

Moon Research Program of Türkiye

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Abstract—In this article, the Moon Research Program of Türkiye has been reviewed. Turkish Space Agency prepared the National Space Program of Türkiye and the National Space Program was published in 2022. NSP includes ten main goals to determine the strategy of Türkiye in the field of space in ten years. Moon Research Program is one of them. While preparing National Space Program, to see the current situation in Türkiye and the world and to gather reviews from space sector players in Türkiye workshops, were done with these participants. Developing deep space technologies, planet exploration programs and Moon missions were some of the prominent topics in these workshops. Additionally, it was seen that there was an increasing trend for Moon missions in the space sector in the world. Therefore, to make Türkiye one of the competent participants in the space race and increase the capabilities and human resources in the space area, the Moon Research Program Project (AYAP-1) was initiated.

Keywords—Türkiye, national space program, moon mission, space technologies, space strategy.

I. INTRODUCTION

In Article 447 of the 11th Development Plan, published by the Presidency of the Republic of Türkiye Strategy and Budget Department and covering the years 2019-2023, has a target, which is “Our country's position in the global competition in the field of aviation and space will be strengthened.” [1]. In the context of the targets, 447.1. numbered in the article contains a target, which is “National Space Program will be prepared and put into practice.” [1].

In the “Presidential Decree Concerning Turkish Space Agency” dated 13.12.2018 and numbered 23, in subparagraph (a) of the 1st paragraph of Article 4, which includes the duties of the Turkish Space Agency (Türkiye Uzay Ajansı-TUA), “To prepare the National Space Program in line with the policies determined by the President and make arrangements for its implementation.” statement is included [2].

In this context, one of the 10 goals within the scope of the National Space Program (Milli Uzay Programı-MUP), which was introduced in 2021 and published in 2022, through preparatory work carried out by the Turkish Space Agency, is the Moon Research Program [3]- [5]. Within the scope of the goal, the aims and steps of the Moon Research Program were established, and studies were started following the introduced of the National Space Program.

Moon programs have been at the centre of the space race between the United States and the Soviet Union since the 1950s [6]. Since the USA made the first manned flight to and landing on the Moon in 1969, missions with 24 astronauts on the Moon have been carried out by the USA, and unmanned various missions have been carried out by many different countries [7].

Long-standing research on the Moon remained in the background for a while due to the high costs after the Cold War period [8]. Nowadays, the Moon is back in the foreground due to reasons such as providing launch efficiency to Mars and other celestial bodies due to low gravity, as well as the production of potable water with its frozen water and other materials, rocket fuel production and economic returns [9]. In recent years, many countries have started to carry out moon programs, and efforts to develop special launch vehicles, transfer vehicles and space stations specific to these missions have been accelerated [10]. Especially the USA, Russia, and China, which are developed countries in the field of space, have large investments in these missions [11]. In addition to base-building projects, it is also planned to perform manned missions on the Moon again [10].

In the workshops held with the participation of the sector representatives operating in the field of space in Türkiye within the scope of the preparation of the National Space Program, suggestions were made for the Moon Missions under the title of deep space and exploration missions, and determinations were made to carry out studies in this field in Türkiye as well [3].

II. THE ANALYSIS OF NATIONAL SPACE PROGRAM STRATEGY DEVELOPMENT WORKSHOPS

Within the scope of the National Space Program studies, a series of workshops were held with the participation of the representatives of the space industry in Türkiye, between 28 September and 8 October 2020 [12]. Main topics that discussed in these workshops were that to analyse the current capabilities of Türkiye in space studies, to identify the areas of development, and to get the opinions of the stakeholders in the space sector for these purposes [3], [12]. Developing programs and technologies for deep space, planetary exploration programs, Moon missions and developing spacecraft were among the prominent suggestions at these workshops [12]. Actually this topic was the eight most

repeated topic by participants in these workshops under the main topic of space segment and ground segment [12].

A. Mention frequency analysis of National Space Program Strategy Development Workshops Analysis Report

As a result of the current situation analysis made in the workshop, Turkey's application areas in the field of "space and ground segment" were determined [12]. While determining these fields, how often the concepts of these fields were expressed was determined by a mention frequency analysis. The mention frequency analysis made is given in the table.

TABLE I. MENTION FREQUENCY OF APPLICATION FIELDS OF SPACE

Application Fields Mention Frequency	Mention Frequency
Earth Observation Satellite/ Development of Satellite Constellation	24
Scientific/Experimental Satellite Program	18
Data Evaluation, Processing Infrastructure and Capabilities	15
Subsystems and Components of Satellite	12
BKZS (Regional Navigation and Timing System)	11
Development of Communications Satellite	11
Commercial Space Program	10
Platform for Deep space and Exploration Program	9

Space Object Tracking System	9
Development of Ground Station and Subsystems	8

^a. Space and Earth Segment Application Fields National Space Program Strategy Development Workshops Analysis Report

When Table I “Mention Frequency Of Application Fields Of Space” is examined, it can be seen that the platform for deep space and exploration program is in the eighth place among the application areas related to the ground and space segment as it is stated before [12].

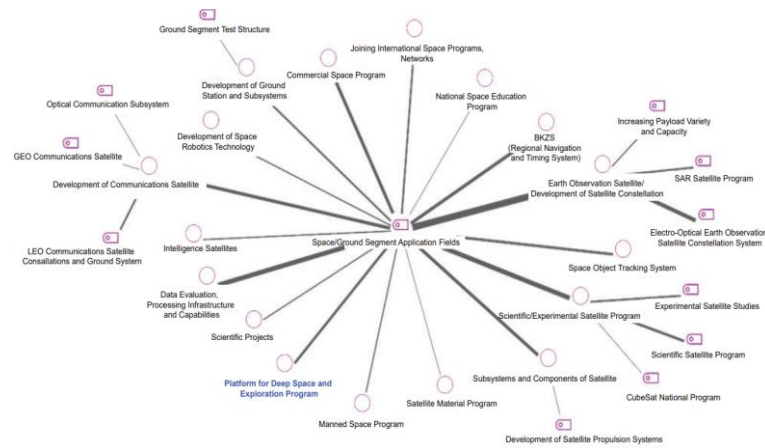


Fig.1. Space and earth segment application fields [12]

As a result of the workshop report, the concept of platform for deep space and exploration program includes suggestions such as the development of technologies for deep space, the preparation of projects in the field, planetary exploration programs, lunar missions and spacecraft development [3], [12]. At this point, the platform for deep space and exploration program being in the top 10 as a result of frequency analysis has formed the infrastructure of the studies in this field. "Moon Research Program" is among these studies.

III. MOON RESEARCH PROGRAM

Within the scope of the studies after National Space Program Strategy Development Workshops Analysis, A lunar mission target was set within the scope of the concept of the platform for deep space and exploration program. The Moon Mission in the National Space Program was named the Moon Research Program (Ay Araştırma Programı - AYAP) [3]. The context of the AYAP was defined as a hard landing to make first contact with the moon's surface in the first phase (AYAP-1), and in the second phase, reaching the moon's surface with a soft landing (AYAP-2) [3]. In the first phase, it is planned to achieve a hard landing [13] by reaching the

Moon, including the firing of our own national and original hybrid rocket [14] after launching the spacecraft in near-earth orbit with international cooperation [3]. In the second phase, it is planned a soft landing on the Moon by launching the moon vehicle in a national launch vehicle into near-earth orbit with national rockets [3], [15].

Within the scope of the project, the first national spacecraft for deep space will be developed in our country. In this context, the new generation hybrid propellant rocket engine (Hybrid Propulsion System - HIS) to be used to transport our spacecraft to the Moon is being developed with national resources .

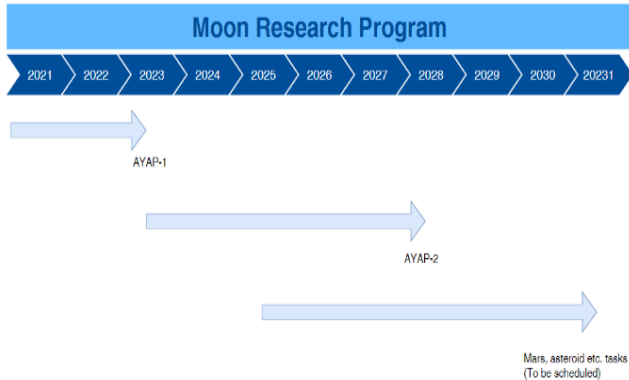


Fig.2. MUP, gantt diagram of moon research program [3]

A. Hard Landing on the Moon

Since the moon is the closest celestial body to the Earth, lunar programs, which are frequently preferred to explore deep space research technologies and scientific equipment, were preferred to improve their applications in terms of deep space in Türkiye [12]. Since the Apollo missions, numerous lunar landing and lunar exploration programs have been successfully carried out by some countries [16]. As it is known, landing on the moon and making separations brings with it a very complex series of technological developments and complex processes. At this point, the lunar mission cannot be considered a single step in the development of these complex requirements. Considering the previous successful programs, two stages were determined for this task. The first of these is hard landing on the moon.

A hard landing on the moon is launching a rocket that must hit the moon by developing the necessary technology and systems. With the concept of impact, it is mentioned here that the spacecraft crashes without reducing or reducing a very small amount of its speed. This mission is the first phase of the Moon Research Program called AYAP-1 [3].

B. Soft Landing on the Moon

The second phase of the two-stage lunar mission is to land safely on the lunar surface [3]. It is part of this mission to land a spacecraft with a rover on the lunar surface as a result of this soft landing and then receive data from that rover [3], [17]. Making a safe landing on the lunar surface comes with some complex requirements. Requirements such as slowing down the landing speed required for soft landing of the spacecraft and the rover inside on the lunar surface, receiving and transmitting data are the planned targets to carry Türkiye's deep space development to a very advanced point

in this mission [17]. This mission is the second phase of the Moon Research Program called AYAP-2 [3].

IV. CONCLUSION

In conclusion, through the AYAP-1 project, it is aimed that Türkiye will successfully carry out the first Moon mission and be one of the few countries that can carry out scientific activities on the Moon. At the same time, it is aimed to pave the way for the commercialization of these systems by gaining space heritage for the subsystems that Turkish engineers are developing domestically and nationally. With this Project, Türkiye will gain experience in launch technologies and space systems operating in deep space, from high radiation-resistant equipment technology to communication. It will be ensured that the infrastructure is formed for the studies in many fields from autonomy to artificial intelligence and the trained human resources are increased.

By realizing this project Türkiye will be one of the few countries on Earth that can develop a spacecraft that reach the Moon and carry out scientific activities on the Moon.

By using Hybrid Propulsion System in this project, Türkiye will have the first national space propulsion system that will be used for deep space missions and that can compete with its competitors in the international arena.

For this project, Türkiye will develop and use national equipment and subsystems and gain them space heritage, and will gain experience in operating space systems in deep space missions.

By achieving this project, increasing awareness on space technologies and sciences in Türkiye is aimed.

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