AD ASTRA

Program badań nad astropolityką i prawem kosmicznym

Nr 3/2022

Konsorcjum Naukowe Ad Astra
INSTYTUT METROPOLITALNY
WYDZIAŁ PRAWA I ADMINISTRACJI UNIWERSYTET GDAŃSKI
WSAiB WYŻSZA SZKOŁA ADMINISTRACJI I BIZNESU IM. E. KWIATKOWSKIEGO W GDYNI
WSAiB STUDENCKI KLASTER MORSKI I KOSMICZNY WYŻSZA SZKOŁA ADMINISTRACJI I BIZNESU IM. E. KWIATKOWSKIEGO W GDYNI

European Space policy regarding Space security and safety and role of SSA programme

DOI: 10.53261/adastra20220302

dr hab., Małgorzata Polkowska, prof. ASzWoj
Katedra Prawa Międzynarodowego Instytutu Prawa Akademii Sztuki Wojennej
https://orcid.org/0000-0002-6633-2222

INTRODUCTION

Numerous European countries, whether pursuing Space activity or not, share serious concerns as to armaments in Space. Space defence might become an important issue in the international arena because counteracting the emerging hazards will probably entail not only development of operational technologies and capacities but also formation of political alliances or attempts at determining certain "rules of conduct" concerning Space operations on the international level[1].

European Space Situational Awareness constitutes operational monitoring and understanding of the orbital environment and the behaviours of entities being its part. Surveillance and tracking sensors (e.g. radar, optical, laser ones) acquire data on objects (active and defunct satellites, debris, fragments, Space weather and NEOs), which are processed and incorporated into the database (catalogue). Thus obtained data are aggregated and create a Space image, serving, among others, for warning operators against possible collisions of objects. At present, in Europe SSA constitutes a key operational domain.

RULES OF SPACE SECURITY AND SAFETY POLICY IN EUROPE AND COOPERATION WITH NATO

Individual countries remain the primary entities in the field of Space defence. At present, numerous countries regard Space as a strategic domain, next to the land, sea, air and, to an increasingly greater extent, cyberspace, but have adopted different policies and doctrines depending on their priorities and concerns. European countries (even members of the European Union and NATO) also have diverse management structures, in which roles and obligations of ministries, Space agencies and private entities are divided in a different manner. Only a few countries have adopted full strategies of Space defence and boast advanced capacities in the broad spectrum of Space applications related to defence.

Although military programmes are sensitive and military systems are operated on the national level, the European Union strives for tightening the cooperation between the member states regarding these issues. The EU supports bilateral and multilateral agreements and those concluded as part of intergovernmental organisations, including in particular within NATO. This alliance is the key component of the collective defence of many European countries as well as the USA and Canada.

In the past, NATO had its own SATCOM system (i.e. NATO I, II, III, IV). Since 2010, NATO has relied on the capacities being at certain member states' disposal and on commercial solutions, in particular as regards SATCOMs. Similarly to other defence sector entities, this alliance has changed its approach to Space defence recently by adopting a new policy in this regard[2].

During the summit of NATO member states in July 2018, the growing importance of Space in the strategic and operational environment was acknowledged and it was decided to prepare a general Space policy of NATO. It was stated that there was no need for NATO to develop its own Space capacities while it could use such equipment that was made available by the member states (which maintained their sovereign control over said equipment). The members of the organisation approved the NATO Space policy in June 2019[3], and acknowledged Space as NATO's operational military domain in December 2019[4].

Earlier, cooperation of the EU member states in the field of military Space programmes was initiated[5]. The European cooperation in matters related to Space defence will still be shaped by the growing role of the European Union both in the area of Space and defence.

The period 2014–2020 was characterised by considerable progress achieved thanks to the EU Space programmes, in particular Copernicus, which already delivers a range of various services, and Galileo, which will achieve full functionality soon. The announcement of new EU initiatives related to GOVSATCOM and SSA/STM additionally positions the European Union as the central entity of the European Space sector, in particular in the area of security oriented applications.

In the field of security and defence, the EU is still expanding its competences and role by preparing a consistent framework that facilitates European cooperation and supports various strategic goals. The matters have gained momentum lately with the adoption of new initiatives, including the European Defence Fund, for the purpose of supporting investments in joint research and purchase of modern defence equipment and technologies. Space-related initiatives were included in the EU security and defence framework on all levels, including the political one. As a result, a Space Task Force was designated within EEAS. Furthermore, a new Directorate-General for Defence Industry and Space was established. Questions emerge here as to how defence-oriented applications and operations will be included in the EU Space programme and how this will affect EU priorities, for example in relation to the strategic autonomy and defence doctrine.

Any progress in the area of Space defence depends on the political will of the European countries (acceptance of changes leads to modification of management) and of the European Union (necessity to prepare a common programme for the member states). Essentially, cooperation in the field of Space defence cannot make use of "side effects" (where integration in one sector of the economy or industry creates incentives for integration in others) and must be initiated on the EU member states level[6]. As mentioned above, numerous countries, whether pursuing Space

activity or not, express serious concerns as to armaments in Space. Space defence might become an important issue in the international arena because counteracting the emerging hazards will probably entail not only development of operational technologies and capacities but also formation of political alliances or attempts at determining certain "rules of conduct" concerning Space operations on the international level[7].

Cooperation of EU member states in the field of military Space programmes was initiated relatively early[8]. The European cooperation in matters related to Space defence will still be shaped by the growing role of the European Union both in the area of Space and defence.

Space security is central in the activities of the EU diplomacy now, which also promotes a consistent "European way". Security plays an increasingly greater role in commercial Space markets and supports the competitiveness of the European industry.

The European Space Agency (ESA) is the key component in building the potential of the EU. It has launched a range of initiatives, including a cybersecurity centre of excellence[9]. Another European institution, EUMETSAT, deals with radio frequency, liquidation of Space debris, Space weather, conservation of resources, delivery of in situ data, cooperation with member states and partner organisations[10].

Also the European Space Policy Institute (ESPI) works in this direction[11]. As stated by the researchers from this institute, at least 10% of GDP in the European Union member states depends to a certain extent on the Space potential tapped. ESPI regards Space security as one of the key challenges for Europe[12].

EUROPEAN SPACE SYSTEMS AND EQUIPMENT

Europe is equipped with complete and modern Space infrastructure at present, including spaceships, ground stations, launch pads, spaceports as well as all systems and equipment necessary for developing, manufacturing, implementing, operating and maintaining Space systems. As a supranational institutional entity, the European Union is the owner of Space infrastructure as part of the present flagship programmes: Galileo, EGNOS and Copernicus. The majority of Space technology, infrastructure, and services can serve both civilian and military purposes. Thus, they can make a contribution to the development of an innovative and competitive European Defence Technological and Industrial Base. These assets require protection in the difficult Space environment.

Space systems contribute to the development and make it possible to pursue EU's Common Security and Defence Policy (CSDP) to an increasingly larger extent. Nevertheless, Europe contends with continually changing security threats that are more varied, less noticeable, and less predictable than before. In order to overcome them, capabilities of unbiased political assessment, reasonable decision-making, prevention policies, and effective actions are necessary. Space equipment makes it largely possible to counteract these threats through their global surveillance, positioning and data transfer capabilities[13].

The EU assigns the direct operation of Space infrastructure to partner organisations. Entities handling these tasks include in particular the European Space Agency (ESA), the European GNSS Agency (GSA), EUMETSAT, Frontex and the European

Union Satellite Centre (EUSatCen). The European Parliament has recently approved the establishment of GOVSATCOM and its budget of EUR 10 million; this organisation commenced collaboration with the industry, satellite communications providers, and users in the period 2019–2020. In addition, EUR 442 million were allocated for SSA and GOVSATCOM for the period 2021–2027 as part of the EU Space policy.

Moreover, EU member states pursue both civil and military programmes; these are, among others, Space agencies and defence departments, which own and operate the national Space infrastructure. Commercial entities, such as EUTELSAT, SES and INMARSAT are owners of their Space infrastructure.

In their well understood own interest, European countries cooperate in the Space policy matters with the ESA and EUMETSAT, by transferring to them a considerable part of their budget sums allocated to Space activity.

The ESA conference (attended by the ministers from EU member states and Canada) decided to increase the funds earmarked for the activity of this organisation at the session in November 2019. Owing to that, a budget of nearly EUR 14.39 billion for 2020 was passed. The highest sums were declared by Germany – EUR 3.29 billion, which accounted for 22.9% of ESA's budget, and France – EUR 2.66 billion (18.5%). Considerable amounts were declared also by: Italy – EUR 2.28 billion (16%), the United Kingdom – EUR 1.65 billion (11.5%) and Spain – EUR 0.852 billion (5.9%). The participation of other European countries and Canada in the budget was to be considerably lower[14].

In 2019, the problems related to Space management and, among others, the budget for the period 2021–2027 were the subject of intense discussions on the European Union level. A final agreement was not reached in this regard, though, but relevant documents were prepared. Obviously, the crisis related to the COVID-19 pandemic might interfere with the accomplishment of EU plans[15].

EUROPEAN EARTH AND SPACE OBSERVATION PROGRAMMES

Created for the purpose of Earth observation, the Copernicus programme is based on a fleet of satellites called Sentinels. At present, Sentinel 1A–1B, 2A–2B, 3A–3B and Sentinel 5P satellites are in orbit. On 20 March 2019, the Sentinel 3 mission achieved full operational capacity with its second satellite monitoring the ocean, Sentinel 3B. The launch of Sentinel 4, 5, 6 satellites was scheduled in early 2020. The fleet of Copernicus programme satellites is characterised by various capabilities and has a range of applications: from land monitoring to sea level surveying. The Copernicus programme services in 2019 developed and expanded, covering in particular:

- Copernicus Atmosphere Monitoring Service (CAMS) provides accurate and up-to-date information on global fires, in particular in Australia, the Arctic and Amazonia. This service was extended in July 2019, which led to the preparation of particulate matter emission forecasts.
- Copernicus Climate Change Service (C3S) has become a global service. Its database (CDS), since the creation, have been used by users from 171 countries, who have reported above 31 million queries.
- Copernicus Marine Environment Monitoring Service (CMEMS) prepared and shared a catalogue containing, among others, variable data on wind, waves and ocean currents and published another report on the state of oceans.

- Copernicus Land Monitoring Service (CLMS) has extended by successive dynamic maps of the observed areas.
- Copernicus Emergency Management Service (CEMS) monitored dangerous events on Earth. At the first joint meeting of the European users of the "emergency management" service in May 2019, 184 stakeholders shared their experiences related to the use of this service and the requirements for its future development.
- Copernicus Security Service (CSS) continued serving its users in the area of border control (EBCGA/Frontex), maritime surveillance (EMSA) and supported the internal activities (SatCen); furthermore, it launched new services and expanded the databases.

Already in 2017, the Space Climate Observatory (SCO) was founded on the initiative of France. Two years later (1 February 2019), the first international meeting was organised, which was attended by representatives of 25 European Space agencies and four international organisations. The meeting was devoted to the activity of the observatory and the plans of its development[16].

In 2019, the number of European satellites operated by private entities (124) exceeded the number of satellites operated by public civil and military institutions (95). This is the direct consequence of the leading position of the European satellite operators in global markets, in particular in the field of satellite telecommunication. The satellites operated by European institutions include 44 Space systems in total: 17 operated by the ESA (including 5 EU Sentinel satellites), 5 operated by EUMETSAT and 22 Galileo satellites owned by the EU and operated by GSA with the support from private operators.

The satellites operated by national civil and military institutions include 45 Space systems: 23 of them are operated by national Space agencies, while 22 – by military authorities. The remaining 23 satellites are owned mainly by other private entities, such as Airbus, Skynet (working for the British Ministry of Defence) or DMC International Imaging. Each particular European Space infrastructure covers ground stations, which can run separately or interact with other systems. Finally, Europe has an autonomous access to Space, covering the required industrial configuration, an operational spaceport (in French Guiana) and a wide range of launch pads with a low, medium and high carrying capacity.

A portion of European capacities depends on numerous agreements signed with the USA by European intergovernmental organisations (i.e. ESA and EUMETSAT), institutions of member states (France, Germany, the United Kingdom, Italy, Spain and Belgium) and European commercial satellite operators and service providers. These agreements concern mainly the launch and purchase of satellites (or parts for their manufacturing) and the use of spaceports, chiefly for the purpose of launching satellites into Space. Considerable benefits can be brought also by collaboration in the field of security and safety in Space as part of SSA.

In 2000, the Council of the ESA adopted a resolution regarding protection of Space environment. Said resolution established a task force, coordinated by ESOC (European Space Operations Centre) in Darmstadt, whose objective is to work on determination of security and safety standards of satellites in orbit. The task force assembled representatives of the ESA and national agencies and in 2002 it introduced preventive measures and the principle of orbit protection. In November 2008, the ESA initiated a Space Situational Awareness (SSA) programme, in which 19 ESA member states participated. The programme aims to support the development

of an independent European capacity to assess Space threats to systems in orbit or on Earth. Subsequently, the programme was converted into the Space Safety programme, extending the hitherto Space environment surveillance by components aimed at counteracting threats actively or mitigating their effects.

The European Commission published the first edition of an European radio navigation plan in March 2018, for the purpose of determining and reducing threats related to dependency on GNSS[17]. Also military and civil protection operations rely to a considerable extent on Space assets in terms of navigation, positioning, communication and intelligence[18]. The considerable progress in the implementation of EU programmes in the period 2014–2020 increase also the importance of the services-oriented Space policy, which aims to build users' trust, encourage them to use Space services, and as a consequence maximise the benefits from the European Space infrastructure.

The growing need to enhance Space security and safety in Europe results, in the short term, from the four key factors: 1) ensuring continuous and considerable investments made by public and private entities, 2) protecting the European economy and society from threats related to its significant dependency on Space infrastructure, 3) ensuring the infrastructure's capability of providing services which can be reasonably trusted, in particular to users in the field of defence and security, 4) guaranteeing European autonomy and freedom to act in the area of security and safety in Space[19].

In addition, equipping Europe with a system ensuring versatile and independent SSA capabilities will contribute to Europe's image as a credible partner for talks in the international arena. The EU is aware that security and safety will play an increasingly greater role in commercial Space markets[20]. The European Parliament and the Council of the EU emphasised in the Communication of 4 April 2011 titled "Towards a Space strategy for the European Union that benefits its citizens" that the shared competence (conferred upon the EU by the TFEU) in the area of Space were associated with a close partnership with member states. The resolution of the European Council of May 2011 regarding a strategy for European Union's actions in Space and the resolution of the Council of 6 December 2011 emphasise again the need to establish effective systems of SSA actions[21].

The European Space Agency and experienced national Space agencies (French, German and Italian) play a key role in building the potential in Space. These agencies cooperate closely in the field of SSA with military authorities[22]. The indirect involvement of the United Kingdom in the SSA programme is manifested in the expansion of the RAF radar base in Fylingdales (North Yorkshire Moors) – its primary mission is early warning against nuclear attacks and anti-missile defence for the American system. It can be also used for detecting and tracking Space objects. Data are sent from Fylingdales to the American Combined Space Operations Center (CSpOC), where they are compared with the information acquired by the Space Data Association and the Space Surveillance Network (SSN). As a result of these actions, a common image of situation in Space is created, which is transferred, among others, to the United Kingdom. The British authorities signed also new protocols of cooperation in the area of exchange of Space information, among others, with Australia and New Zealand. Actually, though, the United Kingdom is not planning to develop its own SSA programme for the time being[23].

As already mentioned, in 2009 the ESA initiated an optional SSA programme, focusing only on civil aspects. It was divided into three segments: Space Surveillance and Tracking (SST), Space Weather (SWE) and Near-Earth Objects (NEO). In 2014, the European Commission permitted also the establishment of a framework of support for SST (Space Surveillance and Tracking), also known as EU SST, by implementing relevant decisions for the purpose of setting up operational SST capabilities in Europe. At present, the European SSA programme is composed of three primary components and actions: gathering data, ordering the gathered data systematically, and issuing credible collective information and forecasts[24]. This system handles also Space weather and location of natural and manmade objects circling around Earth.[25] Moreover, multiple SSA objectives refer to protection of important Space and Earth resources against adverse effects of the impact of Space[26].

EUROPEAN CONSORTIUM FOR SPACE SURVEILLANCE AND TRACKING (EU SST)

Space Situational Awareness (SSA) is a dual-use mission by nature. As Space becomes busier and busier, the exact knowledge of the domain is of key importance to all satellite operators, regardless of whether these are military, civil or trade matters. In order to protect Space infrastructure, objects in orbit, including active and defunct satellites, it is necessary to track as many objects in orbit as possible. Many technologies used for measuring and tracking objects in Space originate from an anti-missile defence system, and military entities are still using sensors for Space surveillance worldwide. This double dimension of SSA is reflected also in the European framework of support for Space object surveillance and tracking (EU SST). Over the past decades, the major European countries have actively participated in the global efforts towards improvement of Space operations security, Space security and Space infrastructure resilience. However, it was not until 2014 that the European Union prepared a unique model of multilateral action of EU member states in the field of Space surveillance and tracking, which would not prejudice their sovereignty. The joint efforts at the national, intergovernmental and supranational levels aimed to live up to the challenge posed by the growing scale and complexity of the use of Space, by developing operational, technical and normative approaches to detection, description, understanding and mitigation of the risk related to the growing number of objects in Earth's orbit[27].

The primary legal act of the EU regarding implementation of an SSA programme is the Decision of 2014 on managing and financing the Consortium for Space Surveillance and Tracking – EU SST (541/2014/EU)[28]. Today EU SST is in the process of being transformed as part of the European Union space programme and related activities in the area of Space Traffic Management (STM)[29].

The task of the Consortium was to combine resources of European countries in order to secure the European and national Space infrastructure. The member states make a contribution being their optical and radar sensors. Based on the processed data, such SST services will be implemented as assessment of risk, information and warnings concerning real and predicted Space events involving manmade Space objects. Such events include in particular satellite collisions, orbiting fragments of objects, or uncontrolled entry of manmade Space objects in Earth's atmosphere.

This information was to be shared with the interested parties, including EU institutions, member states, and satellite operators, registered in the EU SST Service Pro-

vision Portal and handled by the EU SatCen (previously European Union Satellite Centre – EUSC).

Initially, the Consortium was composed of representatives of national Space agencies of the leading European countries: Germany, France, Spain, Italy and the United Kingdom. Romania, Portugal and Poland joined this group at the turn on 2019[30].

In 2018, the European Commission sent a report on Space Surveillance and Tracking in the period 2014–2017 to the European Parliament and the Council of Europe. The requests and recommendations included in particular issues regarding preparation of a long-term vision of strategic objectives and general guidelines on the EU level, further simplification of the EU SST subsidy management system and changes in the subsidy management[31].

The works performed by the EU STT are supervised by the European Commission. Operating 24/7, the Consortium has 12 radars, 34 telescopes and 4 lasers. The goals of the Consortium are pragmatic: to build a network of sensors and to transmit data (services are provided by various Consortium member states). At present, the system is used by 148 entities, including 87 organisations and 20 EU member states. The Consortium performs surveillance of 138 registered (civil, military and commercial) satellites, of which 45 are located in LEO, 30 in MEO and 63 in GEO. It was decided that the Consortium's activity might be pioneering for the European Space Traffic Management (STM) system.

The operation of the sensors is controlled by the member states; the security matters concern not only the member states but also other EU member states and even third countries. The shared data are available in operational centres, including in Poland or the United Kingdom[32]. The Consortium has signed numerous cooperation agreements, including with the USA; there are also multiple bilateral agreements, e.g. Germany-France, Italy-USA. A Security Committee was established within the Consortium for the purpose of sensitive data protection[33]. However, the later fate of the Consortium is unknown: it still does not have a full decision-making autonomy. Talks concerning the Consortium are in progress[34]. Despite that, in April 2019 it was decided to upgrade the database, which was to become a starting point for the construction and maintenance of an European catalogue of Space objects[35].

Since its establishment, the EU SST Consortium has gradually developed SST capabilities with the support from the European Union with the use of various financing lines (H2020, Galileo and Copernicus programmes). Sensors belonging to the Consortium member states (including radars, telescopes, and laser measurement stations) serve for examining and tracking Space objects located on all levels of Earth orbit: LEO, MEO, HEO and GEO. Every day thousands of measurements from EU SST sensors are shared via a joint database available to the operational centres (OC) and supplied to the users via the SST Service Provision Portal (SST Portal). These data underlie the future EU SST catalogue to be compiled by Germany.

The Service Provision Portal (managed by SatCen, which acts as a front desk) is responsible for providing three SST services: collision avoidance (CA), re-entry analysis (RE) and fragmentation analysis (FG). At present, French and Spanish OCs are responsible for the CA service; the Italian OC handles the RE and FG services.

The collision avoidance service offers assessment of risk of collision between spaceships or between a spaceship and Space debris (warnings are sent). This service is tailored to the user's needs; it includes messages and reports enabling the user to assess the future risk.

Re-entry analysis (RE) is a service referring to the possibility that manmade Space objects re-enter Earth's atmosphere. The RE service routinely monitors all bodies and objects weighing more than 2,000 kg or, if there is no information about their mass, provides their area (if it exceeds 1 m^2). When such objects are close to a predicted re-entry into Earth's atmosphere, a request is sent to all EU SST sensors to acquire additional data to make the data more specific and accurate. The service is tailored to the user's needs as it allows the user to select areas of interest in the territories of EU member states (and the territories associated with them).

The fragmentation analysis (FG) service ensures detection and characterisation of disintegration of objects in orbit. The short-term FG aims to quickly confirm such an event and its characteristics (e.g. object and event type, quantity of detected fragments, position in orbit). The medium-term FG provides further details of the event based on the orbital parameters of the catalogued fragments. This analysis covers visual information of the fragments. The long-term FG supplements the earlier analyses with information concerning a simulation of an event with the use of an appropriate model of disintegration or collision, which contains data on the ratio of the object's area to mass and density and on the predicted number of fragments[36].

A meeting between the management staff of the EU SST and the researches interested in this topic was held in late 2019. It was communicated that the Consortium undertook a range of research & development works to improve SST results on the European level in the future. For this purpose, "architectural" studies were established to simulate various scenarios, composed of one or more sensors (existing or in development), as to their individual or collective performance level. The preliminary results of these studies reveal that by 2021 the Consortium will have the possibility to catalogue the majority of the objects sized above 35 cm in GEO. As regards LEO, various surveillance radars with various performance levels depending on the updates to be performed, which were proposed by the member states, were examined. The upgraded network will detect more than 16 thousand objects with the size greater than 7 cm. All radars in total will deliver more than 40 thousand "traces" (observations) daily, which will make it possible to catalogue over 6 thousand objects, including 35% of objects with the size greater than 10 cm. Moreover, the performance of several networks studied in the perspective of 2028 covers a simulated orbital population, taking into account inclusion of constellations and CubeSats based on current forecasts. In this scenario, the network will detect more than 32 thousand objects with the size greater than 7 cm. All radars in total will deliver more than 200 thousand traces daily, which makes it possible to catalogue over 19.5 thousand objects, including 65% of objects with the size greater than 10 cm. Mega-constellations will be taken into account in the successive step[37].

On 16 November 2020, the second remote seminar with 400 registered participants was held. The session was opened by Pascal Faucher, the Chair of EU SST, who presented the hitherto achievements of the Consortium and outlined the plans for its further development. María A. Ramos, the SST Technical Chair, presented the current work organisation in the Consortium and the network of sensors, which is composed of: 4 lasers, 10 radars (3 surveillance, 7 tracking ones), 32 telescopes (17 surveillance, 15 tracking ones). Solaris telescopes for the EU SST observatory in Chile were manufactured by Poland.

The success achieved by the Consortium is an argument that confirms the necessity for the societies to prepare for the coming changes in the Space environment.

Better access to the technologies, growing number of equipment launched into orbit, miniaturisation of Space assets, emergence of large constellations and new operational concepts, such as satellite services or technologies of satellite removal from Space, are only some of the changes and events that will contribute to the further increase in the complexity of the human use of the Space environment. In order to mitigate the risk to which they are routinely exposed, such entities dealing with Space whose primary goal is to secure their assets and maintain the access to orbit are involved in activities with the use of Space environment (SSA)[38].

CONCLUDING REMARKS

Europe is convinced, that given the pace of the development of situation in orbit and the growing importance of Space as critical infrastructure, the significance and scope of this area will increase in the coming decades. In line with the changes in the environment to which EUSST will have to adapt in the near future, the traditional paradigms of operation and management, originating from the legacy of the Cold War anti-missile defence, are changing. They have transformed to a considerable extent recently, for example through the sheer fact that private entities have joined the process. Therefore, the SSA system in Europe prepares for future actions, which are to be planned and taken by assemblies of many heterogeneous organisations rather than single entities. The tendency of sovereign democratic European countries to develop cooperation in this field, such as security, and EU SST is noticeable already in this decade.

[1] ESPI Report 72, *Executive Summary – Europe, Space and Defence. From "Space for Defence" to "Defence of Space"*, February 2020, pp. 4–8, www.espi.or.at [access: 29 April 2021].

[2] J.A. Olsen, *A New Concept for Air, Space and Cyber Power in: Air and Space Power in NATO: Future Vector: Part I, Joint Air Power Competence Centre,* Kalkar 2014, pp. 100–105; AUTOR, *Future Security environment. Present Paradox, Future challenge*, Joint Air Power Competence Centre, March 2014, pp. 96–99.

[3] See: https://www.space24.pl/nowa-polityka-kosmiczna-nato-zatwierdzona [access: 23 March 2020].

[4] See: https://www.space24.pl/centrum-operacji-kosmicznych-w-planach-nato-miejsce-baza-ramstein [access: 23 March 2020].

[5] M. Polkowska, *NATO and Space Security* [in:] D. Kawa (ed.), *International Security and State borders,* Toruń 2019, pp. 167–184; *SCI-318 Specialists' Meeting (RSM) on 'The Space Domain and NATO Operations: A Critical S&T Review' Army Education & Training Command, and School of Applied Military Studies,* Turin, Italy, June 25–27 2019; conference minutes and author's notes.

[6] ESPI Report 72, *Full Report – Europe, Space and Defence. From "Space for Defence" to "Defence of Space"*, February 2020, pp. 19–38, https://espi.or.at/ [access: 23 April 2021].

[7] *Ibidem*, pp. 4-8.

[8] M. Polkowska, NATO..., op. cit., pp. 167–184; SCI-318 *Specialists' Meeting (RSM) on 'The Space Domain and NATO Operations*, op. cit.

[9] K.-U. Schrogl, *Security in Outer Space: Rising Stakes for Civilian Space Programmes,* ESPI Conference, 27 September 2018.

[10] A. Monham, *Securing EUMETSAT's Mission from an Evolving Space Environment,* SMI's Military Space Situational Awareness 2020 Conference (virtual), 3–4 September 2020.

[11] ESPI *Report 64, Security in Outer Space: Rising Stakes for Europe*, June 2018, https://espi.or.at [access: 23 March 2020].

[12] A. Vernile, *The rise of private actors in the Space Sector*, ESPI, Cham 2018, p. 61.

[13] See: https://ec.europa.eu/growth/sectors/space/security [access: 29 April 2020].

[14] *ESPI Yearbook 2019...*, op. cit., p. 6. See: www.espi.or.at [access: 23 March 2020].

[15] *Ibidem*.

[16] *Ibidem*.

[17] See: https://ec.europa.eu/docsroom/documents/28325/attachments/1/translations/en/renditions/na-tive [access: 29 April 2021].

[18] *Dependence of the European Economy on Space Infrastructures Potential Impacts of Space Assets Loss*, PwC 2017, p. 146. See: https://op.europa.eu/en/publication-detail/-/publication/e5450aac-0d4d-11e8-966a-01aa75ed71a1/language-en [access: 23 April 2021].

[19] Ch.D. Johnson, *Handbook for new actors in space*, Space Security Foundation 2017.

[20] B. Baseley-Walker, *Current international space security initiatives* [in:] W. Rathgeber, K.-U. Schrogl, R.A. Williamson (eds), *The fair and responsible use of space. An International Perspective*, Vienna 2010, pp. 116–117.

[21] 2011/199/EU: European Council decision of 25 March 2011 amending Article 136 of the Treaty on the Functioning of the European Union with regard to a stability mechanism for Member States whose currency is the euro, OJ L 91 of 6 April 2011, pp. 1–2.

[22] W. Villadei, *Italian SSA and STM lines of effort,* SMI's Military Space Situational Awareness 2020 Conference (virtual), 3–4 September 2020.

[23] B. Bowen, *British Spacepower: Context, Policies, and Capabilities* [in:] K.-U. Schrogl (ed.), op. cit., p. 1374.

[24] S.A. Kaiser, *Legal and policy aspects of space situational awareness*, SP 2015, vol. 31, pp. 5–12.

[25] D. Oltrogge, *Marshalling Space Traffic Management requirements and expectations in the international context*, ESPI 12th Autumn Conference; https://espi.or.at/downloads/category/58-presentations [access: 29 April 2021].

[26] Ch. Bonnal, *Pollution spatiale, l'état d'urgence*, Paris 2016, pp. 21.

[27] R. Peldszus, P. Faucher, *European Union Space Surveillance & Tracking (EU SST) – State of Play and Perspectives,* 71st International Astronautical Congress (IAC) – The CyberSpace Edition, 12–14 October 202; IAC-20-E3.4-56723.

[28] Decision No. 541/2014/EU of the European Parliament and of the Council of 16 April 2014 establishing a Framework for Space Surveillance and Tracking Support, OJ L 158 of 27 May 2014, p. 227.

[29] Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013 and (EU) No 377/2014 and Decision No 541/2014/EU, 12 May 2021.

[30] N. Antoni, C. Giannopappa, M. Adriaensen, *Space and Security Programs in the Largest European Countries* [in:] K.-U. Schrogl (ed.), op. cit., p. 1316.

[31] Decision No. 541/2014/EU; 2013/0064 (COD); Proposal for a Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No. 912/2010, (EU) No. 1285/2013 and (EU) No. 377/2014 and Decision No. 541/2014/EU, COM/2018/447 final – 2018/0236 (COD).

[32] E. Mills, B. Sharp, *UKSA (UK Space Agency) lines of efforts within SSA*, SMI's Military Space Situational Awareness 2020 Conference (virtual), 3–4 September 2020; S. Machin, *Space Weather. The MOSWOC (Met Office Space Weather) in Support of Space Operations*, SMI's Military Space Situational Awareness 2020 Conference (virtual), September 3–4 2020. The United Kingdom withdrew from the Consortium as a result of Brexit.

[33] S. Ducaru, *Security from Space and Security in Space – an operational perspective,* SMI's Military Space Situational Awareness 2020 Conference (virtual), 3–4 September 2020.

[34] M. Becker, P. Faucher, *European Space Surveillance and Tracking,* SMI's Military Space Situational Awareness 2020 Conference (virtual), 3–4 September 2020.

[35] P. Faucher, R. Peldszus, A. Gravier, *Operational Space Surveillance and Tracking in Europe*, document for the first international conference devoted to orbital debris (December 2019). Abstract available on: https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6165.pdf [access: 23 February 2021].

[36] See: www.eusst.eu [access: 15 February 2021].

[37] P. Faucher, *Operational Space Surveillance and Tracking in Europe (EUSST),* webinar, 16 November 2020.

[38] R. Peldszus, *Foresight methods for multilateral collaboration in Space Situational Awareness (SSA) policy and operations*, JSSE 2018, no. 5(2), pp. 115–120.