal Processing Technology 9. Cyber Security Operations 10. Lethality and Platform Protection
Reducing Costs (4) points	1. Electronic Materials Technology 2. Structural & Smart Materials & Structural Mechanics 3. Electronic Warfare and Directed Energy Technologies 4. Electronic, Electrical & Electromechanical Device Technology 5. Information and Signal Processing Technology 6. Mechanical, Thermal & Fluid- Related Technologies & Devices 7. Propulsion and Powerplants 8. Design Technologies for Platforms and Weapons
Ratio of Being Domestic and National (3) points	1. Design Technologies for Platforms and Weapons 2. Electronic Warfare and Directed Energy Technologies 3. Sensor Systems 4. Integrated Systems Technology 5. Personnel Protection Systems 6. Cyber Security Solutions 7. Integrated Platforms 8.Weapons 9. Computing Technologies & Mathematical Techniques

Participant-6	
Meeting National Security Requirements (5) points	1. Lethality and Platform Protection 2. Propulsion and Powerplants 3.Air Defense Systems 4. Guidance and Control Systems for Weapons and Platforms 5. Communications and CIS-related Technologies 6. Structural & Smart Materials & Structural Mechanics 7. Information and Signal Processing Technology 8. Electronic, Electrical & Electromechanical Device Technology 9. Sensor Systems 10. Personnel Protection Systems
Addressing Market Needs (4) points	1. Lethality and Platform Protection 2. Cyber Security Solutions 3. Photonic/Optical Materials & Device Technology 4.Operating Environment Technology 5. Electronic Warfare and Directed Energy Technologies 6.İz Signature Control and Signature Reduction 7. Guidance and Control Systems for Weapons and Platforms 8. Integrated Systems Technology 9. Communications and CIS-related Technologies 10. Signature Related Materials
Competitive Advantage (3) points	1. Structural & Smart Materials & Structural Mechanics 2. Computing Technologies & Mathematical Techniques 3. Propulsion and Powerplants 4. Cyber Security Operations 5. Signature Control and Signature Reduction 6. Guidance and Control Systems for Weapons and Platforms 7. Communications and CIS-related Technologies 8. Mechanical, Thermal & Fluid- Related Technologies & Devices 9. Lethality and Platform Protection 10. Sensor Systems

Participant-7	
Meeting National Security Requirements (5) points	1. Chemical, Biological & Medical Materials 2. Energetic Materials and Plasma Technology 3. Computing Technologies & Mathematical Techniques 4. Mechanical, Thermal & Fluid- Related Technologies & Devices 5. Information and Signal Processing Technology 6. Structural & Smart Materials & Structural Mechanics 7. Electronic Materials Technology 8. Photonic/Optical Materials & Device Technology 9. Electronic, Electrical & Electromechanical Device Technology 10. Signature Related Materials
Addressing Market Needs (4) points	1.Weapons 2.Weapons Systems 3. Personnel Protection Systems 4. Propulsion and Powerplants 5. Design Technologies for Platforms and Weapons 6. Sensor Systems 7. Equipped Personnel 8. Battlespace Information 9. Electronic, Electrical & Electromechanical Device Technology 10. Communications and CIS-related Technologies
Providing High Added Value (3) points	1. Chemical, Biological & Medical Materials 2. Energetic Materials and Plasma Technology 3. Computing Technologies & Mathematical Techniques 4. Electronic Materials Technology 5. Information and Signal Processing Technology 6. Human Sciences 7. Electronic Warfare and Directed Energy Technologies 8. Signature Control and Signature Reduction 9. Smart Manufacturing Systems 10. Defense Analysis

Participant-8	
Competitive Advantage (5) points	1. Chemical, Biological & Medical Materials 2. Structural & Smart Materials & Structural Mechanics 3. Electronic Materials Technology 4. Signature Related Materials 5. Photonic/Optical Materials & Device Technology 6. Energetic Materials and Plasma Technology 7. Computing Technologies & Mathematical Techniques 8. Electronic, Electrical & Electromechanical Device Technology 9. Human Sciences 10. Sensor Systems
Creating Other Technology Areas (3) points	1. Structural & Smart Materials & Structural Mechanics 2. Signature Related Materials 3. Photonic/Optical Materials & Device Technology 4. Electronic, Electrical & Electromechanical Device Technology 5. Chemical, Biological & Medical Materials 6. Human Sciences 7.Operating Environment Technology 8. Computing Technologies & Mathematical Techniques 9. Information and Signal Processing Technology 10. Signature Related Materials
Meeting National Security Requirements (2) points	1. Electronic Materials Technology 2. Structural & Smart Materials & Structural Mechanics 3. Signature Related Materials 4. Photonic/Optical Materials & Device Technology 5. Electronic, Electrical & Electromechanical Device Technology 6. Chemical, Biological & Medical Materials 7.Systems and Systems Level 8. Information and Signal Processing Technology 9. Operating Environment Technology 10.Human Sciences

Participant-9	
Creating Asymmetric Effect (5) points	1. Directed Energy Technologies 2. Information and Signal Processing Technology 3. Cyber Security Operations 4. Communications and CIS-related Technologies 5. Cyber Security Solutions 6. Battlespace Information 7. Signature Related Materials 8. Electronic Materials Technology 9. Energetic Materials and Plasma Technology 10. Computing Technologies & Mathematical Techniques
Meeting National Security Requirements (3) points	1.Conventional Weapons Systems 2.Electronic Warfare 3. Directed Energy Technologies 4. Cyber Security Solutions 5. Information and Signal Processing Technology 6. Communications and CIS-related Technologies 7. Cyber Security Operations 8. Lethality and Platform Protection 9. Propulsion and Powerplants 10. Design Technologies for Platforms and Weapons
Being National (3) points	1. Information and Signal Processing Technology 2. Cyber Security Operations 3. Cyber Security Solutions 4. Directed Energy Technologies 5. Electronic Warfare 6.Conventional Weapons Systems 7. Guidance and Control Systems for Weapons and Platforms 8. Communications and CIS-related Technologies 9. Propulsion and Powerplants 10. Computing Technologies & Mathematical Techniques

C. QUESTIONNAIRE FORM AND DELPHI STATEMENTS

QUESTIONNAIRE FORM

A Model of R&D Performance for Turkish Defense Industry Companies

This study is conducted as part of a dissertation in Science and Technology Policy Studies Program at METU. The purpose of the study is to identify a Model of R&D Performance Indicators for Turkish Defense Industry Companies.

Questions in the questionnaire have no right or wrong answers; the right answer is the one that best reflects your opinions. The 19 Delphi statements in this questionnaire form cover the realizable issues in the defense industry. You are expected to answer the questions given under each Delphi statement based on your experiences.

Thanks a lot for your contributions to the study.

D-1 Delphi Statement

Smart materials with programmable features are to be manufactured for the use of defense industries. They are to be formed to fit the environment where they will be used, and be reshaped when necessary. These materials are not to be disposable, but reusable and reprogrammable.

D.1.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.1.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.1.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.1.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.1.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.1.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.1.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.1.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.1.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-2 Delphi Statement

Imaging systems manufactured for defense industries are to be in micro sizes, run on low energy, be entirely domestic, and have low costs.

D.2.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.2.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.2.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.2.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.2.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.2.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.2.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.2.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.2.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-3 Delphi Statement

High-resolution detector systems with low cooling needs that run on multiple wavelength, and can be used as a sub-system are to be manufactured.

D.3.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.3.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.3.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.3.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.3.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.3.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.3.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.3.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.3.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-4 Delphi Statement

Plasma propulsion engines used in satellites are to be domestically manufactured, and Turkey is to be among the first five leading countries in this area.

D.4.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.4.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.4.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.4.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.4.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.4.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.4.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.4.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.4.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-5 Delphi Statement

For use in space technologies, power systems that can withstand high temperatures are to be domestically manufactured.

D.5.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.5.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.5.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.5.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.5.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.5.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.5.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.5.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.5.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-6 Delphi Statement

Domestic low-cost antenna systems to detect and track visible/invisible sea surface and air targets effectively and accurately are to be developed.

D.6.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.6.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.6.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.6.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.6.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.6.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.6.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.6.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.6.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-7 Delphi Statement

Underwater platforms and weapons systems that are dependent on international procurement in terms of such features as speed, balance, strength, stealth, self-defending, sustainability, war power, and life lengthening are to be domestically manufactured.

D.7.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.7.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.7.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.7.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.7.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.7.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.7.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.7.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.7.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-8 Delphi Statement

Land, air, naval, and space platforms with portable and easy-to-use mission systems possessing qualities of speed, balance, strength, stealth, self-defending, autonomy, safety, cost-effective sustainability, are to be manufactured competitively and exported.

D.8.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.8.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.8.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.8.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.8.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.8.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.8.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.8.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.8.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-9 Delphi Statement

System technologies that direct the electromagnetic energy to target, focus it on target, and create destructive or nondestructive damage on target are to be designed to finally eliminate Turkey's dependency on foreign sources in this area.

D.9.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.9.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.9.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.9.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.9.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.9.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.9.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.9.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.9.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-10 Delphi Statement

Use of robotic organs for amputees is to be made widespread.

D.10.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.10.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.10.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.10.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.10.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.10.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.10.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.10.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.10.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-11 Delphi Statement

Hybrid devices that uses renewable energy sources (solar/wind/biogas etc.), and is capable of generating their own energy day and night are to be developed.

D.11.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.11.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.11.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.11.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.11.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.11.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.11.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.11.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.11.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-12 Delphi Statement

Simulators, trainers and synthetic environments where trainee's cognitive load can be balanced via artificial intelligence, which have high fidelity, which are as free of hardware as possible, where structural, live, virtual, and real trainings can be integrated and given in real time, and which allows for participation in trainings through standard infrastructures are to be developed and exported.

D.12.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.12.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.129.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.12.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.12.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.12.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.12.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.12.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.12.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-13 Delphi Statement

Domestic high-enthalpy plasma flow technologies are to be used in defense industries.

D.13.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.13.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.13.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.13.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.13.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.13.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.13.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.13.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.13.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-14 Delphi Statement

Domestic simulator systems and sub-systems are to be manufactured using virtual reality techniques to simulate the critical cues provided by the real platforms.

D.14.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.14.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.14.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.14.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.14.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.14.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.14.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.14.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.14.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-15 Delphi Statement

Simulators, trainers and synthetic environments that can help improve platforms and systems, can increase operational effectiveness and cost efficiency, can integrate structural, synthetic (virtual), real (live), and virtual trainings, and can also use AR and AI are to be developed.

D.15.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.15.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.15.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.15.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.15.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.15.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.15.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.15.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.15.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-16 Delphi Statement

Electronic Warfare and war gaming simulators that will collect temporal environmental data by real sensors and process it, and produce operational results using also AI technology are to be domestically manufactured.

D.16.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.16.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.16.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.16.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.16.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.16.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.16.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.16.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.16.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-17 Delphi Statement

Simulators that can direct movements through brain waves, and, relying on the coming data, can enable human to experience the result with a signal to be sent back to brain are to be developed.

D.17.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.17.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.17.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.17.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.17.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.17.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.17.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.17.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.17.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-18 Delphi Statement

Certification, verification, and accreditation of airworthiness software for air platforms are to be national and internationally valid.

D.18.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.18.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.18.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.18.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.18.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.18.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.18.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.18.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.18.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D-19 Delphi Statement

Encryption technologies built on quantum switching and coding are to be developed.

D.19.1 Participant's level of expertise about the Delphi statement

1. None 2. Moderate 3. High

D.19.2. Sufficiency of human resources in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.19.3. Level of core knowledge in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.19.4. Hard infrastructure (devices/equipment) capacity in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.19.5. Company capabilities in our country about the Delphi statement

1. None 2. Low 3. Moderate 4. Strong 5.No opinion

D.19.6. Date of execution

1. Before 2023 2. Between 2023 and 2028 3. After 2028 4. Never

D.19.7. Contribution of the issue in the Delphi statement to Turkey's competitive power

1. Negative 2. None 3. Little 4. Fair 5. High

D.19.8. Contribution of the issue in the Delphi statement to Turkey's science, technology, and innovation capacity

1. Negative 2. None 3. Little 4. Fair 5. High

D.19.9. Contribution of the issue in the Delphi statement to environmental awareness and energy efficiency in Turkey

1. Negative 2. None 3. Little 4. Fair 5. High

D. CURRICULUM VITAE

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EDUCATION

Degree	Institution	Year of Graduation
MS	Gazi University, Electrical-Electronic Engineering	2011
BS	Erciyes University, Electronics Engineering	2004
High School	Yozgat Science High School	1996

WORK EXPERIENCE

Year	Place	Enrollment
2018- Present	RTUK, ANKARA	Deputy Head of Permits and Allocations Department
2012- 2018	RTUK, ANKARA	Electronics Engineer
2007- 2012	HAVELSAN, ANKARA	Project Engineer
2005- 2007	HAVELSAN, ANKARA	System Engineer

FOREIGN LANGUAGES

English

PUBLICATIONS

1. Dağ O., Ertem H., Akçam N., "Flir Görüntülerinde Hedef Tespiti", 2. Elektrik Tesisat Ulusal Kongresi, İzmir, (2011)

2. Karapınar H., Dağ O., Ertem H., "Uçuş Simülatörleri Flir Görüntülerinde Hedef Tespit ve Takibi", SAVTEK, Ankara, (2012).

E. TURKISH SUMMARY/TÜRKÇE ÖZET

GİRİŞ

Bilim ve teknoloji alanındaki ilerlemeler, ekonomik ve toplumsal olarak gelişmenin en önemli unsurlarındandır. Bilim ve teknoloji politikaları ise bu gelişmelerin hızını ve yönünü belirleme amacıyla kullanılmaktadır. İstenilen hedeflere ulaşmak için eğitimli ve yetişmiş insan gücüne ihtiyaç duyulmakta birlikte hedef kapsamında Ar-Ge, sanayi ve eğitim politikaları birlikte yürütülmelidir (Yilmaz,2014).

Katma değeri yüksek ürünlerin üretilmesi, rekabet üstünlüğünü korumak ve halkın refahını artırmak için bilimsel ve teknolojik alanlarda ilerlemeler ve gelişmeler kaydetmek gerekmektedir. Bu yapılırken bilim, teknoloji ve sanayi politikalarının ülkenin şartlarına ve dünyadaki mevcut yapı üzerindeki konumuna bakılarak planlamasının yapılması daha doğrudur (Uzkurt, 2014). Çünkü bu politikalar ülkelerin refah seviyesini doğrudan etkilemektedir (Seyrek ve Karakaya,2008).

Bilimsel ve teknolojik gelişmelerle elde edilen kazanımların üretim yöntemlerine aktarılması yeni ürün ve yöntemlerin gelişmesini sağlamaktadır. Diğer bir deyişle Ar-Ge harcamaları yatırım niteliğinde olup yatırımdan elde edilecek karlar Ar-Ge yatırımı değerinden çok daha yüksek olabilmektedir. Ar-Ge faaliyetleri, yeni teknik bilgilerinin elde edilmesi, üretim, yöntem ve süreçlerin geliştirilmesi, özgün tasarımlarının yapılması, ürün maliyetlerinin düşürülmesi ve kalite standartlarını artırmaya yönelik çalışmaları kapsamaktadır (Agir, 2010). Günümüz dünyasında uluslararası piyasada rekabet edebilmek için ucuz ve kaliteli ürünler üretmek gerekmektedir. Bilim ve teknolojiyi ekonomik ve toplumsal faydaya dönüştürebilen ülkeler diğer ülkeler göre rekabet üstünlüğü elde etmektedirler. Bu noktada ülkelerin Ar-Ge harcamalarının, gayri safi milli harcamaya oranı önemli bir göstergedir. Ar-Ge faaliyetlerinde çalışan sayısı, alınan patentler, yayınlanan ve atıf yapılan bilimsel yayınlar, yüksek teknoloji ürünlerin ihracat içindeki oranı gibi göstergeler Ar-Ge

kapsamında değerlendirilmektedir (Agir, 2010). Ar-Ge yatırımları rekabet gücü ve ekonomik gelişmişlik göstergesi olarak düşünülmekte olup uzun vadede ise refah ve verimliliğin artırılmasında anahtar unsurdur (Korkmaz, 2010).

Ar-Ge kapsamında dünyada en fazla kaynak ayrılan sektörlerden biri de savunma sanayii sektörüdür. Genel olarak savunma sanayii Ar-Ge'si ile milli silah sistemlerinin geliştirilmesi ve üretilmesi, yurt dışına bağımlılığın azaltılması, yeni ürünlerle pazar payının artırılması ve ülkelerin stratejik hedeflerinin gerçekleştirilmesi amaçlanmaktadır (Genç, 2013). 1999-2008 yılları arasında dünya genelinde savunma harcamalarında %45 oranında bir artış yaşanmıştır (Genç, 2013).

Türkiye'de savunma sanayii kapsamında yapılan Ar-Ge faaliyetleri son yıllarda hız kazanmıştır. Savunma sanayii Ar-Ge'si kapsamında yapılan çalışmalar sayesinde ekonomi ve diğer sektörler de olumlu yönde etkilenmektedir. Anlaşılacağı üzere Ar-Ge faaliyetleri ülkelerinin gelişmesinde önemli bir yer tutmaktadır. Ar-Ge, maliyet ve yatırım gerektiren çalışmalardır. Dolayısıyla firmalar, bu yatırımları yaparken zarar etmemek ve sonuç almak için biz dizi kontrol ve incelemeler yaparak Ar-Ge faaliyetlerinin durumunu takip etmelidirler.

Ancak her ülkenin savunma sanayiine yönelik kanun ve mevzuatı farklı olduğundan, savunma sanayii konuları gizlilik barındırdığından savunma sanayii Ar-Ge'si konusunda uluslararası verilerin tek ve yaygın olarak kabul gören bir kaynağın olmamasından dolayı savunma sanayii Ar-Ge faaliyetlerinin performansı ölçümü ülkelere göre farklılık arz etmektedir (Gallart, 1999). Ayrıca her bir Ar-Ge projesi ve organizasyonu kendine özgü olduğundan, Ar-Ge'nin ölçümü için genel anlamda ölçütler yoktur (Temel, Kaplan ve Sonkaya, 2016). Bundan dolayı bu tez çalışmasında, Türkiye'de savunma sanayiine yönelik Ar-Ge faaliyetlerinin performans ölçümüne dair metrikler ve ölçüm yöntemlerinden bahsedildi. Bu kapsamda *Türk Savunma Sanayii Firmalarının Ar-Ge ve inovasyon vizyonu ne olmalı?* sorusuna cevap aranarak, teknoloji değerlendirme kriterlerinin ağırlıklandırılması ve teknoloji alan sıralaması yapıldı. Sonrasında savunma

sanayiine yönelik ortaya çıkan 19 adet Delphi cümlesiyle ilgili iki turlu Delphi anketi gerçekleştirildi. Anket neticesinde ön plana çıkan D.14 Delphi cümlesi:

Gerçek platformlardaki ayırt edici kritik karakteristik özellikleri simüle etmek için sanal gerçeklik teknikleri kullanılarak yerli simülatör sistem ve alt sistem teknolojileri üretilecektir. ile ilgili D.14.8 sorusunu: *Delfi cümlesindeki konunun Türkiye'nin bilim teknoloji ve yenilik yeteneğine katkısı* gerçekleştirmek için 2023'e ve 2023-2028 yılları arasında yapılması gerekenler ilgili teknik uzmanlarla yapılan yüz yüze görüşmeler dikkate alınarak belirlendi.

TÜRK SAVUNMA SANAYİİ TARİHİNE KISA BAKIŞ

Yavuzyılmaz (2014) savunma sanayiini ülke savunması için yatırım yapılan ve bu amaçla hizmet ve çeşitli üretim süreçlerinin işlenmesi ile ilgili organizasyonların bulunduğu sanayi türü olarak tanımlamaktadır. Türk Savunma Sanayii' nin geçmişi, Osmanlı Devleti'nin İstanbul'u almasına kadar uzanmaktadır. Zamanla Osmanlı Devleti' nin sınırlarının genişlemesiyle birlikte ekonomisi büyümüş ve buna bağlı olarak ta harp sanayii gelişmiştir. Örneğin muhasara altına alınan kalelerin dövülmesinde kullanılan toplar, deniz savaşlarında kullanılmak üzere donanma için tersanelerde üretilen gemiler gelişim göstergesi olarak sayılabilir.

Turan (1999), Osmanlı Devleti'nin 1683 Viyana kuşatmasındaki başarısızlık sonrası gerileme sürecine girdiğini ifade etmiştir. Teknik ve ekonomik alandaki gerileme neticesinde savunma sanayii alanında ön planda olan konumunu kaybetmeye başlamıştır. Bu süreç Türkiye Cumhuriyeti Devleti' nin 29 Ekim 1923 tarihinde kurulana kadar devam etmiştir. Önder (2005),' e göre Cumhuriyet ilan edildikten sonra Askeri Fabrikalar Umum Müdürlüğünce başta İstanbul olmak üzere Anadolu'nun muhtelif şehirlerinde olan işletme ve fabrikalar merkezi bir yönetim altında toplanmıştır. 1924 yılında Ankara'da hafif silah ve top tamir atölyeleriyle fişek fabrikası, Gölcük'te Gölcük tersanesi inşa edilmiş, bir yıl sonra Şakir Zümre tarafından İstanbul Haliç'te ilk özel sektör savunma sanayii fabrikasının temellerinin atılmış, 1926 yılında Tayyare ve Motor Türk A.Ş. kurulmuş, 1930'lu yıllarda İstanbul'da Nuri Killigil tesisleri, 1940 yılında Nuri Demirağ uçak fabrikası

tarafından NUD-36 eğitim uçağı 24 adet imal edilmiş ve 1944 yılında NUD-38 altı (6) kişilik yolcu uçağı üretilmiştir. Önder (2005), Ankara'da Türk Hava Kurumu tarafından kurulan uçak fabrikasının 1944 yılında eğitim uçağı, ambulans uçağı, hafif nakliye uçağı ve planörler ürettiğini bunun yanında 1943 yılında Nuri DEMİRAĞ tarafından kurulan uçak fabrikasının ise AR-GE ve sipariş yetersizliğinden kapanmak zorunda kaldığını belirtmiştir.

Karakaş (2009)' a göre Amerikan Başkanı Roosevelt tarafından 1941 yılında "Ödünç verme ve Kiralama" kanunu gereği Türkiye'ye İngiltere üzerinden 50 adet 155 milimetrelik havan topu ve 18500 ton cephane verilmesine onay verildi. Türkiye 1947'de Truman Doktriniyle Amerika Birleşik Devleti'nden askeri yardım almaya devam etti ve 1952 tarihinde NATO'ya üye oldu. Kurt (2017), Türkiye' nin NATO üyeliği neticesinde Türk Silahlı Kuvvetleri sisteme bütünleşmiş olduğunu ancak bu üyelik sonucunda Türk Silahlı Kuvvetleri'nin askeri ihtiyaçlarını planlama ve yönetme kapasitesinde azalma meydana geldiğini belirtmiştir.

Köseoğlu (2010), 1950 yılında çıkarılan 5591 sayılı Kanunla, Makine ve Endüstrisi Kurumu'nun kurulduğunu ve sermayesinin tamamının devlet tarafından sağlandığını ayrıca çıkarılan bu kanun ile Askeri Fabrikalar Umum Müdürlüğünün, Makine ve Endüstrisi Kurumuna devredildiği belirtmiştir. Önder (2005)' e göre 5591 Sayılı Kanun kapsamında kuruma devredilen kuruluşlar şunlardır:

- Silahtarağa Av Fişek Fabrikası
- Bakırköy Barut Fabrikası
- Kayaş Kapsül Fabrikası ve Mermi İmalathanesi
- Mamak Gaz ve Maske Fabrikası
- Ankara Marangoz Fabrikası
- Ankara Silah Fabrikası
- Ankara Fişek Fabrikası
- Elmadağ Barut ve Patlayıcı Maddeler Fabrikası
- Kırıkkale' de bulunan fabrika, tesis ve bütün binalar

1974 yılında Türkiye, Kıbrıs Barış Harekatı' nı gerçekleştirdi. Bu harekat sonrası Türkiye' ye silah ambargosu uygulandı. Ambargo, Türkiye' nin Truman Doktrinleri ile başlayıp NATO'ya girmesiyle gerileme sürecine giren milli savunma sanayiinin önemini açık şekilde göstermiştir. Bunun sonucunda, Hava kuvvetlerine yönelik TUSAŞ, HAVELSAN, Aydın A.Ş., Deniz kuvvetlerine yönelik DİTAŞ ve NETAŞ, Kara Kuvvetleri için de ASPİLSAN ve ASELSAN şirketleri kurulmuştur.

Savunma Sanayii Başkanlığı

1985 yılında 3238 sayılı kanun ile Savunma Sanayiinin gelişmesi amacıyla Savunma Sanayii Geliştirme ve Destekleme İdaresi Başkanlığı (SAGEB) kuruldu ancak 1989 yılında bu kurum Savunma Sanayii Müsteşarlığı adı altında yeniden yapılandırıldı (Köseoğlu,2010). Savunma Sanayii Müsteşarlığı, 2017 yılında Türkiye Cumhuriyeti Cumhurbaşkanlığına bağlanmış 2018 yılında yayınlanan 703 sayılı KHK (kanun hükmünde kararname) ile yeniden yapılandırılarak Savunma Sanayii Başkanlığı ismini alarak, modern bir savunma sanayii geliştirmek ve Türk Silahlı Kuvvetleri'nin modernizasyonunu sağlamak amacıyla;

- Savunma Sanayii İcra Komitesinin aldığı kararları uygulamak
- Proje bazında alınacak programların sözleşmelerini yapmak
- Milli savunma sanayiini, ihtiyaçlara göre yeniden düzenlemek, ülke dışı sermaye ve teknoloji fırsatlarını bulmak
- Mevcut mali imkanlara göre alım programlarının finansman modellerini yapmak
- Gereksinimlere göre ihtiyaçları, özel sektör ve kamuya yaptırmak.
- Kamu ve özel sektör yatırımlarını desteklemek
- İhtiyaca göre ürünlerin geliştirilmesi, prototiplerinin yapılması, mali teşvikleri tespit etmek
- Kullanıcının istekleri doğrultusunda proje bazında teknik ve mali konuları dikkate alarak sözleşmeler yapmak
- Ürünlerin ihracatı ve off-set konularını takip etmek
- Mali olarak kredi alma ve verme, gerekli durumlarda şirket kurmak

İle görevlendirilmiştir. Tez çalışması kapsamında Savunma Sanayii Başkalığı ‘nca odak grup çalışmasına katılımcı bazında, Delphi çalışmalarına ise anket kapsamında destek sağlayabilecek Ar-Ge çalışmaları yürüten firmaların isimlerinin belirlenmesi hususunda destek sağlanmıştır.

LİTERATÜR ARAŞTIRMASI

Bu tezde Ar-Ge performans ölçümüne ilişkin literatür çalışması üç başlık altında gruplandırılarak yapılmıştır. Bu başlıklar sırasıyla şöyledir:

1. Ar-Ge performans ölçüm metrikleri
2. Ar-Ge performans ölçüm yöntemleri
3. Savunma sanayiinde Ar-Ge

Yapılan sıralamaya göre her bir konu başlığı ile ilgili makaleler incelenerek değerlendirilmiştir. Bölüm sonunda incelenen makaleler sonucunda genel değerlendirme yapılmıştır.

Ar-Ge Performans Ölçüm Metrikleri İle İlgili Çalışmalar

Chiesa, Frattini, Lazzarotti, Manzini ve Troia (2008), son yıllarda performans ölçümünün şirketlerin rekabet avantajı sağlamaları ve bu avantajı devam ettirmelerinde önemli rollü olduğundan ayrıca bu ölçümler sayesinde elde edilen raporlar üst düzey yöneticilere sunularak şirketlerin durumu hakkında bilgi verildiğinden söz etmektedir. Ölçüm yapılırken paylaşılmasından imtina edilen konuların başında ticari mali sırlar gelmektedir. Chiesa ve arkadaşları (2008)’ göre Performans ölçümümün amaçları,

- Kaynak dağılımını ayarlamak, proje ilerlemesini izlemek ve proje karlılığını değerlendirmek
- Personeli motivasyonunu sağlamak
- İletişim ve koordinasyonun geliştirilmesi sağlamak
- Öğrenmenin artırılması sağlamak
- Ar-Ge risk ve belirsizliklerinin azaltılmasını sağlamak

olarak sıralanırken, uygulanacak birimler;

- Belirli bir çalışma alanındaki veya teknolojik disiplin içindeki Ar-Ge faaliyetlerinden sorumlu birimler
- İş birimlerinin özel Ar-Ge birimleri
- Proje ekipleri
- Bireyler

olarak belirtilmiştir. Chiesa ve arkadaşları (2008) çalışmalarında performans ölçümünde dikkat edilmesi gereken bağlamsal faktörleri de şu şekilde sıralamıştır:

- Şirketin Ar-Ge stratejisi
- Ar-Ge organizasyonunun türü
- Gerçekleştirilen faaliyetlerin türü (temel araştırma ve / veya uygulama araştırma ve / veya geliştirme) ve risk düzeyinin ilişkili seviyesi
- Zaman, para, insan teknolojisi ve know-how bakımından performans ölçüm sisteminin uygulanması ve kullanımı için mevcut kaynaklar
- Şirketin faaliyet alanı

Laliene ve Ojanen (2015) çalışmalarında, Araştırma ve geliştirme (Ar-Ge) faaliyetini organizasyonel seviyede değerlendirirken, etkinlik ve verimlilik açısında geçerli bir şekilde değerlendirme için en doğru göstergeleri seçmenin son derece önemli olduğundan bahsetmektedir. Çalışmada bir araştırma organizasyonunda Ar-Ge ölçümü, yedi başlık ve bunların altındaki göstergelerden oluşmaktadır. Metrikler, kaynaklar, proje yönetimi, insan kaynağı yönetimi, planlama, yeni teknoloji çalışması ve geliştirmesi, çıktı ve sonuçları kapsamaktadır. Laliene and Ojanen (2015)' göre Ar-Ge faaliyet süreçleri; *Girdi - Süreç - Çıktı - Transfer Sistemi - Sonuç* şeklinde modellenmiştir. Girdide, parasal ve parasal olmayan kaynaklar, insanlar, fonlar, araçlar ve bilgi yer almaktadır. Süreçte, temel araştırma, uygulamalı araştırma ve deneysel geliştirme bulunmaktadır. Çıktıda, bilimsel ve teknolojik performans sonuçları mevcuttur.

Kulatunga, Amaratunga ve Haigh (2006) çalışmalarında, 1970 yıllarda Ar-Ge ile ilgili performans göstergeleri;

- Ürünler (patentler, teknik yayınlar veya teknik yayınlara atıflar)
- AR-GE'den (kazançlar, satışlar) imtiyaz sahibi olan mali yardımlar;
- Bireysel Ar-Ge projelerinin başarısı ile ilgili kararlar

olarak sınıflandırılırken 2000 yıllarda şirket amaç ve hedefleri doğrultusunda başarı sağlamak için mali ve mali olmayan önlemlerin alınması hususunu kapsayan performans ölçümlerinin gerekliliği vurgulanmaktadır. Ayrıca çalışmada ölçütler bakımından, çıktı kalitesi, hedefe ulaşma,zamanında yapılan iş miktarı,proje tamamlama yüzdesi,yapılan işin miktarı,müşteri memnuniyeti,müşteri kabulü, pazar payı ve satış hedefleri,finansal hedeflere ulaşma,eğitim durumu,nitelikli personel,koordinasyon ve geri bildirim mekanizmaları,yeni ürün satışlarının yüzdesi,ürün geliştirme maliyetleri ve stratejik hedeflere ulaşma kriterleri metrik olarak belirtilmektedir.

Chiesa, Frattini ve Manzini (2009) çalışmalarında performans göstergeleri olarak; Ar-Ge süreçlerinin başlığı altında: İnsanın memnuniyeti, kaynak tüketimi hedefleri, kalkınma hedefine ulaşılması,maliyetler,gelişime saygı,zamansal kilometre taşları Ar-Ge işlemleri başlığı altında: Çalışmaya saygı, prosedürler,hedeflerin başarılması,maliyetler ve zamanlanmış kilometre taşları Yenilik yeteneği başlığı altında: Teslimat kapasitesi,çıktı olarak istenilen özelliklerin karşılanması Oryantasyon başlığı altında:Yetenek hedefi,önemli alanlar,büyüyen potansiyeller Ar-Ge süreçlerinin verimliliği başlığı altında: Zamanlanmış kilometre taşlarına uymak finansal perspektif başlığı altında: Araştırma projelerin karlılığı belirtilmektedir.

Lee, Park ve Choi (2009) çalışmada girdi olarak projeye verilen toplam mali kaynak ve insan kaynağı olarak doktoralı araştırmacı sayısı çıktı olarak ise ulusal ve uluslararası bazda SCI (science citation index) yayınlanan bilimsel ve teknik makale sayısı, ulusal ve uluslararası patent ofislerinden alınan patent sayıları ve proje kapsamında alınan yüksek lisans-doktora dereceleri belirtmekteler.

Chiesa, Frattini, Lazzarotti ve Manzini (2008) çalışmalarında metrik olarak, ortalama müşteri memnuniyeti, yıl boyunca elde edilen teknolojilerin/uzmanlıkların uluslararası uygunluğu, yeni teknolojiler / yetkinlikler kazanmak için gereken zaman, ortalama hizmet maliyet farkı, zamanında tamamlanan projelerin yüzdesi,müşterilerle görüşme sıklığı, bilimsel alandaki şirket araştırmacılarının yayınlarının atıf sayısı,istenen hedef oranında tespit edilen yeni müşterilerin yüzdesi,şartlı/tanımlı işbirliklerinin sayısı,tamamen memnun işbirliği unsurlarının yüzdesi olarak tanımlanmaktadır.

Ar-Ge Performans Ölçümünde Kullanılan Yöntemler İle İlgili Çalışmalar

Ojanen ve Voula (2003) göre, Ar-Ge faaliyetleri ve Ar-Ge personeli ile ilgili özellikler performans analizini zorlamaktadır. Çalışmada, ölçüm boyutları sınıflara ayrılmış olup bunlar sırasıyla Ar-Ge performans analiz seviyesi, değerlendirilecek Ar-Ge türü ve ölçülecek Ar-Ge sürecinin fazıdır. Makale Balanced Scorecard (BSC) yaklaşımının strateji ve vizyonu öne çıkaran farklı performans ölçütlerini ilişkilendiren bir yaklaşım olduğunu vurgulamaktadır.

Parisi ve Rossi (2015) yaptıkları çalışmada şirketlerin Ar-Ge performans ölçümlerini Balanced Scorecard ile nasıl birleştirilebileceğini anlatarak Balanced Scorecard'ı Finansal, Müşteri, Yeterlilik ve İnsan olmak üzere dört farklı bakış açısına göre ele aldılar. Makalede, mevcut ölçüm sistemlerinin sonuç odaklı olduğunu, alınan tedbirlerin mali yönden yapıldığını ancak ürün tasarım ve geliştiricilerin yönetim sorunları bakımından tedbir noktasında yetersiz kalındığı belirtilmekte, ayrıca proje ve yenilik stratejilerinin programın genel başarısını etkilediğini dolayısıyla performans ölçümünün de şirketin genel olarak stratejisini desteklemesinden söz edilmektedir. Makalede performans ölçütlerini tanımlamak için beş kategoriden bahsedilmekte bunlar, maliyet, kalite, zaman, yenilikçilik ve kâra katkıdır.

Zizlavsky (2014), Balanced Scorecard'ın küçük ve orta büyüklükteki şirketlerde stratejik yönetim kontrol sistemi olarak uygulanmasına odaklanmaktadır. Çalışmada, yönetim kontrolü, yöneticilerin kuruluşun hedefine ulaşması için

kaynakları bulma ve bunları etkin ve verimli bir şekilde kullanıldığı süreç olarak tanımlanmaktadır.Makalede önemli performans ölçüm yöntemleri olarak,Performans Ölçüm Matrisi , Performans Piramidi , Entegre Performans Ölçüm Sistemleri, Performans Prizması,Veri Zarf Analizi, Kuantum Performans Ölçümü veya Verimlilik Ölçüm ve Geliştirme Sistemi ve en çok bilinen yönetim modeli modeli Balanced Scorecard'dır. Zizlavsky (2014)' e göre inovasyon süreçlerinin iyi anlaşılması iş modelinin de iyi olmasını sağlayacak olup bu nedenle değer zincirine dayanan ve kritik şirket süreçlerini kapsayan süreç sınıflandırması olarak Balanced Scorecard'ı kullanmayı öneriyor. Zizlavsky (2014) çalışmasında Balanced Scorecard'ın, finansal, müşteri, dahili iş süreçleri ve potansiyel (öğrenme ve gelişme) olmak üzere dengelenmiş dört perspektifi kullandığından söz etmektedir.

Santos, Lucianetti ve Bourne (2012) göre performans ölçüm sistemlerinin kullanılmasının amacının kuruluşların strateji uygulamalarını kolaylaştırmak ve performanslarını artırmak olduğunu ifade etmektedirler. Çalışmada çağdaş performans sistemlerinin sonuçları üç bölüme ayrılmış olup sırasıyla insanların davranışları (çalışanların eylemleri, tepkileri, motivasyonları), örgütsel yetenekleri(rakabet avantajı, stratejik uyum, organizasyonel öğrenme) ve performans (firma,yönetim ve takım performansı) sonuçları.

Peng, Hu ve Xin (2012) çalışmalarında Ar-Ge biriminde çalışan mühendislerin performanslarını ölçmeye çalışmışlar. Mühendislilerin performans ölçümünün diğer Ar-Ge çalışanlarının performans ölçümünden farklı olabileceğini öne sürmekteler. Çalışanlarda değerlendirme kriterleri, ahlak, yetenek, çalışkanlık ve performans olmuştur. Çalışmada, personel kalitesi; bilgi düzeyi, öğrenme yeteneği, inovasyon özelliği, problem çözme becerisine bakılarak sınıflandırılmıştır.

Lee, Park ve Kim (2013) çalışmalarında kamu Ar-Ge projelerinin performansını ölçmek için yeni bir balanced scorecard çerçevesini geliştirmişler. Lee ve arkadaşaları (2013) göre balanced scorecard, bir organizasyonda başarı faktörleri türetir ve onları yönetim stratejine bağlar ayrıca organizasyonel performansı dört açıdan ölçer: finansal, müşteri, iç iş süreçleri ve öğrenme ve büyüme.

Savunma Sanayiinde Ar-Ge Çalışmaları

Jacobsson ve Philipson (1996) göre ülkeler ve şirketlerin rekabet avantajını devam ettirebilmesi dolayısıyla ekonomik olarak büyümeleri, bilimsel ve teknolojik bilgileri üretmelerine, kullanmalarına ve yaymalarına bağlıdır. Makalede eğer küçük firmalar verilerin paylaşmazlarsa bunun veri kaybına yol açtığını, patentin ise dünyada yol açıcı ve yeni olması, ticari olarak uygulanabilmesi ve uygulayıcıya çözümler sunması gerektiğinden, İsveç'in metal ve mekanik alandaki göstergelerinin öne çıktığından söz edilmektedir.

Gallart (1999) çalışmasında savunma alanındaki Ar-Ge faaliyetlerinin giderek arttığını, ancak nicekliksel analizin yapılmasında savunma Ar-Gesinin tanımlanmasının gerekliliğinden söz etmektedir. Çalışmada, OECD tarafından savunma ve sivil alandaki Ar-Ge çalışmaların ayrımın zor hale geldiğinden, savunma Ar-Ge konusundaki verilerin tek ve yaygın olarak kabul gören bir kaynağı olmadığından ve ülkelerin, savunma araştırmaları için farklı mevzuatlara sahip olduğundan, savunma Ar-Gesinde ulusal bazda karşılaştırılabilir tek veri kaynağının OECD de olduğundan, OECD ye ait savunma Ar-gesi tanımlarının ise yanlış tahminlere yol açabileceğinden söz edilmektedir.

Chakrabarti ve Anyanwu (1993) göre Amerikada savunma Ar-Gesi sayesinde özellikle bilgisayar dünyasında yeni teknolojilerin gelişmesi sağlandı. Bunun karşılığında Elektronik, bilgisayar, yarı iletken malzemeler ve havacılık sektörü savunma sanayiinin gelişiminde önemli rol almış olan alanlardır. Savunma Ar-Ge harcamaları sivil alana yönelik mal ve hizmet talebini oluşturdu. Savunma Ar-Gesi ile sivil ekonomi arasında aşağıdaki maddeler kapsamında ilişki bulunmaktadır.

- Askeri Ar-Ge kapsamında temel ve uygulamalı araştırmaların yapılması,
- Savunma alanından sivil alana teknolojin geçmesi,
- Savunma harcamalarının sanayi politikası olarak uygulanması,
- Gerektiğinde sivil kullanım için savunma tesislerinin dönüşümü,

Hartley (2006) çalışmasında savunma Ar-Ge sinin bir ülkenin silahlarını çoğaltmasını yerine teknoloji kullanarak askeri yeteneğinin geliştiğini ifade etmektedir.Savunma Ar-Gesinde çalışan bilimsel personel ve Ar-Ge çıktılarının sivil alanda kullanımı ekonomi gelişimini etkilemektedir. Savunma Ar-Ge verileri OECD Bilim ve teknoloji göstergelerinden ve SIPRI yıllığından elde edilebilmekte. Veri olarak savunma harcamalarının gayrisafi milli hasıladaki yeri, devlet tarafından fonlanan Ar-Gede savunma Ar-Ge paylarına bakılabilmekte (Hartley, 2006).

Literatür İncelemesi Sonucundan Yapılan Değerlendirmeler

Genel olarak Ar-Ge projelerinde bakılabilecek metrikler şunlardır:

- Cari harcamalar,
- Yatırımlar,
- Parasal ve parasal olmayan kaynaklar
- Maliyetleri düşürme oranları,
- Satış değerleri ve hedefe ulaşma oranı,
- Planlanan ve fiili proje harcamalarının kıyaslanması,
- Ar-Ge personeli için yapılan harcamalar,
- İnsan kaynakları ve teknolojilerin miktarı ve niteliği,
- Çalışanların motivasyonu,
- Yeni teknolojiler ve çığır açan kavramlar,
- Proje kapsamında yapılan yüksek lisans ve doktora tezleri,
- Ulusal ve uluslararası patent ofislerinden alınan patentler ve sayıları,
- Yapılan bilimsel yayınlar,
- Bilimsel yayınlara yapılan atıf sayısı,
- Bilginin toplanması için çalışanların öğrenmeye teşvik edilmesi,
- Organizasyonel ve bireysel yaratıcılığa ilişkin yetenek performansı,
- Edinilen bilgi ve kullanılabilirliği,
- Etkinlik ve verimlilik bakımından, kavram yaratma, proje seçimi, teknoloji edinimi,
- Kullanılan ekipmanların kalitesi,

- Başarıyla tamamlanan projelerin sayısı ve niteliği,
- İşi zamanında bitirme yüzdesi,
- Projede risk ve belirsizliklerinin azaltılması,
- Geliştirilen yeni ürünler ve kalitesi,
- İnovasyon projelerinin başarı yüzdeleri,
- Yapılan inovasyon ürünlerinin pazardaki başarı yüzdeleri,
- Ar-Ge projesinin büyüme ve rekabete olan katkısı,
- Kurumsal stratejik hedeflere ulaşma başarısı,
- Müşteri odaklı projelerin yüzdesi,
- Kurumsal olarak pazarda bilinirlik oranı ve itibarı,
- Diğer kuruluşlarla iş birliği yeteneği,
- Şartlı/tanımlı iş birliklerinin sayısı ve başarı yüzdesi,
- Müşteri memnuniyeti oranları,
- Satış sonunda müşterilere sağlanan destekler,
- Ürünlerin tedarik zinciri kanalının olması ve altyapısının sağlanması,
- Geri bildirim mekanizmalarının varlığı ve çalışması

Literatürde performansın neden ölçülmesine ilişkin bir çok öneri bulunmakla birlikte ölçüm yöntemleri olarak, Performans Ölçüm Matrisi , Performans Piramidi , Entegre Performans Ölçüm Sistemleri, Performans Prizması, Veri Zarf Analizi, Kuantum Performans Ölçümü ve Balanced Scorecard (BSC) kullanıldığından bahsedilmektedir.Ar-Ge performans ölçümünde kullanılan yöntemler arasında en yaygın olanı Balanced Scorecard (BSC) yaklaşımıdır. Balanced Scorecard, uygulanan stratejiye göre kuruluşların performansının ölçmekte olup diğer ölçüm sistemlerinden farklı olarak stratejik hedeflerin ve somut olmayan sonuçların, performansı arttırmak için takip edilmesi gereken operasyonel önlemlere dönüştürülmesini sağlamaktadır. Ayrıca, BSC şirketlerde stratejik yönetim kontrol sistemi olarak uygulanmaktadır. Bu yaklaşımla bir kuruluşun görev ve stratejisinin anlamlı şekilde ölçülmesi mali perspektif hedefleri, müşteri perspektif hedefleri, yenilik ve öğrenme perspektifi hedefleri bazında ilgili metrikler kullanılarak yapılmaktadır. Genel olarak Balanced Scorecard (BSC) ile finansal, müşteri,

yeterlilik (dahili iş süreçleri) ve insan (öğrenme ve gelişme) olmak üzere dört farklı bakış açısına göre ele alınarak performans ölçümü gerçekleştirilmektedir.

Ülkelerin teknolojik yenilik ihtiyaçlarının olması Ar-Ge yatırımlarının artması ile doğru orantılıdır. Savunma Sanayii Ar-Ge sinin gelişimi ve ortaya çıkardığı ürünler sayesinde ordulara teknolojik anlamda üstünlükler sağlamaktadır. ABD'de savunma sanayii Ar-Ge si projeleri ile bilgi teknolojilerinde gelişim sağlanmış olup bunun etkisi ile elektronik, bilgisayar, yarı iletken malzemeler ve havacılık sektörü çok büyük yol katetmiştir. Anlaşıldığı üzere savunma Sanayi Ar-Ge' sine yapılan yatırımlar, sivil sektörlerin gelişimiyle ekonomik gelişim, teknoloji, bilimsel bilgi ve iş gücü gelişimi de sağlamaktadır.

ÇALIŞMA METODU

Bu bölümde, tez kapsamında kullanılan nitel araştırma, odak grup yöntemi ve anket hakkında bilgiler verilmektedir. Devamında anket türleri, anket sorularının oluşturulması, Delphi tekniği, Delphi tekniğinin uygulama safları, planlaması, katılımcıların belirlenmesi konuları ele alınmaktadır. Son olarak iki turlu Delphi anketinin nasıl yapıldığı anlatılmaktadır.

Odak Grup Yöntemi

Odak grup görüşmeleri yapılırken, hem derinlemesine mülakat hem de gözlem tekniklerinin özelliklerinden yararlanılır. Gruplar oluşturulurken homojen veya farklı özelliklere sahip karışık kişilerin bir araya gelmelerinden faydalanılır. Gruplar oluşturulduktan sonra, bir kişi oturumu yönetmek üzere görevlendirilir bu kişiye moderatör denir (Coşkun, Altunışık, Bayraktaroğlu ve Yıldırım , 2004**).** Yönlendirici yani moderatör, katılımcıların fikirlerini ifade edebilecekleri, konuşmaların ve tartışmaların uygun ortamda yapılmasından sorumludur. Odak grup görüşmeleri, 8-12 kişi ile birlikte yaklaşık 1 ile 3 saat arası sürmektedir. Moderatör, toplantı esnasında gözlemci olmalı ve yorumlara müdahil olmayarak tarafsız bir tutum sergilemelidir. Ayrıca moderatör katılımcılara karşı nazik davranmalı ve empati yapmalıdır.

Görüşme için önce araştırma konusu belirlenir sonrasında kimlerin, nerede, ne zaman bir araya gelerek görüşme yapacağı kararlaştırılır. Katılımcıların araştırma konusuna vakıf kişilerden seçilmesine dikkat edilir. Sorulacak sorular ve alt başlıkları daha önceden belirlenmelidir. Açık uçlu sorular sayesinde katılımcıların tamamının görüşmeye katkı sunması sağlanmalıdır (Böke, 2014). Birbirini tanıyan gruplarda katılımcılardan bazıları diğerleri üzerinde psikolojik baskı kurarak onların konuşmasını katılım sağlamalarını etkileyebilirler.

Grup görüşmeleri araştırmalara önemli ölçüde katkıda bulunabilir. Odak grup görüşmelerinin önemli özelliklerinden birisi, elde edilmesi güç olan verilerin grup etkileşimi sayesinde ortaya çıkması sağlanmasıdır. Grup ortamı, katılımcıların görüşlerini, algılarını açıklamalarına imkan vermektedir. Bu görüşmeler, pahalı olmayıp, verileri esnek ve çok ayrıntılıdır. Elde edilen veriler, grupta meydana gelen etkileşimin yazılı kayıtlarıdır. Grup görüşmeleri, nitel ve nicel araştırma yöntemlerinde kullanılırlar (Punch, 2011).

Anket

Anket, cevap verenlerin önceden belirlenmiş sırada ve yapıda oluşturulan sorulara verdikleri cevapları elde etmeyi sağlayan veri toplama aracıdır. Araştırmacılar tarafından ihtiyaç ve alınmak istenen cevaplar doğrultusunda sorular hazırlanmalıdır. Bu olmadığı takdirde anketin geçerli ve güvenilir olması tartışma konusu olabilir. Bir anketin yapılabilmesi için öncelikle araştırma konusunun belirlenmesi, sonrasında katılımcıların seçilmesi, soru formlarının oluşturulması, soru formunun geçerliliğinin teyit edilmesi, kapak sayfasının hazırlanması, anketin gerçekleştirilmesi ve son olarak anket izleme çalışma aşamalarının gerçekleşmesi gerekmektedir (Coşkun ve arkadaşları, 2004).

Delphi Tekniği

Araştırmacılar tarafından, araştırma konusuna yönelik çözüm önerileri sunulurken farklı görüşler ortaya çıkmaktadır buda fikirlerin çatışmasına sebebiyet verebilmektedir. Delphi tekniği ise bu çatışmaların ortadan kaldırılmasına yardımcı

olan uzlaşmayı amaçlayan yüz yüze görüşmelerin yerine dikkatli bir şekilde hazırlanan anketlerin kullanıldığı bir uzlaşma aracıdır (Gençtürk ve Akbaş, 2013). Delphi yöntemi nitel verileri toplamak için çok uygun olup nitel, nicel ve karma yöntemleri kullanabilen yapılandırılmış bir süreçtir (Skulmoski, Hartman ve Krahn, 2007).

Delphi tekniğinin, katılımda gizlilik, istatiksel analiz ve kontrollü geri besleme olmak üzere üç önemli özelliği bulunmaktadır.Gizlilik ilkesi delphinin en önemli özelliklerinden biridir.Katılımcıların gizli olması araştırma konusu hakkında ortaya çıkacak olan fikirlerin çoğalmasını sağlamaktadır. Grup içinde baskın olanlar, yani saygı duyulan, iyi tanınan kişilerin düşüncelerinin şartsız olarak kabul edilmesi gizlilik özelliği ile engellenirken aksi durumda da baskın bireylerin fikirlerinin sorgulanabilir olması durumunu düşünmelerinin de önüne geçilmiş olunur. Kontrollü geri besleme özelliği ile peşpeşe anketler yapılarak bir sonraki ankette katılımcıların bir önceki ankete vermiş oldukları cevapların istatistiksel analizleri belirtilerek kıyas yapılması sağlanmaktadır. Böylece araştırma konusu için yapılan ankete verilen cevaplarda uzlaşma sağlanır (Şahin, 2001). Delphi anketinde gerçekleştirilen tur sayısı iki ile on arasında değişmektedir, bununla birlikte anket yaygın olarak iki veya üç tur ile sınırlıdır (Day ve Bobeva, 2005).

Planlama: Delphi anketine başlamadan önce bir planlama yapılır. Bu planda çalışmanın amacı, değişkenlerin belirlenmesi, Delphi önerilerinin geliştirilmesi yapılır. Delphi önerileri, tüm katılımcılar tarafından açıkça anlaşılacak şekilde kaleme alınmalıdır (Melander, Dubois, Hedvall ve Lind, 2019).

Katılımcılarının Belirlenmesi: Delphi anketine katılım sağlayacak kişiler, araştırma konusuna katkı sağlayabilecek tecrübeli, nitelikli kişiler arasından seçilmelidir. Bu kişilerin, araştırma konusuna vakıf olmakla birlikte çalışmaya derinlik katılabilmeleri son derece önemlidir (Şahin, 2001). Seçilecek örneklemin homojen olması isteniyorsa on ile onbeş kişilik katılımcı yeterlidir. Eğer karışık bir örneklem seçilecekse birkaç yüz kişi katılım sağlayabilir.

Birinci Tur Delphi Anketi: Birinci tur Delphi anketinden beklenen, katılımcılara yöneltilen Delphi cümlelerinde geçen konulara yönelik teknolojik öngörülerin gerçekleşmesi, edinilebilmesi, ilgili bazı alanlar üzerine etkisi gibi hususların katılımcılar tarafından değerlendirilmesidir. Delphi cümleleri ile ilgili sorular, uzmanlık düzeyini, mevcut durumu, yapılabilirliği, gerçekleşme tarihini ve ülkeye olan katkısını ölçmeyi amaçlayan başlıklardan oluşmaktadır (Çakır, 2016). Delphi anketinin katılımcılara ulaştırılması ile birlikte birinci tur Delphi anketi başlamış olur. Artık belirli bir süre içerisinde katılımcılarından birinci tur Delphi anketine vermiş oldukları cevaplar beklenir. Katılımcılardan gelen cevaplar analiz edilerek gerekli notlar çıkarılır ve birinci tur Delphi anketi tamamlanmış olur. Sonrasında ikinci tur Delphi anketinin hazırlık safhasına geçilir.

İkinci Tur Delphi Anketi: Birinci tur Delphi anketine katılım sağlayan kişilerin cevapları analiz edilerek bir grafik yada tablo şekline dönüştürülür. Birinci ankette her bir Delphi cümlesi için verilen cevaplar ile birlikte katılımcının kendi cevaplarını gösteren grafiksel, tablo veya resim halindeki notlar mümkünse ikinci tur Delphi anketine yerleştirilir değilse ilk tur anket cevapları e- posta aracılığı ile katılımcılara gönderilir. Bu sayede kişiler ikinci tur anketine başladıklarında, birinci tur anketine vermiş oldukları cevaplarla birlikte ankete katılan herkesin her soru için vermiş oldukları cevapların dağılımına bakarak kendi cevaplarını gözden geçirme şansı elde ederler. İkinci tur ankette yine aynı sorular sorulmaktadır.İstedikleri takdirde ikinci tur ankette önceden vermiş oldukları cevapları değiştirebilirler veya değiştirmeden soruları atlayarak anketi sonlandırabilirler. İkinci tur Delphi anketi katılımcıların belirli bir sürede cevap vermeleri beklenir. Sonrasında anket sonlandırılır. Anket tamamlandıktan sonra analiz işlemine geçilerek sonuçlar değerlendirilir.

VERİ ANALİZİ

Bu tez çalışması kapsamında veri toplama aracı olarak iki adet odak grup çalışması ve iki turlu Delphi anketi yapılmıştır. Bu bölümde odak grup çalışmasından ve Delphi ankentinden elde veriler analiz edilmiştir.

Birinci Odak Grup Çalışması

Birinci odak grup çalışması, 23 Şubat 2018 cuma günü 13:30-18:00 saatleri arasında Türkiye Teknoloji Geliştirme Vakfı binasında gerçekleştirildi. Çalışmaya, alanlarının uzmanı farklı paydaşları kapsayan akademi, kamu ve iş dünyasından dokuz kişi katıldı. Katılımcılar iki gruba ayrılarak iki masa oluşturuldu. Birinci masada beş kişi ikinci masada ise dört kişi çalışmayı yürüttü. Çalışma iki bölüm halinde gerçekleştirildi. Birinci bölümde katılımcılara "Teknoloji Değerlendirme Kriterlerinin Ağırlıklandırılması" amacıyla öncelik sıralaması "1" ile "5" arasında,"1" en düşük "5" en yüksek derece olmak üzere, önceden belirlenen *rekabet üstünlüğü, diğer teknoloji alanları yaratmak ve milli güvenlik gereksinimlerini karşılmak* başlıklarına katılımcıların ilave yaptığı diğer teknoloji kriterleri derecelendirilerek değerlendirildi. Katılımcılar tarafından da eklenen teknoloji kriterleriyle birlikte toplam ondokuz teknoloji kriteri belirlendi. Bu değerlendirmelere göre teknoloji kriterlerinin her birinin almış olduğu derecelendirme puanının toplam puana bölünmesiyle elde edilen ağırlıklandırılmış değerler her bir teknoloji kriteri için ağırlıklandırılmış puan sonucunu vermektedir. Ağrılıklandırma sonucunda ilk üç sırada yer alan teknoloji kriterleri, 0,299 puanla birinci sırada *Milli Güvenlik Gereksinimlerini Karşılamak*, ikinci sırada 0,267 puanla *Rekabet Üstünlüğü* ve üçüncü sırada 0,125 puanla *Diğer Teknoloji Alanları Yaratmak* olmuştur.

Çalışmanın devamında Savunma Sanayii Müsteşarlığı Teknoloji yönetim Daire Başkanlığınca yayınlanmış Savunma Sanayii Teknoloji Taksonomisi-Kısaltmalar ve Terimler Sözlüğü (SSB taksonomi sözlüğü, 2017) dokümanında yer alan 35 teknoloji alanı için, katılımcılar tarafından bir önceki bölümde belirlenen teknoloji değerlendirme kriterlerine göre teknoloji alan sıralaması yapıldı. Teknoloji alanları ve derecelendirmelere bakılarak ilk üç sırada yer alan *Milli Güvenlik Gereksinimlerini Karşılamak, Rekabet Üstünlüğü* ve *Diğer Teknoloji Alanları Yaratmak* başlıklı teknoloji kriterlerine göre Delphi anketinde kullanılmak üzere ikinci odak grup çalışmasında nihai hale getirilecek taslak Delphi cümleleri hazırlanmıştır.

Birinci odak grup çalışmasının devamında ikinci bölüme geçilerek vizyon çalışması gerçekleştirilmiştir.Vizyon çalışması, fikir tepsisi yöntemi olarakta isimlendirilen yöntem kullanılarak yapıldı (Tüsside, 2004). Bu yöntemde masa-1 ve masa-2 olarak ayrılan gruplara tepsi olarak kullanılan A3 boyutunda kağıtlar dağıtıldı. Bu kağıtlara her katılımcı aklına gelen fikri makul sürede post-it lere yazarak yapıştırdı.Sonrasında tepsiyi sağ tarafında bulunan katılımcıya iletti. Tüm fikirler ortaya çıkana kadar süreç devam etti. Ortaya çıkan fikirler birleştirilerek konu başlıkları elde edildi. Konu başlıkları, kendi aralarında 1 en küçük, 5 en büyük değer olarak puanlandırılarak *Vizyon Cümlesi* oluşturuldu. Çalışmada her iki gruba *Türk savunma sanayii firmalarının Ar-Ge ve inovasyon vizyonu ne olmalı?* sorusu yöneltilerek vizyon cümleleri oluşturmaları istendi.

Birinci masada yer alan birinci grup, yöneltilen soruyu firmalar açısından değerlendirerek *Ülke İhtiyaçları doğrultusunda, odaklandığı ve güçlü olduğu teknolojilerle, özgürce ürün ve hizmetleri ihraç edebilen, uluslararası düzeyde rekabetçi ve teknolojisini yönetebilen bir şirket olmak* vizyon cümlesini oluşturdular.

İkinci masada yer alan ikinci grup ise *Türk savunma sanayii firmalarının Ar-Ge ve inovasyon vizyonu ne olmalı?* sorusunu Türkiye özelinde ele alarak *Temel teknolojilere sürdürülebilirlik kazandıran, çok disiplinli çalışmaları hayata geçiren, yenilikçi ve uluslararası pazarda marka olan, bir yaşam alanı olarak uzayı temel alan yerli ve milli savunma sanayii* vizyon cümlesini oluşturdular. Aşağıdaki tabloda ikinci grubun ürettiği fikirler ve puanlanan konu başlıkları verilmektedir.

Böylelikle Delphi çalışmasında kullanılmak üzere birinci vizyon cümlesi için stratejik amaçlar aşağıdaki gibidir.

1.Stratejik Amaç: Uluslararası Düzeyde Rekabetçi Olmak
2.Stratejik Amaç: Ülke İhtiyaçlarını Karşılayabilen Teknolojiler Üretmek
3. Stratejik amaç: Ürün ve Hizmetleri İhraç Edebilmek

Delphi çalışmasında kullanılmak üzere ikinci vizyon cümlesi için ise stratejik amaçlar şöyledir:

1.Stratejik Amaç: Temel Teknolojilere Sürdürülebilirlik
2.Stratejik Amaç: Çok Disiplinli Çalışmalar
3. Stratejik amaç: Yenilikçi ve Uluslararası Pazarda Marka Olmak

İkinci Odak Grup Çalışması

İkinci odak grup çalışması, 27 Nisan 2018 cuma günü 14:00-18:00 saatleri arasında Türkiye Teknoloji Geliştirme Vakfı binası kıvılcım salonunda gerçekleştirildi. Çalışmaya konunun uzmanı üniversitelerden, kamu kurumlarından ve savunma sanayii firmalarından on bir kişi katılım sağladı. Katılımcılar üç masada toplam üç grup halinde çalışmayı sürdürdüler. İkinci odak grup çalışması iki bölümde gerçekleştirildi. İlk bölümde kısaca Delphi tekniği hakkında bilgi verildikten sonra aşağıda görülen birinci odak grup çalışmasında elde edilen teknoloji alanları kapsamında hazırlanan Delphi anketinde kullanılmak üzere birinci beş adet Delphi cümlesi hakkında katılımcıların görüşleri ve ilgili teknoloji alanları kapsamında katılımcıların Delphi öneri cümleleri alındı.Ayrıca on bir kişiden oluşan üç gruptan ayrı ayrı ortak Delphi öneri cümleleri talep edildi.

Çalışmanın ikinci bölümünde ise yine katılımcılardan Delphi anketinde kullanılmak üzere ikinci beş adet Delphi cümlesi hakkında katılımcıların görüşleri ve ilgili teknoloji alanları kapsamında katılımcıların Delphi öneri cümleleri alındı ve ikinci odak grup çalışması tamamlandı. Aşağıda çalışmada katılımcıların değerlendirdiği on adet Delphi cümlesi bulunmaktadır. Delphi cümleleri oluşturulmasında Savunma Sanayii Başkanlığı tarafından hazırlanan Savunma Sanayii Teknoloji Taksonomisi-Kısaltmalar ve Terimler Sözlüğünden yararlanılmıştır (SSB taksonomi sözlüğü,2017).

Birinci Tur Delphi Anketi

27 Nisan 2018 cuma günü yapılan İkinci odak grup çalışmasında katılımcılara değerlendirmeleri amacıyla sunulan on adet Delphi cümlesine ek olarak çalışmanın sonunda katılımcıların önerdiği yeni Delphi cümleleriyle birlikte toplam on dokuz adet Delphi cümlesi, birinci ve ikinci tur Delphi anketinde kullanılmak üzere hazırlandı. Bu cümlelerin altında,

- Uzmanlık düzeyi,
- Ulkemizdeki insan kaynağı yeterliliği,
- Ülkemizdeki temel bilgi düzeyi,
- Ülkemizdeki fiziki altyapı (alet/teçhizat) kapasitesi,
- Ülkemizdeki firmaların yeteneği,
- Gerçekleşme tarihi
- Türkiye'nin rekabet gücüne katkısı,
- Türkiye'nin bilim teknoloji ve yenilik yeteneğine katkısı,
- Türkiye'de çevre duyarlılığı ve enerji verimliliğine katkısı

konu başlıklarını kapsayan toplam dokuz soru eklendi. Bu kapsamda Toplamda katılımcılarına sorulmak üzere yüzyetmişiki adet soru bulunmaktadır.

Delphi Anketi Katılımcılarının Belirlenmesi

Tez konusu ve anket sorularının savunma sanayi sektörüne yönelik olmasından dolayı katılımcıların da savunma sanayiinden olması kararlaştırıldı. Bu kapsamda Savunma Sanayii Başkanlığı Sanayileşme Dairesi ile irtibata geçilerek Ankara'da bulunan Ar-Ge faaliyetleri yapan, ankete katılım sağlaması mümkün olan firmaların iletişim bilgileri talep edildi. Başkanlık tarafından bu kapsamda, kısa adı *EYDEP* olan *Endüstriyel Yetkinlik Değerlendirme ve Destekleme Programı* çerçevesinde savunma sektörü firmalarının endüstriyel yetkinlik envanterinin çıkarılmasını, yetkinlik seviyelerinin saptanmasını ve geliştirilmesini hedeflemek amacıyla akredite edilen, içerisinde Ar-Ge birimi olan yedi adet firmanın iletişim bilgileri paylaşıldı. Bu firmalara ek olarak Türk Silahlı Kuvvetlerini Güçlendirme Vakfı

bünyesinde olan Havelsan A.Ş., Aselsan A.Ş., Tusaş, Roketsan gibi kuruluşlardan, üniversiteler ve kamu kurumlarından ayrıca diğer savunma sanayii kuruluşlarından katılımcılar seçildi.

Birinci tur Delphi anketi internet ortamında "Google Form" anket formu kullanılarak tasarlandı. Anketin uygulamasında internet ortamın seçilmesi zaman ve kişilere ulaşım açısından avantaj sağladı. Bu kapsamda yukarıdaki tabloda görülen kurum ve kuruluşlarda çalışan yüz altmışyedi kişiye elektronik posta ve telefonla ulaşularak

"https://docs.google.com/forms/d/e/1FAIpQLSe8TUerIB_QWJXN2wap9mSCiz9sTHIIBUZLG2KGiT96rxEcGw/viewform?usp=sf_link" ilgili internet adresinde yer alan birinci tur Delphi anketine katılım sağlamaları istendi. İlk cevap 22 Haziran 2018 de alındı. Birinci tur Delphi anketi 06 Temmuz 2018 tarihinde sonlandırıldı. Anketin başlangıcından sonlandırılacağı zamana kadar yüzaltmışyedi kişinin tamamına defaatle elektronik posta, telefonla ulaşarak ankete katılmaları için hatırlatmalar yapıldı.Yüzaltmışyedi kişiden doksan dördü cevap vererek dönüş yaptı

Birinci Tur Delphi Anketi Cevaplarının İncelenmesi

Birinci tur Delphi anketi dönüş sağlayan doksan dört kişinin verdiği cevaplar uzantısı "csv" olarak "Google Formlar" uygulaması üzerinden alınmıştır. Microsoft Excel'de işlenebilmesi için "csv" uzantılı cevaplar "tsv" formatına çevrildi. "tsv" uzantılı dosya excelde açılarak virgül ayracı yardımıyla hücresel verilere dönüştürülerek analiz yapılabilir hale getirildi. Bu dönüşüm sonrasında veriler incelenerek sonuçlar değerlendirildi.

İkinci Tur Delphi Anketi

Birinci tur Delphi anketine alınan cevapların ağırlık ortalaması doksan kişi bazında doyum noktasına ulaşmaktadır. Bu sebeple bu noktada birinci tur Delphi anketi sonlandırıldı. 2018 yılı temmuz ayının ortasında ikinci tur Delphi anketi başlatıldı. Anket yine internet ortamında "Google Form" kullanılarak

“https://docs.google.com/forms/d/e/1FAIpQLSfgW4dF4brlLJ5IPWVnYegywh7biT5ODgMW6Rc1hQBfKpNH4A/viewform?usp=sf_link”

ilgili internet anket adresinde gerçekleştirildi. İlk turda ankete katılım sağlayan doksan dört kişiye ikinci tur anketine katılmaları için elektronik posta ve telefon yoluyla ulaşılarak çağrı yapıldı. “Google Form” anket uygulamasının kısıtlarından dolayı katılımcıların ilk tur ankete vermiş oldukları cevaplar ikinci tur anketine içine yerleştirilemediğinden katılımcıların her birine, bir önceki tur anketine vermiş oldukları cevaplar pdf dokümanı halinde elektronik posta ile gönderildi. Ayrıca ikinci tur anketi içerisinde bütün katılımcıların her bir soru için birinci tur anketine vermiş oldukları cevapların dağılımını gösteren grafikler yerleştirildi. Böylelikle katılımcılara ilk tur anketine vermiş oldukları cevapları, genel cevap dağılımlarıyla kıyaslayıp cevaplarını değiştirme imkanı verildi.İkinci tur Delphi anketi soruları, birinci tur Delphi anketi sorularının tamamen aynısıdır. Bu uygulama biçimi kaynağını Delphi tekniği uygulamasından almaktadır. İkinci tur Delphi anketi 25.10.2018 tarihinde sonlandırıldı. Bu ankete dönüş yapan kişi sayısı 58 (elli sekiz) olarak belirlendi.

İkinci Tur Delphi Anketi Cevaplarının İncelenmesi

İkinci tur Delphi anketine doksan dört kişiden elli sekiz kişi dönüş sağladı. Dönüş sağlayan Elli sekiz katılımcıdan da otuz dördü cevaplarını değiştirmiş olup geri kalan yirmi dört kişinin cevaplarında değişiklik olmamıştır. Bu kişilerin verdiği cevaplar, uzantısı “csv” olarak “Google Formlar” uygulaması üzerinden alındı. Microsoft excelde işlenebilmesi için “csv” uzantılı cevaplar “tsv” formatına çevrildi. “tsv” uzantılı dosya excelde açılarak virgül ayracı yardımıyla hücresel verilere dönüştürülerek analiz yapılabilir hale getirildi. Bu dönüşüm sonrasında veriler incelenerek sonuçlar değerlendirildi.

Birinci ve İkinci tur Delphi Anketi Cevaplarının Birleştirilmesi

İkinci tur Delphi anketi yapıldıktan sonra alınan cevaplar birinci tur Delphi anket cevapları birleştirildi. Sonuç olarak bazı katılımcıların ikinci tur ankette, ilk ankete

vermiş oldukları cevapları değiştirerek daha sağlıklı cevap vermeleri sağlandı. Böylelikle anket verileri nihai halini aldı. Temel değerlendirmeler artık bu veriler üzerinden yapıldı. Yapılan analizler sonucunda ankette yer alan D.14 Delphi cümlesi:

Gerçek platformlardaki ayırt edici kritik karakteristik özellikleri simüle etmek için sanal gerçeklik teknikleri kullanılarak yerli simülatör sistem ve alt sistem teknolojileri üretilecektir.

ile ilgili D.14.8 sorusu: *Delfi cümlesindeki konunun Türkiye'nin bilim teknoloji ve yenilik yeteneğine katkısı* en yüksek puanı alarak ilk sırada yer aldı.

YÜZ YÜZE GÖRÜŞMELER

Bu bölümde teknolojik faaliyet hedefi olarak belirlenen D.14 Delphi cümlesine yönelik iş alanları içerisinde "sanal gerçeklik teknolojileri" olan ve Ankara'da bulunan;

- SİM-TEK (Sim-Tek Simülasyon ve Bilgi Teknolojileri Şirketi)
- BITES (Bites Savunma Havacılık ve Uzay Teknolojileri A.Ş.)
- HAVELSAN (Hava Elektronik Sanayi A.Ş)
- SİMSOFT (Simsoft Bilgisayar Teknolojileri Ltd. Şti.)

firmalarının ilgili teknik personeliyle yüz yüze gerçekleştirilen görüşmelerden söz edilmektedir. Görüşmelerde teknolojik faaliyet hedefine yönelik katılımcılara genel olarak neler yapılması gerektiğinden bahsedilmektedir.

Yüz Yüze Görüşmelerde Sorulan Sorular

D.14 Delphi cümlesi "Teknolojik Faaliyet Hedefi" olarak tanımlandı. Sonrasında bu hedefin gerçekleşmesine yönelik olarak sorular tasarlanarak yüz yüze görüşmelerde ilgili teknik uzmanların bu soruları cevaplaması istenildi. Aşağıda teknik uzmanlara yöneltilen sorular yer almaktadır.

Teknolojik Faaliyet Hedefi: Gerçek platformlardaki ayırt edici kritik karakteristik özellikleri simüle etmek için sanal gerçeklik teknikleri kullanılarak yerli simülatör sistem ve alt sistem teknolojileri üretilecektir**.**

Soru 1: Teknolojik faaliyet hedefine yönelik gerçek platformlar nelerdir?

Soru 2: Teknolojik faaliyet hedefine yönelik gerçek platformlardaki ayırt edici kritik karakteristik özellikler nelerdir?

Soru 3: Teknolojik faaliyet hedefine yönelik bu platformlarda kullanılacak sanal gerçeklik teknikleri nelerdir, nasıl geliştirilir?

Soru 4: Teknolojik faaliyet hedefine yönelik yerli simülatör sistem ve alt sistem teknolojileri nelerdir, nasıl üretilmelidir?

Soru 5: Teknolojik faaliyet hedefine öncelikli teknoloji alanları ve bu alanların alt alanları nelerdir?

Soru 6: Teknolojik faaliyet hedefine ulaşmak için 2023 yılına kadar neler yapılmalı, politika önerileriniz nelerdir? (Kanuni düzenleme, tübitak desteği, üniversite – sanayi işbirliği vb.)

Soru 7: Teknolojik faaliyet hedefine ulaşmak için 2023-2028 yılları arası neler yapılmalı, politika önerileriniz nelerdir? (Kanuni düzenleme, tübitak desteği, üniversite –sanayi işbirliği vb.)

SONUÇ

Sonuç bölümünde tez kapsamında yapılan çalışmalardan ve D.14 Delphi cümlesi teknolojik hedefine ulaşmak için 2023’ e kadar ve 2023-2028 yılları arasında kamu, üniversite ve özel sektör tarafından neler yapılmasına dair yol haritasından söz edilmektedir.

Delphi Cümlesi Teknolojik Faaliyet Hedefi Yol Haritasi Ve Politika Önerileri

Savunma sanayiinde sanal gerçeklik (Virtual Reality-VR) uygulamaları algılama hissini artırmak için kara, hava, deniz platformlarında, füze ve füze rampalarında, silah sistemlerinde, insansız hava sistemlerinde, iş başı eğitim sistemlerinde kullanılabilir. Her sistemin fiziksel veya dinamik olarak simülasyonu veya simülatörü yapılabilir. Platform eğitim sistemleri, iş başı eğitim sistemleri yaygın olarak kullanılmaktadır.

Bunun yanında uygulanabilme kolaylığı bakımından platformlar ne kadar az karmaşık olursa simülasyonlarda buna göre dahaz az karmaşık olacaktır. Mekandan bağımsız mimari ortam ve unsurlar sanal gerçeklik ile simüle edilebilirler dolayısıyla tasarım hataları ve değişiklikler önceden belirlenerek sonrası için tedbir alınması sağlanır.

Buna örnek olarak uzay teknolojileri verilebilir, Dünya üzerinde oluşturulamayacak ortamlar sanal gerçeklik ile duyu algılamalarını da katarak simüle edilebilir. Sanal gerçeklik uygulamalarıyla karmaşık yapıdaki platformların tasarımında her bir parçanın üç boyutlu (3D) modelinin olması, gelişmiş bir görüntü üretecinde üretilmiş gerçekçi bir sanal görüntü ile ürün montaj-demontaj işlemlerinin yapılabilmesi sistemlerdeki arızalar simüle edilerek onarımları yapılabilmekte böylelikle risk ve maliyet açısından avantaj sağlanmaktadır. Bu imkanlar hem mühendisler hemde son kullanıcılar için kolaylık sağlamaktadır.

Sanal gerçeklik kullanılarak kullanıcı dostu (user friendly), renk açısından uyumlu ve kullanıcı açısından erişilebilir ürün ve parçalar tasarlanabilir. Dokunma hissinin kullanıcılar tarafından algılanabilmesi için haptik sistemlerle etkileşim tekniğini kullanılabilir. Sanal gerçeklik konusunda, sanal gerçeklik gözlükleri ve giyilebilir ürünler ile sensörlerin üretilebilmesi hususu önem arz etmektedir.

Önümüzdeki yıllarda giyilebilir sanal ve artırılmış gerçeklik (VR, AR) gözlüklerinin kullanımının yaygınlaşması beklenmektedir. Buna örnek olarak Google firmasının ürettiği “Google Glass” ürünü verilebilir. Sanal ortamı daha gerçekçi yapmak için

hand tracker veya sanal gerçeklik eldivenleri kullanılabilir. Sanal ortamda hareket etme alanını genişletmek için Omni walker vb. cihazlar kullanılabilir ve hareket alanı sınırsız hale getirilebilir.

Senaryo bazında kullanıcının vücudunun tamamen takip edilmesi ihtiyacına göre Kinect vb. trackerlar kullanılabilir. Sanal ortamla birlikte hareket hissinin elde edilmesi amaçlanırsa daha çok sensör ve 2D ve 6D elektrikli hareketli platformlar, performanslı simülasyon motorları kullanılabilir.Tüm bunların yanında yerli olarak üretilmeyen parça, materyal, yazılım ve modeller kritik öneme sahiptir.

Bu kapsamda sanal gerçeklik teknolojilerinin gelişimi için aşağıdaki teknoloji alanlarına ve bunların alt alanlarına ihtiyaç bulunmaktadır. Bu alanlara yönelik çalışmalar yapılmalıdır.

1. Oyun motorları
    - Grafik motorları

2. Coğrafi bilgi sistemleri
    - Haritalama sistemleri

3. Yazılım teknolojileri
    - Yazılım proje yürütme teknolojileri
    - Yazılım entegrasyon teknolojileri
    - Gerçek zamanlı (real time) yazılım teknolojileri

4. Üç boyutlu modelleme teknolojileri
    - Sanal gerçeklik gözlükleri
    - Sensör teknolojileri
    - Giyilebilir sensör teknolojileri

5. Görüntü işleme
    - Video Management
    - Görüntü Sıkıştırma ve aktarımı

6. Optimizasyon teknikleri
    - Grafik işleme teknikleri

- Kullanıcı arayüzü ve kullanıcı deneyimi(UI/UX),

2023 yılına kadar teknolojik faaliyet hedefine ulaşmak için üniversiteler,Tübitak, Savunma Sanayii Başkanlığı ve Bilim,Sanayi ve Teknoloji Bakanlığı tarafından yapılması önerilen konular aşağıda maddeler halinde belirtilmektedir.

1.Üniversiteler tarafından yapılması önerilen konular:

Üniversitelerde öğrenciler oyun ve modelleme simülasyon alanına yönlendirilmelidir. Bu kapsamda "openGL" gibi dersler ilgili bölümlerde mecburi olarak öğrenciler tarafından alınmalıdır. Oyun sektörüne yönelik modelleme ve grafik amaçlı bilgisayar programları öğrenciler tarafından yaygın olarak kullanılmalı ilgili bölümlerde bu programlara yönelik dersler açılmalıdır.

Oyun, modelleme ve simülasyon alanlara yönelik yüksek lisans ve doktora programları açılmalı ve yaygınlaştırılmalıdır. Sanal gerçeklik konusunda faaliyet gösteren firmalarda üniversite öğrencilerine staj imkânı sağlanmalıdır.

2.Tübitak tarafından yapılması önerilen konular:

Sivil ve askeri Ar-Ge projeleri başlatılmalıdır. Bu kapsamda sanal gerçeklik konusunda milli yazılım ve donanım ihtiyacına yönelik çağrılı Ar-Ge projeleri başlatılmalıdır.

3. Savunma Sanayii Başkanlığı tarafından yapılması önerilen konular:

Savunma sanayii başkanlığı sanal gerçeklik konusunda çalıştaylar düzenleyerek bu alandaki tecrübelerin başka alanlarda kullanımını planlamalı ayrıca verilecek eğitimlerle insan kaynağı yeteneklerinin artırılmasını sağlamalıdır.

Sanal gerçeklik konusunda test, doğrulama ve değerlendirmeye yönelik standartları belirlemelidir. Üretilen savunma sanayii araçları için simülatör üretimi mecburi hale getirilmeli veya teşvik edilmelidir. Bununla birlikte devletimizin ilgili kurumlarıyla koordineli olarak yurt dışı için pazarlama desteği sağlamalıdır. Sanal gerçeklik

konusunda ihtiyaç halinde başvurulabilecek ilgili firmaların yeteneklerinin derlendiği bilgi havuzu oluşturulmalıdır.

4.Bilim Sanayi ve Teknoloji Bakanlığı tarafından yapılması önerilen konular:

Başta sanal gerçeklik ve artırılmış gerçeklik gözlüğü olmak üzere son kullanıcıya yönelik ürünlerin üretimini teşvik programına dâhil etmelidir. Sanal gerçeklik alanında üniversite-sanayi işbirliği kapsamında ilgili kurum çalışanları bir araya gelerek teknoparklara verilen destekler ile birlikte teknoloji üretimi gerçekleştirilmelidir. Sektör paydaşları ile düzenli olarak toplantılar yapılmalıdır.

2023-2028 yılları arasında teknolojik faaliyet hedefine ulaşmak için:

1.Üniversiteler tarafından yapılması önerilen konular:

Sanal gerçeklik konusunda, öğrencilere yönelik ödüllü proje yarışmaları düzenlenmelidir.Kodlamaya yönelik Milli Eğitim Bakanlığı ile işbirliği yaparak kodlama eğitiminin yaygınlaştırılması sağlanmalıdır. Üniversite-sanayi işbirliği kapsamında sanal gerçeklik konusunda faaliyet gösteren firmalarla ortak proje çalışmaları yapılmalıdır.

2.Tübitak tarafından yapılması önerilen konular:

Sanal gerçeklik konulu doktora programları desteklenmelidir. Ayrıca Tübitak tarafından desteklenen projelerde mümkün olduğu kadar firmalara esnek davranılarak herhangi bir eksiklikle karşılaşıldığında ek süreler verilerek firmaların projeleri tamamlamaları sağlanmalıdır.

3.Savunma Sanayii Başkanlığı tarafından yapılması önerilen konular:

Firmaları teşvik edici yarışma projeleri düzenlemeli, sanal gerçeklik üzerine çalışan firmaların kurulmasını desteklemeli ve bu tür firmaların bir araya getirildiği platformlar oluşturulmalı. Ayrıca sanal gerçeklik konusunda özel uzmanlık istenen alanlarda firmalar yönlendirilmelidir. Sanal gerçeklik gözlüklerinin donanım

bakımından milli olarak üretilmesine yönelik ilgili kurumlarla birlikte planlama yapılmalıdır. Ayrıca Türkiye'den ihraç edilen her araçla birlikte ilgili simülatör sistemin de birlikte verilmesi veya satılması sağlanarak simülatör sistemlerinin kullanımının arttırılması gerçekleştirilmelidir.

Firmalar tarafından üretilen sanal gerçeklik ürünlerinin bakım idame ömür devri gibi konularda başarılı olmaları sağlanmalıdır.Yurtdışı fuarlarda sanal gerçeklik konusunda çalışan firmaların katılımlarının mali olarak desteklenmesi sağlanmalıdır. Ayrıca bu ürünlerin tanıtımında yurtdışı ve yurt içinde bulunan elçiliklerle koordineli çalışmalar yürütülmelidir.

4.Bilim Sanayi ve Teknoloji Bakanlığı tarafından yapılması önerilen konular:

Sanal gerçeklik konusunda Ar-Ge yatırımı yapacak firmalara mali ve vergi konularında destekler sağlanmalıdır. Yerli ürün kullanımı kanunlarla teşvik edilmeli ve ithalatın azaltılması sağlanmalıdır.Yerli ve milli ürünlerin fikri mülkiyet ve patent hakları korunmalı ve bu ürünlerin ihracatında yaşanabilecek problemleri öncesinde çözecek tedbirlerin alınması sağlanmalıdır.

Sanal gerçeklik konusunda milli markaların oluşumuna ve dünyada yaygınlaşmasına katkı sağlamalıdır. Ayrıca bu firmalar yurtdışına yaptıkları projelerden dolayı ihracata verdikleri katkılardan dolayı desteklenmelidir.

Sonuç olarak, sanal gerçeklik teknolojisi hızlı gelişen bir teknoloji olup savunma sanayii özelinde gelişen bu teknolojiyi ülke olarak henüz daha başında yakalamış bulunmaktayız.

Yazılım ve donanım alanındaki yapılacak pozitif çalışmalarla bu teknolojinin kullanımı ile üretilecek ürünlerin ihracatından ilerleyen yıllarda büyük miktarda ekonomik gelirler elde edilmesi kaçınılmazdır. Bu kapsamda firmalar, üniversiteler ve kamu kurumları birlikte koordineli olarak çalışarak bu teknolojiden yararlanıp dünya markası olacak ürünlerin üretimi sağlamalıdır.

Yakın gelcekte ise sanal gerçeklik teknolojisinin devamı niteliğinde olan artırılmış gerçeklik teknolojilerine yatırım yapılmalıdır. Artırılmış gerçeklik teknoloji başta savunma sanayii alanında olmak üzere diğer pek çok sektörde de kullanılacaktır. Bu teknolojilerin günümüzde hızlı bir şekilde gelişen 5G ve yapay zeka uygulamalarıyla birlikte kullanımı mümkün olacaktır. Bu sebeple ülke refahını artırmak ve ekonomik büyümeyi sağlamak için gelişen bu yeni teknolojilerde ülke bazında yatırımlar, projeler ve üretimler yapılmalıdır.

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