

REVIEW OF BULGARIAN SPACE-RELATED ACTIVITIES WITHIN THE GEO INITIATIVE AND THE EU COPERNICUS PROGRAM

L. PASHOVA¹ and L. FILCHEV²

¹*National Institute of Geophysics, Geodesy, and Geography - Bulgarian Academy
of Sciences, Sofia, Bulgaria,
E-mail: lpashova.nigg@geophys.bas.bg*

²*Space Research and Technology Institute - Bulgarian Academy of Sciences,
Sofia, Bulgaria,
E-mail: lachezarhf@space.bas.bg*

Abstract: The free and open data policy of the Group on Earth Observation (GEO) and the EU Copernicus program helps many Bulgarian scientists, start-ups, and SMEs to choose Earth Observation (EO) data as a core for their research projects, development of applied products and services. This review summarizes the organizational activities undertaken at different levels to coordinate the efforts of stakeholders for technological development and innovation in the field of space in Bulgaria, directly or indirectly related to the use of EO over the past three decades from a scientific point of view. Bulgarian participation in GEO and ESA Plan for European Cooperative State (PECS) Agreement is also discussed. A review of normative documents, international agreements, the country's participation in space-related programs, research and applied projects, organizational activities, educational initiatives, and training is carried out. The main challenges facing the scientific community in Bulgaria and its efforts to participate actively in space-related international programs, projects and initiatives are outlined. Finally, opportunities for future cooperation within the global initiatives and programs with special consideration such as GEO, EuroGEO, Galileo, Copernicus, EGNOS, and others are given.

Keywords: GEO, Copernicus, Academia, Industry, National space policy.

1. INTRODUCTION

The fully integrated European Union (EU) space programme opportunities spanning 2021-2027 are expected to enhance European competitiveness and sustainable development. The program brings together all EU activities: Galileo, European Geostationary Navigation Overlay Service (EGNOS), Copernicus, Space Situational Awareness (SSA) programme and GOVSATCOM, in one programme

providing a coherent framework for investment and developing new space-driven services that will benefit EU citizens and businesses (EC, 2016). Some of the initiatives are related to the European priorities in space research and innovation policy to support Green deal, Digital economy and Prosperity, Space R&D, Digitalisation and Innovation addressing the societal challenges, Space solutions for Sustainable Balkan regional perspectives, including the Danube and the Black Sea regions. Several European and national economies' governing policies and economic sectors rely on products and services developed using satellite image data, geolocation information, and satellite communications. Space-based applications and services support environmental protection, transport safety, precision farming, shipping route monitoring, urban and regional planning, and other public sectors. The potential areas of EO data application are tremendous and not yet fully utilized.

The opportunities offered by the EU space program contribute to enhancing European competitiveness and sustainable development. The newly formed EU Space Programme Agency and the new Directorate-General for Defence Industry and Space within EC and European Space Agency (ESA) will govern EU Multiannual Financial Framework 2021-2027 in the following programme period. The topic 'Space' will significantly impact technological innovation in EU countries and their industrial development and progress. In Bulgaria, this transitional preparatory phase was earmarked by a national conference, "Defense and aerospace industry and research" held in Sofia in 10-12 July 2017. This conference was attended by several EC representatives, the Executive Director of the European Defence Agency, Bulgarian ministries, and dozens of scientists and entrepreneurs in information technology, defence, and space research from different European countries. Recently, the initiatives such as 'Space for better future - EU space research and innovation policy to support Green deal, Digital economy and Prosperity', 'New ecosystems for sustainable growth - supporting accelerated economic development and addressing sustainability, green and inclusive growth and 'One Planet' have been announced. These initiatives will have their imprint on the national and international priorities of EU member states. Currently, in Bulgaria, such EU activities are advertised in public space.

The management of Bulgarian participation in space activities is spread amongst different governmental bodies, whilst the Ministry of Economy (ME) coordinates the space policy at the national and European levels¹. The government bodies involved in space activities include several ministries such as ME, Ministry of Education and Science (MES), Ministry of Interior, Ministry of Foreign Affairs, Ministry of Transport, Information Technology and Communications, Ministry of Defence, Ministry of Environment and Water, and other authorities.

This paper presents an overview of Bulgarian space-related activities undertaken under GEO and Copernicus programmes during the last three decades. The review is based on a study of scientific publications, reports, and publicly available information from official sources. Inclusion of the GEO country and signing the Plan for European Cooperative State (PECS) agreement with ESA is shortly described in

¹ Europe's Master Plan for space technology, by ESA and the EU, 2018, 91-94.

Section 2. Highlights of activities carried out by the state, NGOs, scientific and other stakeholders in the period of democratic changes in the country and national legislation, related policy and specially dedicated events are presented chronologically in Section 3. Section 4 presents the scientific community's main challenges in participating actively in international programs, projects, and initiatives in space-related fields. Available opportunities for future cooperation within the global initiatives and programs such as GEO, EuroGEO, Galileo, Copernicus, EGNOS, and other endeavours are given in Section 5. General problems related to effective communication, collaboration, and coordination issues at an institutional level need to be addressed to fortify the partnership among governmental institutions, academia, NGOs and business are identified and discussed in Section 6. Finally, some recommendations are given to consolidate the scientific community and intensify the dialogue with state institutions to develop and adopt a national space program and its implementation plan.

2. MEMBERSHIP OF BULGARIA IN GEO, EUMETSAT AND ESA AND RELATED ACTIVITIES

2.1. ACCEPTANCE OF BULGARIA AS A MEMBER-STATE IN GEO

Following the GEO formal establishment in February 2005 by several governments and the European Commission (EC) during the 3rd Earth Observation Summit in Brussels, the number of participating countries has been steadily increasing over time. The central vision is “to realize a future where decisions and actions, for the benefit of humankind, are informed by coordinated, comprehensive and sustained Earth observation information and services”. The main goal of the intergovernmental partnership is to build the infrastructure Global Earth Observation System of Systems (GEOSS). The EO Groups are based voluntarily and coordinated by governments, intergovernmental, international, and regional organizations to implement and effectively use the EO. They support the interaction between existing and emerging global systems and research programs to improve informed policy-making. The first years after establishment were dedicated to building and strengthening the status while organizing, expanding, and enhancing cooperation based on voluntary contributions from member countries and organizations. A stage has now been reached in which users have access to many datasets containing EO, a significant part of which are freely available.

Within Europe, the interdisciplinary efforts of EO Groups, initiated by GEO member countries, are essential for the EC and EU Member States. Several EC Directorates-General are active GEO members. The Directorate-General for Research and Innovation has a leading role, and the Joint Research Centre provides support services.

After the democratic changes in Bulgaria, individual teams from the scientific and educational community have focused on studying the interest and raising public awareness of the benefits of using Earth Observations (EO) in various socio-

economic spheres of life. At the initiative of a scientific team and following coordination procedures between some ministries, Bulgaria's caretaker government decided on full membership of the GEO and the European Space Agency (ESA) with a Minutes of 11.06.2014 from a meeting of the Council of Ministers. Although the Bulgarian Government decided for full membership of the state into both organizations at the same government meeting, there is no official state act to formalize GEO membership and define it as a state commitment.

Soon after this first important step, Bulgaria became the 92nd Member State of GEO. At the XI Plenary Session of GEO in the period 12-14 November 2014, held in Geneva, this act was formally approved (see Pashova & Yovev 2015). Under the motto: 'Under the pulse of the planet', over 275 representatives from more than 45 countries participated in this session. The Bulgarian delegates presented a Statement² stating the country intentions to participate in implementing the 10-year GEO plan. It is also stated that the necessary steps will be taken to unite the efforts of national institutions and organizations whose primary responsibilities are related to the nine areas of socio-economic benefits of GEO, which are: disasters, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity. After Bulgarian inclusion in this intergovernmental partnership, several governmental institutions, academia and NGOs have included in GEO initiatives, contributed to the construction of the GEO Knowledge Center, the GEOSS and the development of research infrastructure networks³. However, due to the change of several governments and administrative changes at the state level, the Bulgarian ME took over the GEO activities coordinating role at the national level in 2016.

After the official acceptance of Bulgaria as a member of GEO in 2014, the state commitments with this national membership still do not give visible and tangible results. National participation in international initiatives and programs related to space activities is less active than other European countries. Despite some achievements in certain areas of application of space technologies, data, products and services, Bulgaria lags significantly behind other EU countries in the face of growing competition in the space sector, development of the digital economy, smart industrial specialization, and digital transformation. Besides, in recent years, the scientific community has repeatedly raised the issue of state policy in space activities. Other interested communities also demand that these activities be publicly discussed for inclusion as priorities in updating the Bulgarian strategy for smart specialization for the programming period 2021-2027 and in the national program "Science and Education for Smart Growth".

2.2. BULGARIAN MEMBERSHIP IN EUMETSAT

The accession agreement between the Government of the Republic of Bulgaria and the European Organization for Exploitation of Meteorological Satellites

² https://www.earthobservations.org/documents/geo_xi/geoxi_bulgaria_statement.pdf

³ National Roadmap of Scientific Infrastructure. Ministry of Education and Sciences, 2017, https://web.mon.bg/upload/4013/Roadmap_2017_ENG.pdf

(EUMETSAT) was signed during the 79th EUMETSAT Council meeting in Darmstadt in November 2013. The Agreement is ratified by a law⁴ adopted by the 42nd National Assembly on 19 March 2014⁵. Our planet's monitoring needs a global satellite system to collect high-resolution information in time and space to ensure reliable coverage. Global and regional Earth-system monitoring can be achieved only through a full international commitment. With Bulgaria joining EUMETSAT as a Member State on 30 April 2014, EUMETSAT has achieved its goal to attain 30 Member States in the same year⁶. Following Article 16.5 of the EUMETSAT Convention, the Republic of Bulgaria pays a significant contribution to EUMETSAT of EUR 1,664,000 against investments already made in the three years to 2017. The country membership of EUMETSAT entitles it to be involved in the governing board strategic decisions; Bulgarian companies can participate in tenders, and Bulgarian citizens can apply for positions in the organization.

Furthermore, the country can have unrestricted access to all EUMETSAT data and products. The National Institute of Meteorology Hydrology (NIMH) contributes actively to developing the applications of the information provided by EUMETSAT. Bulgaria takes an equal part in the joint effort of Europe to develop adequate meteorological satellite systems to maintain the constant flow of data about the atmosphere, Earth surface, sea, and climate, as well as to develop efficient technologies for their increasing use. However, the current situation regarding the use of data from the EUMETSAT constellation shows no significant uptake of users by governmental, academic, and non-governmental organizations, except by specific teams from NIMH. This circumstance implies that NIMH should organize more active dissemination and training activities to facilitate the users' acceptance of satellite data and products offered free of charge as part of the national membership of EUMETSAT.

2.3. PECS AGREEMENT OF BULGARIA WITH ESA

Decisive reasons for creating ESA in 1975 are to pool human, technical and financial resources for developing large space missions; to ensure an industrial policy to develop a competitive and sustainable European space industry; to coordinate national, international, and European space programs. According to Article 2 of the ESA Convention⁷, the primary purpose is to promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications.

Bulgaria has come a long way over the years, from the first achievements in space research in the 70s of the last century to an ESA-PECS full membership, which became a reality only in 2015. Despite strong Bulgarian traditions in space exploration, for more than 25 years after the political and economic system change

⁴ <https://dv.parliament.bg/DVWeb/showMaterialDV.jsp?idMat=83713>

⁵ State Gazzete, Iss. 30/01.04.2014

⁶ <https://www.eumetsat.int/bulgaria-becomes-eumetsats-30th-member-state>

⁷ https://www.esa.int/About_Us/Corporate_news/Convention-Rules

in the early 1990s, the country was among the few European countries that were not members of the ESA. The Bulgarian Government signed the European Cooperative State (ECS) Agreement on April 8, 2015. The 43rd National Assembly adopted the Law on Ratification of the ECS Agreement between the Government of the Republic of Bulgaria and ESA on November 26, 2015⁸. Bulgaria joins ESA as a cooperating country, which opens exceptional opportunities for developing the Bulgarian economy, science, and business, financing the development of space technologies, and transferring high technologies and knowledge. The Government signed the Plan for European Cooperative State (PECS) Charter on February 4, 2016. The ME coordinates national policy related to space activities in Bulgaria and declares that it works to increase Bulgarian industrial innovations and competitiveness and raise awareness of space programs and the data they provide through their platforms.

The overall objective of PECS is to connect Bulgaria with the ESA programs and activities and to prepare it in the most effective way for future accession to the ESA Convention. By signing the ECS agreement, supplemented within one year by the PECS Charter for a five-year implementation plan, jointly agreed between ESA and Bulgaria, our country has the right to participate in ESA procurement and activities. The Government has carried out some activities, mainly in research and development, to develop its space industry experience. Following ESA rules, Bulgaria pays the annual instalment due in three consecutive payments within five years, in proportion: 40% by January 31; 40% by June 30; 20% by October 31 every year during the transitional period. According to the public information provided by the ME, PECS projects approved within the six PECS calls are in Space science, Research and applications, Telecommunications, Microgravity studies, Ground engineering and the utilization sector. Table 1 shows PECS tenders distribution, submitted, and successfully contracted projects during Bulgaria's 5-year PECS program period until 2021.

Following this chain of events, after 2015, several international and national meetings and seminars were organized. During the Bulgarian presidency of the EU in the first half of 2018, some events dedicated to the space program Copernicus were organized with the EC and ESA assistance, the Bulgarian Government, the scientific community, and interested stakeholders.

Table 1: ESA tenders issued under the PECS Program for Bulgaria (2015-2020) (source: ME, Bulgaria).

Number of Call		I	II	III
Tender announced	<i>Open</i>	11/5/2015	11/10/2016	12/2/2018
	<i>Closed</i>	6/7/2015	12/12/2016	13/04/2018
Project number	<i>Submitted</i>	19	25	8
	<i>Contracted</i>	5	9	3

⁸ State Gazzete, Iss. 95/08.12.2015

Table 1: continued...

Number of Call		IV	V	VI
Tender announced	<i>Open</i>	10/12/2018	11/10/2019	15/05/2020
	<i>Closed</i>	27/03/2019	2/12/2019	30/06/2020
Project number	<i>Submitted</i>	18	17	under evaluation as of Nov. 2020
	<i>Contracted</i>	5	7	?

A two-day workshop, “Balkans from space” organized by the Bulgarian Presidency on the EU Council and the ESA, was held on 18-19 April 2018. The event was focused on the space-based services for regional strategies in the digital economy, innovative solutions enabled by EO, Space systems in general and Copernicus in the Balkans and the Black Sea regions.

The feasibility study of Bulgaria under the auspices of ME was launched in 2019 under the PECS program for 2015-2021⁹. The overall objective is to provide a feasibility study to assess Bulgaria's development potential in the space sector and its readiness to cooperate with ESA. Review and evaluation of the Bulgarian subjects with potential for entering the space market, development, and testing of a methodological approach for assessment of the industrial and scientific potential, as well as recommendations for the development of a national space program as a condition for Bulgaria's membership in ESA are the expected results of this study.

3. BULGARIAN LEGISLATION RELATED TO SPACE ACTIVITIES

Our country has significantly reduced research and development volume in recent decades and applied production in space research. The contrast is particularly striking compared to the 1980s when Bulgaria was among the few countries to launch astronauts, participate in ambitious space missions to Venus and Mars and successfully implement the latest advances in microelectronics in space. After the democratic changes in 1989 in Bulgaria and the state's lack of commitment in space activities with the national policy, the occurred socio-economic changes affected all areas of the country's social development. Through the promulgation in the State Gazette of laws and other normative documents, the elaboration, consultation, and official adoption required time and coordination among some interested stakeholders. The first attempt to develop a Bulgarian space program was made at the beginning of the 21st century as an initiative of several Bulgarian Academy of Sciences (BAS) research institutes. The draft space program has been developed but has not been approved by the Government then.

⁹ Feasibility Space Study of Bulgaria (FS2B). ESA Contract No. 400012869/19/NL/CRS under the PECS (Plan for European Cooperating States), 2020, https://spaceweeksofia.com/?page_id=648

Nevertheless, over time, several national regulations related to space activities, the obligations of Bulgaria as a member of the EU, and the need to transpose into national legislation several European directives have been adopted (see Fig. 1). Some of these provisions are related to spatial data, EO and relevant information, access to them and their sharing. One of the essential laws is the one passed in 2008 for the e-Government. The main goal of e-Government, through which the Ministry of Transport, Information Technology and Communications (MTITC) coordinates the policy of the Bulgarian Government, is to meet public needs by ensuring the quality and accessibility of administrative services. The e-Government has programs that include reusing open data and data-driven digital governance, assessing the role of information and communication technologies in the public sector, business planning, and developing activities related to the space industry. By developing a National Spatial Data Infrastructure (NSDI), all stakeholders can benefit directly from geospatial information and location intelligence (see Pashova & Bandrova 2017). They can extend the EU INSPIRE Directive use to other thematic sectors and coordinate vital programs and services for space-based applications from the EU and interinstitutional activities at the national and international level. Bulgaria takes part in the Danube strategy¹⁰ and the Sea basin strategy: the Black Sea¹¹, which are dedicated to the future of the EU regional policies. The funded projects involving EO data use through different EU instruments can be previewed at the Maritime Data Hub¹². The list of approved EU projects under the priority areas of the strategies using EO data is listed in Section 4.2.

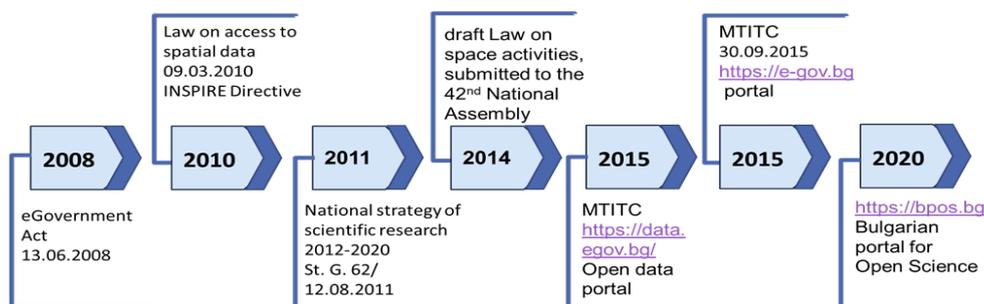


Figure 1: Timeline of some Bulgarian legislation acts and strategies since 2008.

The policy of the Bulgarian e-Government should encourage the development and application of space science and technology in favour of the socio-economic benefit of the country to support the ongoing transformation of traditional production and industrial practices, combined with the latest intelligent technologies, the so-called Fourth Industrial Revolution (or Industry 4.0), to strengthen the cooperation between the state and the industrial IT associations, to increase the competitiveness of the Bulgarian economy internationally. Bulgaria has few national supercomputer

¹⁰ <https://www.danubestrategy.eu>

¹¹ https://ec.europa.eu/oceans-and-fisheries/ocean/sea-basins/black-sea_en

¹² <https://blackseablueconomy.eu/projects/maritime-datahub>

facilities located in BAS¹³ and SofiaTech Park. The latter is also a home of a petascale supercomputer PetaSC and a part of the EuroHPC network¹⁴. On the BAS “Avitohol” are already hosted applications related to geohazards, space geomagnetism, and marine applications using EO data from the Copernicus programme.

Bulgaria has adopted several laws and subsequent provisions on space activities, related areas of public importance and organizational work. After adopting specific national legislation, normative documents are subsequently updated, regulating the rights and obligations of state institutions, agencies and interested stakeholders. Some of these legislative documents directly respond to advancing the national economy, research and development, and education. In 2014, for example, a preliminary text of the Space Activity Act was prepared.

Due to the Government's resignation and early parliamentary elections caused by the instability of the ruling majority in the 42nd National Assembly, this act remained in its archives. Nevertheless, Bulgarian governments have adopted some important legislation, national policies^{15,16}, strategies¹⁷, plans and international agreements over the last two decades. In addition, several laws, by-laws and ordinances regulate participation in the European space program, the development of National Operational and Research Programs and Networks the link between science and business, coordinated by the ME and MES.

Responsibilities for geoscience issues in Bulgaria are distributed among several ministries, government agencies and services that conduct public policy and coordinate activities to develop strategies, plans and roadmaps for implementation in various thematic areas. State bodies' scientific and operational services with monitoring and expert geospatial information, analysis, and assessments are provided mainly by research institutes at BAS and NIMH at MES. Concerning the environment, monitoring activities are carried out by some government agencies and services, including non-governmental organizations and with citizen participation (Volunteered Geographic Information - VGI and Citizen Science - CS).

To respond to the environmental changes and adverse natural events, a national research program "Environmental Protection and Reduction of the Risk of Adverse Events and Natural Disasters" by the Resolution of the Council of Ministers in 2018 and supported by the MES was approved. BAS coordinates the program, and eight other research organizations and universities are partners. The program provides fundamental scientific results to generate new knowledge about the processes and interactions in the atmosphere, hydrosphere, lithosphere, and biosphere at different scales. In addition, characteristics with impacts on various natural disasters, quality of life, health risks and ecosystems are also expected to be assessed.

¹³ <https://www.iict.bas.bg/avitohol>

¹⁴ <https://eurohpc-ju.europa.eu/press-releases/petasc-new-eurohpc-world-class-supercomputer-bulgaria>

¹⁵ <https://dv.parliament.bg>

¹⁶ <https://lex.bg/laws>

¹⁷ <http://www.strategy.bg>

In connection with consultations with European institutions to coordinate the national legislation and space-related policies arising from the Republic of Bulgaria's membership in the EU, Working Group (WG) 35 'Space Policy' was established in 2007 by Decree No. 85 of the Council of Ministers. WG35 has the functions of an advisory body to the ME, with the Minister of Economy approving its members. The experts' list is periodically updated and includes representatives from several ministries, governmental institutions and agencies, academia, universities, industry, NGOs, and stakeholders interested in a space domain. At the beginning of its establishment, WG35 actively assisted the ME administration, discussing all contemporary issues in space at regular meetings. However, working meetings and communication between WG35 and the ME on space policy issues have been limited in the last few years. The ME administration rarely approached it, except on coordinating national framework positions and formal signing of protocols. As a result, WG35 is the only administrative body reflecting public interests from the state administration, academia, and the private and non-governmental sectors with delegated competencies regarding space policy and inter-institutional space action in the country. The authors share the opinion that there is no mechanism for active dialogue between all stakeholders in space activities through which to formulate an active state policy and implement it.

4. BULGARIAN PARTICIPATION IN EU SPACE-RELATED PROGRAMS AND INITIATIVES

4.1. THE EUROPEAN EO PROGRAM COPERNICUS

On November 9th, 2010, the EU Regulation No. 911/2010 on the European Global Monitoring for Environment and Security (GMES) program and its initial operations (from 2011 to 2013) had come into force. With this regulation, GMES is becoming operational. Copernicus is the new name of the EC's EO programme, which is announced on the Competitiveness Council held on December 11 2012¹⁸. In a world facing an increased risk of natural and other disasters, starting from 2014, Copernicus aims to monitor the state of the environment on land, sea, and atmosphere and improve citizens security (Filchev et al. 2018, Filchev et al. 2020). According to recent studies, the program is a driver for economic growth and employment, with the potential to create up to 85,000 new jobs over the period 2015-2030¹⁹.

¹⁸ <https://www.eubusiness.com/topics/research/gmes-copernicus>

¹⁹ https://ec.europa.eu/commission/presscorner/detail/en/IP_12_1345

4.2. EU PROGRAMS AND INTERNATIONAL RESEARCH PROJECTS WITH BULGARIAN PARTICIPATION

Bulgarian participation in international space research projects is based on a bottom-up approach. Bulgarian teams participate in international projects at the initiative of individual scientists, teams from research institutes or universities. The most important EU projects with Bulgarian participation related to GEO and Copernicus are listed chronologically below in Table 2.

Table 2: List of international projects with Bulgarian participation in the field of EO.

Project acronym	Link	Implementation period	EU funding mechanism
EnviroGRIDS	http://www.envirogrids.net	2009-2012	7 th FP
OBSERVE	https://cordis.europa.eu/project/id/265282	2010-2012	7 th FP
Balkan GEO Network	https://cordis.europa.eu/project/id/265176	2010-2013	7 th FP
IGIT	http://igit.geo.info.hu	2011-2015	7 th FP
COSMOS	http://www.ncp-space.net	2008-2012	7 th FP
COSMOS+	http://www.ncp-space.net	2012-2014	7 th FP
Geo-Cradle	http://geocradle.eu/en	2016-2018	Horizon 2020
e-Shape	https://e-shape.eu	2019-2023	Horizon 2020
COSMOS2020plus	http://www.ncp-space.net	2019-2021	Horizon 2020
GATE Centre of Excellence	https://www.gate-coe.eu	2019-2025	Horizon 2020
Goldeneye	https://cordis.europa.eu/project/id/86939	2020-2023	Horizon 2020
DISARM	http://disarmfire.eu	2014-2020	INTERREG
FPCUP	https://www.copernicus-user-uptake.eu	2018-2023	Caroline Hershel
ENVeurope	http://www.enveurope.eu	2010-2014	LIFE
ECO-Satellite	http://ecosatellite.topo.auth.gr	2011-2013	ENPI
BALGEOS	http://balgeos.cc.bas.bg	2008-2010	Other EU
MIS-ETC 171	http://cbc171.asde-bg.org/index_en.php	2012-2014	Other EU

COSMOS and COSMOS+ were National Contact Points networks for the Space theme under the EU 7th Framework Programme for Research & Innovation. The primary aims of the COSMOS, COSMOS+, and COSMOS2020plus projects were to build a strong support network among stakeholders in Europe by raising their awareness of FP7 funding opportunities and the Horizon 2020 space program. During the implementation of these projects, the National Contact Points (NCP) in the space field shared good practice and taken part in joined training courses to improve their skills.

Bulgaria had national representatives from the Space Research and Technology Institute - Bulgarian Academy of Sciences (SRTI-BAS) in the COSMOS+ Network, a project funded within the FP7 from May 2012 to November 2014. The COSMOS+ generally aimed to interlink the NCPs for Space to improve and balance NCP's

services overall quality, add central services, and finally raise the average quality level of submitted proposals. One info day tour event on 16.10.2013 was organized in Sofia, Bulgaria during Horizon 2020: Information Day on ‘Space’ priority organized by the MES. COSMOS2020 was the continuation of the COSMOS and COSMOS+ projects under the EU Horizon 2020 Framework Programme for Research & Innovation. COSMOS2020plus was the further extension of COSMOS2020 for the period of June 2019 - July 2020. It was the final extension within the Horizon 2020 Framework Programme with a continuation of the Cooperation of Space NCPs by the Means to Optimize Services under Horizon 2020²⁰.

The SRTI-BAS and CASTRA have joined the FPCUP consortium in 2017 and participated actively in the Agreement's preparatory phase. The FPCUP project officially started in 2018, but the formal start of activities approved in WP 2018 was postponed to the end of 2019 when the final approval of WP2018 was made. Currently, the Bulgarian participation in FPCUP is in three approved by the EC Actions:

1. Copernicus Awareness Raising Programme for Bulgaria - COPE4BG within WP2018²¹,
2. Copernicus Promotion Activities in Bulgaria within WP2019²², and
3. Developing support for monitoring and reporting of GHG emissions and removals from land use, land-use change and forestry (CLIMA)²³.

Some results related to the recent organization of Copernicus seminars are being carried out in the framework of the COPE4BG project, and all the expected results of the individual FPCUP implementation activities can be reviewed following the hyperlinks provided below.

The scientific and educational community in Bulgaria has repeatedly raised the issue of pursuing an active state policy in space activities. These activities can be publicly discussed for their inclusion as priorities in state policy and updated versions of the concept of smart specialization (IP) of Bulgaria for the programming period 2021-2027 and of the national program ‘Science and Education for Smart Growth’. We hope that the Government and the responsible ministries will take the leading role, initiating such a discussion.

4.3. INTERNATIONAL RESEARCH NETWORKS

Within the European Cooperation in Science and Technology (COST²⁴) Bulgarian scientists have participated in the following Actions directly related to EO, i.e. „Antenna Systems & Sensors for Information Society Technologies – ASSIST“ (2007-2011), ES0604 „Atmospheric Water Vapour in the Climate System – WaVaCS“ (2007-2011), ES0702 „Propagation tools and data for integrated Telecommunication, Navigation and Earth Observation systems – EG-CLIMET“

²⁰ <https://cordis.europa.eu/project/id/857691>

²¹ <https://www.copernicus-user-uptake.eu/>

²² <https://tinyurl.com/em5tbpas>

²³ <https://tinyurl.com/yb3b89t9>

²⁴ <https://www.cost.eu>

(2008-2012), IC0802 „Propagation tools and data for integrated Telecommunication, Navigation and Earth Observation systems“ (2008-2012), ES1309 „Innovative optical Tools for proximal sensing of ecophysiological processes – OPTIMIZE“ (2014-2018), TD1403 „Big Data Era in Sky and Earth Observation – Big-Sky-Earth“ (2015-2019), and CA17134 „Optical synergies for spatiotemporal sensing of scalable ecophysiological traits – SENSECO“ (2018-2022).

Researchers from academia and university communities are involved in research networks that conduct research using EO and Remote Sensing (RS) to develop a wide range of valuable products, applications, and services. SRTI-BAS and IO-BAS became members of the European Association of Remote Sensing Laboratories (EARSeL) in 2009, and since 2012 Bulgaria has had a national representative at the EARSeL Council²⁵ (see Filchev et al. 2013). Such network is the South-Central European Regional Informational Network (SCERIN²⁶), a regional network of the coordinated international program Global Observation of Forest and Land-use Dynamics (GOFc-GOLD²⁷). The Formulation Workshop of SCERIN (initially SEERIN) was in the park-hotel 'Moscow', Sofia, Bulgaria on April 17, 2012. Since its launch, researchers from institutes of the BAS have been actively participating in the network meetings. SCERIN is an informal network of scientists and other professionals based on scientific interests in South-Eastern and Central Europe, which strives to ensure continuity and collaboration between the scientists, professionals, and existing RS networks in the region. SCERIN network has strong linkages with the Northern Eurasia Earth Science Partnership Initiative and the North Eurasia Future Initiative under Future Earth auspices. These initiatives are programs to support research on the Earth system internationally.

The European Association of Remote Sensing Companies (EARSC) is a professional industrial body (trade association) with the mission to foster the growth of the Earth-observation (EO) services sector²⁸. In Bulgaria, the TAKT-IKI Ltd. is a member of EARSC.

4.4. SCIENTIFIC FORUMS ORGANIZED IN BULGARIA

In recent decades, several international and national conferences have been organized with professional associations and unions. Most of them include broader scientific topics, while others include narrowly specialized thematic areas in geosciences. In general, the topics discussed in these forums are dedicated to data and information from satellite missions, RS, EO, geoinformation and recent advances in space technology. Some essential scientific forums are presented here.

²⁵ <http://www.earsel.org>

²⁶ <https://www.scerin.eu>

²⁷ <https://gofcgold.umd.edu>

²⁸ <https://earsc.org>

Regular scientific forums which took place during the reviewed period:

- Congress of the Balkan Geophysical Society²⁹, since 1996.
- International Conference on Cartography and GIS (ICC & GIS)³⁰, since 2006.
- International Symposium "Modern technologies, education and professional practice in geodesy and related areas",³¹ organized annually by the Union of Surveyors and Land Surveyors, since 1991.
- Space, Ecology, Safety (SES), organized by SRTI-BAS³², since 2007.
- Inter-agency Interaction in Crisis Management and Disaster Response³³, organized by the Crisis Management and Disaster Response Centre of Excellence (CMDR CoE), since 2013.
- Surveying, Geology and Mining, Ecology and Management (SGEM)³⁴, since 2000.

Important scientific forums which took place during the reviewed period:

- Digital Earth Summit³⁵, 2010.
- FIG working week 2015³⁶, in Sofia, Bulgaria, 17–21 May 2015.
- 3rd Annual Seminar of the Disaster Risk Management Knowledge Centre³⁷, 2018, BAS-JRC.
- European Maritime Day Conference³⁸, in Burgas, 31 May – 1 June 2018.
- International Geography Conference - GEODECADE³⁹, 2020, Bulgarian Geography Society and EUROGEO.
- First International Conference on ENVIRONMENTAL protection and disaster RISKS⁴⁰, 2020.

4.5. NATIONAL SPACE-RELATED SEMINARS

One of the first EO-related workshops held after Bulgaria's accession to the EU was the NIMH Bulgaria - EUMETSAT training workshop "MSG Land Applications: Drought and Fire" in Sofia from 7 to 10 September 2009. It was a significant event for Bulgaria and the Balkan states. EUMETSAT products and monitoring and forecasting activities in the Balkans were presented⁴¹. Two national GMES Operational Capacity Workshops have been organized with EC, ESA, Government,

²⁹ <http://www.bggs.eu/nforums-en.html>

³⁰ <https://cartography-gis.com>

³¹ <http://geodesy-union.org>

³² <http://space.bas.bg/SES/index.html>

³³ <https://www.cmdrcoe.org>

³⁴ <https://www.sgem.org>

³⁵ https://cartography-gis.com/digitalearth/digital_earth.html

³⁶ <https://fig.net/fig2015>

³⁷ <https://drmkc.jrc.ec.europa.eu/partnership/Annual-Seminar/Meeting-2018>

³⁸ https://webgate.ec.europa.eu/maritimeforum/sites/default/files/2018-conference-report_en.pdf

³⁹ <http://geodecade.com>

⁴⁰ http://envirorisk.bas.bg/files/envirorisks_flyer.pdf

⁴¹ <http://info.meteo.bg/conferences/EUMETSAT07092009/Programme.pdf>

international organizations, academia, research organizations, universities, and NGOs. The first seminar on the operational capacity of GMES - a joint initiative of the Bulgarian Government and the EC was held on March 25 and 26, 2010, at the Sheraton Hotel, Sofia. The European EO Program provides data useful in a range of issues, including climate change, citizens security and border surveillance, land, sea, and atmosphere - each will be observed through GMES, helping to make our lives safer. The second seminar for Earth observation - GMES on operational capacity was organized in Sofia on March 17 and 18, 2011 in coordination with the EC. The Bulgarian Government has actively supported these two workshops. NGOs and stakeholders took an active part in several international organizations such as the EC, ESA, and leading research organizations from Bulgaria and abroad.

The next event related to the Copernicus programme's promotion was a keynote lecture made by Mr Udrivolf Pica from Copernicus Support Office. SRTI-BAS invited him as a part of the Copernicus Academy activities for a keynote speaker at the 13th annual international scientific conference "Space, Ecology, Safety" held in Sofia on 2-4 November 2017⁴². On 5 November 2017, at the RATIO event in the Sofia Event Centre, the Bulgarian audience met with scientists from leading European research centres such as CERN, EC, Goldsmiths, and the University of London. In a language accessible to all, the speakers introduced the audience to topics dedicated to elementary particles in the universe, dark matter and dark energy, the Copernican satellites' work and the data usage for various purposes.

The SRTI-BAS and GeoPolymorphic Cloud supported by the ME have jointly organized, as part of their Copernicus Academy and Copernicus Relays activities, the 1st national Copernicus workshop with training⁴³ held in the BAS-Administration and SofiaTech Park on 22-23 November 2018, before starting the Work Programme 2018 of the Framework Partnership Agreement on Copernicus User Uptake (FPCUP) project. Following the official launch of FPCUP's WP2018, the 2nd Copernicus National Seminar was organized by SRTI-BAS and Cluster Aerospace Technologies, Research and Applications (CASTRA), represented by GeoPolymorphic Cloud⁴⁴. Both events intended to resume the promotional activities on a national level, after the Copernicus information-day organized by the EC in Sofia on 17 April 2018, regarding Copernicus and promote the use of Copernicus data and products among national governmental, scientific, business, and NGOs. The events were well-attended and adequately matched the user community, which proved successful as a concept and implementation. Both workshops managed to gather a broad audience sustained, diversified, and increased in the following editions. The feedback from the attendees and trainees is predominantly positive, which justifies the efforts to re-establish the national Copernicus platform⁴⁵ to exchange results and ideas and create opportunities to spur a debate on the use of Copernicus data and products across various domains.

⁴² http://space.bas.bg/bg/news//files/events/2017_SES_Programme.pdf

⁴³ <https://cope4bg2018.copernicus.bg>

⁴⁴ <https://en.cope4bg2020.copernicus.bg>

⁴⁵ <https://copernicus.bg>

National Forum for Modern Space Research was organized for the first time by the Cosmos branch of the Union of Physicists in Bulgaria with the financial support of the Faculty of Physics at Sofia University “St. Kliment Ohridski”⁴⁶. Partners of the event have been Eureka Foundation, National Research Fund at the MES, Research Fund of Sofia University, and SofiaTech Park. The event was held on October 21 and 22, 2020 in SofiaTech Park, John Atanassov Innovation Forum. During the forum, participants learned about the state of research conducted by established Bulgarian scientists in three scientific sessions: 'Fundamental Space Research', 'Aerospace Technology', and 'Applied Space Research'. Draft versions of a National Strategy and Program for the Development of the Space Industry and Technologies and a National Scientific Program for Space Research have been discussed with representatives of the scientific community, business, industry, and public administration.

5. EO EDUCATION AND TRAINING IN BULGARIA

5.1. TRAINING AND EDUCATIONAL EVENTS

The 7th ESA Training Course on Radar Remote Sensing - Sofia 2016 has been organized by ESA and Faculty of Geodesy, University of Architecture, Civil Engineering and Geodesy (UACEG) and the Ministry of Economy⁴⁷. The course has addressed to participants from universities, scientific communities, institutions, and organizations using geoinformation. It was dedicated to researchers, students, PhD students and young professionals from Bulgaria, Slovenia, Latvia, Lithuania, and Slovakia (PECS countries).

5.2. BULGARIAN MEMBERS IN THE COPERNICUS ACADEMY

The SRTI-BAS is a Copernicus Academy member since 2016⁴⁸. As a part of its activities, it promotes Copernicus among the scientific community and creates public awareness through its annual conferences, journal, and lectures. The SRTI-BAS organizes an annual international conference “Space, Ecology, Safety - SES” (since 2005)⁴⁹ and publishes a book of proceedings in print and digital. The Journal “Aerospace Research in Bulgaria” has a longer tradition with a standing topic of EO (est. 1978, Web of Science indexed since 2005⁵⁰). The institute publishes books on fundamental and applied space science and technology topics and EO⁵¹. Some of these books are considered as seminal for Bulgaria in the EO domain. Teams from the institute have published curriculum materials for schools within EEOBSS (ESA-

⁴⁶ <https://bulgarianspace.online>

⁴⁷ <https://rrs16.esa.uacg.bg>

⁴⁸ <https://tinyurl.com/4ayyhse4>

⁴⁹ <http://space.bas.bg/SES/index.html>

⁵⁰ <http://journal.space.bas.bg>

⁵¹ http://space.bas.bg/bg/publishing_activity/books_and_journals.html

PECS⁵²) and E#COS_LAB (OP “Education with Science”, BAS-MES⁵³) projects and atlases (“Space School” initiative supported by Bulgarian Astronautical Society⁵⁴). Some of the EO dissemination activities include lectures for pupils and teachers in Bulgaria within the “Space School” initiative - 17 schools, 6 schools within EEOBSS, and 8 schools within E#COS_LAB projects. The “Space School” initiative also organized two GIS days for education in Sofia in 2017 and 2018. Jointly with other scientists from BAS, the institute has participated in Sofia Science Festival with a stand⁵⁵ and in science festivals in Sofia and Blagoevgrad in 2020, and in the Astro-party Baykal annual editions since 2018.

The second Bulgarian member of Copernicus Academy is the Department of Meteorology and Geophysics of the Sofia University “St. Kliment Ohridski”. The Department's staff participates in integrating the Copernicus products from the thematic services in the taught disciplines in the Department of Meteorology and Geophysics in bachelor and master programs such as Climate Physics, Physical Oceanography, Satellite information in weather analysis, Remote Sensing of the Earth, and others⁵⁶. Since 2018, public lectures and seminars on topics related to the Black Sea-Marine Forecast Centre⁵⁷ and Remote Sensing are organized on a regular basis.

5.3. BULGARIAN MEMBERS OF THE COPERNICUS RELAYS

GEOPolymorphicCloud and the Risk Space Technology Transfer Office at the BAS are members of the Bulgarian Copernicus Relay. Both organizations actively utilize the Copernicus data and services in their work routines, organizing hackathons and workshops in cooperation with the Copernicus Academy members, open lectures, and on-site virtual training. Recently, GEOPolymorphicCloud has restarted issuing a monthly bulletin on Copernicus and works with SRTI-BAS and CASTRA to set up the national Copernicus portal.

5.4. HACKATHONS

The hackathons in Bulgaria are presently organized by few entities related to the BAS and Technical University in Sofia. A contemporary but not exhaustive list of the events is provided below.

- NASA International Space Apps Challenge – Bulgaria⁵⁸. Since 2013 generated about 180 projects with over 800 participants.

⁵² <https://eeobss.space>

⁵³ <https://bit.ly/3lgI2aZ>

⁵⁴ <http://spaceschoolbg.eu>

⁵⁵ <https://www.britishcouncil.bg/sofia-science-festival/experiments/zone-42>

⁵⁶ http://mg.phys.uni-sofia.bg/news_en.html

⁵⁷ <http://bsmfc.net>

⁵⁸ <http://spaceappschallengebulgaria.eu/en>

- First Copernicus Hackathon in Bulgaria dedicated to the EU EO program "Copernicus" takes three days - from April 19 to 21, 2019, and was held in the Technical University⁵⁹.
- Two international Hackathons - ActInSpace 2020 and Copernicus Hackathon Sofia 2020 - due to covid 19 all planned events have been postponed for November 2020⁶⁰.
- NASA "Scientist for a Day" – 2019-2020 is regularly organized for students in grades 5-12 with the support of several organizations⁶¹.

5.5. EXHIBITIONS

Over the years, different exhibitions related to EO have taken place, mainly in Sofia. For example, the travelling European Space Expo's opened in Sofia's Square Alexander I von Battenberg, from 16 to 25 May 2014. The interactive touch screen and unique visual design attracted 35,443 visitors. It also proved to be a popular field-trip destination for area school children, with more than 35 schools visiting the exhibition. Sofia deputy mayor opened the Expo joined by the Directorate General's Head of Information Activities for Industry and Entrepreneurship at the European Commission. Throughout the week, various informative sessions were held on topics related to Galileo, space and security, weather forecasting and the latest achievements in space research⁶².

An exhibition with ten pictures taken by the 2nd Bulgarian astronaut Alexander Alexandrov on board of MIR space station with a Hasselblad photo camera was exhibited in "Sofia Largo" on 07.06.2018 commemorating 30 years from his space flight⁶³. The exhibition "Central Europe through the eyes of the European Space Agency" presents photos of different geographical objects taken from space. The exhibition was organized jointly by the Embassy of France in Bulgaria, the French Cultural Institute and ESA during the "The Night of Ideas 2019" on January 31, 2019. As of February 1, 2019, it was on display in the French Embassy building in Sofia⁶⁴.

The SRTI-BAS exhibited photographs not shown taken from the spaceship "Soyuz 33" by the first Bulgarian cosmonaut Georgi Ivanov with a Kiev-4 photo camera on its 50th anniversary. The exhibition "Earth through the eyes of the first Bulgarian cosmonaut Georgi Ivanov" was shown on display in the lobby of BAS from 6 to 12 November 2019. Three set-ups of the exhibition entitled "Capitals" were carried out within the "Space School" initiative of SRTI-BAS. The exhibition commemorated Sofia's 140th anniversary as a capital city. The eight posters contained maps prepared by geospatial technologies and modelling and satellite images.

⁵⁹ <https://hackathon2019.rst-tto.com/en>

⁶⁰ <https://hackathon.rst-tto.com/en>

⁶¹ <https://edutechflag.eu/nasa-scientist-for-a-day-2020>

⁶² <https://www.euspa.europa.eu/news/sofia-welcomes-european-space-expo>

⁶³ <https://impressio.dir.bg/photography/nebesnata-krasota-na-zemyata-prez-ochite-na-aleksandar-aleksandrov>

⁶⁴ <https://vhugo.org/bg/la-nuit-des-idees-sofia-2019>

During the Sofia Space Week April 24-28, 2020, an Exhibition of “New technologies and innovations 4.0” with the participation of leading companies in the aerospace sector was held. It ensured a platform for exchanging ideas and discussions between a wide range of international experts, researchers, decision-makers at the political level, industry representatives, users of space applications, and non-governmental organizations.

6. STATUS, CHALLENGES, AND FURTHER STEPS

After the 1980s, Bulgaria has significantly reduced research and development volume and applied production in space research. Bulgaria was among the few countries to launch astronauts into orbit, participate in ambitious space missions to Venus and Mars and successfully apply for the latest advances in microelectronics. Unfortunately, the right ideas for cooperation between the research community and business, the participation of Bulgarian companies in tenders and competitions at the European level in space technologies and applications, do not find sufficient state support and are not implemented in practice. The lack of an active state policy in space activities and the weak participation in international programs, initiatives, and cooperation, in which Bulgaria is a full member or partner, significantly hinders the effective use of national scientific opportunities for socio-economic development. Some problems at the institutional level that need to be addressed to strengthen the partnership between Government, academia, NGOs, and business have been identified in several forums and meetings.

These circumstances require a rethinking of national policies and strategies to effectively use all opportunities for Bulgaria's participation in the European Space Program and international space initiatives. The authors of this article share the view that space issues should be included in the priorities in updating the concept of smart specialization and research infrastructures of Bulgaria for the programming period 2021-2027, the National Development Programme Bulgaria 2030, and the national program “Science and Education for Smart Growth”. High value-added space data and applications, combined with the rapid development of innovation and the digital economy, can offer considerable benefits to the public sector, help to achieve national priorities, and develop the potential of small and medium-sized businesses and start-ups. The opportunities for Bulgaria's future cooperation as an EU Member State in space activities are determined by the national membership and representation in GEO and EuroGEO, the ESA PECS program, and other international programs initiatives described above sections. Elaborating national regulations governing the provision and use of EO, increasing awareness and interest of stakeholders in GEO and Copernicus activities are necessary steps to benefit Bulgarian society. The funding mechanism of the National Science Fund at the MES should promote public-private partnerships and strengthen the mechanism of public control over state institutions that coordinate European funding programs related to space activities. The scientific community is expected to be an active participant in the dialogue with state institutions and stakeholders to strengthen networking and

national, regional, and international collaboration. Academia, universities, and NGOs have started to participate voluntarily in regional and European initiatives of GEO and EuroGEO.

The free and open data policy of the Copernicus program helps many Bulgarian scientific teams, start-ups, and SMEs to choose this data as a core for their research projects and services. The MES finances the Bulgarian scientific community for the development of national centres of excellence and competence. Thirteen Bulgarian research and innovation centres receive EC support, including four ‘Centres of excellence’, i.e., fundamental research institutions and nine ‘Centres of competence’, focused on applied research activities with potential industrial uptake. Their subjects are in sectors such as mechatronics, digital technologies, creative and gaming industries and biotechnology and other areas in line with the priorities of Bulgarian smart specialization strategy, its industrial and innovation strategy based on local competitive strengths. Thus, Bulgarian scientists can successfully integrate into the EU research environment to take advantage of all the technologies and achievements in space science.

Intending to focus and centralize the national policy in the field of innovation and research in September 2020, the Government approved a decree establishing a ‘State Agency for Research and Innovation’ as a specialized body at the Council of Ministers for the development and implementation of the policy on research, innovation, and technology transfer. This Agency should deal with the strategic planning, management, financing, and management of research and innovation programs and conduct and support structural reforms. Furthermore, a new policy should be pursued to maximize the effectiveness of the activities favouring the transformation of the Bulgarian economy into one based on knowledge, innovation, and technology.

7. CONCLUSIVE REMARKS

Space science and technologies have a significant impact on the modern world. They are no longer just a scientific field but also have a significant economic aspect with critical social, political and defence dimensions. Since the second half of the 20th century, space technology has gradually become an integral part of many sectors of the socio-economic activity of modern society. Each country's participation in space activities determines its position in the international community, especially those in Europe and the world. The Republic of Bulgaria has a 50-year tradition in the field of space research and technology. The country perceives space activities as an opportunity for the growth of national science and economy. The Bulgarian space sector's development is closely connected with the European space policies and strategies of ESA and the EU. By increasing its space activity, the Republic of Bulgaria gradually builds its reputation as a reliable partner in bilateral and multilateral international cooperation. Copernicus EO's free access to data and information plays a vital role in the digital economy and policy-making processes that benefit citizens and the EU economy. Bulgarian institutions and

companies participate in ESA tenders, which allows them to develop their capacity by cooperating with other ESA member countries. Developing innovative products and services, these Bulgarian teams contribute to the Copernicus six-core, top-quality services and applications.

The EC established links with ESA, developing a joint space strategy in 2000 and a space policy in 2003 with flagship space programmes: Galileo for satellite navigation and Copernicus for earth observation. Bulgaria's successful integration into the EU presupposes active participation in setting the EU space policy's main priorities and the EU executive bodies⁶⁵. The signing of the ESA PECS charter by the Republic of Bulgaria is a prerequisite for developing an appropriate strategic framework such as the National Space Program. It will provide a basis for future progress in the Bulgarian space sector, focusing on its space activities and decision-making for participation in European and international projects. The program should stimulate further close cooperation between academia, business, and industry, contribute to developing their capacity and increase the return on public investment in the space sector. Through which the main actors can synchronize their activities for more effective implementation of the tasks of national and European nature, a specific mechanism should refer to the new Space Strategy of Europe 2021⁶⁶ and the new industrial strategy for Europe 2020⁶⁷. In the coming decades, strong international cooperation and the active participation of Bulgarian state institutions, academia, industry, non-governmental organizations, and society should play a significant role in the country's sustainable development in the changing environment.

Note from authors: All links provided in this text have been accessed and are working on the day of publishing this article.

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⁶⁵ <https://www.consilium.europa.eu/en/policies/eu-space-programme>

⁶⁶ <https://data.consilium.europa.eu/doc/document/ST-13758-2016-INIT/en/pdf>

⁶⁷ https://ec.europa.eu/growth/industry/policy_en