# TURKISH SPACE AGENCY
2022

# NATIONAL SPACE PROGRAM STRATEGY DOCUMENT
2022-2030

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# 01.
# ANALYSIS OF THE SITUATION IN THE WORLD

### 1.1 General Global Trends and Space Economy

Space activities were born out of the curiosity of humanity to explore the unknowns of space. In the twentieth century, humanity gained the capability to access to space. The space race that emerged in the post-World War II period has become a process that includes many political, strategic, and technological elements. Thanks to this process, a tremendous technological leap has been realized, and humanity has reached a high technological level that cannot be compared with that of a century ago. Today, thousands of satellites are operating in orbit. TV broadcasting, internet, phone services, precise monitoring of Earth through Earth observation satellites having optical and radar payloads, smart transportation applications with navigation satellites, and provision of many services in areas such as urban planning and agriculture have been made possible. Thereby, space studies have transformed into activities that touch human lives and produce added value.

It is known that space agencies form the basis of countries' space activities. Thus, many developed countries began establishing their space agencies and space administrations after World War II. In this sense, via space agencies; nations ensure the healthy development of their space ecosystems; present perspectives, goals, and strategies for the future by program and policy documents prepared by space agencies, thereby providing a planned development. Today, in addition to space activities planned and implemented by space agencies, the involvement of the private sector in space activities has been increasing. Private companies operate launch bases, manufacture launch vehicles and spacecraft, and offer related space services.

New technologies for manufacturing skills and capabilities for space studies are accelerating participation of the private sector in space activities. Henceforth, many critical components can be produced at low cost and in a quick manner. With the private sector's involvement in space economies, countries are performing legislation and regulation studies to strengthen space ecosystems, increase their space-related capabilities, and attract domestic and foreign companies.

The global space economy has been growing rapidly. The space economy, which reached 424 billion US dollars by 2020, has a growth rate of approximately 8%, well above the global growth rate.[1]

[1] Space Foundation, “The 2019 Global Space Economy” in The Space Report q2, 2020, pg.3

It is foreseen that space activities will also develop in the areas of space tourism, satellite constellations, manufacturing in the space environment, and space mining in the upcoming years, and with these activities, growth in the space economy will increase. In addition to the developed countries that have space agencies and administrations from the past up until now, many developing countries, which would like to benefit from this important field of financial and technological gain, have established their space agencies since the 2000s. Today, approximately 80% of the space economy is comprised of revenues obtained from commercial space activities.[2] This situation indicates a paradigm shift in space activities.

Space activities encompass an area that should be managed strategically in all aspects. This area should be managed with a holistic ecosystem and value chain perspective. The fact that a significant part of the studies in the field of space (robotics, sensors, automation, quantum technology, rocket technology, space medicine, etc.) is not limited to space, and that the investment made has also applications on Earth, reinforce the importance of space activities. For this reason, the scope of space programs includes many complementary areas, from the development of necessary human resource to international cooperation, and from raising space awareness in society to mission planning.

Although space activities are quite costly for countries, the technological and strategic power and reputation gained have been an important motivating factor in bearing these costs. For example, although significant resources were spent on the Apollo program of NASA, this program has earned the United States of America great technological and strategic power and reputation both in the national and international area. Besides, thanks to the successes achieved in the program, a reference point has been established for allocating resources to the space studies to be performed in the future. Today, in addition to the ongoing importance of strategic power and reputation brought by space studies from the viewpoint of states, economic and technological benefits that will be obtained from these programs are also taken into account while developing space programs. Moreover, many countries have been conducting their space activities by merging their competencies and budgets through strategic collaboration.

Space programs of countries could vary depending on factors such as national needs, technological competence, economical capacity, human resource, international cooperation capacity, and geographical location. The outcomes of space studies have been playing a significant driving role in the development of a country in the general sense and in enhancing its industry. In addition, space studies have been fueling innovation, enabling emergence of new technologies, knowledge, and inventions that can be used in different sectors. In this

[2] Space Foundation, “The Space Economy” in The Space Report q2, 2020, pg.1

regard, space studies lead to an increase in productivity and employment not only in the space field but also in all the sectors it affects. Throughout the world, within the framework of the perspective mentioned above, significant investment is made in the space field both in the private sector and at the governmental level, and in this context, strategies related to space are developed.

## 1.2 Development of Space Activities

### 1.2.1 Overview of Investments in Space and Space Activities

Government budgets allocated for space programs reached 81 billion dollars by 2020, a 20% increase took place when compared to 2015.[3] Beyond the officially announced values for space programs, it is also known that countries invest in various space projects and also take supportive steps towards their private sectors within their legal frameworks. Moreover, the ratio of government space expenditure to Gross Domestic Product (GDP) is an important parameter. It is known that the share of space programs in the GDP has increased significantly during the important development years in countries that have made breakthroughs in the space field. Within the space expenditure of governments, in terms of budgets for civilian and military studies, it is necessary to mention a balance in which civilian expenditures are one step ahead. As civilian programs and commercial space initiatives are started in many countries, it is expected that the share of civilian expenditure will increase, and the ratio in the total budget will exceed 65%. Information related to civilian and military space expenditure of governments is given in Table 1.

*Table 1. Government Expenditures in Space, 2019 [4] (Entire World)*

| Share of Total Expenditure in GDP | 0.09% |
|---|---|
| **Military Expenditure** | 29.8 billion US dollars |
| **Civilian Expenditure** | 51.1 billion US dollars |
| **Total** | 80.9 billion US dollars |

When Table 2 is examined, it is seen that developed countries are at the first ranks regarding government expenditure in 2019, but countries like China, Japan, and India in the Asia-Pacific region also come to the forefront.

[3] [4] Government Space Programs, Euroconsult 2020

*Table 2. Leading States and Agencies in Space Expenditure 2019* [5]

| Country | Civilian (billion US dollars) | Total (billion US dollars) | GDP % |
|---|---|---|---|
| **USA** | 22.5 | 43.4 | 0.21 |
| **European Space Agency (ESA)** | 5.1 | 5.1 | - |
| **China** | 3.7 | 6.0 | 0.04 |
| **France** | 2.7 | 3.3 | 0.12 |
| **Japan** | 2 | 2.7 | 0.06 |
| **Germany** | 2 | 2.2 | 0.06 |
| **Russia** | 1.8 | 3.4 | 0.2 |
| **India** | 1.7 | 1.7 | 0.05 |
| **Italy** | 1 | 1.1 | 0.05 |

The number of countries investing in space has been increasing with economical and technological developments and the spread of space applications. Another indication of interest in space studies is the number of space agencies worldwide. Today, more than 70 countries have their own space agencies.

Space studies, in general, concentrate on the launch, remote sensing satellites, satellite-based positioning and timing systems, space sciences, exploration and manned space missions, communications satellites, and space security areas. These areas will be examined in more detail in the upcoming chapters. Considering the focus on these areas, it is evaluated that there will be a focus on manned space missions and space exploration, as in the 1960s and 1970s. But this time, the matter of establishing permanent stations on celestial bodies such as Moon, Mars and utilisation of their resources are on the agenda. In this context, in the upcoming decade, it is expected that importance of the activities related to space exploration, launch systems and relevant navigation systems will increase.

Besides, great growth in the production of small satellites which has relatively lower cost has occurred in recent years. Substantial increase is observed especially in the utilization of small satellites for remote sensing, communication and scientific research.

[5] Government Space Programs, Euroconsult 2020

### 1.2.2 Launch

Launch domain is one of the most important areas that space studies focus on. The fact that access to space is made possible by launch technologies has been encouraging many countries to gain this competence. Launch vehicle programs are essentially conducted by space agencies throughout the world. Nevertheless, the launch sector is a comprehensive domain that encompasses organizations manufacturing launch vehicles and their subsystems, providing launch services, and operating spaceports. This sector, which was a privilege of states for years, has been coming forward regarding commercialization in recent years. Increase which takes place in the number of launches over the years is seen in Figure 1.

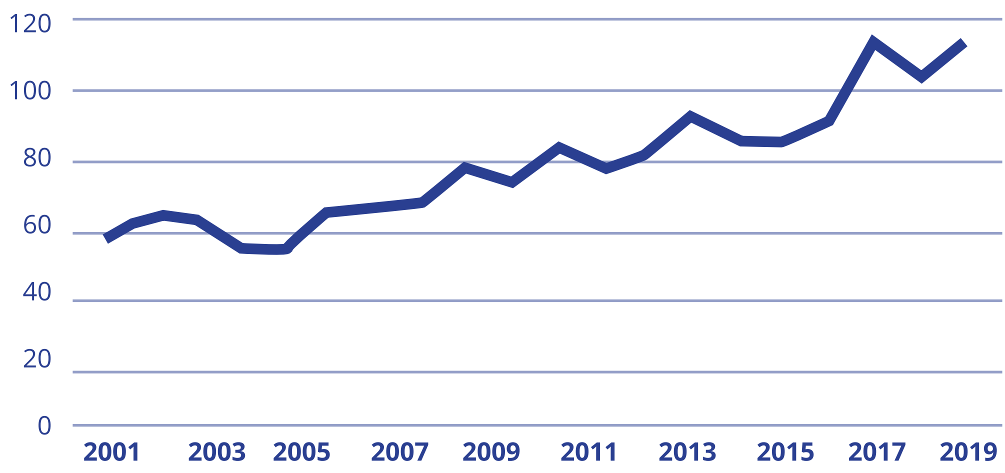



*Figure 1. Number of Launches in the Last 20 Years* [6]

Reducing launch costs, launches with multiple deployment (launching multiple satellites at once), reusability, launching from aircraft platforms, and space shuttle studies stand out as studies that will shape the upcoming 20 years in the launch sector.

With the emergence of reusable launch systems, launch costs have begun to decrease. Studies on the development of launch vehicles in which the upper stages can be reused as well as the first stage is currently underway.

[6] Space Foundation, Space Report q4, 2020

### 1.2.3 Remote Sensing

Remote sensing domain constitutes one of the most important investment fields within general space investments. As it is a priority domain, in addition to the expenditure of developed countries, the expenditure of developing countries is also proportionally high on the subject of earth observation. Images and data obtained from remote sensing satellites can be used in many different areas, such as the environment, urban planning, cartography, agriculture, identification of natural resources, prediction and monitoring of disasters, security, and meteorology.

Along with the improved performance and resolution in remote sensing satellites, increase in the amount of data produced in recent years makes it difficult to process the obtained data effectively. With the increase in the number of remote sensing missions in the upcoming years, long-term storage and processing of the collected data will become a more important issue.

### 1.2.4 Satellite-Based Positioning and Timing

Satellite-based positioning and timing is one of the domains with the potential to provide the biggest gain in the space field. Satellite-based positioning and timing systems are actively used in many areas, such as smart transportation applications, aviation, urban planning, cartography, maritime, defense, autonomous vehicles, financial operations, and synchronization of critical infrastructure.

Satellite-based positioning systems are dual-use systems that have both military and civilian areas of use. The main purpose of the countries investing in satellite-based positioning systems is not to be dependent on foreign sources in terms of positioning, navigation, and timing capabilities while generating commercial returns from the civilian positioning market.

*Table 3. Active Global and Regional Positioning Systems in the World*

| System | Country/Union | Range | Situation |
|---|---|---|---|
| **GPS** | USA | Global | Provides service at full capacity since 1995. |
| **GLONASS** | Russia | Global | Provides service at full capacity since 2011. |
| **Galileo** | EU | Global | The system, which has reached global coverage, is planned to attain its full capacity with the launch of new satellites in the upcoming years. |
| **BeiDou** | China | Global | Attained its full capacity in 2020. |
| **NavIC** | India | Regional | Provides service at full capacity since 2018. |
| **QZSS** | Japan | Regional | Initially designed as a GPS augmentation system, it provides service with four satellites since 2018. It is planned to bring independent operation capability to the system by increasing the number of satellites to seven in 2023. |

As seen in Table 3, there are six different satellite-based positioning systems in operation today. While GPS of the USA, GLONASS of Russia, Galileo of the EU, and BeiDou of China have global coverage; NavIC of India and QZSS of Japan have regional coverage. Countries such as Australia, New Zealand, South Korea, Pakistan, and Türkiye also aim to develop regional positioning systems.

In the upcoming years, it is expected that augmentation systems which increase positioning accuracy and precision, especially for end users, will come to the forefront. Another critical issue is the development of preventive systems regarding blocking and spoofing of positioning signals. Ensuring continuity of services for critical systems is also an important field of study.

### 1.2.5 Space Sciences, Exploration Vehicles, and Human Space Missions

Expenditure on space sciences and exploration vehicles are positioned at the top ranks in the global space expenditure. In general, the development of these vehicles is planned and executed by space agencies.

Looking at the history of space exploration missions, Luna 1 and right after, Pioneer-4 space vehicles left the geocentric orbit and entered into a heliocentric orbit for the first time in 1959. Later, exploration missions towards planets and their moons in the Solar System were performed. There exist space vehicles that operate and maintain communication out of the boundaries of the Solar system and in the interstellar region.

In addition to these, landing and sample return operations have been performed for asteroids. In this area, new operations are also in the planning stage.

In recent years, a great increase in the Lunar missions are observed and it is expected that these missions shall also increasingly continue in the upcoming years. In particular, USA, China and Russia are positioned at the top rank in this field. In addition to propellant production on the Moon and acquisition of economic benefits from natural resources on the Moon, the utilization of the Moon as an intermediate station (gateway) is seen as primary motivation source.

Mars exhibits a structure similar to that of Earth. As it is evaluated that Mars contains abundant amounts of elements and compounds such as water in the frozen state, it has become the most important target after the Moon.

Today, human space activities are in general carried out with International Space Station (ISS) operations. In addition to the reinforcement of the ISS which is in use since 1998 with new modules, construction of new space stations is on the agenda of countries developed in the space field.

### 1.2.6 Communications

Communication satellites predominantly perform functions such as TV broadcasting, internet, telephone services, encrypted and secure communication. Civilian and commercial users shape the communications market to a significant extent. From a technological point of view, it is expected that there will be great demand for Ka-band satellite communications in the upcoming years.

In this domain, especially with the trend towards electric propulsion systems, increase in the life spans of satellites is expected. In addition, in-orbit servicing of satellites is one of the subjects that is researched. In this way, reduction in the renewal cycles for the satellites and positive contribution to the space debris problem are envisaged.

Navigation payload can be added as a secondary payload to the communications satellites in the geostationary orbit. While communications satellites are widely used in the geostationary orbit, their use in the low earth orbit was initiated in the last years.

### 1.2.7 Space Security

Space security, in its general sense, means the ability to access to space and operate assets in space in a “reliable and sustainable” manner. In this context, spending on subjects such as tracking of objects in space, performing conjunction assessments, taking protective measures against ill-intentioned initiatives are included in this domain. When the current space strategies of countries such as the USA, India, Japan, China, Russia, and the European Union are examined, it is seen that almost every country has goals related to space security. Increase in the number of objects in space; establishment of communications and earth observation systems that include many satellites in the Low Earth Orbit (LEO); increase in the space debris comprised of space vehicles and their parts that are out of function and are still in the orbit, and the need of protecting satellites and astronauts from other potential offensive threats are among the priority issues of countries conducting activities in space. It is foreseen that investments in this domain shall continue increasingly.

### 1.3 Evaluation of Developed and Developing Countries Prominent in the Field of Space

The Space Race began with the first satellite that has been launched into space, Sputnik-1 by the Union of Soviet Socialist Republics (USSR) in 1957. In 1961, Yuri Gagarin was sent to space in the Vostok 3KA capsule and became the first man to travel into space.

In the space race that started with Sputnik-1, the USA and the USSR were the leading countries, and then countries such as France and Canada joined this race. Today, while USA and Russia are still positioned at the top rank in space studies; they are followed by countries such as China, Japan, India, the EU countries and the European Space Agency members.

Milestones in the space studies by countries are shown in Table 4.

*Table 4. Milestones in Space Activities*

| Program | Country /Union | Year | Information |
|---|---|---|---|
| **Sputnik-1** | USSR | 1957 | First satellite placed into Earth orbit. |
| **Luna-1** | USSR | 1959 | Escaped from the Earth's gravity and entered a heliocentric orbit. |
| **Pioneer 4** | USA | 1959 | Escaped from the Earth's gravity and entered a heliocentric orbit. |
| **Vostok 3KA** | USSR | 1961 | First human spaceflight mission. |
| **Syncom 3** | USA | 1964 | First operational communications satellite in geostationary orbit. |
| **Luna-9** | USSR | 1966 | First human-made vehicle landing on the Moon. |
| **Apollo 11** | USA | 1969 | First manned landing mission to the Moon |
| **Salyut 1** | USSR | 1971 | First space station |
| **Mars 2** | USSR | 1971 | First human-made spacecraft landing on Mars. |
| **Mariner 9** | USA | 1971 | Placed in the Mars orbit by National Aeronautics and Space Administration (NASA). |
| **Pioneer 10** | USA | 1972 | Flew by Jupiter, Saturn and Uranus, reached beyond the Solar System. Communication is not active. |
| **Landsat 1** | USA | 1972 | First remote sensing satellite. |
| **Skylab** | USA | 1973 | First space station of the USA. |
| **Voyager 2** | USA | 1977 | Took role in the study of the outer planets, leaving the Solar System, it entered into the interstellar region in 2018. |
| **Voyager 1** | USA | 1977 | In 2012, it left the Solar System and entered into the interstellar region. |
| **Mir** | USSR /Russia | 1986 | Space station that was used by the USSR and later by Russia for 15 years. |
| **Hubble Space Telescope** | USA | 1990 | The space telescope that had a role in the discovery of many celestial bodies. |
| **Cassini-Huygens** | USA | 1997 | Launched for studying Saturn, its rings and moons. The Huygens space probe made a successful landing on Saturn's moon Titan in 2005. |

| Program | Country /Union | Year | Information |
|---|---|---|---|
| **International Space Station (ISS)** | Multinational | 1998 | Actively used multinational space station operated by National Aeronautics and Space Administration (NASA), Russian Federal Space Agency (ROSCOSMOS), Japan Space Exploration Agency (JAXA), European Space Agency (ESA), and Canadian Space Agency (CSA). Weighing 420 tons, it is the largest human-made object in space. |
| **New Horizons** | USA | 2006 | In 2018, it left the Solar System and entered into the interstellar region. |
| **Selene** | Japan | 2007 | First satellite sent by Japan into lunar orbit. |
| **Chang'e 1** | China | 2007 | First satellite sent by China into lunar orbit. |
| **Tiangong-1** | China | 2011 | China's first space station. In 2018, it was deorbited in a controlled manner by a reentry. |
| **Curiosity** | USA | 2011 | It is a rover sent to Mars for an exploration mission. (Landing was successfully performed in August 2012.) |
| **Mangalyaan** | India | 2013 | Indian satellite placed into Mars orbit. |
| **Hayabusa-2** | Japan | 2014 | The vehicle developed by JAXA took a sample from the asteroid Ryugu and brought it back to Earth. |
| **OSIRIS-REx** | USA | 2016 | Launched with the goal of taking samples from the asteroid Bennu and returning them back to Earth. The spacecraft is scheduled to return to Earth in 2023. |
| **Tiangong-2** | China | 2016 | It is China's space laboratory. |
| **Tianwen-1** | China | 2020 | Satellite and rover mission sent to Mars by China. |
| **Hope** | UAE | 2020 | It was sent to Mars orbit with international cooperation. |
| **Perseverance** | USA | 2020 | A rover and a helicopter have been sent to Mars. (Landing was successfully performed in February 2021) |
| **Chang'e 5** | China | 2020 | It landed on the Moon, and taking samples from the surface, it brought them back to Earth. |

# ANALYSIS OF THE SITUATION IN TÜRKİYE

# 02.
# ANALYSIS OF THE SITUATION IN TÜRKİYE

## 2.1 Overview of the Situation in Türkiye

Türkiye, whose space budget and human power have been increasing since the 2000s is a candidate to become an important player in the space industry thanks to the important capabilities gained in particular through its communications and earth observation satellites and its educated human force. Ensuring independence in the access to and utilization of space, strengthening the space ecosystem, improving the possibilities of using space for the benefit of society, taking an ever-increasing share from the global space market, developing international cooperation opportunities which reinforce the peaceful use of space are among the priority targets of our country. In the last years, private sector organizations and universities have increasingly started to take a part in space activities. In addition to this, there exists a manufacturing basis in Türkiye which performs activities in other sectors but can integrate with the space activities thanks to its capabilities. Moreover, our young and qualified human force constitutes an important potential.

While the space activities of our country have improved to a significant degree in recent years, the field of space is still open to development for Türkiye. As a matter of fact, less than 1% of the total number of satellites around Earth that are currently operational belong to Türkiye. Similarly, the share we get from the space market is not yet at the desired level. The capacity on the subjects of space weather, space sciences, and launch is not also at the desired level. Increasing the quantity and quality of space-qualified subsystems and space platforms is important.

National Space Program bears vital significance in determining the strengths and weaknesses in the field of space, space-related capabilities, and needs of our country along with new areas of activity. With the preparation of the National Space Program that covers the upcoming 10 years, Türkiye has determined the subjects of study related to space on which it shall focus.

## 2.2 Space Ecosystem of Türkiye

Space ecosystem of Türkiye covers a broad spectrum including satellite operators, users of space-derived data, research and development organizations, manufacturing centers, educational institutions, planning and supportive organizations.

In the past years, an extensive transformation started towards gaining indigenous and national competencies and ensuring technological independence in Türkiye. The most important entity that emerged from this transformation is the Turkish Space Agency (TUA) which was established with the Presidential Decree no. 23 published in the official gazette dated 13 December 2018 no. 30624. The establishment of the Turkish Space Agency met a need that was felt for decades in this field. As space has been embraced as a priority subject in its economical, technological, strategic, and political aspects, space activities in Türkiye are expected to accelerate with the establishment of TUA.

It is expected that TUA shall provide a significant contribution towards increasing the space capabilities of our country, determining needs and important areas of technological development, functioning of organizations belonging to a broad spectrum in a coordinated manner, preventing repeated investments, and developing the space ecosystem. Besides, matters such as representing our country in all international associations and organizations in the field of space, coordinating the work being conducted, determining national strategies, reducing external dependence, increasing competitive power internationally, and utilization of outer space for peaceful purposes are among the duties and authorities of TUA.

## 2.3 Important Space Studies of Türkiye

Türkiye, which has a developing space ecosystem, has the competence to design, manufacture, and test communications and earth observation satellites. Studies towards developing launch capability have been initiated. Moreover, Türkiye is able to meet many of its needs devoted to space systems with indigenous and national means through the infrastructure and human resource it owns.

Important space studies of Türkiye shall be assessed under the subtitles of satellite, launch, and space science.

### 2.3.1 Satellite Studies

Türkiye has covered a significant distance in the last 25 years and has become the possessor of the scientific and technical infrastructure required to produce its own satellites. The satellite projects of Türkiye are given in Table 5.

Türkiye has stepped into satellite activities firstly with communications satellites.

After the launch of TURKSAT 1B satellite in 1994, TURKSAT 1C in 1996, TURKSAT 2A in 2001, TURKSAT 3A in 2008 were launched respectively. TURKSAT 3A, 4A, 4B and 5A satellites are still active. TURKSAT 5A communications satellite was launched into space on 8 January 2021. Having full electric propulsion, TURKSAT 5A shall provide service in support of the existing active communications satellites. TURKSAT 5B, which was launched on 29 December 2021, shall support the communication infrastructure of countries in a wide geography with its high data transmission capacity.

TURKSAT 6A project is being conducted with the aim to develop the national communications satellite of our country. TURKSAT 6A communications satellite, which contains many “first time” achievements, is planned to be launched into space in the upcoming years and advance our country even further in the field of communication.

Remote sensing satellites also constitute an important area of activity in Türkiye. With BILSAT project, in addition to the establishment of ground station and satellite manufacturing/test laboratories within TUBITAK Space Technologies Research Institute (TUBITAK UZAY), Multispectral Camera (COBAN) and Real Time Image Processing (GEZGIN) equipment have been designed and this equipment have gained space heritage. Within the scope of RASAT Satellite project, satellite assembly, integration and test laboratory were established, more than 100 expert personnel in the subjects of satellite design, manufacturing and testing were raised. High Performance Flight Computer (BILGE), X-band Transmitter and Real Time Image Processing (GEZGIN-2) equipment have gained space heritage.

Table 5. *Türkiye's Basic Satellite Activities in the Field of Space*

| Name | Year | Basic Features |
|---|---|---|
| **TÜRKSAT 1B** | 1994 | First satellite launched |
| **TÜRKSAT 1C** | 1996 | Direct link between Europe and Central Asia |
| **TÜRKSAT 2A** | 2001 | TV broadcasting purposes / Russia in coverage |
| **BİLSAT** | 2003 | Remote sensing satellite |
| **TÜRKSAT 3A** | 2008 | High usage capacity/Communications and TV broadcasting |
| **RASAT** | 2011 | First Earth observation satellite designed in Türkiye |
| **TÜRKSAT 4A** | 2014 | TV broadcasting / China-UK-Africa coverage |
| **TÜRKSAT 4B** | 2015 | Fast Internet |
| **GÖKTÜRK 2** | 2012 | High-resolution national Earth observation satellite |
| **GÖKTÜRK 1** | 2016 | First sub-meter Earth observation satellite |
| **TÜRKSAT 5A** | 2021 | Broadcasting and data transmission on three continents |
| **TÜRKSAT 5B** | 2021 | Extensive broadcasting area and fast internet service |
| **TURKSAT 6A** | In Progress | First national communications satellite |
| **IMECE** | In Progress | First domestic and national high resolution Earth observation satellite |
| **GÖKTÜRK 3** | Planned | SAR Satellite/High resolution |
| **GÖKTÜRK 1Y** | Planned | To replace the GÖKTÜRK-1 |

With GÖKTÜRK-2 project, Türkiye has developed a high-resolution satellite with indigenous means. In the scope of the GÖKTÜRK-1 project, procurement of a sub-meter resolution satellite has been realized. Additionally, Space Systems Integration and Test Center (USET) where manufacturing and testing of satellites shall be performed has been taken into service in TUSAS within the context of the project. With IMECE Earth Observation Satellite Project, which started in 2017, it is aimed to develop sub-meter resolution satellite to fulfill Türkiye's high-resolution imagery needs. Currently operational GÖKTÜRK-1 and GÖKTÜRK-2 satellites are in service in the remote sensing field.

As a result of these studies, many satellite subsystems (flight computer, transmitting and receiving antennas, satellite structures, etc.) have been developed in Türkiye. Currently, work is underway to develop various satellite components (satellite propulsion system, solar panel, battery, SAR payload, various parts belonging to optical and radar payloads, etc.) and gain space heritage for them.

Cubesat studies in Türkiye started in 2005 within Istanbul Technical University. Scientific and experimental cubesat studies of Türkiye are given in Table 6. Today, many universities and organizations have been conducting studies related to cubesats.

*Table 6. Scientific and Experimental Small Satellite Activities of Türkiye*

| Name | Launch Date | Category |
|---|---|---|
| **İTÜpSAT1** | 2009 | Experimental |
| **TÜRKSAT 3USAT** | 2013 | Amateur Radio Communications |
| **BeEagleSat** | 2017 | Scientific |
| **HAVELSAT** | 2017 | Scientific |
| **UBAKUSAT** | 2018 | Amateur Radio Communications |
| **ASELSAT** | 2021 | Experimental |

The interest towards cubesats and small satellites in the world has been increasing. It is aimed that the studies towards these systems, which have relatively low cost and short development cycle and which could significantly improve frequency of data acquisition, will continue increasingly.

The roadmap that is prepared for Türkiye's satellite and space studies is presented in Figure 2.


*Figure 2. Türkiye Satellite Road Map 1994-2040*

### 2.3.2 Launch Studies

With the aim of Türkiye's having independent access to space and within the context of a contract signed between Defence Industry Agency (SSB) and ROKETSAN in 2018, Micro Satellite Launch System (MUFS) has been started to be developed. The purpose of the project is to gain satellite launch capability which will support the sustainability of Turkish satellite programs and access to space independently. Within the program, studies are ongoing for the establishment of a Satellite Launch Center in Türkiye.

Having engines with liquid propellant, the first prototype of SR-0.1 sounding rocket that was developed by ROKETSAN within the scope of MUFS Development Project was launched into space in 2020. This successful test launch has become a historical step in that, Türkiye has started its scientific studies in space.

When the MUFS Development Project is completed, it is aimed to gain the capability to place satellites weighing 100 kilograms and below into LEO.

Within the scope of a contract signed between SSB and DELTA V Space Technologies, it is aimed to develop an experimental prototype of a space rocket engine based on hybrid propellant technology.

## 2.4 Manufacturing and Test Capabilities / Infrastructure Inventory

Within the field of space technologies, our country has thermal vacuum, vibration, acoustics, electromagnetic interference and compatibility, radiation, shock, mass properties measurement, and test infrastructure for the environmental tests. In addition, there exists various infrastructures devoted to visual analysis systems, satellite propulsion systems, moisture, dust, and icing measurements on the subject of environmental test conditions. For the functional tests and integration, solar panel deployment, compact antenna, accurate positioning with laser tracking, and integrated test infrastructure exist. Besides, tests of optical payloads can also be done in our country. There are also studies on the development of star tracker, inertial navigation systems and their components.

Launch test infrastructure is being established in our country. In this context, laboratories on propulsion and combustion technologies, liquid propellant and characterization laboratories have started to operate.

Our country has various facilities for the production of electric propulsion systems, optical systems, electronic systems (antenna, semiconductors, integrated circuits, etc.) in compliance with international space standards under clean room conditions.

Similarly, there are various capabilities for manufacturing composite structures, and parts such as multi-layer insulation. Capabilities are also improving on the subjects of mirror coating, chemical processes, surface and paint processes, thermal treatment.

It is important that all these production and test facilities are reinforced in line with current needs and that new facilities are established on the basis of needs.

### 2.5 Space Sciences

Currently, there are 38 telescopes in our country (Table 7). The majority of telescope infrastructure is used in science and society studies. Ground-based astronomical observations have advanced in our country. Besides, satellite-based astronomy studies related to the high-energy region of the spectrum are also being carried out.

*Table 7. Space Sciences Infrastructure in Our Country and Telescope Inventory*

| City | Institution Name | Telescope Diameter (m) |
|---|---|---|
| **Adana** | Cukurova University UZAYMER | 0.50, 0.30 |
| **Adıyaman** | Adıyaman University Observatory | 0.60 |
| **Ankara** | Ankara University Kreiken Observatory | 0.80, 0.40, 0.35, 0.15 |
| | METU Observatory | 0.38 |
| **Antalya** | TUBITAK National Observatory | 1.50 (RTT150), 1.00 (T100), 0.60 (T60), 0.40 (ROTSE), 0.40 (YT40), 0.30 (BİTOM) |
| | Akdeniz University Observatory | 0.60 (UBT60), 0.25 (AUT25) |
| **Çanakkale** | Çanakkale Onsekiz Mart University Ulupınar Observatory | 1.22, 0.40, 0.30 |
| **Erzurum** | Atatürk University ATASAM (Eastern Anatolian Observatory) | 4.00 (DAG), 0.50 (ATA50), 0.30 (MASS/DIMM), 0.30 (GDIMM) |
| **Eskişehir** | Eskisehir Technical University Yunus Emre Observatory | 0.60, 0.40, 0.40 |
| **İstanbul** | Kandilli Observatory | 0.20 |
| | Istanbul University Observatory | 0.60 (IST60), 0.40 (IST40) |
| | Yeditepe University | 0.40, 0.15 |
| **İzmir** | Ege University Observatory | 0.40, 0.35 |
| **Kayseri** | Erciyes University UZAYBİMER | 0.40, 0.35 and Radio: 12.8 |
| **Malatya** | Inonu University Observatory | 0.35 |
| **Samsun** | Samsun Ondokuz Mayıs University Observatory | 0.35 |

TUBITAK National Observatory (TUG) has been providing telescope services and research infrastructure for observational astronomy and astrophysics research of universities and research institutions with the telescopes in its inventory.

The 4-meter diameter DAG telescope that is being built within Atatürk University ATASAM is expected to make significant contributions to observational astronomy and astrophysics research, especially in infrared region. The radio telescope at Erciyes University is the only radio telescope in Türkiye.

In addition to the existence of specialized research power in optical observations in our country, it is envisaged to develop infrastructures for different wavelengths outside the optical spectrum and to enhance related human resource.

## 2.6 Human Resource, Educational Institutions, and Supports

Our country attaches great importance to the matter of raising human resource. Every year, a large number of qualified human force are graduating from aerospace, space, and aeronautical engineering departments of our universities. There are departments related to different engineering fields (computer engineering, mechanical engineering, electrical and electronics engineering) needed for space activities and departments related to space sciences (astronomy and space sciences, space sciences and technology, physics, and physics engineering, etc.) It is important that the large number of existing departments are qualitatively improved, the infrastructure and laboratory facilities are improved in the field of space.

It is obvious that a significant potential shall arise if the human resource is effectively assigned to the projects to be carried out in the field of space. Some part of this human resource is employed in the universities and aerospace sector, another part heads towards different sectors, and a significant part goes abroad. In order to prevent brain drain, to ensure reverse brain drain, and to be able to obtain maximum benefit from the qualified workforce in this field, it is important to develop the space sector by primarily strengthening the Turkish Space Agency and increasing the number of space projects.

# GOALS OF THE NATIONAL SPACE PROGRAM

# 03.
# GOALS OF THE NATIONAL SPACE PROGRAM

Ten goals have been determined within the scope of Türkiye's National Space Program. The basic policies taken into consideration while setting up these goals are as follows:

- *Independent Access to Space*
- *National Independence in Critical Technologies*
- *Contribution to Science*
- *Use for Peaceful Purposes*
- *Soft Power*
- *Commercial Benefit*
- *Social Awareness*

## 3.1 Moon Research Program

### 3.1.1 Introduction

Nowadays, the race to the Moon and Mars has been accelerating among the countries which are advanced in space technologies. This race is not held only with the motive of national pride or scientific progress. While de facto borders are drawn in new sovereignty areas, a chess game which has technological, economical, and political consequences, is also being played.

In these circumstances, with the initiated the Moon Research Program (AYAP), Türkiye has also taken a role in studies towards the Moon and other celestial bodies. The accomplishment of the Program will enable us to have opportunities that so few countries would have in the future, as well as practical results like transforming acquired technologies into financial contributions in space and other areas, raising our country's position in the area of science, increasing interest towards science and technology in society, and increasing the soft power of our country through international cooperation.

### 3.1.2 Aim

The aim of the program is, by sending a rover to the Moon:

- Gaining experience in space systems operating in deep space, launch and propulsion technologies, and getting space heritage for our systems,
- Advancing our country in the field of space by becoming one of the few countries that have reached the Moon,

- Increasing awareness in our country regarding the subjects of science and technology, especially about space,
- Contributing to science and technology with scientific experiments on the rover,
- Increasing our opportunities for international cooperation in the field of science and technology, and
- Establishing the technical infrastructure for conducting research on celestial bodies, such as Mars and asteroids.

### 3.1.3 Strategies and Principles

While carrying out the program with the least possible risk and highest possible efficiency, the following strategies and principles will be taken into consideration for ensuring maximum technology acquisition:

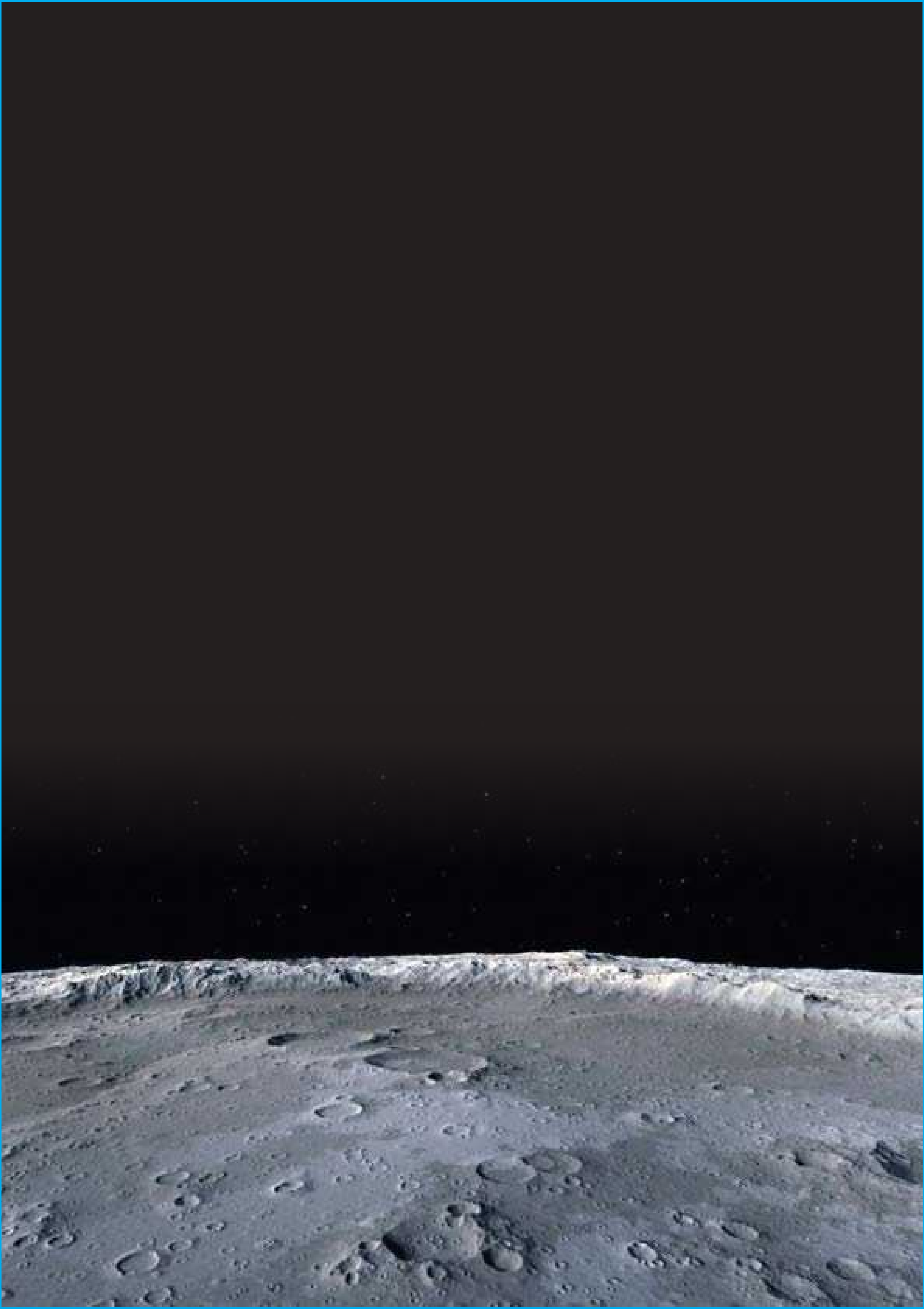
- Existing capabilities for space will be utilized to the maximum extent. Within this framework, the system design and integration of spacecraft will be national.
- Technology acquisition at each stage will be planned considering the next stage, but it will be kept at a level that will not increase the risk excessively.
- The contribution of our universities and scientific community will be kept at a maximum level in selecting and designing the scientific payloads that will reach the surface of the Moon, and in the data analysis.
- By planning the Moon Research Program in stages, risk and schedule will be balanced.
- In case foreign country organizations want to participate in projects, a path to international cooperation will be kept open in a way that does not damage the national technology acquisition of projects.

### 3.1.4 Projects and Activities

The program is planned in two phases. In the first phase, an indigenous spacecraft, which will be launched into Earth's orbit with international cooperation, will reach the Moon. The spacecraft, named AYAP-1, will make a hard landing on the Moon by firing in space its hybrid rocket engine which is developed nationally.

At the end of the first phase, essential technologies, such as engines for spacecraft propulsion, orbit determination and control software, long-distance communication, autonomy developed for spacecraft propulsion, will be validated in space. It is aimed that the first phase of the Program is realized by the end of 2023, at the 100th anniversary of our Republic.

In the second phase, AYAP-2 spacecraft, which will go into space by our national launch vehicle and will reach the Moon by using our indigenous engines, will make a soft landing on



the surface of the Moon. The rover, which will be inside the AYAP-2, will land on the Moon's surface and conduct scientific research there. This vehicle is aimed to reach the Moon in 2028.

In case projects proceed successfully, national and international projects will be planned for celestial bodies. Mechanisms will be created for validated technologies to support the National Space Program, to be commercialized and to be transferred to other technology areas.

### 3.1.5 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 3.

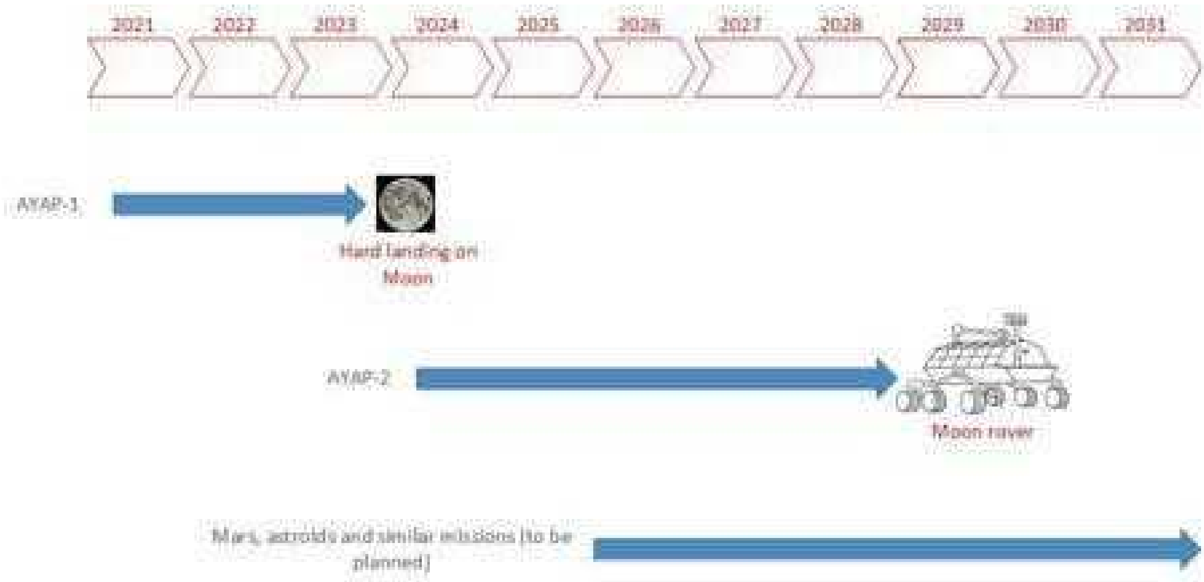



*Figure 3. Gantt Diagram of Moon Research Program*

## 3.2 Unification of Satellite Production Under a Single Framework and Indigenous Satellite Development Program

### 3.2.1 Introduction

Activities on space technologies have been carried out under the coordination of various institutions and organizations until today. Within this time period, important capabilities have been acquired for designing, manufacturing, testing, and integration of satellites and their subsystems. Due to the fact that these capabilities are gathered in different institutions and organizations, acting quickly becomes difficult, duplicate capabilities appear, and resources cannot be used efficiently at every stage from the design of a space system to its operation. By gradually gathering basic capabilities under a single roof, the way will be paved for the existing capabilities' serving National Space Program efficiently and effectively.

### 3.2.2 Aim

Gathering satellite production under one roof to create a commercial brand that can compete globally in the field of new-generation satellite development is aimed. In this way;

- Carrying out satellite production activities with the highest efficiency and effectiveness,
- Realizing the goal of independence in satellite technologies with minimum resources,
- Private sector’s benefiting from public capacities easily from a single point,
- Increasing the competitiveness of the Turkish space industry will be ensured.

### 3.2.3 Strategies and Principles

The following strategies and principles will be considered in order to gather satellite production under one roof and implement the indigenous satellite development program efficiently:

- The basic satellite production, testing, and integration capabilities of our country will be gradually merged into a national company to be established under the coordination of the Turkish Space Agency,
- Attention will be paid to preserving the competitive structure, and
- It will be ensured that the existing infrastructure is utilized effectively and economically.

### 3.2.4 Projects and Activities

The establishment of the company will be realized by completing necessary activities with the relevant institutions and organizations under the coordination of the Turkish Space Agency.

### 3.3 Regional Navigation and Timing System (BKZS) Program

#### 3.3.1 Introduction

Nowadays, satellite positioning, timing, and navigation systems are widely utilized on a global scale in many civilian fields including internal security, aviation, highways, railways, informatics, banking, disaster management, cartography, communications, agriculture, mining, and maritime sectors. Benefiting from these systems, the use of which becomes increasingly widespread and a part of our daily lives, has turned into a necessity rather than being an option. Many new technological applications, such as Industry 4.0, Internet of Things, smart cities, autonomous systems, etc. are being built based on these systems, and applications that are creating added value based on these systems are becoming widespread. Therefore, the uninterrupted provision of services by the Global Navigation Satellite Systems (GNSS) has already become a critical issue for countries in the world.

The danger that awaits users who benefit from all navigation satellite systems, both global and regional, is that the signals reaching the GNSS receivers can be easily blocked by the systems broadcasting at the same frequencies on earth, and the receivers can be jammed or even spoofed. In addition, satellites may lose functionality during natural events like solar storms or because of cyber-attacks. In such cases, there is a risk of GNSS satellites' staying inactive for a long period of time. Since it is understood that the interruption of GNSS-based applications causes significant harm to the economies of countries, preventative measures are tried to be taken. However, a technology that can completely replace these systems does not exist yet.

It is inevitable that Türkiye, which is among the notable economies of the world, would be seriously affected by possible GNSS interruptions. Therefore, alternative positioning, timing and navigation systems, and auxiliary resources must be planned.

#### 3.3.2 Aim

As there is the possibility of intervention to all global and regional navigation satellite systems, considering the priority is being given to alternative positioning, timing, and navigation technics, a gradually progressing program is proposed. With this program:

- Prioritizing the critical systems, keeping the effects of possible GNSS outages and interventions to a minimum level,
- Benefiting from positioning, timing, and navigation services with higher accuracy and availability by users
- Ensuring that our country would have a share in the positioning systems market are aimed.

### 3.3.3 Strategies and Principles

To achieve the program goals with high efficiency and to ensure the acquisition of critical technologies with low risk, the following strategies and principles will be considered:

- Realizing complementary investments using the current infrastructure and capabilities within the scope of the regional positioning, timing, and navigation system program,
- Meeting primary needs by enhancing existing capabilities,
- Utilizing more than one GNSS that complement each other,
- Conducting a feasibility study to define the program,
- Developing critical technologies for the program rapidly will be aimed.

### 3.3.4 Projects and Activities

The regional positioning, timing, and navigation system program has been planned in phases under the following topics.

#### 3.3.4.1 Feasibility Study

Although the main lines are determined under the headings below, there is still a need to conduct a feasibility study which takes into account users, all stakeholders, and all the activities that have been done until now. For this purpose, a detailed roadmap that ensures efficient use of resources will be put forward by initiating the feasibility study.

#### 3.3.4.2 Improving the Robustness of Existing Systems

It is aimed to minimize the adverse effects of GNSS outages and interventions on the systems operating in our country, while priority is being given to critical systems.

Hence, firstly, it will be ensured that critical receivers use at least two of the four GNSS systems which provide services on a global scale at the same time. Moreover, to meet the strategical sectors' positioning, timing, and navigation needs uninterruptedly; alternative systems that use the information provided from satellites and ground collectively and that are based on technologies such as artificial intelligence, sensors, artificial vision, Internet of Things will be developed.

#### 3.3.4.3 Satellite Based Augmentation System (SBAS)

There is a need for a satellite-based augmentation system that will provide service regionally to the geography where Türkiye is located. Developments in civilian aviation are built on these systems, known as SBAS in short. SBAS installed around the world can be interoperated. Currently, our country does not have an SBAS. On the other hand; EGNOS, the European Union SBAS system, covers our country partially. For ensuring that this system's service area would be extended to cover all of the Türkiye, work on performing necessary negotiations and planning additional terrestrial reference stations will be conducted.

In addition, TUSAGA-Aktif (CORS-TR), which is a ground-based augmentation system currently operational, will be supported, and performing signal distribution from space will be planned.

In this way, users in our country will be able to access these services faster and more accurately.

**3.3.4.4 Regional Navigation and Timing System (BKZS)**

Civilian services provided by GNSS can be used without any limitations. However; when it is considered in the scope of positioning services providing high-level accuracy, there is a possibility that GNSS under the control of other countries may not be used during critical periods. It is aimed to provide the needed positioning and precise time information in the geography where Türkiye is included, in a 7/24 secure manner and through a reliable regional navigation satellite system that is entirely controlled by our country. Within the scope of the Regional Navigation and Timing System goal, named as BKZS in short, primarily a pre-feasibility study will be conducted and feasibleness of the system will be analyzed. Studies will be planned for developing a navigation satellite constellation, establishing a ground control system, and developing positioning receivers.

It is aimed to develop the components of the BKZS by using the national means at a maximum level. In this context, the development and production of critical indigenous components (atomic clocks etc.) that can be used in the positioning satellites will be supported. Testing these components and gaining space heritage will be ensured by carrying out experimental cubesat projects. Afterwards, system and sub-system level tests will be conducted in space by launching an experimental BKZS satellite. In this way, experience regarding production and operation of the navigation satellite will be obtained; feedback will be gained for developing system components and fully operational satellites. It is planned that the first BKZS satellite will be built as an augmentation system in the first phase, and will have an additional SBAS payload. It is aimed that, from the fourth BKZS satellite onward, national GNSS positioning, timing and navigation services would begin to be provided to users; the TUSAGA-Aktif (CORS-TR) would be used to produce precise location information by upgrading it to be compatible with BKZS; the system would reach its full performance after the satellite constellation is completed; BKZS coverage area would be expanded by launching subsequent satellites. In addition, necessary studies will be carried out to establish an innovative satellite system that will work with artificial intelligence and ground-based systems.

#### 3.3.4.5 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 4.

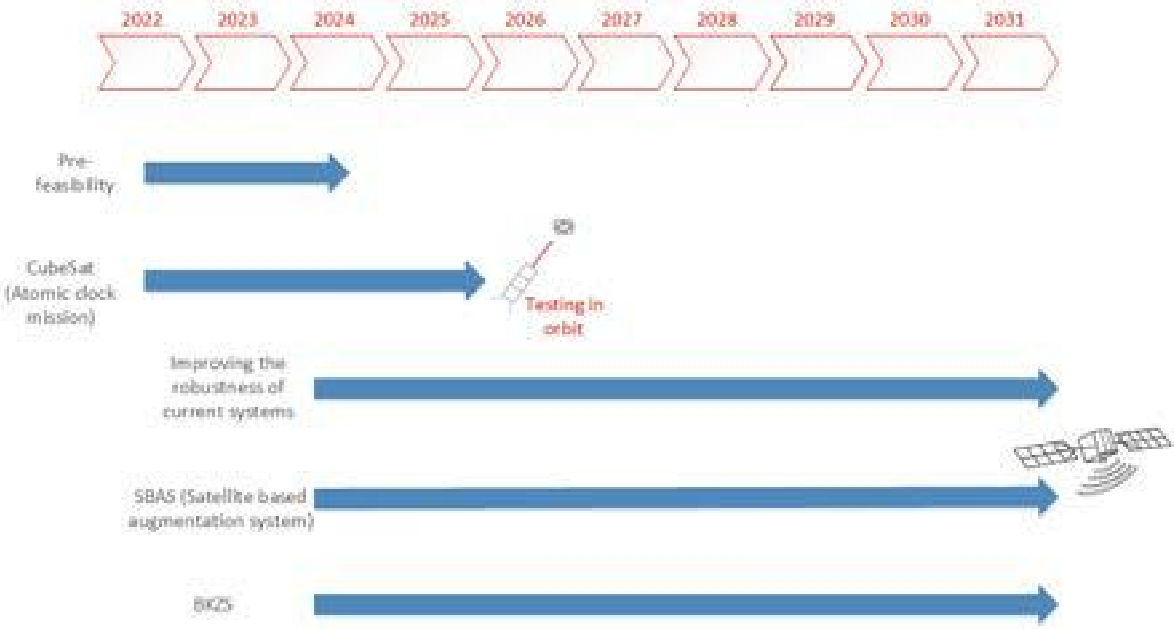



*Figure 4. Gantt Chart of Regional Navigation and Timing System (BKZS) Activities*

### 3.4 Access to Space and Spaceport Program

#### 3.4.1 Introduction

Access to space has critical importance on realizing studies in the field of space. Access to space, which is even provided by commercial companies nowadays, is a capability that should be acquired with regards to the implementation and sustainability of science and technology, technological developments it brings to other sectors, prestige and diplomatic power to be earned in international relations. For this reason, studies have been initiated to gain independent access to space to realize the National Space Program.

Struggling for having the capability of independent access to space, will also bring along technological developments in different fields within the country. Research and development studies to be carried out during the design and production of subsystems, projects to be realized in the fields of materials and fuel, and studies to be carried out for the establishment of launch systems, will have the opportunity to be applied in different areas later on, and will bring new inventions and products.

#### 3.4.2 Aim

The aim of the program is, by gaining capability of independent launch for our country:

- Sending indigenous spacecraft to space independently,
- Creating a sustainable and competitive industrial ecosystem for launch technologies in our country.

### 3.4.3 Strategies and Principles

While conducting the Program with the least possible risk and the most effective way by considering the studies carried out in our country, the following principles and strategies will be considered to ensure the maximum level of acquisition of technology:

- Carrying out the studies that will be included in the Program with the relevant institutions and organizations in coordination;
- Conducting a feasibility study that comprises the options for a spaceport as well, in order to realize the launch vehicle development program in a cost-effective, competitive and sustainable manner;
- Taking into consideration the opportunities for technological development and commercialization on a global scale.
- Creating a roadmap for technological development for the acquisition of critical technologies.
- Establishing international collaborations that will also contribute to acquisition of launching capability which considers commercial activities.
- Encouraging the use of innovative technologies for the launch vehicle system to stand out in the world as a capable and competitive system.

### 3.4.4 Projects and Activities

A parallelized and phased approach will be established to acquire independent launch capability. In this context:

- A feasibility study that will determine the appropriate launch vehicle and the spaceport will be conducted.
- A critical technology roadmap belonging to the launch vehicle will be created.
- A project for the establishment of the spaceport, the requirements of which will be defined based on the results of the feasibility study, will be initiated.
- A Launch Vehicle System that will have specifications in line with the priority target, will be developed.
- Technology acquisition projects for critical technologies will be implemented.

### 3.4.5 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 5.

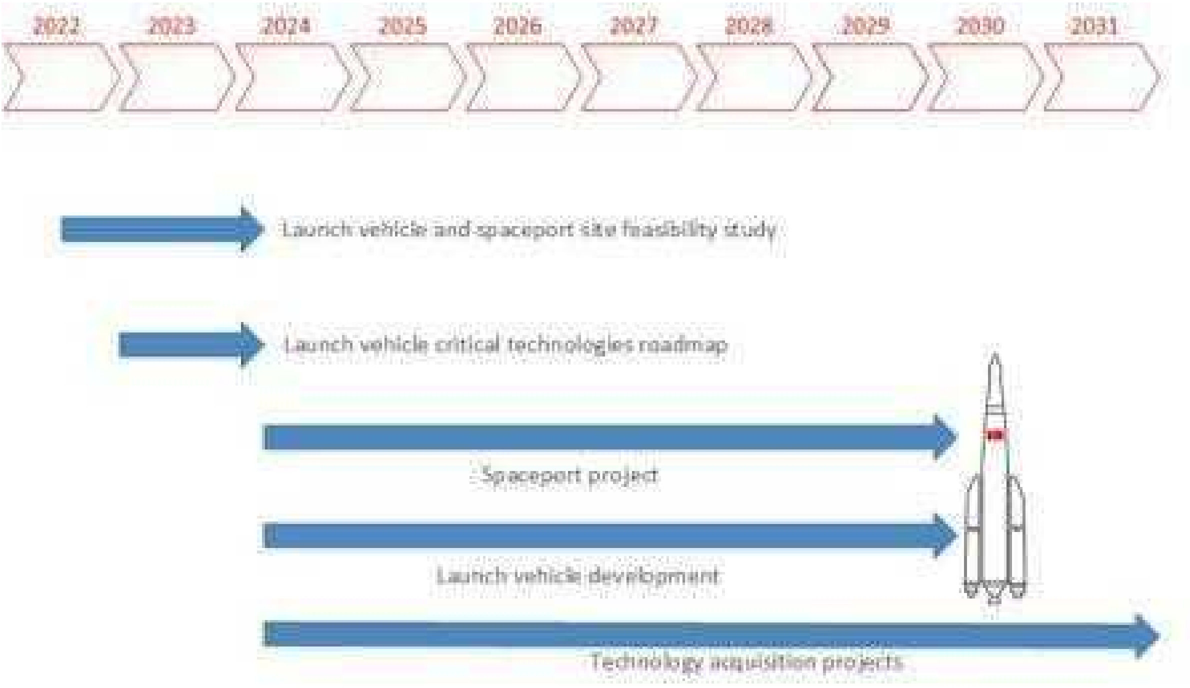
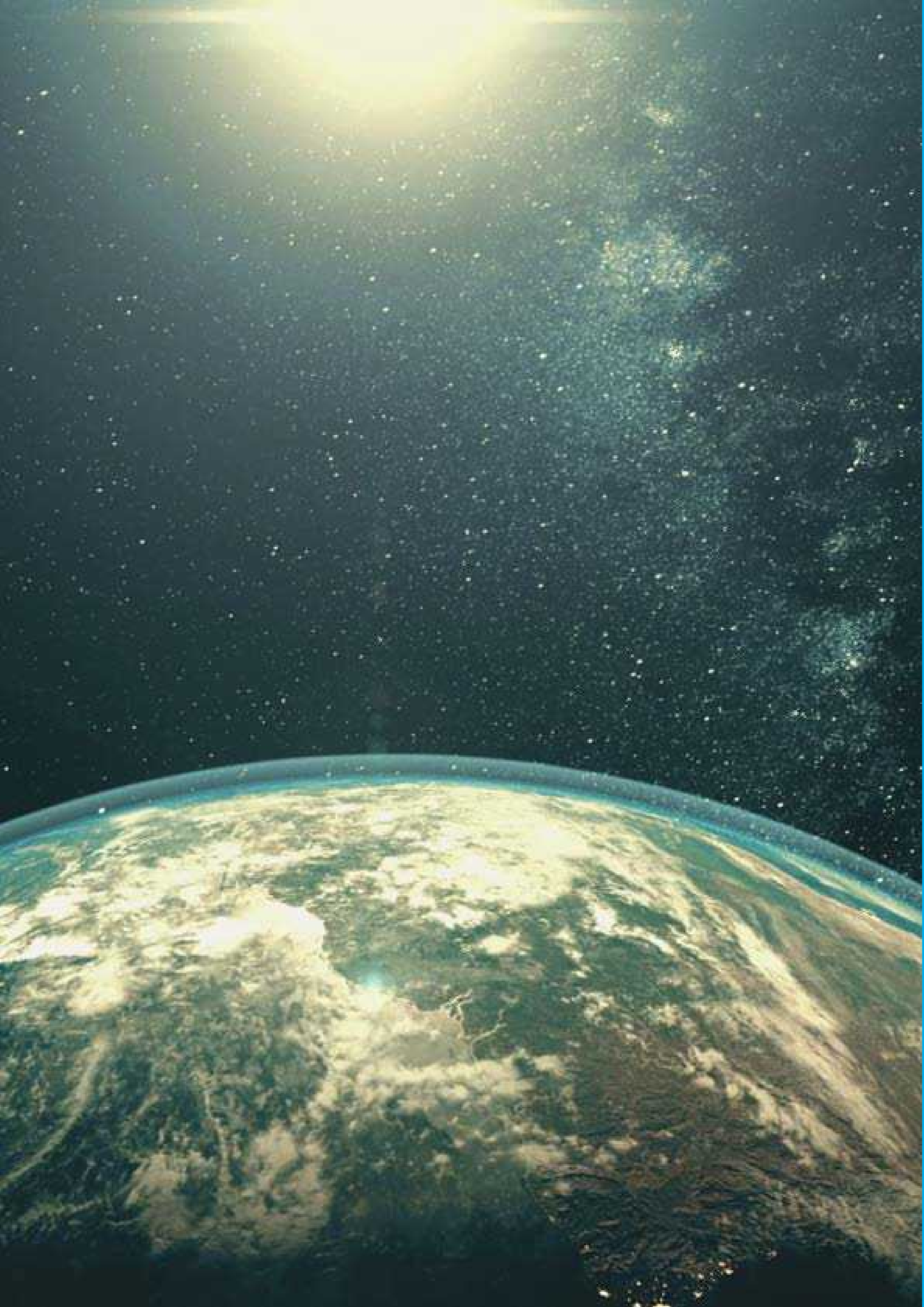



*Figure 5. Gantt Diagram of the Access to Space and Spaceport Program*



## 3.5 Technological Research on Space Weather

### 3.5.1 Introduction

Space weather, which is a branch of space physics, studies the varying conditions in the Solar System. The Sunspot cycle, Solar storms and upper atmospheric layers (stratosphere, mesosphere, thermosphere, ionosphere, and magnetosphere) are included in the area of interest of space weather. This area has begun to gain significance gradually as the effects of space weather in our lives were understood in addition to the development of space technologies.

The physical events taking place in the near space primarily affect the systems existing in space. As they affect the satellite lifespan, they can also cause disruptions and interruptions in services such as telecommunication and navigation services provided by satellites. On Earth, as solar storms can cause electrical transmission systems to switch off and long-term blackouts on large scales, they can also affect various areas including telecommunication, geophysics measurements, and even climate.

Therefore, continuous monitoring and forecasting of space weather and understanding physical phenomena better are necessary. Several international institutions and some countries have established centers and formed projects for this purpose, and space weather-oriented services are being provided.

In our country, there is also a necessity for a center that would coordinate studies about space weather, space sciences, and astrophysics, and would provide basic services and conduct international cooperation activities. On the other hand, there is a need for supporting the studies of universities and research facilities on space weather, and building projects for experiments that will be conducted in space is also necessary.

### 3.5.2 Aim

- Forming technical and scientific infrastructure and accumulation of knowledge that will provide the security and sustainability of space missions that will be needed,
- Ensuring the continuity of the space weather services,
- Contributing to the universal science by raising Türkiye’s scientific competence and level of international cooperation on space weather and space sciences.

### 3.5.3 Strategies and Principles

The following strategies and principles will be considered to achieve the goal in a most effective way:

- Among the BKZS sub-projects, supporting ionospheric research in particular;
- Integrating space weather research, studies on radiation-resistant semiconductor development, and the use of radiation test infrastructures into the projects,
- Supporting the payloads on space weather missions in satellite projects.
- Establishing a center that gathers space weather observations data and provides space weather services through running space weather models;
- Ensuring that the center that would be established, works with international organizations.

### 3.5.4 Projects and Activities

The projects and activities below are planned to reach the desired level in space weather and related branches of space physics cost effectively and quickly. In addition, matters of raising public awareness and enhancing human capital in this field were evaluated within other relevant goals.

#### 3.5.4.1 Establishment of Space Weather Application Center (UHUM)

For this purpose, the structure and functions of similar organizations in the world will be investigated, the model and duty fields of the Center will be defined, opinions from stakeholders working in this field will be collected and administrative processes will be initiated by drafting legislation in the light of these opinions.

The Space Weather Application Center to be established is expected to support and integrate scattered academic studies, to establish the link between academic studies and services (such as space weather, monitoring of near space objects, space environment simulations), to ensure the continuity of services and to represent Türkiye in appropriate international organizations.

#### 3.5.4.2 Improving Radiation Resistance Capabilities

First of all, coordination will be made for the use of the radiation test infrastructure established in Türkiye at the international level, and projects will be developed to conduct tests with higher-level particles. In parallel, our simulation capabilities related to the radiation levels to be exposed in the space environment will be transformed into a service that will support the National Space Program.

Procurement of some radiation-resistant electronic components is a critical area. A plan will be made for the components that will be needed in this area and projects for the design and production of radiation-resistant semiconductors will be supported within the framework of this plan.

#### 3.5.4.3 Infrastructure Installation

There is a limited number of measurement devices in our country for the monitoring of space weather. Measuring stations will be established gradually to increase the number of measurement devices and use them within a network. Installations will start with magnetic measurements, the installation of measurement infrastructure will be accelerated with the activation of UHUM.

#### 3.5.4.4 Space Experiments

Cubesat projects that could be carried out with small budgets will be utilized for measurements and experiments to be carried out in space. For this purpose, project proposals will be collected from universities and research institutions, data processing and theses will be foreseen in the proposals, SMEs will be included in the project as much as possible during the realization phase and a monitoring mechanism will be established by TUA to reduce the risks of the project.

#### 3.5.4.5 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 6.

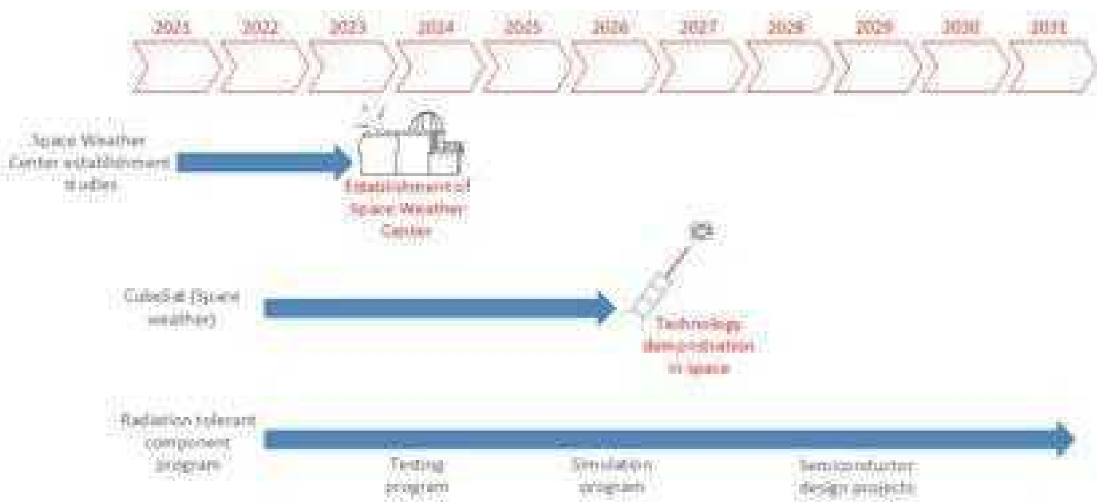



*Figure 6. Gantt Diagram of Space Weather Activities*

## 3.6 Observation and Tracking of Space Objects from the Ground

### 3.6.1 Introduction

Satellites and rocket parts sent into space and objects in Earth's orbit are increasing rapidly every year. A significant amount of space junk has formed around our Earth with the addition of scattered fragments from satellites that collided or were struck in space for tests. It is estimated that there are hundreds of thousands of objects larger than one centimeter in diameter in orbit. This debris poses a great threat to satellites and astronauts in space, and the threat is increasing gradually. In addition, there is also a slight risk that asteroids and comets pose a danger to our Earth.

Today, countries that are advanced in space technologies, detect, catalog and track these objects with various systems located on the ground. In this way, measures can be taken to get protected from these objects. In addition, there is a need of knowing some satellites orbits' with great accuracy by monitoring them from the ground. Monitoring of natural celestial bodies is also important both in terms of pre-detection of threats and scientific studies.

In order to monitor the objects in orbit and the celestial bodies in our Solar system, there is a need to make observations, to detect and track the objects with robotic systems, and interpret the results of the observations in our country also. For this purpose, a program has been established to improve our infrastructure for observing space and to support the National Space Program.

### 3.6.2 Aim

The aim of the program is; achieving space situational awareness through the monitoring of active satellites, space debris and near-space objects from the ground and, in the future from space, and thus;

- Ensuring the security of our assets in space,
- To be able to plan our space programs with minimum risk,
- Contributing to the functions of our satellites by gaining the ability to detect independently their orbits with high accuracy,
- To be able to enter into international cooperation on the security of space assets, and
- Conducting scientific analysis studies for space objects.

### 3.6.3 Strategies and Principles

When carrying out the program, the following strategies and principles will be considered in order to reach the required skill level quickly:

- Collecting data from a wide geography with maximum international cooperation,

- Installing optical systems by considering meteorological-atmospheric conditions in different regions of our country and improving the quality of observation,
- Using the optical systems that will be installed efficiently by considering more than one function,
- Initiating small-scale projects to develop the technologies required for non-optical systems in advance,
- Gradually commissioning the radio frequency and laser-based ground systems, and
- Integrating space-based systems into the system in the medium term.

### 3.6.4 Projects and Activities

#### 3.6.4.1 Creating the Near-Earth Observation System

An automatic space observation system for scientific and operational purposes will be established. For this purpose, apart from utilizing already existing telescope systems, low-brightness objects will be monitored by installing robotic telescopes with diameters greater than one meter. A large-diameter telescope will be added to already existing systems for tracking objects within the solar system in the long term. Establishing a center is being planned to operate this system, provide services to users and provide other space services. The tasks of performing operations routinely, providing services, benefiting the scientific world from the system, and maintaining the development of the system will be realized by this center. At the same time, opportunities for international cooperation will be explored.

#### 3.6.4.2 Advanced Technology Projects

**Space-Based Observation**

For the purpose of observing the objects in the Earth's orbit from space, an experimental optical cubesat mission will be carried out first. Depending on the success of this mission, a space system will be designed that will be integrated into the ground-based system which will be operated by the Center.

**Laser**

Firstly, a laser-based distance measurement system will be designed for technology demonstration, and performance measurements will be performed. A system will be developed that will be integrated into the operational system operated by the Center by benefiting from the results of this study.

**Radar**

A feasibility analysis will be carried out for a low-cost space-observing RADAR project.

### 3.6.4.3 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 7.

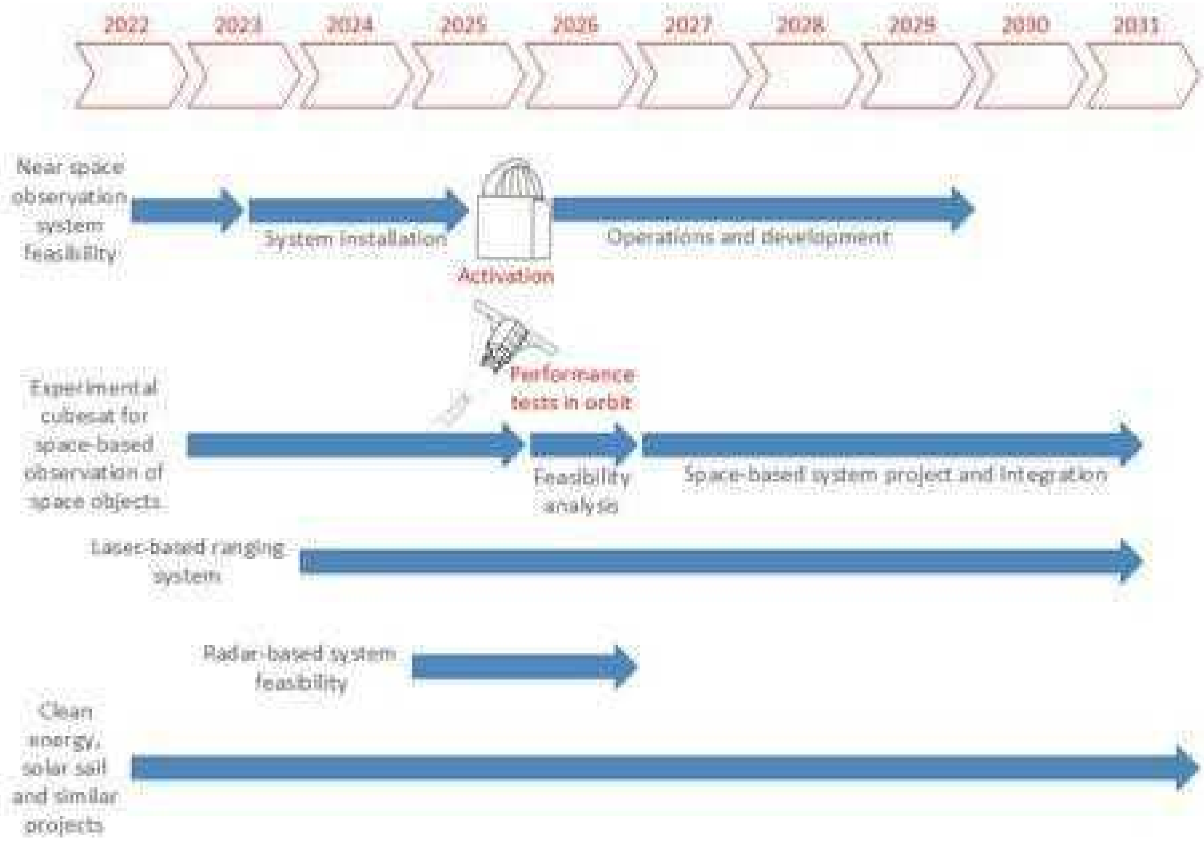



*Figure 7. Gantt Diagram of Observation and Tracking Activities of Space Objects from the Ground*

## 3.7 Development of the Space Industry Ecosystem

### 3.7.1 Introduction

Space has been an area where states continuously provide financial support, and for which sources are allocated due to its strategic nature. In addition, space, for a while, has become a commercial area where private companies have started to conduct activities. Thus, space activities have transformed into a profitable activity, slowly ceasing to be a burden on the budget of states. Exporting space-related goods and services has also become an activity that brings foreign exchange along with providing soft power.

The countries that see the great potential this situation creates, with the aim of being able to utilize this in the best way, have been conducting studies of developing space activities ecosystem to get the maximum gain.

The term ecosystem has a definition that includes financing conditions, state policies, innovativeness policies, research and development infrastructure, legislation relevant to the subject matter, and even cultural and social norms with regards to activities conducted within a specific economical area.

For our country that has important goals in the critical field of space, developing space industry ecosystem is one of the important targets.

### 3.7.2 Aim

The purpose of the program is, by strengthening the space industry ecosystem;

- Establishing a sustainable, innovative, enterprising, dynamic, efficient, and competitive space industry ecosystem, in a way its self-sufficiency level will increase in the course of time.
- Turning the field of space into an area of activity that brings technological and financial return, by virtue of space industry ecosystem to be established.

### 3.7.3 Strategy and Principles

With the aim to establish the space industry ecosystem as fast and effective as possible, the following strategies and principles shall be considered:

- Following an integrative strategy that is also parallel to plans and strategies such as National Science, Technology and Innovation Strategies, Türkiye Entrepreneurship Strategy and Plan of Action, SME Strategy and Plan of Action,

- Being in maximum coordination with all relevant organizations and institutions,
- Keeping in mind the issues of state policies, legislation, financing, entrepreneurship, innovation, human resource, physical infrastructure, and sustainability,
- Creating the ecosystem conditions in a way that the elements at all levels within the ecosystem will become most efficient and dynamic, in order for the space industry to become competitive in the international arena,
- Forming the structure that will clarify the roles between universities, research institutions and institutes, private sector and users and that will create the value chain,
- Increasing the integration of the shareholders by establishing a Space Technology Development Region,
- Ensuring a work share that is in compliance with the defined roles during the funding of the research projects and considering the commercialization element in particular,
- Arranging the intellectual rights that will emerge from the projects in compliance with commercialization and protecting background intellectual rights.

### 3.7.4 Projects and Activities

In order to establish the desired space industry ecosystem in the fastest and most efficient way, the activities listed below will be conducted:

- The data gathered within the scope of National Space Program studies will be evaluated with the perspective of establishing a space industry ecosystem and procurement of additional information that might be needed from the essential institutions and organizations will be ensured.
- Entire legislation on the subject will be analyzed and the positions of the shareholders relevant to the subject will be identified.
- Studies of creating necessary legislation, policies, and strategies will be conducted with maximum cooperation with the shareholders.
- The data about the space ecosystem will be periodically monitored and shared.
- A company that will gather public capabilities in the field of satellites under a single roof will be established.

## 3.8 Establishment of Space Technology Development Region

### 3.8.1 Introduction

Although the world's first technology development region was established in the USA in 1951, the concept of a technology development region (TDR) gained popularity in the 1970s. Although there have been studies in this field in our country beforehand, regulation was constituted in 2001 and primary studies have gained momentum after this date. After the increase in studies in this field, gathering experience and observing the benefits of technology development regions, the number of TDRs increased rapidly.

By the end of August 2021, 89 technology development regions have been declared and 73 of them are in operation. The number of companies in these technology development regions was 6,967 and 72,399 people were employed.

With the establishment of a specialized technology development region in the field of space, in addition to the general benefits provided by technology development regions, it will be ensured that companies creating high added value working in this field come together, a very valuable core will be created for the space ecosystem of our country, and it will be ensured that R&D studies are carried out in a sustainable way with a high synergy.

### 3.8.2 Aim

The aim of the program is, through establishing a space technology development region;

- Creating synergy by gathering companies working in the relevant field,
- Increasing R&D ability of companies and enhancing innovation
- Contributing to the development of the space industry ecosystem.

### 3.8.3 Strategy and Principles

To get the most out of the Space Technology Development Region, the following strategies and principles will be considered:

- Ensuring that especially SMEs that have capabilities that can be utilized in the field of space are included in the Space Technologies Development Region with appropriate incentive mechanisms and promotion,
- Developing methods to cooperate with universities conducting studies on the subject,
- Ensuring maximum coordination with space ecosystem development activities,

- Encouraging international companies to take part in the technology development region as well.

#### 3.8.4 Projects and Activities

In order for the technology development region to be established in the most appropriate place and to be encompassing all relevant companies;

- By widely disseminating the establishment of the technology development region, the participation of all companies that can take part shall be ensured.
- By book-building, technology development region infrastructure will be planned by considering potential future expansion requirements.
- The process will be accelerated by cooperating with and transferring knowledge to the technology development regions with similar capabilities.
- The infrastructure will be designed specifically in a way that can accommodate a large number of small technology companies.
- Infrastructure planning shall be performed for exploiting tests and services related to the space industry from within the region to the extent possible.
- Infrastructure to host international and national meetings and training events will be established.

### 3.9 Space Awareness and Human Resource Development

#### 3.9.1 Introduction

Space is a field of technology that requires high competencies. Competent human resource is one of the most important components of this field. It is not possible to obtain human resources quickly unlike other components.

It is not enough for people who will work in the field of space technologies to receive solely the appropriate academic education. They need to be supported through the necessary guidance and internships during their academic education. In their professional lives, they need to gain experience by taking part in related projects. In addition, it is essential to carry out support programs to bring the human power raised in the relevant application areas to the field of space.

Mistakes made in space projects are often irreversible and often cost a lot. Therefore, it is imperative that the human resources to work in these projects are properly trained.

It is very important to develop public space awareness both for directing talented young people to the space field with the aim of raising the human resource needed and for ensuring the full support of the society towards these activities. In addition, it is necessary to ensure the awareness of the society in that space studies are not only for scientific purposes, for demonstration of technology or for awakening national pride, but also for making significant direct and indirect contributions to the development of our country as a strategic field. In the field of space, which is already an inherently interesting subject, the necessary public awareness can be easily achieved by increasing the importance given to science and society studies. The benefit obtained in the field of space will also have reflection on other fields of science and technology.

### 3.9.2 Aim

The aim of the program is to supply in the best possible way the human resource that will be needed for our country to achieve its goals in space technologies and to carry out studies to maximize public support towards space studies.

### 3.9.3 Strategy and Principles

In order to achieve the aim in the most effective way, the following strategies and principles will be considered:

- Popularization of the space subject by doing/having done/supporting science-society studies,
- Preventing brain drain and returning the qualified human power settled abroad to our country,
- Providing resources and scholarships for the initialization of target-driven academic projects and theses with the purpose of building human resource,
- Developing cooperation programs with academic and semi-academic institutions on the subject of raising human resource,
- Planning of internships and exchange programs domestically and abroad

### 3.9.4 Projects and Activities

The following activities are designed for the development of space awareness and human resources:

1. To determine the human resource and areas of expertise needed in the field of space, creation of a human resource inventory by conducting surveys and similar studies among industrial and research institutions working in this field,

2. Within the scope of the National Space Program, determining the human resource needed and creating a roadmap to build this resource,
3. Acting in coordination with universities and Higher Education Council (YÖK) in order to establish undergraduate, graduate, or doctoral programs in areas where there are deficiencies,
4. Launching conventional events, supporting existing events, and hosting similar international events for raising awareness about space,
5. Planning and realizing outreach activities, industry-academia cooperation programs, academic scholarships, project support, and similar activities in accordance with the National Space Program,
6. Organizing short courses, workshops, and summer schools in special areas needed by the industry,
7. Undertaking initiatives before international institutions for the realization of some of the international courses, workshops, and summer schools in Türkiye.

### 3.10 Turkish Astronaut and Science Mission Program

#### 3.10.1 Introduction

Persons who are trained and launched into space to manage the vehicle or perform other tasks in a spacecraft are called astronauts in the United States, cosmonauts in Russia, and taikonauts in China. The word astronaut has been used for many years in our country for the term, which does not yet have an accepted Turkish equivalent.

Although there is more than one definition of going into space, the most commonly used definition is to reach above an altitude of 100 km, also known as the Karman line. To date, about 600 people from 38 countries have crossed the Karman line. However, a Turkish citizen has not yet reached space.

While the Cold War was going on between the USA and the Soviet Union, the space race began with the launch of Sputnik 1 which is the first satellite of the USSR. Sending humans first into space and then to the Moon had been an important component of this race, and this part of the race resulted in USA landing on the Moon in 1969. In these years, although the primary purpose of human activities in space is to obtain political prestige, scientific knowledge and, in particular, technology to be obtained have been important incentive factors.

The race for human spaceflight has continued with space stations placed in orbit where people can stay for long durations. This race later turned into a cooperation and the International Space Station (ISS) project was realized with the collaboration of NASA (USA), ROSCOSMOS (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada). Various tests and scientific experiments can be carried out on the ISS. By the end of 2020, 242 astronauts, cosmonauts, and passengers from 19 different countries had been on board the ISS.

On the other hand, our country is in an effort to accelerate its progress in space technologies. With the establishment of TUA and the announcement of the National Space Program, space activities in Türkiye are expected to accelerate. In this context, a Turkish person's traveling to space and also performing scientific experiments as a complementary activity are planned.

### 3.10.2 Aim

The following are the aims of the Turkish astronaut and science mission:

- By ensuring that a Turkish citizen has access to space through international cooperation and takes part in scientific activities to be carried out in space;
    - Providing opportunities to Turkish scientists on the subject of research that can be carried out in space,
    - Increasing Türkiye's visibility in the field of space,
    - Encouraging young generations to work in the field of space,
    - Increasing interest towards science and technology,
    - Enabling the accumulation of knowledge on space biology and closed ecosystems in space

### 3.10.3 Strategy and Principles

In order to reach the goal in the most effective way, the following strategies and principles will be considered:

- Negotiating the topic of sending Turkish astronauts to space within the framework of international cooperation programs,
- Collecting proposals from universities and research institutions for experiments to be conducted in space,
- Planning outreach activities of Turkish astronauts in advance,
- Conducting supportive experiments in the field of space biology.

### 3.10.4 Projects and Activities

#### 3.10.4.1 Turkish Person in Space

International cooperation negotiations will be carried out under the coordination of TUA in order to enable Turkish scientists to conduct experiments in space. The program will be implemented in an integrated way with space experiments and outreach activities. Proposals from universities, research institutions, and researchers will be collected and evaluated for experiments that can be carried out in space. The person who will go to space is expected not only to fulfill the mission but also to keep the interest in science and technology alive among our young people and Turkish society with activities such as conferences, interviews, speeches, etc. to be held after the mission.

#### 3.10.4.2 Space Biology Experiments

Capability development on the subject of creating closed and sustainable ecosystems in space is expected and it is aimed that this capability is also utilized in Moon Research Program in the future. International cooperation opportunities will be evaluated to be able to conduct experiments in this field, which requires engineers and biological experts working together.

#### 3.10.4.3 Gantt Diagram

The schedule of the proposed activities and projects is shown in Figure 8.

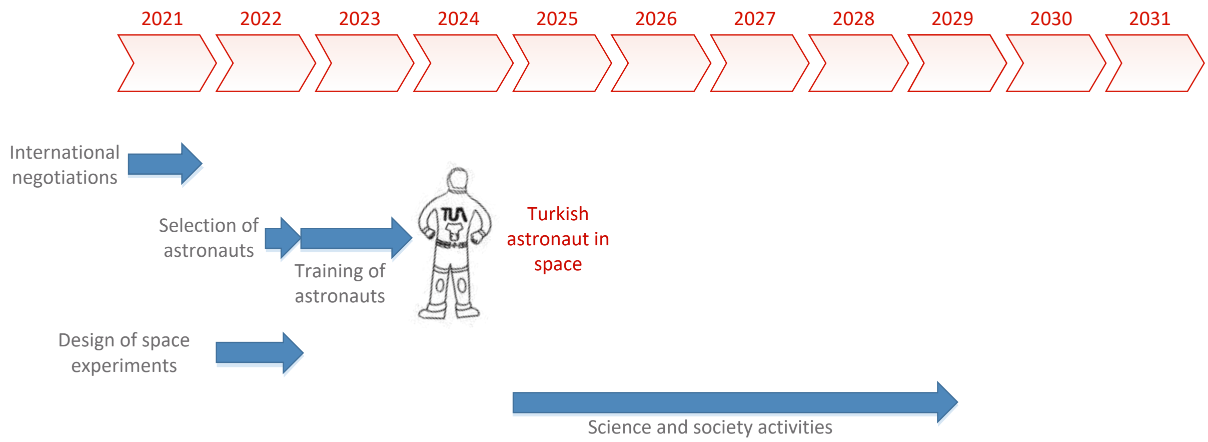
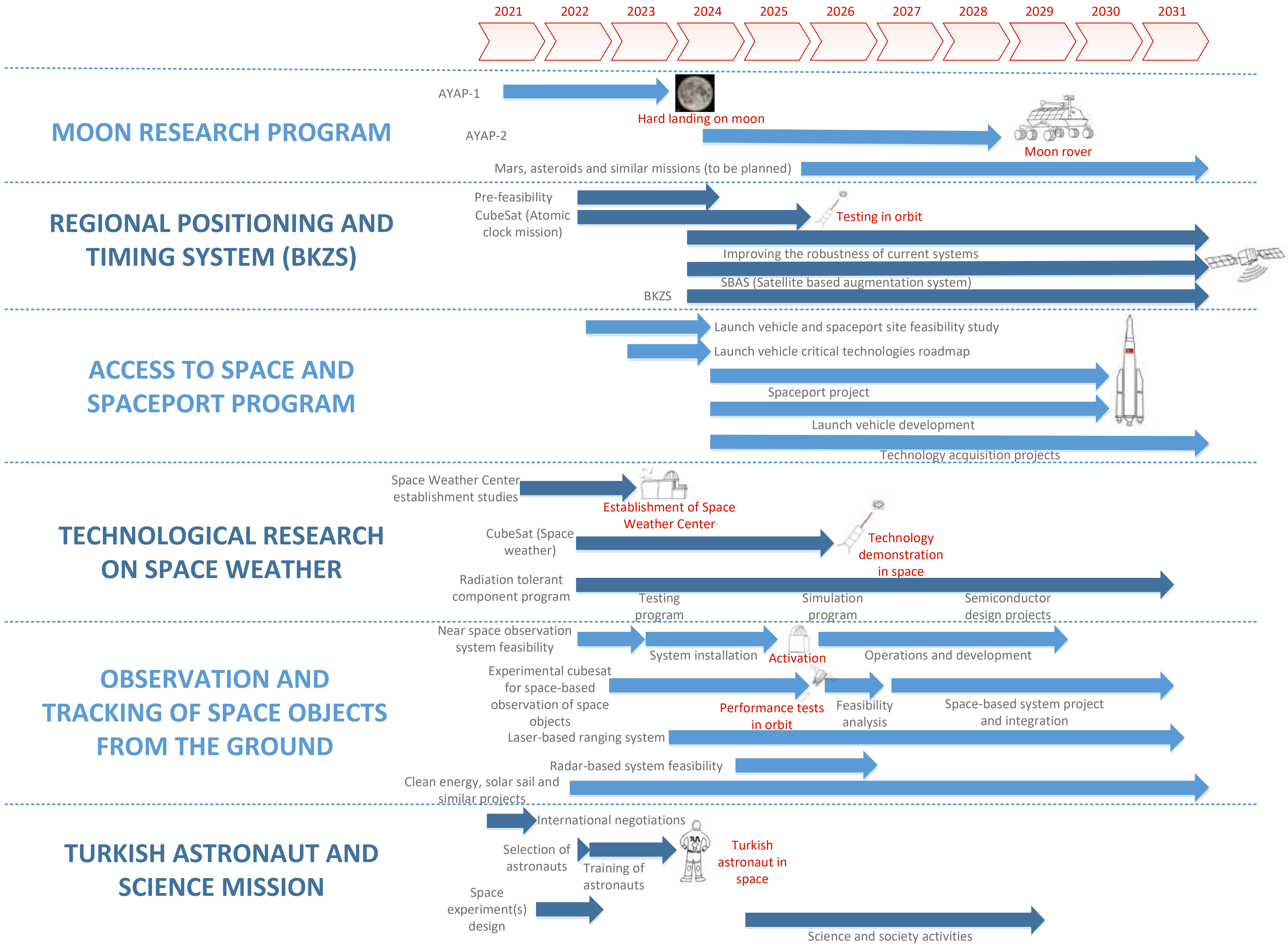



*Figure 8.Turkish Astronaut and Science Mission Gantt Diagram.*



2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
MOON RESEARCH PROGRAM
AYAP-1
Hard landing on moon
AYAP-2
Moon rover
Mars, asteroids and similar missions (to be planned)
REGIONAL POSITIONING AND TIMING SYSTEM (BKZS)
Pre-feasibility
CubeSat (Atomic clock mission)
Testing in orbit
Improving the robustness of current systems
SBAS (Satellite based augmentation system)
BKZS
ACCESS TO SPACE AND SPACEPORT PROGRAM
Launch vehicle and spaceport site feasibility study
Launch vehicle critical technologies roadmap
Spaceport project
Launch vehicle development
Technology acquisition projects
TECHNOLOGICAL RESEARCH ON SPACE WEATHER
Space Weather Center establishment studies
Establishment of Space Weather Center
CubeSat (Space weather)
Technology demonstration in space
Radiation tolerant component program
Testing program
Simulation program
Semiconductor design projects
OBSERVATION AND TRACKING OF SPACE OBJECTS FROM THE GROUND
Near space observation system feasibility
System installation
Activation
Operations and development
Experimental cubesat for space-based observation of space objects
Performance tests in orbit
Feasibility analysis
Space-based system project and integration
Laser-based ranging system
Radar-based system feasibility
Clean energy, solar sail and similar projects
TURKISH ASTRONAUT AND SCIENCE MISSION
International negotiations
Selection of astronauts
Training of astronauts
Turkish astronaut in space
Space experiment(s) design
Science and society activities

Turkish
Space Agency

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