

TECHNOLOGICAL DEVELOPMENT OF TURKISH AEROSPACE

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Abstract

In today's rapidly developing and differentiating world, technological developments show their effects in every field. This change is also reflected in the conditions of global competition. Businesses are working to maintain their presence in the market with environmental conditions and technological innovations shaped in line with rapidly changing customer demands, expectations, and needs. Technology and innovation management is important especially for the developments in the aviation and space sectors and for the survival of the enterprises in the changing global market. Companies adapt to today's conditions very quickly. Turkish Aerospace Industry Inc. (Turkish Aerospace), which has become the technology center of Türkiye and the region in the fields of development, modernization, production, system integration, and life cycle support of aerospace industry systems and is among the top hundred global players in its sector, continues to shape the future and the sector by using all the tools of innovation management effectively and holistically. In today's world, where the global balance of power is changing rapidly and extraordinary developments such as wars and pandemics are experienced, all nations feel under pressure and trends in technology are changing rapidly. Crises create opportunities for technological breakthrough and innovation. Successful exit from the crisis is only possible with innovation, technology development, and nationalization activities. In addition, it is important to successfully transfer the technologies emerging within the scope of international regulations and digital transformation policies, especially the European Green Agreement, to the defense and aviation sector. Another important issue for competition is to predict the operational environment of the future, and to analyze which technologies will come to the fore. In line with the analysis of global trends and the future, shaping innovation roadmaps, targeting the right technological gains, realizing appropriate investments, and initiating projects are all possible with technology management activities. In this study, Turkish Aerospace Industries Inc. (TUSAŞ)'s place in the aviation sector, its technological development, technology roadmap studies in the company, technology readiness level measurements, dissemination of technology gains, localization and nationalization, patent engineering, intrapreneurship, and open innovation and R&D management in TUSAŞ. Information about the applied models is given. The acceleration of the company in recent years and its position in the world market have been evaluated. TUSAŞ continues to work towards becoming a world brand as a company with the power to shape the future. The goal is to be among the top 10 companies worldwide.

Keywords

Turkish Aerospace Industry, TA, Aviation, Technology, Defense Industry, Technology Roadmap, Space Technologies

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1. Introduction

Turkish Aerospace Industries Inc. (Turkish Aerospace), which was founded on 28 June 1973 entered a rapid growth process after the nationalization movement carried out in 2005 and started to show itself in the international arena as Türkiye's leading aviation and space center. According to the 2021 Defense Industry Companies ranking, it is 68th in the world (Defensenews, 2021). The goal of Turkish Aerospace is to be among the top 10 companies in the world. In this direction, it accelerates its work and makes investments on the path of growth. In other words, the defense industry is the driving sector of development and industrialization for developing countries. For example, Türkiye invested approximately US\$ 18.7 billion in various defense projects in 2017 (SIPRI Military Expenditure Database, 2018). It formulates its strategies to reach a turnover of 10 billion USD in 2027.

Considering the satisfaction of its internal and external stakeholders, Turkish Aerospace Industries Inc. as a company that offers many products in the field of defense and aviation to our country and friendly countries, it is advancing towards its goals as a company that strengthens its technological direction and engineering infrastructure day by day. The aircraft, produced in a very short time compared to equivalent production processes, reveals its quality as a pioneer in its field with its various achievements such as the human resources it has trained and the writing of our country's first aviation process and certification documents.

Turkish Aerospace works with great effort and devotion to carry many domestic and national products to the sky. It continues to change with its unique discipline by reshaping its works in order to produce more aircrafts. The implementation of an effective technology and innovation management together with the acceleration of new technologies, Research and Development (R&D) investments and production stages plays an important role in the realization of this dream and change.

Thanks to the strategic investments made in recent years, Turkish Aerospace has reached a respected and enviable position in the global market with its technologies and the importance it gives to unconditional customer satisfaction. Turkish Aerospace's activities are carried out by seven strategic units: Manufacturing, Aerostructure, Aircraft, National Fighter, Helicopter, Unmanned Aerial Systems and Space Systems. Its structural unit carries out business development activities abroad. With very recent change, Executive Vice President of Manufacturing is responsible in all production activities of the company. Aircraft, National Fighter, Helicopter, Unmanned Aerial Systems and Space Systems, which are described as product groups, carry out design and integrated product activities.

When we examine the aviation history of our country carefully, the origins of the activities are based on the last period of the Ottoman Empire and especially the first years of the republic. The activities, which gained momentum with the establishment of the Republic, unfortunately ended with the start of Marshall aid. Factories started to close one by one. (Dervişoğlu, 2007; Vecihi Hürkuş, 2008).

The problems our country has experienced in recent years and the power-based changes in the world have required our country to have a strong defense industry infrastructure. As a result of the national design and production that started in 2005, it has reached the stage of producing a wide variety of platforms. The wide range of products and activities provides Turkish Aerospace a unique position in the world. Originally developed ANKA Medium Altitude Long Endurance Unmanned Aerial Vehicle System, High Payload Capacity

(YFYK) Unmanned Aerial System – AKSUNGUR, TURNA and ŞİMŞEK Aircraft Systems, HÜRKUŞ, HÜRJET, National Fighter, T625 Utility Helicopter GÖKBAY, E/O Reconnaissance Surveillance and Communication Satellites, Small GEO Communications Satellites, Advanced Avionics Modernization Suites for Fixed and Rotary Wing Aerial Platforms, T129 Attack and Tactical Reconnaissance Helicopter, T70 Utility Helicopter, A400M Military Transport Aircraft, Special Mission Aircraft System Integrations, as well as the design and production of military and commercial aerospace components are among Turkish Aerospace product and activity range. In 2023, work continues to release the National Fighter from the hangar and to carry the jet training and light attack HÜRJET to the sky for the first time. In addition, the first delivery of the general purpose GÖKBAY, the completion of the production process of the Heavy Class Attack Helicopter with the TÜRKSAT 6-A satellite, and the mass production of AKSUNGUR, which started its first field mission, continue without slowing down.

With our activities based on sustainable growth and dual use of technology, it has been possible to gain the ability to produce both civil and military platforms together domestically. A strong aviation infrastructure has started to form in our country and Turkish Aerospace has become the pioneer of the sector. As of the first quarter of 2022, it has reached nearly 12,000 employees and a closed area of 650,000 square meters. Turkish Aerospace, which has very modern and world-class facilities, has made moves to develop its human resources in recent years. In this context, it has started to cooperate with many universities and technology institutions both in the country and abroad. The goal is to become a world brand aviation and space company that has achieved global competitiveness.

In this study, the position and leadership of Turkish Aerospace in our country on the way to develop the original products to our country has been evaluated, and in this direction, detailed information is given about the following tools and methodologies of technology and innovation management.

- Turkish Aerospace Technology Roadmap
- Indigenization and Nationalization activities
- Patent Engineering activities
- Intrapreneurship and Open Innovation activities
- R&D Management activities

As it is known, the basis of these activities is R&D activities that start by making use of basic sciences. Technological innovations accelerate these developments (Carayannis et al. 2015; Schilling and Shankar, 2020). The studies, which started with basic R&D and continued until product-specific development activities, accelerated the development of Turkish Aerospace and strengthened its position.

In most of the organizations operating in the defense and aerospace industry, it is observed that the structures are cumbersome and the workflow is quite slow and low-efficient. In this sector, where defense industry customers are dominant, the long-term projects and slow progress of the works should be considered quite normal by the governments. In other words, senior managers working on defense industry projects often have to take unforeseen risks as a result of defense industry activities. Decisions usually take place in the long run (Yigit et al., 2021). In developing countries like ours, this situation needs to be improved

since the political processes of the countries are more dynamic. For this reason, Turkish Aerospace's mission is different from the leading companies of the world.

Large-scale companies can implement growth models based on R&D with their own means. However, there is a greater need for the contribution and regulatory role of the governments in increasing the R&D capacities of Small and Medium Enterprises (SMEs), which constitute a very large part of the economy. In countries such as South Korea and China, which have shown rapid growth in the recent past, it is seen that these growth models based on R&D are specifically planned for SMEs (Seo and D. Cho, 2020; Petti et al., 2017). In order for the aviation industry to achieve the expected growth, it is absolutely necessary to grow within an ecosystem (Gemici and Öztürk, 2020). Turkish Aerospace is aware of this and carries out very detailed studies in this context. Joint projects and development activities also gained momentum.

2. The Impact of International Crises on Our Country's Technology Ecosystem and Turkish Aerospace Technology Roadmap

Companies that can make realistic predictions about the operational environment and technologies of the future will be able to create knowledge and gain a sustainable superiority by revising their infrastructure and systems. While the possibility of conventional warfare gradually decreases in the future, it is predicted that asymmetric threats will begin to emerge. In our digitalized world, it is inevitable that cyber threats will increase. Concepts such as "land superiority", "sea superiority", "air superiority" that determined operational success in the past have been left to concepts such as "air-space superiority", "cyberspace superiority" and "electromagnetic warfare superiority" (Friedman, G., & Friedman), M., 2002). It does not seem possible to achieve other advantages without the advantage of the electromagnetic spectrum. It is considered that network-centered command control and interoperability will play an active role in the operation. Among the important developments that will shape the operational environment of the future, there are technologies such as autonomy, artificial intelligence, human-machine interaction, and unmanned systems working in flocks. It is predicted that the possibility of controlling and militarization of space will increase in the future (Kleinberg, H, 2007). Future scenarios such as unmanned space vehicles, satellite jamming, anti-satellite weapons and placing weapons in space are on the agenda. Considering all these future operational environment scenarios, it is evaluated that technologies for speed, range, altitude, maneuver, low visibility, increased situational awareness, autonomy, unmanned systems, high command and control level, network security will gain increasing importance in the (Kupchyn et al., 2021). In addition, in line with the changes in operational conditions, it is predicted that advanced thermoplastic materials, nanotechnology, shape memory, self-healing and adaptive materials will come to the fore in the future.

It is seen that environmental threats such as global warming, carbon-based mobility and the measures taken also shape our sector. Within the scope of the European Green Agreement, it is predicted that sustainable approaches that focus on the environment will come to the fore in the design of ecological investments, energy technologies, aircraft, and aircraft components. The European Green Consensus is a step taken by EU countries to leave a cleaner, livable, and better world for the future (European-green-deal, 15 May 2022).

Turkish Aerospace Technology Roadmap (TRM) is a planning tool that includes the technologies required for the products and processes within the scope of Turkish Aerospace

field of activity, and information on the acquisition of these technologies. Turkish Aerospace's technology strategies that are compatible with its vision, goals and competencies and can provide sustainable competitive advantage on a global scale; It is of great importance in terms of determining the technologies suitable for the relevant strategies and making and managing the necessary planning in order to ensure the acquisition of the determined technologies. In order to realize the technology issues that need to be acquired, TRM carries out studies in coordination with strategic objectives. TRM is the focal point of our R&D, technology and innovation management activities.

In line with the vision of becoming a "a global brand aerospace company" with unique products and global competitiveness, current developments and technological trends in the world are followed systematically. Technologies that will contribute to our competitiveness and studies on capabilities that are not currently available in our country are among the areas we focus on. Different methods are being tried for technology transfer.

While determining the technology issues that shape our company, the technologies on which both the relevant Turkish Aerospace departments and the world's leading aerospace and defense companies, research institutions and universities are studied and analyzed. Throughout these studies; examination, analysis and reporting of technological developments in Türkiye and in the world; researching technology predictions in line with Turkish Aerospace goal of providing sustainable competitive advantage on a global scale; identifying technology issues that need to be acquired in the short, medium and long term; it is important to coordinate these technologies with the relevant groups and to create acquisition plans. Within the scope of acquisition plans, timeline, stakeholders and project setup are defined related to the relevant technology. There is also a taxonomy in TRM, which is used to classify technology topics and define their relationship with each other correctly. Technologies that will shape the future are determined by analyzing the technologies on which the world's leading aerospace and defense industry companies and research institutions are working on, and the subjects that are considered to provide a competitive advantage to our company are added to our technology roadmap. In this context, it is predicted that technology trends in artificial intelligence, digitalization, cybersecurity, sustainability, and material-manufacturing will guide the development of the aviation and space industry.

Advanced materials are among the critical issues that we work on in the aerospace and defense industry. The search for light and durable materials in aircraft for reducing fuel consumption and performance continues in parallel with the development of technology. At the same time, innovative manufacturing methods such as additive manufacturing and thermoplastic production methods are studied. Tools and processes that will accelerate the product development and production process are among the subjects that are intensively studied. With the maturation of technologies such as artificial intelligence and big data; analysis, modelling and simulation, failure prevention or early detection of failures are also prominent areas of study.

In addition to the preparation of the Technology Roadmap, the measurements of the Technology Readiness Levels (TRL) of the technologies are critical in terms of quickly solving the risks that may arise during technology development and minimizing their negative effects on the product development process. Unfortunately, due to financial concerns, it is not possible for even large companies to show interest in cutting edge technologies that are developing, have high risks and have no market yet. In order to overcome these barriers, it is necessary to establish supports or mechanisms to provide

support. Only in this way an innovation ecosystem can be created that can support the entire process from 1 to 9 at the technological readiness level.

Technologies for our unique platforms such as National Fighter, HÜRJET, ANKA, T625 GÖKBAY and ATAK-2 constitute a large part of the topics in our Technology Roadmap. It mainly focuses on subjects in technological competence areas such as materials, manufacturing, structural, aerodynamics, avionics, air and spacecraft systems, and informatics. Developing solutions that provide operational superiority to the Turkish Armed Forces by integrating the most advanced technologies into our original products is among our main goals. In addition, R&D activities and investments for aircraft concepts and technologies that will come to the fore in the future are continued by increasing.

It is predicted that the new opportunities offered by technological developments will shape the future of the defense and aerospace industry. In this direction, studies on automation and digitalization technologies, new materials, alternative energy sources, artificial intelligence, data analytics and Industry 4.0 technologies come to the fore (Öztürk, 2018). It is expected that the use of nano-doped composites, new generation coatings, additive manufacturing and thermoplastic composite materials will become widespread in our industry in the future (Ateş et al., 2021). Innovative aerodynamic designs, innovative avionic technologies, propulsion systems, pilot and platform health tracking systems, innovative navigation systems, autonomy and cognitive pilot technologies are predicted to shape the future. It is considered that as shape-shifting wings and metamaterials, flapless wings, innovative material qualification methodologies, new test procedures, non-destructive testing technologies, development of material modeling platforms, additive manufacturing and nanomaterials will also provide competitive advantage. The issues regarding the applications of the developments in the specified fields in the aviation sector are closely followed and are also covered in our technology roadmap.

Active participation and contribution provided to studies such as TRM and Technology Taxonomy carried out by our external stakeholders. The Composite Technologies Roadmap study, which was carried out under the leadership of the Presidency of Defence Industries, in which Turkish Aerospace assumed the role of the leading institution, is among the successful examples. Within the scope of this study, it has contributed to the activities of determining the technology issues that our country needs and the current situation in this field, and planning for the development of composite technologies that have strategic importance and have a direct impact on our national security.

Scientific and technological cooperation activities are planned with internal and external stakeholders within the framework of the subjects included in the Technology Roadmap. The TRM guides the training of human resources in order to meet the need of engineers and researchers for the competence areas that Turkish Aerospace should acquire. Collaboration projects and academic studies are initiated by announcing the areas of need to universities. Programs to train human resources are also carried out with universities.

3. Indigenization and Nationalization

Developing technologies that will shape the future of the defense and aerospace industry, providing competitive products and services with domestic opportunities and national technologies are among the strategic objectives of Turkish Aerospace. In this context, the advantages of domestic and national production of critical technologies which are the cause of being dependent on abroad are very important. The restrictive regulations applied by the countries that develop technology in the defense industry adversely affect the activities

of opening and maintaining the originally produced defense systems to new markets. For this reason, it would be appropriate to support and increase the indigenization and nationalization efforts in related technology areas. In addition, prioritization is required in order to consolidate the needs of all sectors and to determine the focus areas so that the relevant investments are in place. Also, it is critical to direct similar technological needs to the technology focus, which has gained capability through indigenization and nationalization efforts to ensure sustainability. As a result of these efforts, our foreign dependency will decrease, and companies that gain domestic capability will be able to export value-added products by gaining a share in foreign markets.

The restrictive regulations explained above are the internal regulations created by the countries with the concern of national security, and they are the rules that determine the principles applied in the transfer of military and/or civilian goods, services or technology that are subject to foreign trade. Due to export restrictions and embargoes, companies may face with supply problems. In order to eliminate this situation, intensive studies are carried out within the scope of indigenization of products that are difficult to supply and contain critical technology. Reducing dependency on import items that may fall under such restrictive regulations in critical technology areas, development of domestic industry in parallel with international markets, increasing the share of medium-high and high technology products in industry and exports are handled within the scope of indigenization studies.

Measures are taken against restrictive regulation risks by creating “national” and “domestic” resources in critical technology areas. The critically important materials, subsystems and systems that our country has difficulty in supplying are determined and prioritized within the scope of nationalization and indigenization activities, and acquisition plans are prepared. In the activities handled within this scope, the needs of the aerospace and defense industry are considered as the driving force, while at the same time, it is aimed to create economies of scale by targeting the consolidation of other sector needs. As a result, it is aimed to create the main players that can develop the system, subsystem and components domestically. Marketing strategies that will enable the developed product to be opened to the foreign market are also developed together with our stakeholders. With this perspective, the needs of critical systems on all our platforms are consolidated and Indigenization Roadmaps are prepared on the basis of subsystems. With this approach, all components of the technology acquisition process are planned strategically, and it is aimed to create a structure that will make both companies and the sector sustainable.

The concepts of indigeneness or indigenization and nationalization were introduced by if we explain in detail by quoting Prof. Öztürk’s work;

“Indigenization” is the realization of the production of a product within the borders of the country, regardless of intellectual property ownership. This production can also be done under a foreign license. If we define the concept of nationalization; “Nationalization” means owning the entire life cycle of a product, from design to production, to logistics support, including intellectual property ownership. It is of great importance for the country to carry out all these activities within the country until it reaches a certain power. Many countries that have a voice on the world stage have also used this approach. In order to reach this point, indigenization and nationalization studies must be carried out without compromising within a systematic and planned program. When a certain power is reached, the establishment of our own supply chain in the world will become much easier and the doors will begin to open one after the other. However, it should not be forgotten that it is

very important that critical technologies always remain domestic and national. Otherwise, weaknesses may be encountered both in the administration of the country and in the defense of the country.” (Ozturk, 2022).

The geography of our country necessitates indigenization and nationalization studies. The region’s mobility and long-standing problems require a strong defense industry. In this direction, serious work should be done. Data and information management, which is gaining importance in every field today, is of great importance in the correct construction of the relationship between Technology Acquisition and Industrialization. It is considered that the success of the indigenization and nationalization efforts can be achieved by establishing this relationship on solid foundations. In this direction, studies on the comprehensive analysis of the capabilities owned in the country have been intensified in line with the strategic goals of our company. Systematic approaches are discussed for the correct definition of Turkish Aerospace needs and the planning of resource use in order to meet these needs. It is of great importance to develop constructs that will lay the groundwork for the creation of economies of scale in line with the needs that are correctly defined and the analyzes put forward. It is aimed to reveal comprehensive action plans by matching the needs of our company with the analysis of the capabilities of domestic industry organizations and R&D centers.

4. Patent Engineering

The number of patents and their commercial qualities are one of the important parameters in determining the development index of countries. In our country, important studies have been carried out in this field in recent years. Our country is not very advanced in this sense. Although the number of patent applications owned by Turkish Aerospace is not yet at a level to compete with its competitors in the world, the number of national and international patent applications continues to increase thanks to the patent engineering unit established in 2018. Strong countries have high performance in this area.

Patent database analyzes are widely used to follow the work of competitors and to design products that will make a difference or be an alternative to competitors. The importance of patent database analysis is especially mentioned in our company and in all the environments we have access to, in this context, “patent engineering” trainings, including the application of patent database analysis, are given to thousands of engineer candidates studying at various universities in our country. It is evaluated that the technical solutions developed by spreading the patent database analysis culture in all defense industry companies can be ensured to be fast and effective. Patents that are free to use after the expiry of the protection period of other leading companies in the sector are also closely followed. Explaining the invention correctly and determining the scope of protection are as important as realizing the invention. It is known that the power of specification writing is a factor that directly affects the commercial value of the patent. Qualified patents containing main claim and sub-claim sets with a wide scope of protection in accordance with international standards are written within Turkish Aerospace. It is considered that qualified specification writing can only be carried out with trained personnel who have experience in technologies in the company’s field of activity. In addition, we are working on the methodology of the patent valuation process and the infrastructure of our commercialization method is being created.

To master the technical details of innovative technologies; to determine the “State of the Art” of the known and current state of the technique by analyzing the patent database;

patent engineering activities are carried out in order to carry out studies for the incorporation of the “TRIZ” method, which was developed on the basis of patent analysis in order to prepare innovative design solutions, into the design culture of our company.

In these studies; to be involved in product design processes and to prevent possible patent infringement, thus preventing products from being recalled from the market, and serious financial penalties and sanctions that may arise from license lawsuits; performing specification writing that will provide strategic protection that will increase the commercial value of the invention; It is aimed to ensure that the products can be licensed in order to be original, domestic and national.

Thanks to the investments made in the patent engineering unit, Turkish Aerospace Industries has grown by 50% every year in national, international, and utility model applications since 2018 compared to the previous year. In addition, Turkish Aerospace has earned various awards for its intellectual and industrial property awards applications. In recent years, Turkish Aerospace Industries, which received “World Intellectual Property Organization (WIPO) Best Domestic Invention Award”, “Sertaç Köksaldı Intellectual Property Rights Achievement Award”, Istanbul International Inventions Fair (ISIF’19) Grand Prix and International Federation of Inventors Associations (IFIA) Grand Prix awards respectively, continues to carry out studies that will increase the patent application and quality.

5. Innovation Management, Intrapreneurship, and Open Innovation

Going beyond product development or improvement; maximum importance is given to innovation activities carried out within the scope of developing brand new products, services, and business models with commercial added value by providing additional income to the company. Within the framework of our Innovation and Technology Policy, by creating an aerospace ecosystem with the quadruple helix model that enables R&D, innovation, indigenization, and nationalization and focuses on raising human resources, new innovation strategies are developed in university, government, industry, entrepreneurship ecosystems and common mind platforms.

In this context, studies are carried out on the subjects of “intrapreneurship” and “open innovation” in order to develop new products, services and business models that our Company will need more effectively. This issue has been on the agenda for many years in the world. For the first time in history, in the 1930s, the famous Austrian economist and political scientist Joseph Alois Schumpeter defined innovation as the driving force behind economy and development and predicted that economies would be reshaped with innovative activities (Hagedoorn,1996).

Intrapreneurship; it is the whole of the work carried out by projecting and implementing innovative ideas that are regularly gathered from the company employees in areas related to the innovation focus of the company. In this context, innovative ideas are developed and implemented by employees with an entrepreneurial approach. It is aimed to commercialize the innovative thinking of the employees by realizing them with the opportunities and systems offered by the company. In this framework, the entrepreneurship approach is adopted by the employees of the company, from the idea stage to the commercialization of the innovation proposals that will bring new revenue to the company. Benefiting from company resources and administrative / technical infrastructure (IT support, competent employees, legal issues, intellectual property management, training and mentoring support to develop entrepreneurial ideas, financial support, etc.); the opportunity to implement

innovative ideas faster with company opportunities while continuing their current business; the opportunity to realize the entrepreneurial idea in line with the company's priorities with the project team that it can create, without commercial risk and anxiety; supporting employees to think like entrepreneurs, contributing to improving the current way of doing business and establishing an entrepreneurial culture within the Company with agile and accelerating processes, the opportunity to develop an innovative idea directly with the senior management is provided by in-house entrepreneurship.

Open innovation, in its simplest form, can be defined as innovation studies using sources outside the company. It is seen that businesses need to develop their innovation skills and apply them to the whole sector in order to survive in conditions that require tough competition and struggle to stay in the market. Businesses have started to massively use open innovation and outsourcing to access innovative ideas more easily and find solutions to their internal problems. The taboo that open innovation in the defense industry will harm businesses and cause problems in protecting privacy has disappeared and studies in this area have gained momentum. The main actors of open innovation; entrepreneurs, suppliers, universities, and customers.

The open innovation system is not an alternative to the intrapreneurship system, but a complement to it. Therefore, both issues are studied holistically in Turkish Aerospace.

Shaping the future of Turkish Aerospace with the contributions of Turkish Aerospace members, thanks to the in-house entrepreneurship program; In order to contribute to these studies, it is aimed to cooperate with the entrepreneurship ecosystem that is developing day by day in Türkiye by focusing on open innovation activities. However, in order to achieve success in this field, as in every other subject, it is of great importance to determine some priority issues and to create innovation focus topics. Short, medium, and long-term innovation focus topics in the field of in-house entrepreneurship and open innovation are determined at workshops held with the participation of senior management and reviewed periodically.

In the relevant workshops, from our current situation as a company; in line with our mission, vision and values, short, medium, and long-term innovation focus areas are determined in order to reach our target situation (in terms of growth rate, turnover, market share, profitability rate). In addition, our innovation strategy is formed as a guide that reveals what level and what kind of approach to be innovative on the relevant innovation focus issues, and how this level can be reached.

The basic approach in our innovation strategy is to continue working with our R&D competence when we are strong in related vertical and horizontal issues and to carry the targeted studies to the expected point by using the in-house entrepreneurship potential within the company. On the remaining issues where the competence and capability of external stakeholders is needed, a methodology is followed for the execution of open innovation activities in cooperation with the entrepreneurship ecosystem.

We also have strategies followed specifically for intrapreneurship activities to be carried out on vertical and horizontal issues. Within the framework of the in-house entrepreneurship program, idea campaigns are organized for short-term innovation focus topics. The aim at this stage is to transform the ideas gathered from Turkish Aerospace into projects and to evaluate them at regular intervals by the "Innovation Committee" established within Turkish Aerospace. In order to achieve this goal, training and mentoring support is provided to Turkish Aerospace employees who submit ideas to related programs. At the

end of the process, it is aimed to work on the commercialization of the projects selected by the Innovation Committee by including them in the company's ordinary business processes. On the other hand, it is planned to work on the subjects that Turkish Aerospace has decided to work on in the medium and long term, by successful in-house entrepreneurs within Turkish Aerospace and / or by special teams selected from among our employees who are experts in their fields and subject to a different process.

On the way to reach the final goals, it is planned to operate open innovation models by making use of sources outside the company, after the studies carried out with intrapreneurship activities are brought to a certain point or during the relevant intrapreneurship activities. As in in-house entrepreneurship, we also have strategies followed for open innovation activities to be carried out on vertical and horizontal issues.

In order to contribute to our company's commercializable patent portfolio, able to commercialize, and to protect these patents in competitive markets on international platforms, joint patent applications with entrepreneurs with innovative ideas at the idea stage, support for these initiatives in the patent writing and application process, so that our company can use the relevant idea for commercial purposes, so that cooperation with a win-win model is carried out as an innovative competency strategy in terms of technology transfer.

In addition, by meeting with the technopolis / technopark managements and by making ecosystem visits; by making cooperation negotiations with venture capitals; mergers, acquisitions, strategic partnerships, and investment models are created for entrepreneurs with the necessary competencies determined specifically for innovation focus issues by collaborating with companies that make accelerating programs with entrepreneurial analysis. These models are; for initiatives deemed appropriate by the innovation committee formed specifically for thematic focus topics; strategy management, subsidiaries, financial affairs, and technology management teams are operated according to the decision made by the supreme board.

In addition, purchasing the shares of venture capital investment funds established to invest in entrepreneurs residing in Türkiye, or investing in venture capital investment trusts or investing capital in entrepreneurs operating in incubation centers within the scope of related laws are among our open innovation strategies.

Strategic solution partnership agreements are made with technoparks and technopolis, and studies are carried out to offer the areas allocated in the name of Turkish Aerospace in the relevant regions as incubation services to entrepreneurs.

Studies are carried out to provide networking opportunities with the defense industry ecosystem in order to conduct R&D together with the identified startups, to provide them with the opportunity to test their technologies at Turkish Aerospace facilities (Proof of Concept, PoC), to purchase products / services, to use different solutions, to provide training / mentoring support, to gain new customers, and to strengthen access channels to new customers and to operate cooperation models with the entrepreneurial ecosystem on the subject of creating military / civilian use cases, with the methodology of co-development, especially for entrepreneurs who have difficulty in positioning themselves in the defense industry at an advanced stage.

Innovation focus topics and processes to be operated in in-house entrepreneurship and open innovation activities, and our company's innovation focus topics and strategy are published and announced openly to the access of all company employees.

6. R&D Management Activities

The number of personnel working in the R&D Center of our company, which is one of the oldest and currently the largest R&D centers in Türkiye within the scope of Law No. 5746, will reach 3.614 as of the end of 2021, and those working in R&D, the total number of personnel reached 3.809 including the technopolis branches. Our company, whose R&D expenditure in 2021 has reached 4.39 billion TL, is second position "R&D Expenditures in Türkiye", "Number of R&D Personnel" and "Number of Female Personnel Working in R&D" categories in the "R&D 250" research (Arge250, 2020).

R&D management activities includes managing the portfolio of R&D projects (managing and monitoring the initiation, execution, change, closing and post-closing processes of R&D projects, executing the application processes for R&D support programs, reporting the R&D portfolio and metrics), R&D Center management within the scope of Law No. 5746, management of technopolis R&D activities within the scope of Law No. 4691, and monitoring of R&D legislation and regulations in our company.

R&D management activities play an important role in the development and implementation of new products and technologies by our company, which works for Turkish Aerospace to achieve its goals by shaping the aviation and space ecosystem in our country.

The most important strength of our company is the production infrastructure. This infrastructure can be sorted as CNC Turning and Milling Machines, Sheet Metal/Composite Forming Machines, Fiber Laying Benches, Pallet Production, Hot Forming Press, Fabric Cutting Machines (Ply Cutter), Ultrasonic Inspection Benches, Robotic Drilling Benches, Automatic Drilling Benches, Honing Benches, Shot Peen Machines, CMM-Coordinate Measuring Machines, Magnetic Particle Inspection Benches, Grinding Machines (Surface, Cylindrical, Gear), Pipe Bending Machines, Sandblasting Machines, Titanium Forming Presses, Autoclave, Composite Curing Ovens, Paint Process Cabinets, Paint Drying Ovens, and Paint Robots. Over the years, our company has gained great experience and has become one of the most important production facilities in the world. In addition, our company's high precision machining, special gear manufacturing, special heat treatments, high technology paint and manufacturing capabilities are insufficient, and technological support and consultancy are needed in this area. Serious R&D studies should be carried out in these areas. The most effective way is to acquire these competencies through R&D.

We need titanium forging capability for the parts to be used in the National Fighter (TF-X). Capacity should be developed by making investments in this area as well. For titanium forging, very high forces are required, as well as heat treatments between pressing operations to ensure temperature homogeneity of a mass with a large thickness. There are also difficulties in die technology depending on the geometry in titanium forging processes. When a titanium part at around 1000 °C is to be shaped between molds made of steel, overheating is observed in the molds and deformations occur and the molds become unusable after a few parts. The temperature differences between the surface and the core of the billet materials cause serious changes in the microstructure. For this reason, the process requires serious experience. Since titanium forgings used for aviation are generally

used in important moving and load-bearing places, these parts are also geometrically large (for example, A350 landing gear body; helicopter rotor components) for this reason forming processes are carried out in hydraulic presses that can apply forces between 20.000 tons and 75.000 tons. Forging is generally used to obtain geometry close to the shape the final part should be, often requiring subsequent machining. The alloy preferred as forging in aviation is a high percentage of Ti-6Al-4V alloy.

Machining of titanium materials also includes many parameters in itself. The most important of these parameters is the heat transfer between the cutting tool and the part. The majority of the heat remaining in the tool during the cutting process causes overheating and later wear problems.

Additive manufacturing technologies are a new industry formation that stands out among the technologies that are on the verge of realizing a transformation that can significantly affect the cost and quality cycles of the industry branches it affects due to its high potential. Additive manufacturing technologies not only make the production process more accessible and faster, but also bring along a new production ecosystem and a philosophical transformation (paradigm leap). In addition, additive manufacturing technologies are rapidly becoming widespread in every field. In order for this technology to be used more effectively, it is necessary to acquire suitable benches, to examine and model the mechanical performances of the manufactured parts, and to acquire technologies such as electron beam melting (EBM). In additive manufacturing technologies, technologies such as additive manufacturing of nano-short fiber-doped thermoplastic materials, Direct Energy Deposition (DED), Selective Laser Melting (SLM) should also be acquired. There are also needs to develop process parameter optimization, material, process monitoring, modeling and simulation, part design, secondary processes, non-destructive testing, and qualification/certification processes on powder SLM and DED techniques. Technological competence should be gained in this area and foreign dependency should be completely eliminated. There are great opportunities in this field, and detailed and comprehensive studies should be carried out in order to transform these opportunities into added value.

On the other hand, rapid steps should be taken in digitalization in manufacturing, and digital transformation methods should be matched with appropriate technologies. In this direction, it is important to prioritize projects that aim to create a virtual copy of the physical world, encourage the existing industry in the direction of big data, automation and artificial intelligence, and equip it with advanced technology. Here, it is very important that hardware manufacturing is done within the country, and an infrastructure should be established in this area.

In our world, where change and innovation are inevitable, we experience periods of technological progress that we can describe as a paradigm leap, constantly changing our life flow. Today, we are in a fourth period of technological advancement: This new era, called Industry 4.0, includes a structure that regulates and controls the entire value chain throughout the product's life cycle. It is possible to create networks that increase value by self-developing according to criteria by integrating all objects in the value chain, physically connecting people, objects and systems to each other in the cyber environment, focusing on increasingly special customer requests, accessing all necessary information in real time, determining the most appropriate value stream using the obtained data, and various factors such as cost, accessibility, resource consumption.

Advances in technology have led to remarkable increases in industrial productivity and agenda-setting effects from the industrial revolution to the present. The basic technologies that make Industry 4.0 possible create innovative effects in the production stages of the aerospace industry, increasing the production speed and quality.

It is necessary to carry out intensive research and development activities in order to increase the competitiveness of our country in production and manufacturing activities and to ensure technological superiority by adapting to these new technological trends simultaneously with the world. In this context, studies and plans should be made on technologies that are important for our country, and it should become a global leader in new generation manufacturing technologies. For these activities, universities, research centers, and technology companies should carry out joint studies in cooperation. Technology centers, which are one of the important stakeholders of the ecosystem, should act as a bridge between universities and companies, and it should be possible to transform technology into a product by increasing the technology readiness level from 3 to 6.

7. Conclusion

Our company, which has grown, developed and changed in recent years, continues its activities without slowing down with the vision of being one of the top 10 aerospace companies in the world. Our company is the leader of our country in the aerospace industry. But our goal is to become a company that manages technology and innovation, keeping a permanent place among world leaders. Our goal is to transform into a technology-oriented, productive, competitive structure. It is obvious that new technologies, innovation perspective, R&D investments and the acceleration of production stages play an active role in the realization of this goal, and we are taking firm steps towards our future goals. Our company, with its various achievements such as aircraft produced in a very short time compared to equivalent production processes, simultaneously trained qualified human resources and writing the first aviation documents of our country, reveals its quality as a pioneer in its field.

We are working hard to respond instantly to the needs of our country's defense industry with more domestic and national products, to be able to compete with the world's leading aerospace companies, and to carry many domestic and national products to the sky. Studies are being reshaped in order to design and manufacture more aircraft.

Being aware of the fact that we can reach our target leader position in the aerospace and defense industry with the contributions of all our internal and external stakeholders, it is of great importance to design and operate models focused on technology and innovation management and to involve the relevant departments in the organization.

For aerospace activities to be sustainable, it is essential to establish a strong domestic supply chain. The ecosystem is the indispensable first condition of aerospace. We need to grow together and get stronger together. It is essential to support this structure with strong human resources, which means strong world-leading universities and entrepreneurship ecosystem. A model that is open to the world but will be damaged by the crisis with the least structure should be adopted, and a harmonious model should be studied in which the global supply chain is not neglected.

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