Proceedings of the 4th South American International Industrial Engineering and Operations Management Conference, Lima, Peru, May 9-11, 2023

The Role of Stakeholders and Their Participation in Additive Manufacturing Technology Roadmapping: A Case of a Defense Industry

Nur Sena Ertem, Gizem Gunaydin and Eren Ozceylan
Department of Industrial Engineering, Engineering Faculty,
Gaziantep University, Gaziantep, Turkiye
senayagbasan237@gmail.com, gizem.gunaydin44@gmail.com, erenozceylan@gmail.com

Abstract

The Turkish defense industry shines out as an extremely significant example in terms of the history of the Republic, the understanding of the concept of the defense industry and its relations with other fields, and of the future of the defense concept. However, in order to sustain this success, it is necessary to use emerging technologies in the defense industry. The use of additive manufacturing technologies, which is one of these technologies, in the defense industry is one of Türkiye's country policies. It is also a fact that the success of this policy depends on the presentation of correct technology roadmapping. In this paper, a stakeholder analysis is conducted to provide a technology roadmapping for the integration of additive manufacturing in the defense industry. Several stakeholders including defense industry companies experienced universities and additive manufacturing institutions are considered. In order to contribute to the technology roadmap, the interests, influences, and powers of the stakeholders are trying to be determined. The results to be obtained at the end of the study will be shared with policy developers.

Keywords
Additive manufacturing, Technology roadmapping, Stakeholder analysis, Defense industry.

1. Introduction
The defense industry consists of a commercial industry involved in research and development, engineering, production and service of military equipment, equipment and facilities. The defense industry is also very important for countries to live in security and prosperity. Every country that has determined its own borders is obliged to protect these borders in order to ensure its own continuity. In order to protect these borders, countries must be able to acquire the necessary tools for all these situations, as well as an army consisting of manpower, which can directly protect or use the necessary equipment (Ozsoy et al. 2019).

In the defense industry sector, it is difficult to manufacture parts using existing technologies. The production problem of these difficult parts can be solved by the additive manufacturing (AD) approaches. Parts with complex geometry that cannot be produced with the traditional method can be manufactured by the AD method. In addition, more functional, lighter and more economical parts are produced with the AD method (Madan et al. 2021).

With the project titled "New Generation 3D Printer Manufacturing Technologies Platform", and supported by TÜBİTAK, it is aimed to develop new generation additive manufacturing technologies and produce high value-added aviation/defense industry products. Within the scope of this project, it is necessary to prepare a technological roadmap and reach the goal. Stakeholder analysis is required to prepare a technological roadmap.

Stakeholder analysis helps to identify individuals, groups and organizations that will be directly or indirectly affected by the results of the project, both positively and negatively. It also enables us to analyze the relations of the identified stakeholders, especially with the project; it also helps us to anticipate conflicts that may arise between different stakeholders. In this project, different stakeholders (TUSAŞ, ASELSAN, ROKETSAN, TEI, GAZİ University EKTAM, Ermaksan, TÜBİTAK MAM, Erzurum Technical University, Sabancı University) were considered.

Following the introduction, the second part of the study includes the literature on the subject. In the third part, the stakeholder analysis approach used is explained. The fourth section presents the outputs obtained, and the last section concludes the study.

2. Literature Review

Today, many companies or organizations aim to grow and stand out in the market they are in. The aim of growth in the serviced sector could be possible with the creation and planning of certain road maps. However, the conditions in the sector are dynamic and changed. For this reason, a roadmap including technology should be created by considering every possibility.

Technology roadmaps are planning tools created for companies, universities, or institutions to achieve new products or targets in line with their strategic plans. While creating a technological roadmap for their organizations, individuals within the organization should work as a team and get the support of the management. It should not be done by a single person or with external backing (Arshed et al. 2012). Technology roadmaps ensure that the right technologies are used at the right time, that technology investments are made healthily, that the available resources are used in the best way, and that these processes continue effectively. It is also an important step for companies to correctly construct their future by helping organizations understand their current needs and predict their future needs.

There are technology roadmaps in many different organizations and fields. This part of the study has examined in which areas technology roadmap has been made before. Technology roadmaps were originally developed by Motorola and Corning in the 1980s to support the interconnection of strategic product and technology plans. Motorola is a technology-based company. It aims to develop and market its products in order to solve customers' problems and increase efficiency. For these goals, Motorola asked technological decision-makers to predict changes in technology. Decision makers were expected to find new ways to do things, research and find new features that would appeal to the market, and keep costs to a minimum. But products and processes have become more complex as time has progressed (Kerr and Phaal 2020). At this point, it has been realized that the technology has developed and there may be a danger of the decision-makers neglecting this development. As a result of this danger, it has revealed company-wide processes that they call the “Technology Roadmap”. Motorola has used two different technology roadmaps, the emerging technology roadmap, and the product technology roadmap. Both roadmaps have differed mainly in time frames while using similar documents (Willyard and McClees 1987), (Probert and Radnor 2003). After Motorola, this method has been adopted and applied by many different organizations in different industries.

In 2015, the technology roadmap was applied to a technology used in the field of mobile learning. In the study, a technology roadmap method covering a certain peri is proposed for a company focused on mobile phone technology used in the field of mobile learning. The proposed technology roadmap developed a strategic perspective at the firm level. At the same time, the company allowed technology analysis with the proposed roadmap and specified the desired technology features. Thanks to this technology roadmap, brings technology and product acquisition to the time dimension (Gazibey and Uysal 2015).

Technology roadmaps were created by including active technologies in space explorations. NASA has followed many technology roadmaps to identify its technological needs and improve its technology development method. As the scope of the countries' space missions has expanded, the current technological developments have lost their clarity. For this reason, more comprehensive technology development ways were sought for the future. As a result, NASA published many road maps in 2015 (Aleina et al. 2016). Within the scope of this study, the preparation of technology roadmaps for the defense industry is discussed. Apart from the studies about education and space explorations, many technology roadmap studies have been carried out in the literature for the defense industry.

A nanotechnology roadmap has been prepared for the Turkish Defense Industry, considering Türkiye's geographical location. A well-organized defense industry that uses advanced technology effectively is needed in order to have a strong army. It is necessary to create awareness about nanotechnology in defense industry companies by preparing a Nanotechnology Roadmap for the Turkish Defense Industry. In addition, this roadmap contributed to the Turkish Armed Forces having advanced weapons, systems, platforms, and sensors (Aydogdu et al. 2017).

Turkish Aerospace Industries Corporation (TUSAŞ) also has prepared a study on the technology roadmap. Meetings were held with the participation of relevant managers and experienced experts for each core competency area. The workshop scenario has been created. TUSAŞ prepared questions answered by expert personnel from different departments. The questions prepared were discussed at separate meetings with the participation of all managers and experts, and the technology roadmap was updated by ensuring consensus. The importance of R&D projects has increased due to reasons such as rapid changes in technology, customer expectations, and the shortening of the life of projects and products day by day. For this reason, HAVELSAN reveals the benefits of using a four-layer technology roadmap and its possibilities for institutions in creating a technology roadmap in the defense industry, taking into account R&D projects (Bulu et al. 2018).

The technology roadmap approach has been implemented and popularized across organizations of various sizes, from small businesses to large government policy projects, to ensure that an organization's strategic goals are effectively aligned with product-related technologies. In addition, this approach has been recognized as an essential element for success. Research has been undertaken by several businesses to contribute to new models of technology roadmap approaches that may result in improved outcomes for a variety of applications. The 2019 study by Alcantara and Martens aims to perform a systematic review of the literature and present a set of models related to the theme by mixing a bibliometric study with network and content analysis on the link between technology roadmap and strategy. It highlights the bibliometric mapping of the article sample as the main contribution. In addition, citation and co-citation clusters were analyzed to present reviews of the articles and authors identified in the technology roadmap models, along with their application comments (Alcantara and Martens 2019).

The biggest benefit of using a four-layer Technology Roadmap is that all employees of the company are in contact with each other. In this way, research projects for different fields were initiated instead of projects targeting the same technologies or the same market. Technology roadmaps have been handled with different topics and different products in different sectors. Technology roadmaps have many studies in which different methods are used together with the developing technology (Peker et al. 2021).

An article published in 2022 systematically reviews the literature to explain the general characteristics of the technology roadmap and stakeholder engagement efforts in the process. Additionally, this article adds to the technology roadmap by building know-how in three ways. First, it has created a portfolio of articles that expands on previous reviews in the field and focuses on industry-level applications from 2000 to 2019. Second, efforts and rigor in stakeholder selection and engagement were evaluated in terms of breadth, depth, and timing. The results show that the overall stakeholder engagement effort is low and the process could benefit from involving thought leaders from diverse fields, particularly from firms, to spark interest in technology development and commercialization. Finally, based on the findings, design recommendations were developed for Technology roadmap practitioners to increase stakeholder engagement in the process (Chakraborty et al. 2022).

An approach was proposed to evaluate and update the technology roadmap creation process. This approach defined the ideal roadmap process based on the available literature. An integrated framework is proposed to guide technology roadmap development from process maturity, system elements, and contextual validity. To validate its effectiveness, its proposed approach has been applied to a roadmap run by a Korean government agency responsible for technology planning at the national level. Evaluation has found that it can help an organization systematically identify the strengths and weaknesses of the roadmap process to create an approach to process improvement. (Geum et al. 2023)

In this section, a detailed literature study was conducted and how to prepare a technology roadmap was evaluated. The roadmap preparation methods found in the literature were examined and evaluated for the technology roadmap to be created for the defense industry within the scope of the study. After a general literature review, the issue of stakeholder analysis to be prepared within the scope of this study was examined. The information obtained has guided the stakeholder analysis to be prepared.

3. Methods

The effective use of technology in product and service processes can be realized by planning technology. Different planning approaches have been developed by companies using the technology planning method and academics doing research on this subject. The most basic of these approaches is based on the creation of a technological roadmap.

Faced with a rapidly changing environment, businesses must clearly define their technology needs/opportunities. Plans should be detailed to define what technology is needed when it is expected to be used, and who will play a role in efforts to develop it. Resources must be used to ensure that plans are carried out. A business considering using technology as a potential competitive tool should ensure that its technology plans support its overall business plans. As a result of this planning process, a map is needed that will define the technology needs of the business and guide the business in the dark future (Omotayo 2015).

A technology roadmap is a needs-driven technology planning process to help identify, select, and develop technology alternatives to meet a set of product requirements. This process includes making appropriate technology investment decisions and financing these investments; It brings together experts to develop a system for organizing and presenting critical technology planning information. The technology roadmap can also help coordinate the development of one or more technologies (Bray and Garcia 1997). The technology roadmap is an iterative process that fits within the scope of joint strategic planning and technology planning. Planning activities should combine three key elements.

- Customer/market requirements,
- Products/services,
- Technologies.

Strategic Planning includes decisions that define and integrate the customer/market requirements that a high-level company wishes to address, and products and services to meet these requirements, given a company vision. Technology Planning involves identifying, selecting, and acquiring technologies to support product and service requirements to implement the strategic plan. Business development encompasses the issues of elaborating and implementing the strategic plan in certain aspects, which specifically includes the development of new products and services or new lines of business. The technological roadmap should focus on the future in terms of the time it shows during its creation. Technology is a changing and developing phenomenon. The roadmap to be created accordingly should be based on predictions and forecasts.

Effective road maps are created with the planning of technology. A technology roadmap, which is an effective tool for technology planning and coordination, also plays an important role in the planning of activities at the initial stage. The technology roadmap process consists of three stages (Robert Phaal, David R. Probert Clare Farrukh, 2004) The first stage includes the preliminary activity, and without this preliminary activity, a roadmap should not be made. The second phase is the development of the technology roadmap. The third phase is the completion and use of the technology roadmap.

Table 1. Technology roadmap stages

PHASE 1 "Preliminary activity"	**1)** Satisfy essential conditions.
	2) Provide leadership/sponsorship
	3) Define the scope and boundaries for the technology roadmap.
PHASE 2 "Development of the Technology Roadmap"	**1)** Identify the "product" that will be. the focus of the roadmap.
	2) Identify the critical system requirements and their targets.
	3) Specify the major technology areas.
	4) Specify the technology drivers and their targets.
	5) Identify technology alternatives and their timelines.
	6) Recommend the technology alternatives that should be pursued.
	7) Create the technology roadmap report.
PHASE 3 "Follow-up activity"	**1)** Critique and validate the roadmap.
	2) Develop an implementation plan.
	3) Review and update.

In today's world, the defense industry is accepted as the basic building block of a country. The development and progress of the Turkish defense industry also gain importance in this sense. In order to sustain the development of the Turkish defense industry, it is necessary to use the developing technologies in the defense industry. The use of additive manufacturing technologies, which is one of these technologies, in the defense industry is among Türkiye's country policies. The success of this policy depends on the delivery of the right technology roadmap. Additive

manufacturing, also known as additive manufacturing, or 3d printing technology, can be defined as a transformative approach to industrial production that enables the production of lighter, stronger parts and systems.

In this paper, a stakeholder analysis was conducted to provide a technology roadmap for the integration of additive manufacturing in the defense industry. Many stakeholders are taken into account, including defense industry companies, experienced universities, and additive manufacturing organizations. "Stakeholder analysis" was primarily researched for the studies on the relevant interest/power matrix of the identified stakeholder groups. In order to contribute to the technology roadmap, stakeholders' interests, influences, and authorities were tried to be determined.

3.1 Stakeholder Analysis

Stakeholder analysis is a method; while preparing a strategic plan, research, and application project, while producing a solution to a problem; It is used in the determination of all stakeholder groups that may be affected by the service provided, the current problem or the possible project, their relations with the service/problem/project, their strengths and effects, the participation strategies and the evaluation of the project results. In other words, stakeholder analysis; while preparing a strategic plan, searching for stakeholders that can contribute to the strengthening of the institution; It is an analysis method used to determine all stakeholder groups, their relations with the problem/project, their strengths and effects, and participation strategies that may be affected by the current problem or potential project while conducting business analysis, preparing a project.

It seems important that the officials of the institution preparing the strategic plan understand the logic of the total quality-oriented new management approach and apply the method knowingly. It is important to analyze the stakeholders well in service and business analyses, strategic plans, research, and application projects, which are becoming increasingly widespread today. In particular, it seems important for the project managers to acquire the right stakeholders for the realization of the project.

In the literature review on stakeholder analysis, it is seen that generally, three methods come to the fore. The most important of these methods is the social network analysis method. In addition, the power/interest matrix and stakeholder cycle method are also used in some studies.

Social network analysis (SNA); It focuses on the relationships among stakeholders in a network, as opposed to stakeholder cycling methodology and power/interest matrices, which focus on the attributes of stakeholders. For example, a construction project is an interactive project system with many elements in a complex structure. Thus, the construction project's relationships among stakeholders are likely to be complex and dynamic. The use of social network analysis has become widespread in projects and/or sector analyses with such complex and dynamic relationships (Lienert et al. 2013).

SNA is shown as a useful approach in the identification and interpretation of information connections, by examining the relationships between research topics, authors, and institutions in a particular field (Scott, 2000). A social network; basically, it is defined as a structure that shows the interaction, cooperation, and effects between people or other multitudes (institutions, etc.). In this context, social network analysis examines the social structure and its effects by seeing it as a network consisting of actors (nodes) and sets of relations that connect actor pairs.

Traditional research only analyzes the relationship between project managers and stakeholders but ignores the interaction between stakeholders. Social network analysis interprets the project environment as a system connected with various relationships and is used to map the interrelationships between stakeholders and the social behaviors of the people involved. While analyzing the stakeholders, questions are asked about their positions, interests, and relations between them, their influence, their networks, and other characteristics, as well as their past, present positions, and future potentials (Brugha and Varvasovszky 2000). The answers to these questions can be used to determine the influence and interest levels of the stakeholders. In order to put it into practice in decision-making processes, it is necessary to obtain information about the behaviors, intentions, interactions between them, agendas, interests, effects, or the resources they have.

Power-interest matrix analysis is also an important step of risk analysis in terms of communication management of enterprises. In this context, it is ensured that both risks are identified and new business opportunities are identified. Businesses use the results obtained from these matrices to develop strategies in the decision-making phase. In this

way, it can be determined which decisions of the enterprises will be rejected or supported by the stakeholders. The Power/Interest matrix is mostly preferred in internal stakeholder analysis studies. The methods described below have been developed in more dynamic and complex inter-organizational sector stakeholder analysis studies.

In project management, one of the methods used in researching stakeholder analysis and stakeholder relations in project-based works is the stakeholder cycle method. A stakeholder cycle method is a tool developed to support the project manager and the project team in managing the project's relationships. In this context, the expectations and needs of the stakeholders are known and recognized, and it ensures that they are included in the management of relations.

3.2 Steps and Application of Stakeholder Analysis Method

The first step in Stakeholder Analysis is to brainstorm who the stakeholders will be. The next step is to prioritize them according to their strength and interest and place it on the power/interest plate. The final step is to decide what will motivate stakeholders and how to gain their support (Jacques 2001).

Stakeholders were determined as the first step while conducting stakeholder analysis within the scope of the study. Within the scope of the project, a stakeholder group was determined that includes TEI, TUSAŞ, ASELSAN, ROKETSAN, ERMAKSAN, TÜBİTAK MAM, Gazi University, Erzurum Technical University, and Sabancı University.

The second step in stakeholder analysis is to identify stakeholder interests and benefits (prioritizing stakeholders). A stakeholder matrix should be created in this step. A stakeholder matrix is visualization from stakeholder analysis where stakeholders are plotted in a matrix. The matrix is built on power/interest boards and assesses stakeholders for power and interest. The power/interest matrix created for stakeholder priority is shown in Figure 1.

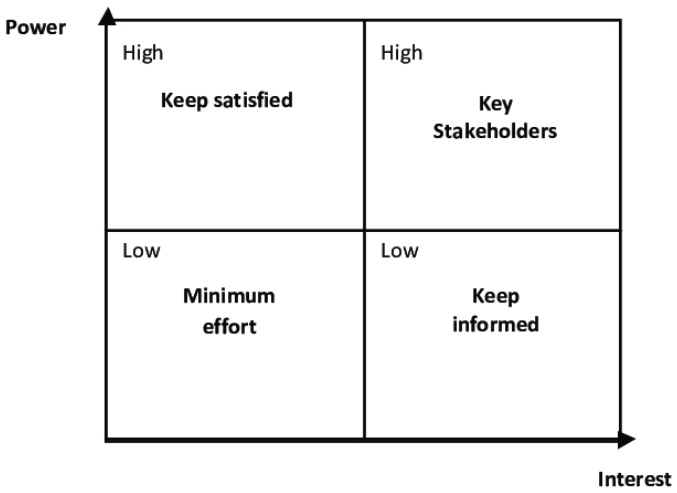

Figure 1. Power / Interest matrix (Júnior et al. 2015)

A question group was prepared to extract the interest/power and interest matrix of the stakeholders determined within the scope of the study. Question groups were prepared by questionnaire so that stakeholders could give more understandable answers. The survey some questions prepared for the stakeholders within the scope of the study are as follows.

1. What are your expectations from the project? Why did you want to be involved in this project?
2. What are the factors that motivate you to take part in the project?
3. What is your knowledge and experience about the project? Have you been involved in a similar project before or have you done research on this subject?
4. How would you describe the power(s) you have over the sector you serve (Evaluate by considering the effects of your sectoral competencies on the formation and outputs of the project)?
5. Are the interests and interests of your institution and industry aligned with the possible outcomes of the project?

6. What are your technological infrastructures? What is your level of technology to contribute to the project?
7. Are there any different issues that you cooperate with other stakeholders within the scope of the project? If so, what are they? There are many stakeholders involved in the project. If you have had the opportunity to work with these stakeholders, what kind of results did you achieve, and which are these stakeholders?
8. Can you rate your interest in the planning, execution, and outputs of the project (Assess the relevance of the outputs of the project to the sector you serve)? Not: 0 to Very High: 5.

The answers to these question groups should be examined in detail. Stakeholders are placed in the interest/power matrix according to the evaluated answers. Stakeholders are classified according to those who have power over the work and those who have an interest in the work.

4. Results and Discussion

Two experts from nine stakeholders (three universities and six companies) were asked the questions mentioned in the previous section and the opinions of 18 experts in total were collected through Google forms. The textual opinions obtained were compiled, summarized and interpreted to fill the matrix in Figure 1. The results are shown in Figure 2. According to the obtained opinions, GAZİ University EKTAM is both the most powerful and the most interested stakeholder. While TEI, ROKETSAN, TÜBİTAK MAM locate at power side, Sabancı University and Erzurum Technical University have interest to the project.

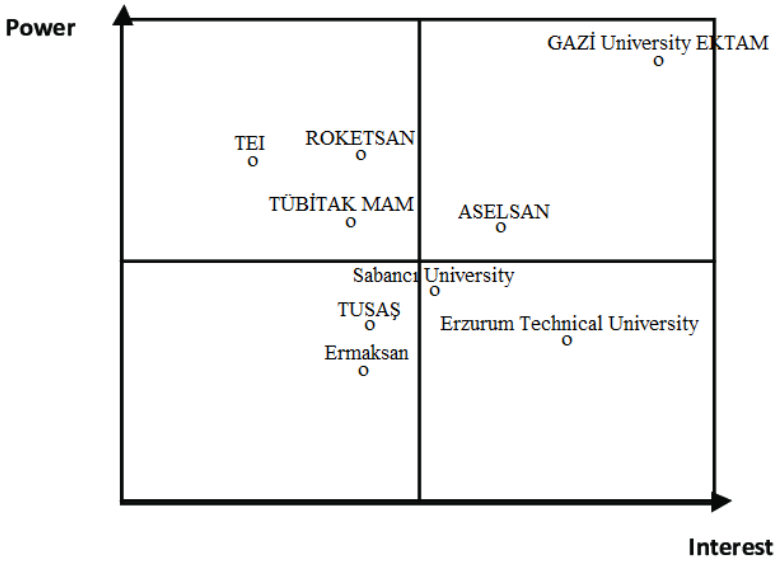

Figure 2. Filled power/interest matrix

5. Conclusion

The defense industry provides the production of defense equipment and services deemed necessary for the security of the countries. The use of AD technologies in the production of defense equipment not only facilitates the production of difficult and complex parts, but also enables more economical production.

In this project, the role and participation of stakeholders was analyzed while preparing a technology roadmap for the defense industry. While preparing the technology roadmap, it was examined in three separate phases: Preliminary activity, Development of the Technology Roadmap and Follow-up Activity. Questions were prepared to determine the interests and interests of the stakeholders (TUSAŞ, ASELSAN, ROKETSAN, TEI, GAZİ University EKTAM, Ermaksan, TÜBİTAK MAM, Erzurum Technical University, Sabancı University) that were determined during the stakeholder analysis. A power/interest matrix has been prepared to prioritize stakeholders.

In future studies, the effects of stakeholders' views on the strategies of the defense industry can be examined and the prioritization of strategies can be studied.

Acknowledgements

This work was financially supported by Scientific and Technological Research Council of Türkiye (TÜBİTAK) with a project titled "New Generation 3D Printer Manufacturing Technologies Platform" and a grant number of 20AG008.

References

Alcantara, D.P., Martens, M.L., Technology Roadmapping (TRM): a systematic review of the literature focusing on models, *Technological Forecasting and Social Change*, vol, 138, pp. 127-138, 2019.

Aleina, S.C., Viola, N., Fusaro, R., Saccoccia, G., Effective methodology to derive strategic decisions from ESA exploration technology roadmaps, *Acta Astronautica*, vol.126, pp. 316-324, 2016.

Arshed, N., Finch, J., Bunduchi, R, 2012, Technology roadmapping and SMEs: A literature review, *In the Proceeding of the DRUID Conference*, https://www.pure.ed.ac.uk/ws/portalfiles/portal/17718212/Technology_Roadmapping_and_SMEs_A_Literature_Review.pdf, Access date: 30.03.2023.

Aydogdu, A., Burmaoglu, S., Saritas, O., Cakir, S., A nanotechnology roadmapping study for the Turkish defense industry, *Foresight,* vol.19,pp.354-375. 2017.

Bray, O.H., Garcia, M.L., Technology Roadmapping: the integration of strategic and technology planning for competitiveness, in: D.F. Kocaoglu, T.R. Anderson (Eds.), *Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET),* pp. 25 – 28, 1997.

Brugha, R., Varvasovszky, Z., Stakeholder analysis: A review, *Health Policy and Planning*, vol. 15, pp. 239–246. 2000.

Bulu, S.Ö., Mendi, A.F., Erol, T., Özbilgin, I.G. Technology Roadmapping in Defense Industry*, World Academy of Science, Engineering and Technology,* vol. 12, pp. 249-252, 2018.

Chakraborty, S., Nijssen, E.J., Valkenburg, R., A systematic review of industry-level applications of technology roadmapping: Evaluation and design propositions for roadmapping practitioners*,Technological Forecasting and Social Change*,vol. 179, pp. 121141, 2022.

Gazibey, Y., Uysal, M.P., E-öğrenmeden mobil öğrenmeye teknoloji yol haritası, Türkiye'de e-öğrenme: Gelişmeler ve uygulamalar, *Cem Web Ofset, Ankara*. pp. 111-127, 2015.

Geum, Y., Farrukh, C., Lee, S., An integrated framework for assessing the technology roadmapping process from multiple perspectives: The case at the sector level. *Journal of Engineering and Technology Management*, vol. 67, pp. 101732, 2023.

Jacques, C., Stakeholder analysis and natural resource management, stakeholder in formation system, *Carleton University.* 2001.

Júnior, A.C.P., Porto, G.S., Pacífico, O., Júnior, A.P.S., Project Stakeholder Management: A Case Study of a Brazilian Science Park *Journal of Technology Management & Innovation,* vol. 10, no. 2, Santiago jul. 2015.

Kerr, C., Phaal, R., Technology roadmapping: Industrial roots, forgotten history and unknown origins, *Technological Forecasting and Social Change,* pp. 155, 2020.

Lienert, J., Schnetzer, F., Ingold, K.,Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes*, Journal of Environmental Management,* vol. 125, pp. 134-148, 2013.

Madan, A.K., Yadav, K., Jain, H., Bhatt, H., Bist, H.,Additive Manufacturing in Aerospace and Defense Industries: A Review, *Journal of Production Research & Management*,vol. 11, pp. 1-5, 2021.

Ozsoy, K., Duman, B. & İçkale Gültekin, D., Metal part production with additive manufacturing for aerospace and defense industry, *Uluslararası Teknolojik Bilimler Dergisi*, vol. 11, pp. 201-210, 2019.

Peker, B., O.,Sener, A.,G., and Kaptan,F., Antinuclear antibodies (ANAs) detected by indirect immunofluorescence (IIF) method in acute COVID-19 infection; future roadmap for laboratory diagnosis, *Journal of Immunological Methods,* vol. 499, pp. 113174, December 2021,

Probert, D., Radnor, M., Frontier experiences from industry-academia consortia, *Research Technology Management*, vol. 42, pp. 27-30, 2003.

Scott, J.P., Social network analysis a handbook, *London: Sage Publications*. Pp. 640, 2000.

Omotayo, F.O., Knowledge Management as an important tool in Organisational Management: A Review of Literature, *Library Philosophy and Practice,* pp. 1238, 2015.

Willyard, C.H., McClees, C.W., Motorola's Technology Roadmap Process, *Research Management*: vol. 30, no. 5, pp. 13-19, 1987.

Biographies

Nur Sena Ertem completed her undergraduate education in Gaziantep University, Department of Industrial Engineering in 2019. In 2019, she started her graduate education at Gaziantep University, Department of Industrial Engineering. She worked as an order preparation specialist in the Production-Planning department of Kartal Halı ve Tekstil, which manufactures carpets in Gaziantep, between 2019 and 2022.

Gizem Gunaydin is a production planning engineer at Zeki Mensucat Polynnova A.Ş. in Gaziantep. She completed her undergraduate education at Gaziantep University, Department of Industrial Engineering in 2021. She is going on her master degree education at Gaziantep University, Department of Industrial Engineering since 2021.

Eren Ozceylan received his Bachelors of Science degree in Industrial Engineering Department in 2007 from the Selçuk University. In 2010, he completed his Masters studies in the same department on supply chain modeling at Selçuk University. In 2013 he completed his Ph.D. research in Computer Engineering Department at Selçuk University. His Ph.D. thesis work mainly focused on simultaneous modeling of closed-loop supply chain and disassembly line balancing problems under fuzziness. He joined the Department of Industrial Engineering, University of Gaziantep in 2014 and is interested in supply chain modeling, fuzzy logic and disassembly line balancing.