

Ten years of Poland in the European Space Agency: perspectives for increased use of Earth observation satellite data

Abstract

The article presents an assessment of Poland's participation in Earth observation programmes within its 10 years of membership in the European Space Agency (ESA). A diagnosis of the current state of affairs makes it possible to assess the actions taken to date by policy-makers and to indicate the directions which should be taken in the future so that satellite data on the Earth's surface is more widely utilised and available.

Keywords

10 years of Poland in ESA • Earth observation data • Polish space specialisations

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Introduction

For many years, observing the Earth, and building complex satellite systems has been the domain of developed countries which could afford multi-year space programmes and allocate significant funds to emerging technologies. Together with the so-called fourth industrial revolution, and the digitalisation and miniaturisation of electronics, the construction of high-tech devices has become cheaper than ever before (Industry 4.0 2023). This trend also applies to the space sector, which, over time, has changed the rules by which it functions—New Space has emerged, which has permanently reshaped the space business model (Paikowsky 2017). Thematically, Earth observation covers a very broad area, which is related not only to the acquisition, processing, and use of data, but also to all the technologies used to obtain them. The development of aviation, satellite technologies, and advanced optics and electronics, as well as advanced data processing techniques, has allowed methods to be improved and, as a result, Earth observation data to be more widely utilised.

The term 'Earth observation' includes all the specialisations related to photogrammetry, photointerpretation, and remote sensing; and, in Poland, the foundations for the development of this field were laid by academic centres. It was as early as the 1960s when subjects related to work on aerial and then satellite images began to be taught at the University of Warsaw, Warsaw University of Technology, and the AGH University of Science and Technology. Over time, a specialised processing centre for remotely sensed data was set up on behalf of the government to provide information for the national economy.

Over the years, Polish scientists and entrepreneurs have specialised in developing so-called 'downstream' solutions¹

(ed. Bukala 2021). In this context, this article considers Poland's Earth observation and its use of remotely sensed data. The article analyses data concerning Earth observation, including specialist literature and data from the European Space Agency, to assess the maturity of Earth observation efforts in Poland and the use of the data derived from them. The analysis focuses on environmental Earth observations, excluding meteorological observations.

Poland in the European Space Agency

The most important international partner in the implementation of Polish space policy is the European Space Agency (ESA). Poland's first contact with ESA dates back to 1994, when an agreement on cooperation in the peaceful use of space was signed, but only as a result of the signing of the *Agreement between the Government of the Republic of Poland and the European Space Agency on the Accession of the Republic of Poland to the Convention on the Establishment of the European Space Agency and the Associated Conditions* (2012), through which Poland became a full member of ESA on 19 November 2012.

The direction of ESA's activities is determined during ESA Ministerial Councils, that is, meetings of the representatives of the member states' governments, at which contributions to ESA optional programmes are declared². Poland has subscribed to each of ESA's nine optional programmes: (i) the Earth Observation

which may result in an application, product, or service which can be applied to the economy or society.

²As part of its activities, the ESA has two types of programmes: (i) mandatory programmes, in which all member states are obliged to participate, where the contribution is calculated on the basis of GNP; and (ii) optional programmes, financed by the member states which participate in them in the amounts declared at ESA Ministerial Councils, which are organised on a regular basis, usually every three years.

¹'Downstream' means any activity based on space technologies or using systems developed for the space sector for applications in the space or terrestrial environment

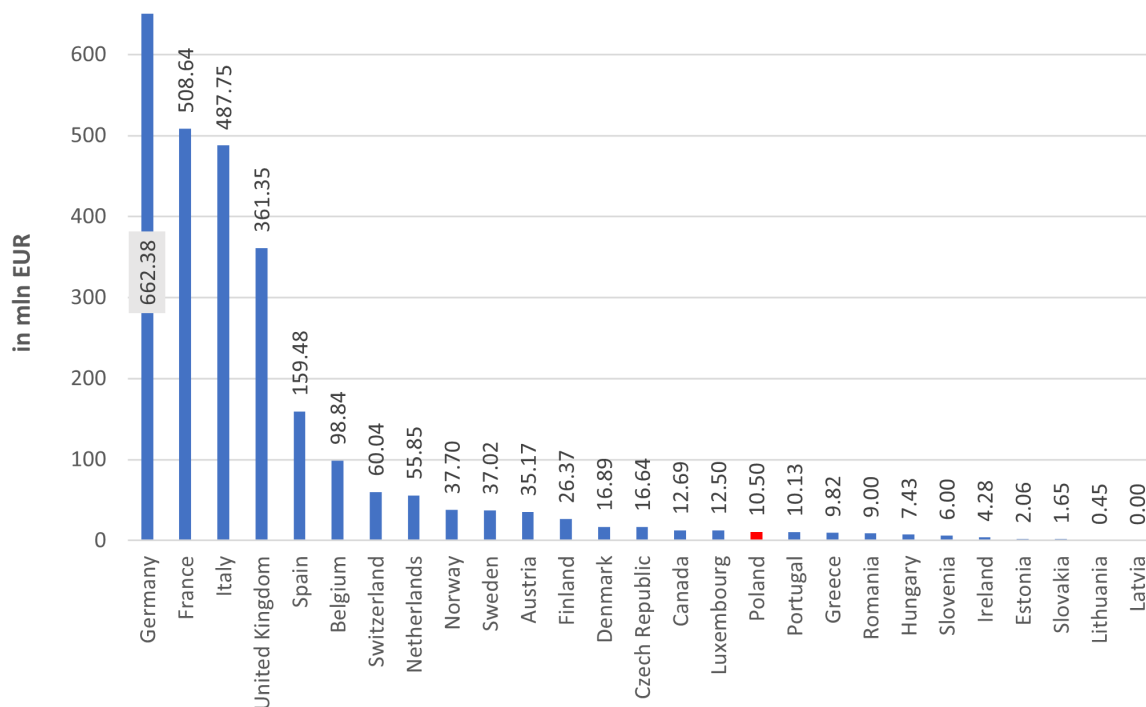


Figure 1. Comparison of the contributions made to the ESA Earth observation programmes declared by member states at the ESA Ministerial Council (CM22) in 2022

Source: own elaboration, based on ESA documents (Subscription to optional programmes at CM22, ESA/C(2022)100, rev. 7)

Programme (EUR 10.5 million), (ii) Telecommunications (EUR 8 million), Navigation (EUR 1 million), Space Safety (EUR 4 million), Exploration (EUR 12.5 million), Scientific Experiment Development (EUR 4 million), Technology (EUR 5.74 million), Commercialisation (EUR 1 million), and Space Transportation (EUR 4 million). For the years 2023–2025, Poland has declared EUR 50.74 million for ESA optional programmes, allocating as much as 20.7% of its contribution to Earth observation programmes. Taking into account the absolute amounts, Poland is ranked seventeenth out of the 27 ESA member states in terms of the amount allocated to the Earth Observation Programme (Figure 1). Considering the country's population and the potential of the sector, it seems that the amount allocated by Poland to Earth observation programmes could be higher.

The declared contribution which Poland made to the ESA optional programmes during the latest ESA Ministerial Council was the largest in the history of Poland's membership (Figure 2). Poland is developing all areas in the space sector, but Earth observation is one of the most important; and it is for this reason the decision was made to allocate a significant part of the contribution to Earth observation programmes³, which for many years has remained at around 20% of the overall Polish subscription. Only the ESA Ministerial Council of 2012 deviated from this trend, during which, Poland allocated almost half of its declared contribution to Earth observation, giving a strong impulse to the development of this area of space technologies.

During the years 2014–2022, Poland invested over EUR 30.65 million in ESA optional Earth observation programmes⁴.

³These programmes can cover both data acquisition technologies and the use of data. However, over the years, Polish entities have specialised mainly in downstream solutions, which mainly focus on analysis.

⁴Poland has contributed to the following ESA Earth observation programmes: EOEP

Over this time, Polish entities obtained nearly EUR 27.50 million in ESA contracts, which is approximately 89% of the money paid by Poland to ESA. This is a very good result, as it should be mentioned that ESA charges about 15% of internal costs for implementation. It is also worth underlining that Poland is currently achieving an exceptionally high georeturn coefficient of 0.99 as of 30 June 2023 (Georeturn 2023) in Earth observation programmes; the coefficient is intended to ensure that all member states which belong to ESA participate equally in the agency's activities, taking into account their financial contribution.

Between 2014 and Q1 2023, Polish entities participated in 102 contracts in the area of Earth observation. In the case of 40 of the contracts, Polish entities played the role of coordinator (prime), which is 39.2% of the total contracts gained in the area of Earth observation. This is definitely good information, which, in this context, demonstrates the maturity of the Polish Earth observation sector.

Polish ambitions

At the 2022 ESA Ministerial Council, Poland decided to subscribe to three optional Earth observation programmes, namely: (i) the Future Earth Observation Programme (FutureEO), (ii) the European Earth Watch Programme – InCubed-2 (InCubed), and (iii) the European Earth Watch Programme – Digital Twin Earth (DTE). Due to huge interest from Polish entities, subscription to these programmes was further increased after the ESA Ministerial Council in 2022 (Table 1).

Due to the budget, FutureEO is the most important Earth observation programme in the European Space Agency. The programme, is intended to set the direction for the development

Period (2, 3, 4, 5) Future-EO, Earth Watch – Climate Change Initiative, Earth Watch – InCubed (+, 2), Earth Watch – Digital Twin Earth, GMES Space Component, Copernicus Space Component 4, and MetOp-SG.

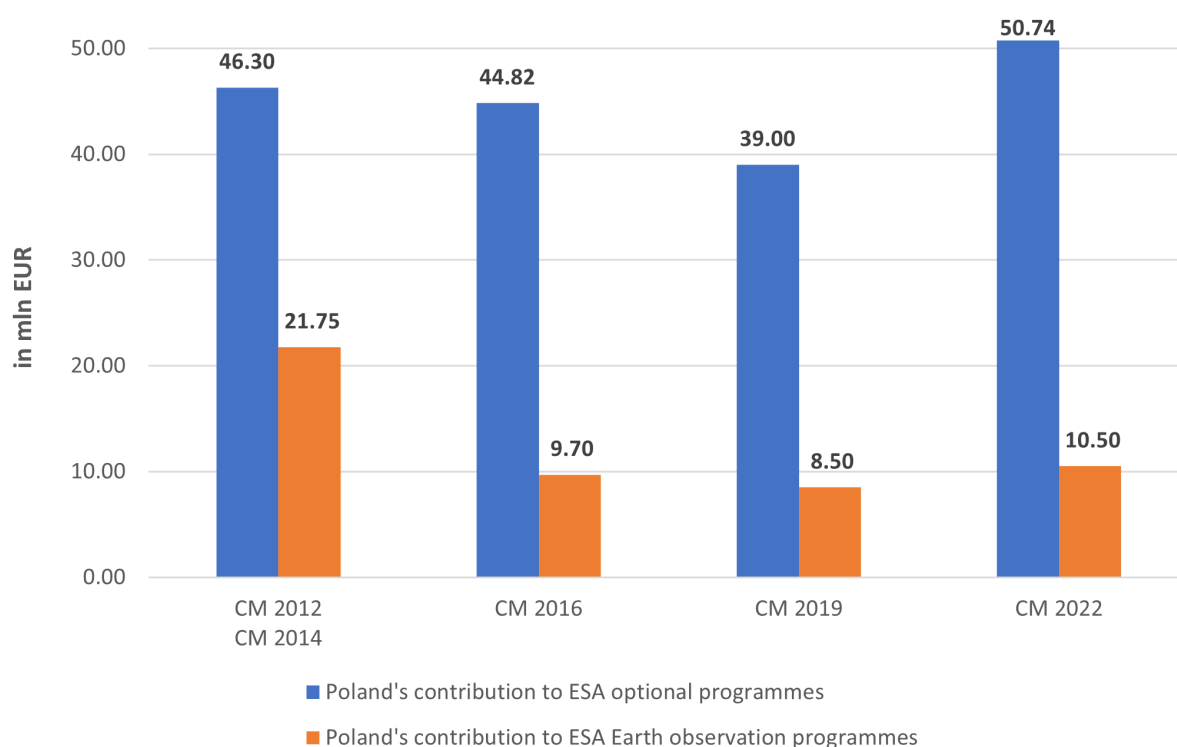


Figure 2. The Polish contribution allocated to Earth observation programmes under ESA's optional programmes, based on declarations at the following ESA Ministerial Councils (CMs). Due to there being no Polish contribution for Earth observation programmes at the ESA Ministerial Council in 2014, this Council is presented in the bar chart together with the ESA Ministerial Council in 2012. Source: own elaboration, based on ESA documents (Subscriptions to optional programmes at ESA Ministerial Council – ESA/C(year)100)

Table 1. Poland's declared participation in ESA's Earth observation programmes during the ESA 2022 Ministerial Council, and the increased subscriptions to these programmes after the 2022 Ministerial Council

Earth observation programme	Declared at the CM22	Increased after CM22
Future Earth Observation Programme	EUR 8,500,000	EUR 1,000,000
European Earth Watch Programme – InCubed-2	EUR 1,000,000	-
European Earth Watch Programme – Digital Twin Earth	EUR 1,000,000	EUR 500,000
Amount	EUR 10,500,000	EUR 1,500,000
Total	EUR 12,000,000	

Source: own elaboration, based on ESA documents (Budget – ESA/AF(year)7)

of Earth observation through innovative ideas for missions, but also the application of the data which are obtained from these missions. It is a research and development programme which aims to improve people's daily lives, stimulate the economy, and create innovation. FutureEO is divided into four blocks: (i) Foundation, Concepts, and Technology; (ii) Research Missions; (iii) Mission Management; and (iv) Earth Science for Society. The last is particularly important for Polish entities, as it is largely related to downstream solutions.

The InCubed solutions is one of the technology commercialisation programmes being developed at ESA. Entities participating in this programme within the framework

of public-private partnerships are refining their technologies in order to commercialise them. InCubed focuses on developing innovative and commercially viable products and services based on Earth observation data. The programme is part of the broader commercialisation ecosystem offered by ESA through its various optional programmes.

The DTE programme aims to support member states in creating the conditions for the broad use of new Earth observation capabilities, including modelling Earth conditions to help predict and counteract certain adverse phenomena on Earth. DTE is intended to help implement the operational ecosystems of Digital Twins (digital Earth models). The programme complements the

European Commission's Destination Earth (DesineE) initiative, which aims to develop a digital Earth model which monitors, simulates, and predicts interactions between natural phenomena and human activities. The overall aim is to contribute to achieving the objectives of an ecological and digital transition. Polish entities have the ambition to be part of these changes, and Poland's participation in this programme can make this ambition become a reality.

ESA's impact on the Polish Space Strategy

The ESA programmes in which Poland participates contribute directly to the objectives of the Polish Space Strategy (PSS), adopted in 2017, which outlines the space sector as 'an important element of the Polish economy based on knowledge and innovation, linked to other areas of the economy in a way conducive to increasing their competitiveness' (PSS 2017). The second strategic objective of the PSS assumes that the 'Polish public administration is to use satellite data for faster and more efficient implementation of its tasks, and domestic enterprises are to be able to fully cover internal demand for such services and export them to other markets'. Lastly, the third strategic objective of the PSS is that both 'the Polish economy and public institutions should have access to satellite infrastructure enabling them to address their needs, especially in the field of security and defence'. Poland is determined to use the full potential of satellite data in public administration, which is a good justification for the further support of activities contributing to achieving the objectives set out in the PSS.

The Polish space sector in ESA

Out of the 215 Polish entities which won contracts with ESA, 49 have done this in Earth observation programmes, which proves that Polish companies and institutions have significant involvement in this area (Commitments 2023). It follows that 22.8% of all Polish entities receiving ESA contracts got them (among others, or only) in Earth observation programmes.

What is particularly important is that Polish entities achieve very high technology readiness levels (TRLs) (ed. Bukala 2021). Based on the ESA Technology Tree (TT 2020) terminology, Polish entities stand out in the technology domain (TD): TD1-On-Board Data Subsystems, and TD 2 - Space System Software (ed. Bukala 2021). The key Polish products and services within Earth observation are software and data processing, as well as information systems for modelling and simulation; a large group also includes applications for end users based on satellite data from observation satellites (ed. Bukala 2021). The above shows that Polish entities have already achieved the ability to develop advanced solutions for the use and application of Earth observation data.

Moreover, it is very interesting that, currently, one of the main areas for Earth observation is information and communication technologies (ICT), which is responsible for several areas, such as data and image processing, on-board software, machine learning (ML), artificial intelligence (AI), and the processing of large data sets (Wilczyński et al. 2023). This creates an opportunity for the sector to be open to professions which have not previously been linked to Earth observation projects.

Perspectives for the use of Earth observation data

The year 2023 has been a breakthrough for the Polish space sector and Poland's activity in ESA, including developing Polish Earth observation, which is due to increase its involvement in the agency's activities. On 28 June, during the ESA Council, Poland declared that it would provide an amount of EUR 295 million for 2023–2025. Apart from the subscription announced at the 2022 ESA Ministerial Council and the subsequent

contribution increases, additional funds are planned for optional programmes, including Earth observation. In addition, Poland, in a bilateral agreement, has allocated EUR 85 million to build a constellation of at least two observation satellites (optoelectronic and radar) and two optical nanosatellites, which are to be built with the significant participation of Polish entities. This will be complementary to the MicroGlob project being prepared by the Ministry of National Defence, which includes a constellation of four optoelectronic satellites (with the possibility of extending it with a radar satellite). In the case of the two constellations mentioned above, a ground segment which is necessary for mission, payload, and communication management is also planned. This will be a very important complement to the 2018 *Understanding between Minister Of Science and Higher Education of the Republic Of Poland and European Space Agency for the cooperation in the frame of the Sentinel Collaborative Ground Segment* (CGS 2018). As a result of the agreement, a satellite data repository was established in Poland. On this basis, the national operator of the Copernicus programme is authorised to directly download and share data acquired by the programme's missions. The Institute of Meteorology and Water Management (IMGW) has been assigned this function, and the data is available via a dedicated interface⁵ and the Sat4Envi platform⁶.

There has been efforts to increase the use of satellite data within the administration. In 2020, the Polish Space Agency (POLSA) published a handbook entitled *Satellite Data for Public Administration* (eds Hejmanowska & Wężyk 2020). In the same year, the concept of building the National Satellite Information System (NSIS) was created to ensure more efficient access for Polish public administration to information from satellite observation. The NSIS is intended to be an interoperable system for receiving, storing, processing, and sharing satellite data, providing monitoring services and information products tailored to the needs of specific public institutions. These institutions, as the 'leading end-users', are to become ambassadors for the use of Earth observation data in public administration. In June 2023, POLSA launched the initial version of the NSIS service⁷.

Discussion and conclusions

Many Polish universities, technological universities and research institutes offer studies related to Earth observation, such as remote sensing, geoinformatics, cartography, and spatial information systems (Specht et al. 2018). Every year in Poland there are more and more graduates who are prepared to use Earth observation data in their professional work. Although there are many Earth observation specialists in Poland today, it seems that the use of Earth observation on a large scale in Poland is still to come, however, this can be helped by educational activities in this field during the early stages of education.

In parallel with the possibility of using publicly available satellite data from the European series of Sentinel satellites, Poland is working on its own constellations of observation satellites, which will provide data with a higher resolution than those from the Copernicus Programme, and be more adapted to local observations with better spatial resolution. The main benefits of public administration using satellite services are: (i) time savings, (ii) improved services provided by institutions, (iii) better decision-making by institutions, (iv) financial savings, and (v) higher liquidity (EURISY 2016).

The space industry, including Earth observation, is an

⁵Copernicus 2023

⁶Sat4Envi 2023

⁷Platforma NSIS 2023.

important branch of the Polish economy, which is developing very dynamically and is gaining in importance. The size of the Polish space sector can be estimated on the basis of entities registered in ESA's System for Tendering and Registration. As of July 2023, there were 475 entities from Poland, of which 100 were small or medium-sized enterprises. In 2022 there were 460 entities, while in 2021 the number was 427 entities (ed. Bukala 2023). It is estimated that 12,000 people work in the space sector (PITA 2023). The development of the space sector is important not only because of the high-tech nature of space endeavours but also because of its interdisciplinary nature. All entities taking an active part in its development are able to acquire competencies, which are often unique, and technological as well as research and development capabilities, which thus results in the economic development, broadly understood, of the country (ed. Bukala 2023), and raising the scientific and technological level of Polish entities.

It is necessary to increase the utilisation of Earth observation data by public administration, and this must first of all consist of raising awareness of the need for such data and demonstrating opportunities for using them. In 2022, POLSA commissioned an analysis of the administrative barriers to the wider use of satellite data in public administration—its results should be the subject of further work. Moreover, the use of satellite data in certain areas of the country's administration will allow budget savings, as specific activities will be performed faster and more accurately, due to automatization and standardised procedures, by a smaller number of employees.

Due to its specificity, Earth observation is crucial for preserving the natural environment for future generations, as it allows global monitoring to be carried out in a repeatable, regular, and standardised manner, while quickly providing reliable information. Developing competencies and increasing the competitiveness of the Polish space sector in this area is one of the challenges to be undertaken.

The implementation of the NSIS concept is an opportunity to ensure effective and continuous access to satellite information

tailored to the needs of users, serving primarily to support public administration in decision-making and the better use of existing resources and infrastructure.

Poland's geopolitical position requires significant investment in space technologies, especially Earth observation. The use of satellite technologies is necessary not only to increase the efficiency of administration and the standard of living of Poles, but it is also crucial in increasing the security and defence of the country.

The dynamic development of the space sector and, in particular, the accompanying ICT sector, including artificial intelligence and quantum technologies, will be an essential driving force for green and digital transformation. Many of the activities undertaken by the European Space Agency are already focused on these issues. Polish representatives at the ESA Ministerial Council in 2022, when subscribing to the FutureEO, DTE, and InCubed programmes, emphasised that Polish Earth observation will also be part of these changes.

The Polish Earth observation domain is at a breakthrough moment. Some national entities have already achieved high competencies, and some regularly provide their proven solutions to various space projects and missions. After many years of Poland's investment in the space sector, public administration support should be directed to help Polish entities in the commercialisation of their developed Earth-observation products. Such an approach will be crucial for the further development of Polish entities, the strengthening of the Polish economy, and, as a result, consolidating the position of the Earth observation domain in Poland.

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