

NATIONAL TECHNOLOGY INITIATIVE IN COMMUNICATION

Dr. Ömer Fatih SAYAN

NATIONAL TECHNOLOGY INITIATIVE IN COMMUNICATION

Dr. Ömer Fatih SAYANⁱ

Deputy Minister of Transport and Infrastructure

Abstract

Within the scope of the National Technology Initiative, Türkiye reduces its dependence on foreign technology, increases its competitiveness in global markets and makes progress in the production of critical technologies. Türkiye aims to become a country that not only uses technology but also produces it. In addition, in line with the 2023 targets of our country; under the coordination of the Ministry of Transport and Infrastructure (UAB) and Information and Communication Technologies Authority (ICTA), with the support of our other institutions, important studies are carried out for the production of products in 4.5G, 5G and satellite Technologies with local and national resources. In this context, ULAK base station, the first domestic and national 4.5G base station developed in our country is used in a total of 1765 sites as of April 2022. In addition, studies are carried out to produce technologies to be used in 5G by both ULAK Communications Inc. and Communication Technologies Cluster (HTK) with domestic and national resources. In addition to these, Türksat's Domestic Communication Satellite Project Türksat 6A, which is one of the most important projects in Türkiye, is progressing rapidly. Türksat 6A is produced with the highest domestic rate, with the contribution of Türksat engineers who received training in space technologies within the scope of the technology transfer program realized during the production process of Türksat 3A, Türksat 4A and Türksat 4B satellites. Aselsan produces many communication devices from military radios to identification of friend and foe systems, from public safety communication systems to satellite communication systems. On the other hand, support is provided by the operators in our country to the studies carried out by the manufacturers, domestic products are also developed by the operators, and the rate of domestic products used in their networks is increasing. In this document, outstanding projects within the scope of the National Technology Initiative in Communication and in this respect, the details of the domestic and national product studies carried out by UAB, ICTA, Aselsan, ULAK Communications, HTK and operators are given.

Keywords

Communication, Mobile, Satellite, Radio, Domestic and National, ULAK, 4G LTE-A Base Station, End-to-End Domestic and National 5G Communication Network, Türksat 6A Satellite, Siber Security

ⁱ ORCID: 0000-0001-5786-4027

1. Basic Indicators of the Communication Sector in Türkiye

With the liberalization process that started in 2004 and the regulations made, the electronic communication sector shows a steady growth. As of the end of 2021, the number of operators operating in the electronic communication sector is 442, and the number of authorizations given to these operators is 792. In 2021, the total net sales revenues of operating operators increased by 16.8% compared to the previous year and reached 67.2 billion ₺. In parallel with the developments in the electronic communication sector, the investments of the operators continue to increase. The amount of investment in 2021 was around 14.5 billion ₺ (ICTA, 2021).

On the other hand, the total amount of traffic generated by fixed and mobile operators in the electronic communications market was 168 billion minutes in 2011, it increased by nearly 100% over the ten-year period and reached 318.4 billion minutes. The traffic amounts between 2010 and 2021 are shown in Figure 1 separately for fixed and mobile. Mobile traffic accounted for approximately 98.4% of traffic in 2021.

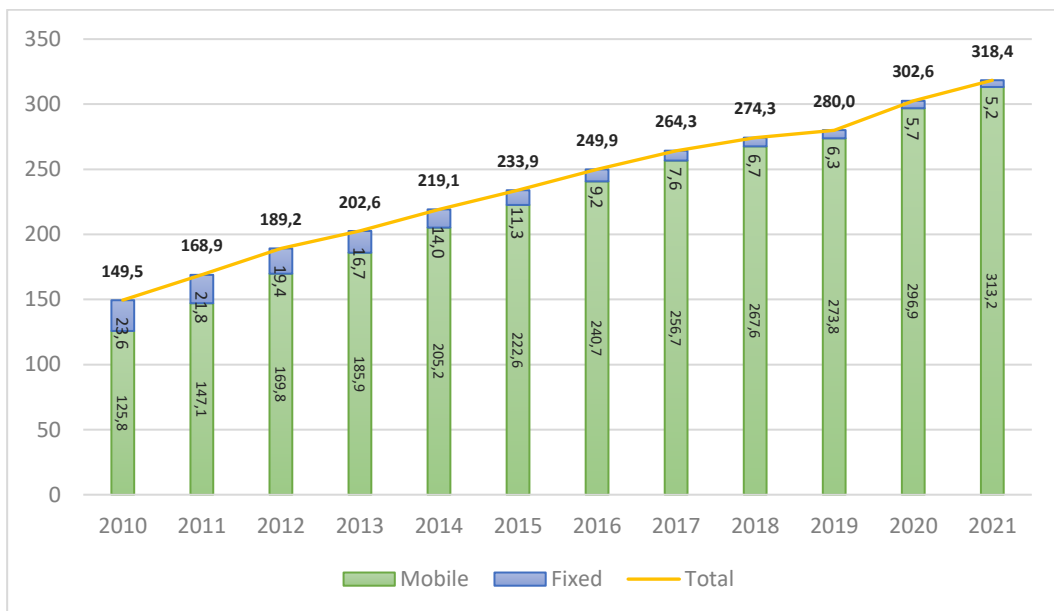


Figure 1. Total Annual Traffic Amounts (Billion Minutes)

Source: (ICTA, 2021)

If we look at the mobile market data, there are a total of 86.3 million mobile subscribers, including machine-to-machine communication (M2M) subscribers, which implies 102% penetration rate. MoU (Minutes of Usage), which expresses the monthly average usage time used in the measurement of mobile phone usage level, was 565 minutes as of the last quarter of 2021. Compared to European countries, Türkiye has been the country that makes the most calls by mobile phone with its monthly average mobile usage time. In mobile broadband, especially with the introduction of 4G LTE-A (4.5G) in 2016, both the prevalence and the mobile data used increased rapidly. At the end of 2016, the total amount of mobile internet usage was 336 thousand Terabytes and the total fixed internet usage was 2.1 million Terabytes, and these rates increased to 2.3 million Terabytes and 10.9 million Terabytes, respectively, at the end of 2021 (ICTA, 2021).

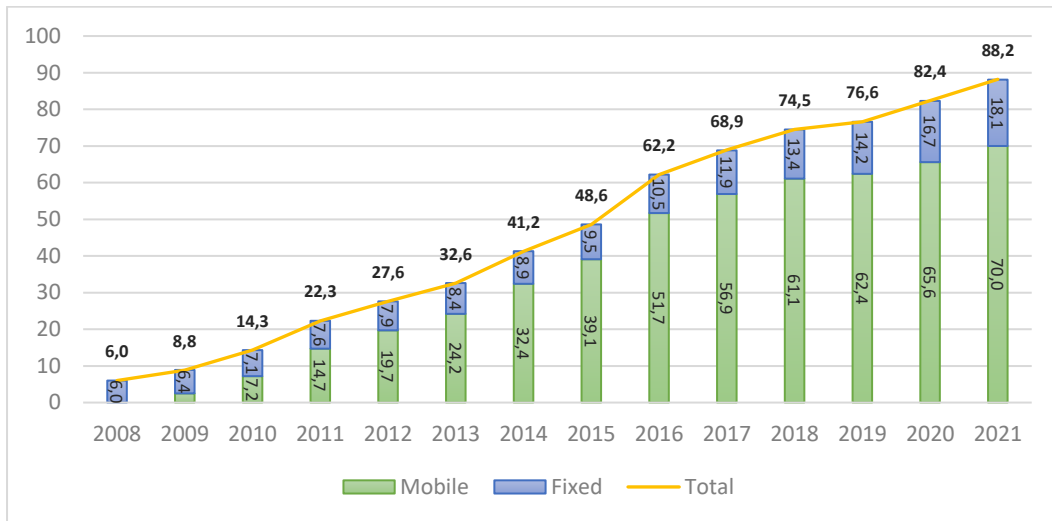


Figure 2. Subscriptions of Broadband Internet (million)

Source: (ICTA, 2021)

Broadband infrastructure in our country continues to develop rapidly. The number of mobile broadband subscribers exceeded 70 million, and the number of fixed broadband subscribers exceeded 18 million, reaching a total of 88.2 million. While the number of fiber subscribers was around 150 thousand in 2011, it approached 5 million (ICTA, 2021).

2. The Studies on Domestic and Nationality Within the Scope of Mobile Communication Technologies

2.1. Domestication Terms of 4G LTE-A Authorization

Many projects and activities are carried out by the Ministry of Transport and Infrastructure (UAB) in order to develop domestic and national communication systems in our country, to increase the use of emerging products in our mobile communication networks and to ensure the domestication of the sector. All these studies also contribute greatly to the transition of our country to 5G with domestic and national products at the maximum level.

In line with the policy determined by the UAB, with the 4G LTE-A authorization of ICTA dated on 27 October 2015, mobile operators are obliged to meet a certain percentage of their investments from domestic products in order to encourage R&D and domestic production.

In this context, investments to be made by operators in 4G LTE-A infrastructures;

- Certain rates (30% in the first year, 40% in the second year and 45% in the third and the following years) over the years, from domestic products,
- At least 10% of the products manufactured in Türkiye by Small and Medium-Sized Enterprises (SMEs), which were established to develop products and systems in Türkiye,

were required to be provided.

From the past to the present, studies have been carried out by the operators for the formation of domestic product supply in the communication sector, decreasing the

dependence on imports, and the formation of a domestic and national production ecosystem. After the auction for 4G LTE-A technology in August 2015, the operators started to provide 4G LTE-A services in 81 provinces in a short time by taking the necessary basic actions within the scope of their authorization-related responsibilities.

Particularly, as a result of the inclusion of domestication as a condition of obligation in the 4G LTE-A authorization, a sectoral movement affected both the supplier companies on the supply side and the operators on the demand side. Aforementioned sectoral mobilization paved the way for changes such as the creation of a domestic and national technology ecosystem in our country and the shift of national positioning to exports rather than imports and ensured that the domestication condition in the investments made by the operators was placed at the top of the purchasing criteria of the operators. As a result of the studies carried out, the rate of domestication in 4G LTE-A networks of operators has reached approximately 33% as of the end of 2021.

2.2. ULAK Base Station and Core Network Studies

In order to develop domestic and national 4G LTE-A base stations, the ULAK project was initiated on 15 February 2013, by the consortium of Aselsan, Netaş, Argela, together with the UAB and the Defense Industry Presidency (SSB).

Established within this scope, ULAK Communication Inc. (ULAK) continues its efforts to contribute to the implementation of high-impact products, systems and projects in order to improve Türkiye's technological competence in the global market within the scope of the National Technology Initiative.

ULAK's domestic and national technology development mission has been taken into account in its communication infrastructures. The developed Ulak base stations are used in both commercial and universal areas, and as of April 2022, these base stations are used in a total of 1765 sites. The image for the installation of the Ulak base station is shown in the Figure 3.



Figure 3. Installation of Ulak Base Station.

Source: (Ulak, 2022)

In addition, as of 2013, within the universal service projects, domestic and national Ulak base stations have been using in approximately 42% of 1778 base stations which installed in 2575 rural settlements throughout the country. It is aimed to further increase these rates in the projects to be realized. The distribution of Ulak base stations within the country is given in Figure 4.



Figure 4. Distribution of Ulak Base Stations.

Source: (Ulak, 2022)

ULAK has undertaken the task of producing innovative, dynamic, creative and R&D-based solutions at world standards for 5G and beyond, in order to make sustainable the developed 4G LTE-A technologies with domestic and national resources and to meet the requirements arising from developing technologies and applications. It aims to produce patents, intellectual and industrial property rights, and develop end-to-end domestic network technologies by carrying out studies with high value added on broadband communication technologies.

While ULAK continues to develop 4G LTE-A base stations as part of its product roadmap according to international standards; Simultaneously, it continues important projects such as “5G Core Network”, “5G Virtualized and Software Defined Networking” and “the New 5G Radio” that complement each other in this field (Ulak, 2022).

In today’s world where data processing and protection are important, with the “ULAK” base station, whose design is completely domestic, Türkiye is on the way to becoming a country that designs, produces, and sells, beyond being a country that buys and uses technology.

During the 5G base station and core network development studies, ULAK benefits from 4G LTE-A productization experience, field experience and similarity between technologies. By harmonizing the source from the existing 4G LTE-A technology with 5G, it continues to work in an approach that focuses on both increasing its area of influence and using resources efficiently.

In the MİLAT R&D Project, which intensively uses Software Defined Networks and Virtualization of Network Functions technologies, productization was achieved in the first place. After this development, MİLAT Network Management and Analysis System (MAYA) was developed. This system, which is a 5G ready product, is used in the field by many institutions. The MAYA architecture is shown in Figure 5.

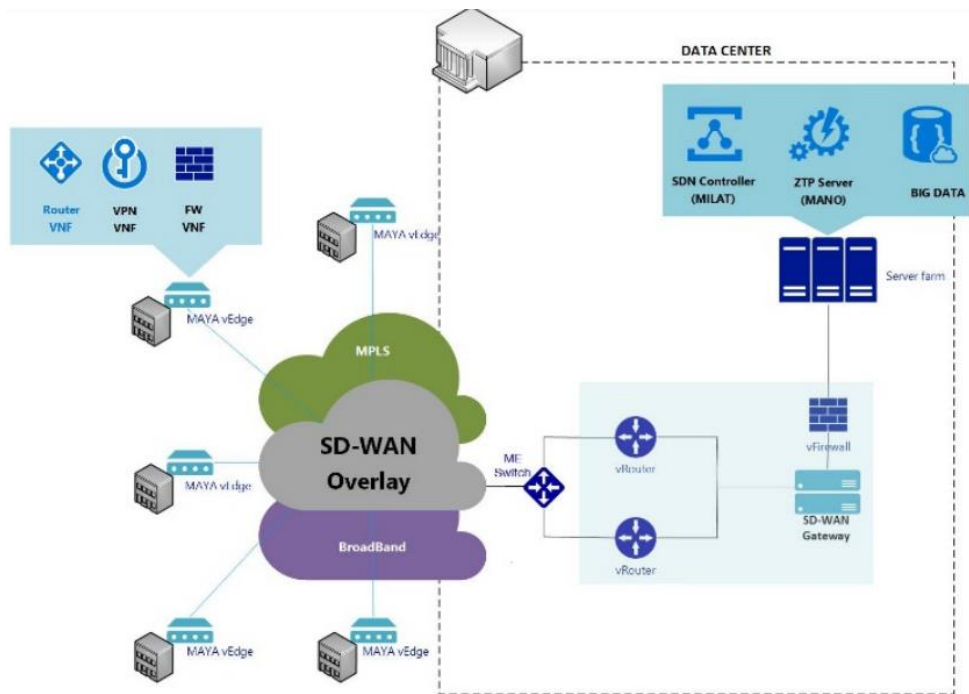


Figure 5. MAYA SD-WAN Solution

Source: (<https://www.ulakhaberlesme.com.tr/maya/maya.pdf>, 2022)

To give information about MAYA:

- MAYA SDN Controller: Provides management for all MAYA vEDGE and SD-WAN Gateways associated with controller. This includes activation, configuration and pushing down the policies.
- MAYA ZTP Server: Allows MAYA Edge devices to be configured and provisioned automatically while reducing manual overhead and cost.
- MAYA Big Data Platform: Provides analytics capabilities to enable networks gain better visibility by collecting, storing and analysing whole network metrics.
- MAYA SD-WAN Edge License: Physical CPE device resident on the customer premises and hosts Virtual Network Functions which is managed by MAYA Controller. vEdge initiate or terminate SD-WAN tunnel over different types of underlay networks (such as DSL, LTE, MPLS)
- MAYA SD-WAN Gateway: Physical device resident on the central networks which terminates and initiates large number of SD-WAN tunnels to enable site interconnectivity. SD-WAN Gateway also managed by MAYA Controller and provides more resources (processing, networking) to forward high network throughputs (<https://www.ulakhaberlesme.com.tr/index.php/tr/maya-katalog>).

On the other hand, studies on V2X (Vehicle to Everything) which one of the most important areas of use of 5G communication technology, were initiated by ULAK and foreign dependency will be eliminated with the development of V2X in our country. Thus,

both the intelligent transportation systems and the communication infrastructure to be established on the road to the autonomous vehicle and the edge computing applications of the intelligent transportation systems will be produced completely domestically and nationally.

ULAK continues to produce technology in the digital factory and industry 4.0 areas where 5G will be used. Ensuring 5G coverage in indoor and outdoor areas, making unmanned transportation vehicles such as AGV/AMR and production workbenches autonomous; Within the scope of these, activities are carried out on the development of edge computing software to manage the applications required and the delivery of services over the cloud. As a result of these studies, the manufacturing facilities in our country will be optimized and the facilities will be made more efficient (Ulak, 2022).

Mobile operators (TT Mobile, Turkcell and Vodafone) also provide support to the domestic and national base station Ulak. In this context, mobile operators contributed to the preparation of the product roadmap, the interoperability tests of the prototypes with other network elements were carried out in their own laboratories, the production process was contributed, detailed technical reports were shared with ULAK, the products were tested on live networks and the Ulak base station started to be used in places that need LTE coverage.

2.3. Studies on 5G

The National Broadband Strategy and Action Plan that put into force by the UAB on 21 December 2017, have following strategies. “Domestic products for the information technologies and communication sector will be developed and used, and R&D capability will be increased” and “R&D and standard studies for 5G and Beyond will be carried out, these studies will be supported by incentive mechanisms, and an active contribution will be made for the development of standards to be applied for 5G and Beyond”.

In this context regarding the domestic and nationality, following actions included in the plan.

- Supporting Domestic Production and R&D Activities in the Electronic Communications Sector.
- Carrying out 5G and Beyond R&D and Standard Studies (UAB, 2017).

In this respect, the studies on 5G are listed below.

2.3.1. End-to-End Domestic and National 5G Network Project

UAB and ICTA encourage the use of domestic products through their work with operators and manufacturers for the purpose of developing R&D studies in the electronic communication sector, increasing the market shares of SMEs and developing the domestic production ecosystem.

In this context, HTK was established within OSTİM (Organized Industrial Zone in Ankara) in 2017 with the support of UAB and ICTA in order to develop a domestic and national production ecosystem in line with the National Technology Initiative targets in the electronic communications sector. HTK, which has become a large organization that includes more than 160 companies and more than 8000 employees, has an important position for the domestic production ecosystem in the sector. In addition, the “End-to-End Domestic and National 5G Communication Network Project” (UUYM5G Project) has

been developed by 17 HTK member companies, 3 of which are mobile operators, in order to meet the hardware and software needs on the road to 5G with domestic and national resources. Financially supported by TÜBİTAK, the project started in 2018 and significant progress has been made in the project in the past. In this context; with the UUYM5G project, the 5G core network, 5G base station, 5G-specific management, service and operational software products and radiolink products, which are critical for 5G infrastructures, are developed with domestic and national resources.

The first phase of the UUYM5G Project was completed as of March 2021, and the prototypes of the above-mentioned products emerged in the first phase. In this context, at an event hosted by ICTA on 23 June 2021,

- Various call and data transfer scenarios have been tested via commercial 5G phones over an end-to-end 5G network such as 5G base station, core network, radiolink, created using domestic and national products,
- Various demo demonstrations were made over domestic and national 5G base stations that can be connected to existing commercial 4G LTE-A mobile networks.



Figure 6. 5G National Products Launching Meeting

Source: (ICTA, 2022)

In the next phases, it is planned to produce higher capacity and advanced versions of these products. In addition, with the work to be continued within the scope of the project, it is aimed to commercialize world-class domestic and national 5G products both to the domestic market and to other countries. Thus, it is aimed that our country will take its place among the few countries that develop products for the communication sector through the UUYM5G Project, which is being carried out as a reflection of our country's National Technology Initiative in the electronic communication sector (ICTA, 2022).

Within the scope of the UUYM5G Project, systems complying with 3GPP Release 15 standards, open standards used as today's emerging technologies by leading operators, open source-based software, container/kubernetes and cloud-native structure, microservices and REST APIs have been developed in accordance with the disaggregation in O-RAN standards.

In addition, the details of the basic systems that a mobile operator will use for 5G, which were developed in the first phase, are given below.

- **5G Core Network:** It has been developed to include IMS and Mission Critical services in accordance with the Service Based Architecture (SBA) structure.
- **5G New Radio-MIMO Active Antenna:** After starting with the 8x8 MIMO target, 16x16 MIMO antennas were developed to evolve into this configuration when 32x32 and 64x64 MIMOs emerged as the larger commercial market.
- **Radio Access Network - Baseband Unit (RAN/BBU):** Two separate strategies were determined for this product, which requires deep know-how. On the one hand, with the target of rapid entry into the market, a software solution open source license was obtained from one of the largest manufacturers and on the other hand, completely domestic and national development was initiated. It has been developed in accordance with the O-RAN standard so that it can work with other than MIMO Active Antennas.
- **Radyolink:** 7 and 13 GHz Radiolink products have been developed. For these products, time and resources were saved by using an indoor unit, the R&D of which was previously done by TÜBİTAK BİLGEM.



Figure 7. TR713-7Ghz Radiolink Device

Source: (<https://www.trthaber.com/haber/bilim-teknoloji/yerli-ve-milli-5g-sebekesi-hedefi-radyolink-basariyla-test-edildi-525728.html>, 2022)

The New Radio and Radio Access Network products developed in the project are the only product sets that have made connection tests with 4G base stations of three major manufacturers (Huawei, Ericsson, Nokia) regarding the 4G-5G connection that will be required in Non Standalone installations.

Each product has been developed with Operations Management System (OSS) in line with TMForum standards, as well as current Virtualization Systems (NFV) used by operators, in accordance with ETSI standards.

The companies involved in 5G New Radio (5G NR), Radio Access Network (RAN), Radiolink, 5G Core Network (5GCN) and Virtualization within the scope of the UUYM5G project are given in Figure 8 (HTK, 2022).

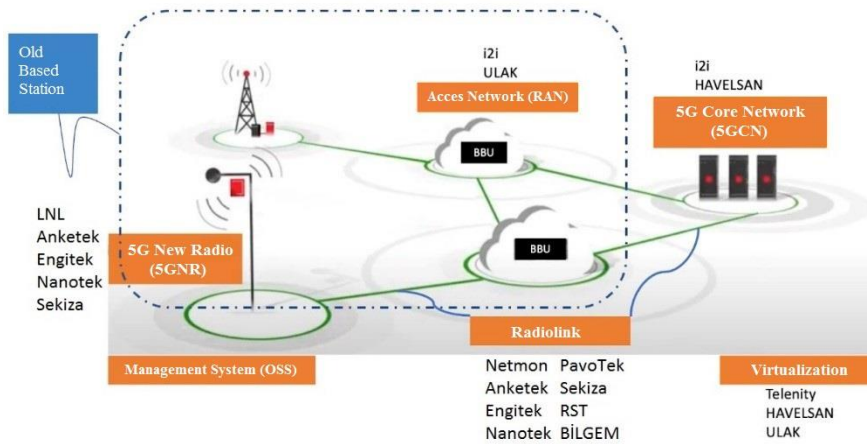


Figure 8. The Companies Involved in the UUYM5G Project

Source: (HTK, 2022)

On the other hand, the developed prototype products are tested by the operators, and feedback is provided by them on the performance of the products as well as the interoperability of the products with other global manufacturer equipment.

2.3.2. Open RAN Works

Various studies are carried out by the operators for Open RAN technology. In this context;

- The cooperation was made with Juniper Networks upon licensing and global scale marketing on the vRAN solution RIC (Radio Intelligent Controller) product, which brings efficiency and flexibility to 5G mobile access networks, and cooperation was made with Net Insight on the productization of a technology in the field of 5G time and frequency synchronization (Turk Telekom, 2022).

Turk Telekom collaborated with Mavenir, one of the leading companies in cloud-based software, and ComPro Information Technologies, a system integrator producing network solutions specific to 5G, on Open vRAN trials. Within this framework, Turk Telekom will conduct a pilot application for Mavenir's award-winning Open vRAN solution. The project will include radio units (RUs) which have 4G and 5G multi-antenna (mMIMO) with Open RAN Alliance compliant beamforming technologies and 4G small cells (www.turktelekom.com.tr, 2022).

- Vodafone launched the “Open Radio Access (Open RAN) Development, Verification, Integration Center” project. The aim of the project is to establish an innovation center in Türkiye. Development, validation and integration of next generation advanced network technologies will be carried out at the center. In addition, efforts to develop new generation network management and security applications at international standards were initiated. With Open RAN technology, it is aimed that the components that make up the radio access network layers can operate independently of hardware and turn into software-based applications. At the same time with open network, it will be possible to provide flexible and high-quality services adjusted to the specific needs of customers. It is predicted that the increased flexibility and efficiency with Open RAN technology can reduce network management costs by about 30% in the long run.

In addition, Vodafone Türkiye takes part in the ongoing open architecture studies in the world and carries out trials. In this context, the importance of Open RAN technology and its future predictions are shared comprehensively with ULAK. Thus, it will be possible to open up the domestic Ulak equipment to the world and to be competitive (Vodafone, 2022).

- On the other hand, Turkcell continues to work on Open RAN technology, which brings together the areas of strength of companies with different expertise and enables more effective management of resources with virtualization. Considering the quality of the service to be offered to the end user, Open RAN technology is tested and participation in the work of international standardization institutions is ensured. With the experience gained through Open RAN tests, it contributes to domestic and national 5G studies (Turkcell, 2022).

2.3.3. 5GTR Forum

In April 2016, ICTA established the “Turkish 5G Forum” also known as the 5GTR Forum a baseline program that brings together Türkiye’s prominent academics, research and development firms, vendors, and operators to discuss 5G development in the country. There are four working groups under the 5GTR Forum. Working groups for Core Network, Physical Network, Service and Applications and Standardization under the 5GTR Forum organization structure, were established to provide 5GTR Forum activities to be efficient. The secretariat of the 5GTR Forum is carried out by ICTA and there are Advisory Board and Academic Board under its organizational structure. 5GTR Forum organizational structure is given in Figure 9 (ICTA, 2022).

5GTR Forum General Assembly



Figure 9. 5GTR Forum Organizational Structure

Source: (<https://5gtrforum.org.tr/organizasyon>, 2022)

Within the scope of 5GTR Forum works, two separate Memorandums of Understanding were signed at the fourth Global 5G Event held in Seoul on 12 November 2017 between 5GTR Forum and 5G Forum Korea and 5GTR Forum and Japan 5GMF in order to develop international cooperation for 5G.

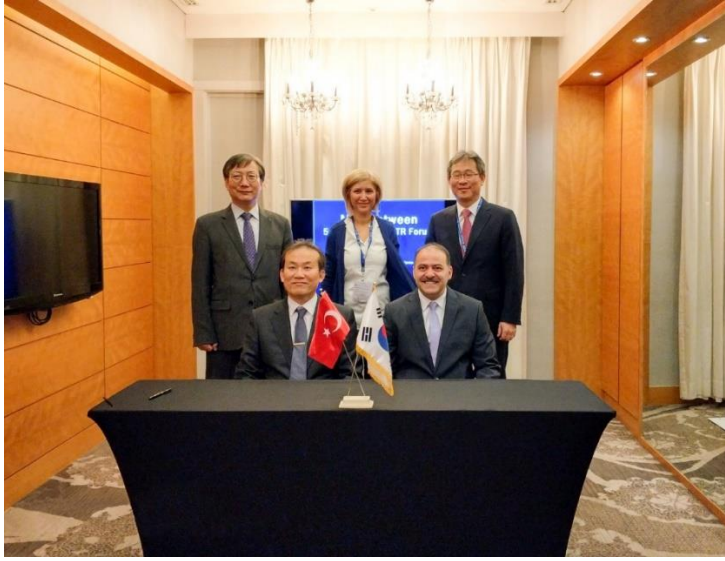


Figure 10. Memorandum of Understanding Ceremony between 5GTR Forum and Korea 5G Forum

Source: (<https://5gtrforum.org.tr/haberler/5gtr-forumu-ile-kore-5g-forum-arasinda-mutabakat-zapti-imzalandi>, 2022)

Various meetings were held by the 5GTR Forum working groups, and a White Paper was prepared in 2018 in order to determine the priorities, strategy and roadmap for 5G and Beyond. In addition, the “5G and Vertical Sectors Report” was also published by the ICTA on 8 March 2018 regarding the usage of 5G and the impact of 5G on vertical sectors (ICTA, 2022).

2.3.4. 5G Valley Open Test Field

The 5G Valley Open Test Field Project, which is conducted under the coordination of ICTA, covers the region between Middle East Technical University, Bilkent University and Hacettepe University’s campuses and ICTA Headquarters. It is aimed to create an environment where universities, research centers, companies, start-ups can test 5G and beyond applications and technologies and create added value in this region. 5G Valley Open Test Field Cooperation Protocol was signed with a ceremony held on 15 August 2017 by ICTA, Hacettepe University, Ihsan Doğramacı Bilkent University, Middle East Technical University, Turk Telekom, Turkcell and Vodafone (ICTA, 2022).



Figure 11. 5G Valley Stakeholders.

Source: (ICTA, 2022)

Among 5G Valley Protocol Members and ULAK Communications, i2i System, Netaş, Spark Measurement Technologies, Huawei Telecommunication, five separate memorandums of understanding were signed on 24 July 2018. In November 2018, ICTA launched the country's first "5G Open Test Site" at the ICTA Market Surveillance Laboratory located in Hacettepe University. Academics, researchers and start-ups can utilize the 5G Valley Open Test Field for R&D tests for 5G and beyond technologies. Tests were carried out on various issues such as 5.9 GHz C-V2X Channel Measurement, Energy Harvesting and Sensor Project, 28 GHz GaAs Doherty Power Amplifier Digital Pre-Distortion (DPD) Measurements, Drone / UAV detection by cognitive passive Radar via 5G signals and micro Doppler method, 28 GHz Channel Measurement in Car, Power Amplifier Modeling Efficiency and Linearization (ICTA, 2022).

2.3.5. 5G and Beyond Joint Graduate Support Program

ICTA also established "5G and Beyond Joint Graduate Support Program" between universities and disciplines to contribute training of qualified human resources that Türkiye will need in 5G and Beyond in short, medium and long term. The program aims to produce sustainable competence on advanced communication technologies and to produce outputs in a wide variety of forms such as patents, projects, articles, spin-off companies and thesis studies. 72 researchers have been employed within the scope of the Program since October 2018, and 43 students are currently attending the Program (ICTA, 2022).

3. Satellite Technologies

The contract for the "Türksat 6A Domestic Communication Satellite Development and Production" Project, which was initiated under the coordination of TÜBİTAK, was signed on 15 December 2014. Türksat 6A Project is financed by UAB, Türksat and TÜBİTAK. This project is of great importance for the future of our country in space. Sub-systems, satellite ground station and software to be used in the satellite are being developed with national means.

Türksat 6A is produced with the highest domestic rate, with the contribution of Türksat engineers who received training in space technologies within the scope of the technology transfer program realized during the production process of Türksat 3A, Türksat 4A and Türksat 4B satellites (Türksat, 2022).

The Engineering Model integration of Türksat 6A satellite was completed at the Space Systems Integration and Test Center (USET) in April 2021, and satellite system level environmental testing continues. Within the scope of these environmental tests, Thermal Balance Test, Acoustic Vibration, Sinus Vibration Tests, Centre of Mass Measurements, Static Load Tests are performed. Flight Model integration activities are carried out simultaneously at the USET headquarters. Among our most important achievements within the scope of the project, the production and tests of 29 domestically developed equipment for qualification and engineering models were completed. The production and testing processes of the equipment to be used in the Flight Model continue.

It is aimed that Türksat 6A, the first domestic communication satellite, will be sent into space in 2023 and that Türkiye will become one of the countries that can produce communication satellites. Our country, which has matured its space systems production capabilities with the Türksat 6A project, will now become a power exporting the space technologies (Türksat, 2022).

Türksat 6A satellite will expand the geography where Türksat provides satellite services with its Eastern coverage area, which also includes India. It will also provide capacity increase and redundancy for other satellites serving in the extremely important 42 degrees East orbit.



Figure 12. Türksat 6A Satellite

Source: (<https://www.tusas.com/urunler/uzay/haberlesme-uydulari/turksat-6a>, 2022)

In addition, Türksat 5B, which will offer broadband satellite communication opportunities to aircraft and ships, is expected to play a very important role in today's world where mobility is increasing day by day.

Türksat A.Ş. also invests in satellite ground systems. With the originally developed SOTM (SATCOM On The Move) solution, mobility is brought to fixed satellite communication

solutions. With the SOTM antenna developed to meet the needs of both military and civilian users, Türksat has become a company that can offer satellite communication services with the antennas it produces under its own brand.

Ka Band HUB system project is carried out with Aselsan in order to develop satellite modems with domestic and national resources. With this project, the Ka Band satellite communication HUB system offered by several manufacturers in the world will be developed in our country and in the coming years, end-to-end satellite communication services will be offered with domestic and national ground systems.

The capacity of the satellite communication service in the aviation sector, which is provided over Ku and Ka Band, is being increased. Ka Band IoT antenna development studies are also accelerated in order to include satellite communication in Internet of Things (IoT) technology, which is one of the important topics of the near future (Türksat, 2022).

In addition, satellite communication systems developed by Aselsan cover the tactics requirements of commanderships at the battlefields and the headquarters and the command centers to which the military units are connected at the battlefield and provide secure voice, video and data transfer with high data rate, each of which is a part of command control systems, in all types of geographic conditions and tactic operations. They can work with satellites under the use of Turkish Armed Forces as well as satellites belonging to friendly nations and NATO which provide service in relevant frequency bands (Aselsan, 2022).

Along with, Aselsan has X-Band and Ku-Band Transportable Manpack Satellite Communication System solutions; it offers SATCOM On The Move Satellite Communication System, which can communicate on the move and SATCOM On The Pause Satellite Communication System, which can communicate in a stationary manner, in Ku-Band and X-Band frequencies, in line with user needs.

Ku-Band Airborne Satellite Communication Systems also are developed by ASELSAN. The systems provide secure and high-speed satellite communication on the move in all operational and environmental conditions. Airborne Satellite Modem has encryption capability to provide secure communication. By means of internal beacon receiver unit, satellite tracking can be done sensitively and continuously. Additionally, Aselsan also offers Shipborne Satellite Communication System solutions for underwater and surface platforms with 38 cm, 45 cm, 1.2 m, 1.5 m and 1.8 m antenna systems (Aselsan, 2022).

4. Radio Communication Systems

Many communication devices are produced by Aselsan with domestic resources. Within the scope of the contract signed between SSB and Aselsan in 2008, V/UHF and HF Software Defined Radios were developed in order to meet the tactical and strategic joint demands of Land, Sea and Aviation units with the TAF Multi-Band Joint Radio Project. In 2018, Inter Communication System has developed in order to meet the demand for external voice and IP data communication of mobile units in tactical field for both inside and outside of platform. In the same year, 5-10 kW High Power HF Transmitter, a system that enables Naval Forces' ship, coast, and beyond horizon communications, has developed. In 2020, new generation tactical handheld software defined networking radio with electronic warfare protection features in V/UHF band, has developed. These military radios that were designed by Turkish engineers, were exported to more than 20 countries including Pakistan, Azerbaijan, Ukraine and Qatar.

On the other hand, production under foreign license was terminated after the integration of national air radio and IFF (Identification for Friend or Foe) devices developed by ASELSAN with regard to air platforms became widespread and their airworthiness gained.

As for public safety communications, Aselsan developed analog direct mode, analog wide area, analog trunk radio devices and systems completely with national resources and started to be used in the field. Civil professional users such as municipalities, taxi stands, distribution companies; Mission critical communication users such as the Police, Gendarmerie, Fire Brigade and Ambulance; and The Turkish Armed Forces has come to communicate with Aselsan radio and systems.

The SK4000 Digital Encrypted radio system, which provides single relay coverage with its over-the-air operational capabilities, has been prepared for private users. Point-to-multipoint encrypted communication was provided by developing the portable radio used on body, the mobile radio used in the vehicles, and the desktop radios used in the fix stations and buildings, among the coverage increasing repeater devices. Towards the 2000s, with the SAGE2000 – Digital Wide Area Covering System, a transition was made from a single relay system to multi-zone wide area coverage systems and the system was served to the use of officials.

As Aselsan gained the ability to design and implement its own crypto algorithm, the SK4000 series devices in the field were updated to reach the SK2 (2nd Generation Digital Encryption) radio system. The SK2 Radio System, which provides practical use and encrypted communication, has been delivered to many user groups, first in the country and then abroad.

Aselsan designed and produced the first domestic mobile phone, “1919”, during the period when communication technologies were passed from the first generation to the second generation in the world. The user interface and operating concept gained in the mobile phone formed the basis of the digital-based 4400 handheld radios.

Transition to the 4700 Series was made with the need for a communication system of the General Commandership of Gendarmerie in the APCO25 open standards. Carrying Aselsan from one success to the next, the 4700 Series Radios are the first American open standards radios in our country and are the first Aselsan product sold in the United States. All of the antennas, repeater, receiver, multiplexer and power combiner RF peripherals of this series purchased from abroad have been transferred to domestic production. General specifications of the 4700 series radio family are given in Figure 13.

General Properties

- Analog and Digital Operations on a Single Radio
- Compatible with P25, SK2 (Aselsan proprietary protocol) or DMR
- Configurable User Informative Alerts
- LCD Display
- Alphanumeric Keypad
- Graphical User Interface
- Call Logging
- Caller ID
- 3-Level RF Output Power
- Channel Scan
- VOX (Only With Audio Accessories)
- Transmit Time-out Timer
- Configurable Menu Options
- Computer Based Maintenance
- Compatible with MIL STD 810 C/D/E/F/G
- Conformity with EIA/TIA-102.CAAB-D, EIA/TIA-603-D and ETSI TS 102 361 standards.
- Backward compatibility in analog mode

Digital Mode Features

- Group Call
- Individual Call
- Emergency Call
- SMS (Radio to Radio)
- Data Transmission (With Data Software Set)
- Status Messages
- Encryption (Optional)
- Phone Book
- Call Alert



Figure 13. Aselsan 4700 Radio Family

Source: (<https://www.aselsan.com.tr/694ee6a1-8d45-416d-8950-ffd378651d08.pdf>, 2022)

In 2011, basic functionality was acquired in a period of 6 months for the “National Cryptography DMR Radio System” requirement of the Directorate General of Security, and the system was put into practice in cities with challenging geography and where security is of critical importance.

In parallel with these studies, the world’s first APCO-based digital mapped radio 4900 ATLAS series was developed. 4900; It has the title of the first multi-tasking radio with operating system with its capabilities such as multi-system, multi-crypto, multi-band, multi-mode in the same device. 4900 series radio family is shown in Figure 14.



Figure 14. Aselsan 4900 Radio Family

Source: (<https://www.aselsan.com.tr/8d517bbf-0639-452c-914f-06975b7a555d.pdf>, 2022)

On the other hand, products in 450, 700, 800, 1800 and 2600 MHz frequency bands were developed for Türkiye's first 4G LTE-A Macro Base Station ULAK.

Due to our country carries risks in terms of disasters and emergencies, the Narrowband - Broadband Integrated Public Safety Communication System project to be established by the SSB at Adana Provincial Directorate of Security is being carried out in order to ensure mutual communication between institutions. Mission Critical 3810 Handheld Terminals are being developed to operate in the VHF or UHF band as APCO and DMR in narrow band, in closed network Mission Critical LTE broadband at 700 MHz, and in 4G LTE-A broadband in commercial network at 800, 1800, 2600 MHz.

The 3700 series radios, on the other hand, can operate the APCO25 and DMR features together in the same radio, in addition to their many technological features. (Aselsan, 2022)

5. Cybersecurity Studies

The National Cyber Emergency Response Team (TR-CERT), which was established in 2013 in accordance with the "National Cybersecurity Strategy and 2013-2014 Action Plan" which put into effect by the UAB, has been directly involved in the ICTA since 2016. TR-CERT continues its activities to improve the understanding of cybersecurity throughout the country, to carry out alarm, warning, and announcement activities to prevent cyber threats, to take control of the incident with on-site response teams in critical situations, and to provide national coordination in response to cyber incidents.

Avcı, Azad, and Kasırğa Projects, developed by TR-CERT entirely with corporate internal resources, make significant contributions to our national cybersecurity. While detection of infected systems and command and control centers is carried out with the Avcı application, studies are carried out to detect slave computers that have been included in botnets by using machine learning and artificial intelligence facilities with the Azad application. On the other hand, while vulnerability scanning and monitoring activities for our country's internet-open resources, especially critical public institutions and critical infrastructures, are carried out with the Kasırğa project, the risks related to vulnerabilities can be proactively prevented in the light of the data received with the Atmaca project, which is integrated into the Kasırğa project (ICTA, 2022).

These applications are actively used in the detection of malware command servers, compromised systems, and infected systems and continue to be developed to enable more sophisticated analysis. With the Atmaca project, which started to be actively used in 2020, the risks of more than 600 vulnerabilities can be prevented proactively. Thus, it is ensured that approximately 16 million IP addresses in our country are checked regularly, threats against especially critical infrastructure sectors and public institutions are detected early and precautions are taken.

The Kule software, which works integrated with other projects to manage all this data more efficiently by expert analysts and to convey the detected cybersecurity deficiencies to the relevant people faster, not only makes the work of the 24/7 staff easier, but also accelerates the work at a high level.

Since 2011, 5 national and 2 international cybersecurity exercises have been carried out under the coordination of UAB, as part of the important steps taken to increase the level of preparedness and incident response capabilities both in our institutions and organizations and at the national level.

In this context, the International Cyber Shield 2019 Exercise, organized by the UAB and ICTA with the contributions of the International Telecommunication Union and the Cybersecurity Alliance for Mutual Progress (CAMP), was held at ICTA on 19-20 December 2019. The exercise hosted 87 participants from 17 different countries. During two days, on the one hand, a practical cybersecurity experience were given to the participants, and on the other hand, information was shared on the steps to be taken in case of possible cyberattacks (ICTA, 2022).

On the other hand, the “National Cyber Shield 2021 Exercise” was held on 12-13 October 2021 under the coordination of UAB and hosted by ICTA. 135 participants from 36 public institutions and organizations, private sector representatives and many guests participated in the exercise.

In these exercises, technical infrastructure and scenarios developed by TR-CERT with domestic and national resources were used.

Cooperation activities with countries and international organizations in the field of cybersecurity continue. TR-CERT, Forum of Incident Response Security Teams (FIRST), Trusted Introducer (TI), Cybersecurity Alliance for Mutual Progress (CAMP), NATO Malware Information Sharing Platform (NATO-MISP), Organization of The Islamic Cooperation – Computer Emergency Response Teams (OIC-CERT) is a member of organizations such as. Threat intelligence sharing activities with these organizations continue. In addition, ICTA and TR-CERT contribute to the cybersecurity activities of organizations such as the UN, ITU, NATO, OSCE, G20, and OECD on behalf of our country.

On the other hand, taking into account the personal security, cybersecurity and national security risks associated with connected vehicles, ICTA decided in 2018 that the connected cars shall use the SIM cards obtained from authorized mobile operators by ICTA (ICTA, 2022).

In addition, operators continue to support the domestic and national ecosystem in the field of cybersecurity.

In the field of Cybersecurity, Turk Telekom carries out totally 32 localization projects. 19 of them are completed, 9 ongoing and 4 planned. The prominent domestic studies of the operator in this field are as follows.

Table 1. *Turk Telekom's Cybersecurity Studies*

Cybersecurity

- SIEM Product Cryptosim
- Finding Tracking Application
- Privileged Account Management
- Multi-Factor Authentication
- Cyberattack Simulation
- Application Firewall (WAF)
- DDos Attack Simulation
- Security Automation and Orchestration Product (SOAR)
- Network Firewall (FW)
- File Integrity Monitoring
- Secure Software Development (DevSecOps)
- Cyber Vulnerability Detection and Analysis System
- Network Audit Compliance Manager
- Role Portfolio Product
- Database Activity Monitoring
- Phishing and Social Engineering Platform
- Websites Integrity Monitoring Service
- Digital Tracking System
- Threat Tracking System
- Network Traffic Analysis (NTA)
- Data Classification and Labeling
- Hardware Security Module (HSM)
- Endpoint Security (EDR)
- Data Leakage/Loss Prevention (DLP)
- Attack Surface Analysis
- Role Portfolio Product

Source: (Turk Telekom, 2022)

On the other hand, Turkcell makes purchases from domestic and national companies that are members of the Cybersecurity Cluster, while ensuring the security of our country's communication infrastructure with domestic and national technologies, it also contributes to the growth of the ecosystem.

In addition, the analysis, design, implementation, and development stages of cybersecurity products are carried out by Turkcell engineers. Patent applications are also made for many products and services developed using domestic and national resources. Tools such as the security code system "Turkcell Captcha", the Cyber Intelligence system "BOZOK", the phishing simulation tool "Phishkopat" are used both within Turkcell and other companies in our country, and export efforts continue (Turkcell, 2022).

Vodafone, on the other hand, continues its efforts to expand the reliable and high-quality communication infrastructure throughout the country, and to develop the capacity to produce different infrastructure components, primarily software, and a competitive investment environment in the domestic technology ecosystem (Vodafone, 2022).

6. Regulation and Supervision Activities

6.1. Regulations Regarding Operator's Investment Obligations

There has been a need to make some changes in the examination processes of the investment obligations brought to mobile operators by the provisions of the IMT-2000/UMTS¹ Concession Agreement and the IMT Authorization Certificate, and it has been evaluated that some improvements will be beneficial. In this context, there is an article in the "Procedures and Principles Regarding the Inspection and Supervision of Hardware and Software Investments to be Used in the Networks of Operators" (Procedures and Principles) approved by the ICTA's decision dated 18.01.2017 and numbered 2017/DK-YED/15. A number of changes and additions have been made.

¹ International Mobile Telecommunications-2000 / Universal Mobile Telecommunications System

In this context;

- In addition to the concept of a domestic product with a certificate, a new definition of a national communication product should be made,
- The establishment of an upper limit of 50% for the purchases made by the operators from a supplier,
- Examining the production processes of the reported Domestic Goods Certified products,
- R&D projects carried out by R&D centers are in accordance with our country's goals and strategies,
- Conducting risk assessments by operators to ensure security in the supply chain and remove supplier dependency and
- Providing information to the ICTA about the investments to be made by the operators regarding critical Network elements regulations have been made.

Thanks to these regulations, it is evaluated that the cooperation between the operators and our domestic producers and the joint work in the supply processes will progress, the R&D and domestic product ecosystem will develop, and the technology and engineering resources of our country will be used more effectively and efficiently (ICTA, 2022).

6.2. Market Surveillance and Inspection Activities

Market Surveillance (MS) activities include all activities carried out by the authorized institution to ensure compliance with technical regulations during the placing and distribution of a particular product on the market or while on the market. In MS activities, it is aimed to determine whether the products supplied to the market comply with the provisions of national legislation and international standards, and to ensure that they do not pose a risk in terms of human health, life and property safety and technical regulations.

The radio equipment manufactured in our country is also inspected within the scope of MS. Our country's domestic and national mobile phone production capacity is increasing day by day. In 2021, a total of 6,604,889 mobile phones in 20 brands and 103 models were manufactured by 15 domestic manufacturers (ICTA, 2022).

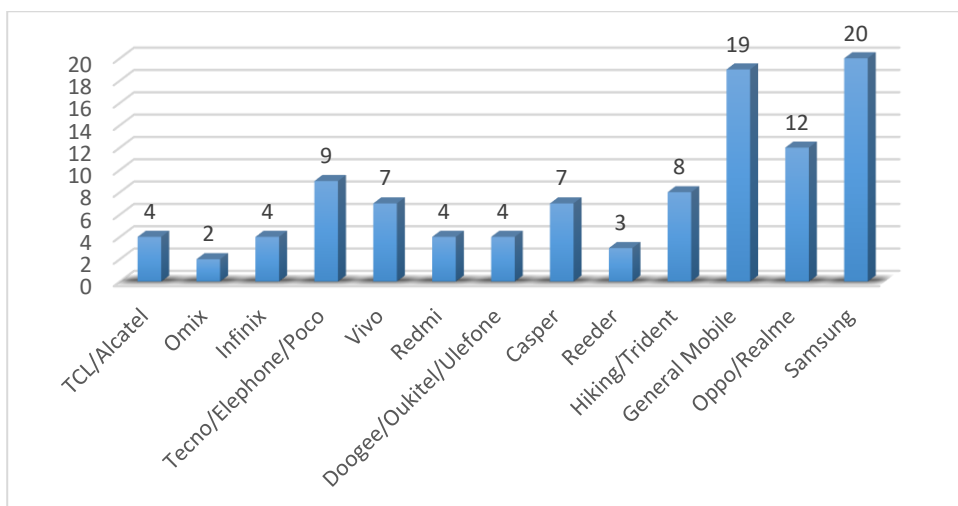


Figure 15. Number of Models Manufactured in Türkiye

Source: (ICTA, 2022)

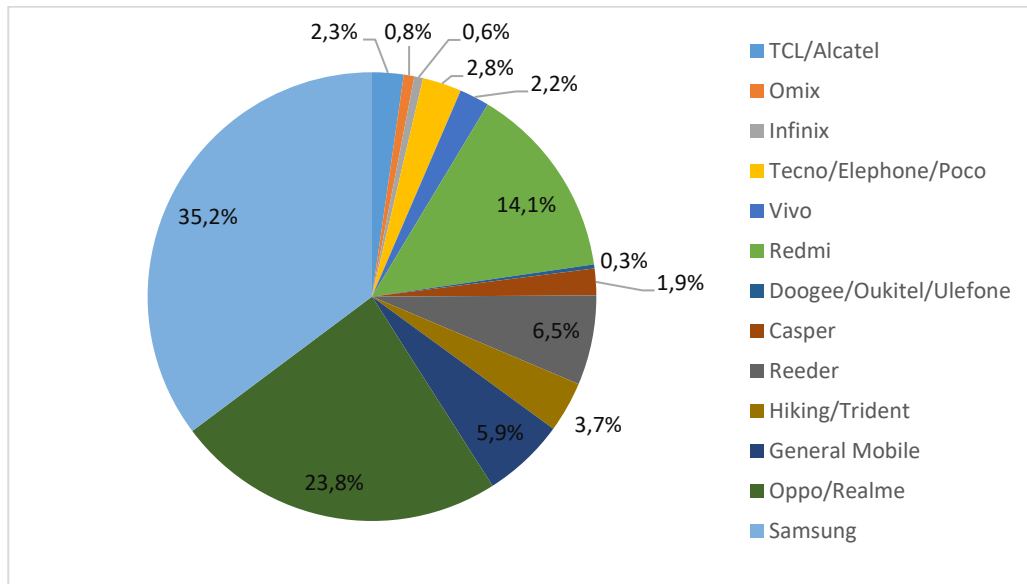


Figure 16. Distribution of Total Production

Source: (ICTA, 2022)

7. Land Communication Systems in the Military Field

With the change of tactical warfare depending on technological developments and the use of purpose-specific systems in the tactical field, the need for data exchange of systems in the field has emerged with increasing intensity. The high capacity, interconnected, hierarchical and complex communication needs required by the various sensors, weapons and command control applications supplied and/or produced were met with a similar approach, and command and control communication subsystems were designed.

For the establishment of communication networks, WiMAX-based high-capacity RF communication equipment, military routing and switching devices, wired network voice and data switching systems, mobile segment (wireless) networks, intercommunication systems with voice and data communication capability, military analog and digital systems needed in command posts, field telephone units, video conferencing infrastructures, data security devices that are constantly active during the communication of these networks and devices for network security are designed, produced and put into service within the country with national resources.

Recently, the increase in the use of unmanned systems in the tactical field, the needs of intelligent decision mechanisms and the reflection of artificial intelligence applications on the tactical field, sensor structures in distributed architecture, the communication needs of swarm systems, the realization of the internal intranets (IoT) of military objects, high-capacity data communication with very low latency in order to meet the needs (5G and beyond) and the activities of transforming current technologies into products have been accelerated.

A few of these devices that have already been implemented and put into use and serve in the field are summarized below.

- **National Operational Headset:** In line with the demands of the Turkish Armed Forces, the operational and ergonomic headgear that it needs in the tactical field and can be used with Aselsan Military Radios is nationally designed and developed. It is aimed to increase the communication security of this product by replacing the currently used foreign products and to nationalize one of the communication elements in the tactical field.

The Headset, which will basically consist of “Tactical Communication Headset, Push-To-Talk Button and Related Cables”, will be able to compete with equivalent products with its ergonomics; with its technology, it will be possible to understand where the sounds come from in three dimensions, and to clear the received external ambient sounds from noise and transmit them to the user in a clean way.

- **Radyolink Device:** ASELSAN has developed radiolink products (GRC: Ground Radio Communication) since 1997, the GRC-5211, GRC-5218 and finally the GRC-5220, whose capabilities have been continuously increased. These radiolinks provide high data rate, high frequency jump rate, information security, resistance to jamming and electronic warfare countermeasures, flexible use with the wide frequency spectrum it supports, high reliability, etc. Thanks to its features, it has been used in many systems and has been exported to many countries abroad (Aselsan, 2022).

The newly developed radiolink device will be 5G based and will have higher data and speed capacity.

- **Broadband Radiolink Antennas:** Broadband Radiolink Antennas are manufactured by ASELSAN in military standards and together with radiolink devices, they provide safe and reliable communication in the tactical field. These antennas can be used on fixed and mobile platforms.
- **2122 e-VoIP Device – Secure VoIP Phone:** This device is an encrypted communication terminal that supports voice, IP data and video communication over IP networks. Its mechanical hardware, software and crypto infrastructure are produced domestically by ASELSAN in accordance with military standards
- **Multi and Single Channel Military Wired Modem Family:** The Military Wired Modem Family (multi-channel and single-channel) based on DSL technology has been developed in order to easily provide the required intensive data (IP) communication with existing two-wire cables, to be used in tactical command posts, especially in case of complete radio silence, which is a precaution against electronic warfare. The aforementioned products are mainly used in fire support and air defense command and control systems (Aselsan, 2022).

8. Other Studies Carried Out by Operators

Contributing to the digitalization of Türkiye’s transportation investments, Turk Telekom has equipped the 1915 Çanakkale Bridge and Motorway, which is the world’s longest mid-span suspension bridge, with smart technologies. We are digitizing our transit highway chain, which connects our cities and continents from Europe to Asia, end-to-end with our Intelligent Transportation Systems (ITS). Within the scope of the ITS project, 101-kilometer route covering the Malkara Çanakkale Highway and the important transit transportation points of our country such as the Northern Marmara Highway, the Gebze-

İzmir Highway, the North Aegean Highway have been equipped with new generation technologies that increase driving safety and efficiency.

Turk Telekom digitizes penal institutions with the Ministry of Justice General Directorate for Prisons and Detention Houses. The project, which first launched in Ankara Sincan Women’s Closed Penitentiary Institution, works with smart multimedia devices and biometric data recognition system. Within the scope of the Integration of Intelligent Technologies into Penitentiary Institutions Project (ACEP), relatives of convicts who could not visit due to various reasons had the opportunity to make video calls with e-Görüş.

Turk Telekom has also implemented the Agriculture 4.0 Application “Autonomous Tractor”, which works over 5G, in order to carry out more sensitive and accurate agricultural operations with TARNET (Turk Telekom, 2022).

Other prominent works carried out by Turk Telekom on domestic and national products are listed below.

Table 2. Turk Telekom’s Works Regarding Domestic and National Products

Mobile	Fixed
<ul style="list-style-type: none"> • Real Time Pricing System • Omnichannel Platform • PCRF (Policy & Charging Rules Func) • Domestic Mobile CEM Platform • Local Base Station • Mobile SMSC • Lithium Battery • Native Antenna • Precision Controlled DX Air Conditioner • EIR (Equipment Identity Register) • CMAA Platform - Commercial Mobile Alert System • Crisis SMS 	<ul style="list-style-type: none"> • VOLTHA SEBA- FTTH Network Virtualization • ARISTO Automatic Failure Management • Artificial Intelligence in Operation • Domestic Net Analysis • Local Alarm Monitoring (SUMMER project) • Native DPI • AAA Conversion • Tivibu GO Application • Universal ONT / Native HGW • Domestic Proactive Assurance • Local Virtual Switchboard • Social Media Monitoring System • Test Automation System • Central Network Automatic Discovery • MPLS Activation Provision • TTSİS Signal Monitoring System • TTNETSİS Signal Monitoring System

Source: (Turk Telekom, 2022)

Since 2015 Turkcell has been working with domestically developed solutions for network automation. SON (Network Optimization & Organization) platform was developed and deployed with a local solution provider to automate critical network management activities that have a significant impact on service quality. The SON system, which improves the quality of electronic communication services and digital services with its automation capabilities, received an award at the “Self-Organizing Network” world conference in 2017. In this context, studies such as Predictive Energy Saving, Customer Centeric Coverage Optimization, Predictive Load Balancing, Service Based Optimization are carried out.

Turkcell Technology enhances AI driven products and company solutions with its state-of-the-art artificial intelligence capabilities. These products:

- **FOYA**, is a platform which hosts capabilities that can detect fraudulent cases and instances using AI models. Detecting fraudulent passport and ID's, face verification, voice confirmation capabilities are presented to be used by all industries with digital onboarding processes.
- **Celly**, is a chatbot product which enhances engagement with customers and provides personalized customer experience. A separate platform has also been created for other companies to develop their own chatbots.
- **SIMA**, is a platform with facial demographic analysis being its main capability, and hosts a group of capabilities which include user verification, fraudulent user detection, age and gender detection, emotional state (mood) detection.

Turkcell technology continues to provide service with other capabilities such as speech to text (and vice versa), recommendation engines, sentiment analysis, summary extraction/topic determination from text, auto correct services and continues to expand its AI driven platforms and product line (Turkcell, 2022).

By Vodafone Group; Domestic 5G product suppliers were included in the “Single Core Network” tender, the preparations for which were started at the beginning of 2021, and the technical requirements expected within the scope of the tender were conveyed to all suppliers through meetings during the process. Thus, contributing to the 5G domestic core network product suppliers’ ability to identify the deficiencies of their products and create their plans for them.

Vodafone Technology Services Joint Stock Company (VTEK) develops software-based innovative products, services, and applications in the field of telecommunications and especially mobile technologies. Since 2006, 107 R&D projects have been carried out within the body of ITU ARI Technocity, and 17 of these projects are still ongoing. Since 2014, 352 patent applications have been made to Turkish Patent Institute, and 80 of these applications obtained patent.

Within the scope of cooperation with the university, joint R&D projects were carried out by Vodafone with faculty members of Boğaziçi, Koç, Kadir Has, Galatasaray, MEF, İTÜ and Gebze Technical Universities (Vodafone, 2022).

References

- Aselsan. (2022, 04 08). National Technology Initiative in Communication - ASELSAN.
- HTK. (2022, 03 21). National Technology Initiative in Communication - Communication Technologies Cluster.
- ICTA. (2021). Türkiye Elektronik Haberleşme Sektörü - Üç Aylık Pazar Verileri Raporu. ANKARA: Information and Communication Technologies Authority. <https://www.btk.gov.tr/uploads/pages/pazar-verileri/ceyrek-raporu-2021-4-ceyrek-22-03-21-kurum-disi.pdf>
- ICTA. (2022, 03 29). National Technology Initiative in Communication - Information and Communication Technologies Authority.
- The Ministry of Transport and Infrastructure (UAB). (2017). National Broadband Strategy and Action Plan (2017 – 2022). <https://hgm.uab.gov.tr/uploads/pages/ulusal-genisbant-stratejisi/ulusal-genis-bant-stratejisi-ve-eylem-plani-2017-2020-b9d0c25d-328c-4eda-a2aa-d374ffacd91a.pdf>
- Turk Telekom. (2022, 04 13). National Technology Initiative in Communication - Turk Telekom.
- Turkcell. (2022, 03 24). National Technology Initiative in Communication - Turkcell.
- Türksat. (2022, 03 24). National Technology Initiative in Communication - Türksat.
- Ulak. (2022, 04 13). National Technology Initiative in Communication-ULAK Communication Inc.
- Vodafone. (2022, 03 29). National Technology Initiative in Communication - Vodafone. <https://5gtrforum.org.tr/5g-vadisi-nedir>
- <https://5gtrforum.org.tr/haberler/5gtr-forumu-ile-kore-5g-forum-arasinda-mutabakat-zapti-imzalandi>
- <https://5gtrforum.org.tr/organizasyon>
- <https://www.aselsan.com.tr/694ee6a1-8d45-416d-8950-ffd378651d08.pdf>
- <https://www.aselsan.com.tr/8d517bbf-0639-452c-914f-06975b7a555d.pdf>
- <https://www.htk.org.tr/yerli-ve-milli-5g-urunleri-tanitildi-haberi-179>
- <https://www.trthaber.com/haber/bilim-teknoloji/yerli-ve-milli-5g-sebekesi-hedefi-radyolink-basariyla-test-edildi-525728.html>
- <https://www.tusas.com/urunler/uzay/haberlesme-uydulari/turksat-6a>
- <https://www.ulakhaberlesme.com.tr/index.php/tr/ulaksahalar>
- <https://www.ulakhaberlesme.com.tr/index.php/tr/maya-katalog>
- <https://www.ulakhaberlesme.com.tr/maya/maya.pdf>
- <https://medya.turktelekom.com.tr/turk-telekom-mavenir-ve-comprodan-open-vran-denemesi>

About Author

**Dr. Ömer Fatih SAYAN | The Ministry of Transport and Infrastructure |
ofatih.sayan[at]uab.gov.tr | ORCID: 0000-0001-5786-4027**

He was born on 10.06.1977 in Istanbul. He completed Istanbul University, Faculty of Engineering, Electronics Engineering and Bahçeşehir University, Faculty of Law, Department of Law and Oxford University St Antony's School Diplomacy Education respectively. Regarding postgraduate education he graduated from Munich Technical University, Electrical and Electronics Engineering, Communications Engineering and Istanbul University, Institute of Science, Biomedical Engineering. He completed his doctorate education at Istanbul University, Institute of Science and Technology, Biomedical Engineering. Dr. Sayan, who started his business life in Istanbul Metropolitan Municipality in 1995. After his university education, he worked in the fields of chip production, mobile phone design and R&D in private companies related to the sector in Türkiye, Germany and the United States. Working on entrepreneurship by taking part in the Silicon Valley initiative, Dr. Sayan gave lectures on IT Law and New Trends in Informatics at various universities in Türkiye and Germany. Dr. Ömer Fatih Sayan has many articles published in various conferences and scientific journals on research topics. Dr. Sayan, who worked on entrepreneurship by taking part in the Silicon Valley initiative, gave lectures on Informatics Law and New Trends in Informatics at various universities in Türkiye and Germany. Dr. Ömer Fatih Sayan has many articles published in various conferences and scientific journals on research topics. Between 2007 and 2014, he served as the Prime Minister's Advisor and the Prime Minister's Chief Advisor. In January 2014, he was appointed as a board member to the Information and Communications Technologies Authority. From August 2015 to July 2018, he served as the head of the Information and Communications Technologies Authority. Dr. Sayan continues his duty as the Deputy Minister of the Ministry of Transport and Infrastructure, which he started as of July 2018. Dr. Sayan, who speaks English, German and French, is married and has 3 children.