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The satellite constellations in the respond to the governmental and military technological requirements of the current space communication trends.

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Abstract

Objectives: The deliberation issues of this article are focusing on the satellite constellations as the governmental and military technological requirements responding to the current space communication trends.

Methods: For the purposes of this research, the following theoretical research methods were applied: analysis, synthesis, abstraction, generalisation and inference.

Results: Paper reveals a brief description of the satcom evolution, as well as, the market analysis of current and emerging trends which clearly indicate that the small satellites and their constellations are presumed to remain the largest and the fastest growing segment both for the structured institutions of European Members in the governmental and military area. This institution performs the solution for innovative R&D projects and in more independent perspective acts with the business domain or administrative diplomatic efforts to create the balanced synergy in undertaken projects for worldwide security factor.

A short, non-technical description of a set of general requirements of civ-mil users for the satcom is also presented in this paper.

Conclusions: The research results presented in the analysed studies are useful for providing the worldwide standards of security and order in spite of developing technologies and competitiveness in faster data processing of outer space technology requirements. There shall be taken into consideration the solution of bilateral cooperation of EU institutions and non- structured EU entities under the common agenda of European investment in the space technologies and science as the resilient structure to strengthen European Continent as the global actor and expert in the government and military requirements of the current satcom trends.

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Introduction

In the world's modern communication trends which have become more global in the satellite-based systems solutions a crucial role is played by the competing high-tech operators providing solutions for the defined governmental and military users with an alerted status of security needs, including a number of priorities, such as: crisis management, diversification in the energy transmission, possible terrorist threats, land and sea monitoring, but also in the operation of a critical infrastructure including the institutional diplomatic communication of administrative type. Recognizing the need of processing the synergies in space, security, defence sector and ensuring the accessibility of well grounded, secured and penny-wise communication satellite services for Europe and the domestic public authorities,

The Governmental Satellite Communication (GOVSATCOM) component has been proposed as an example tool of the future space solution of The EU Space Programme directed with the mandate of trust to the EU structured governmental institutions. On the other hand, The European Space Agency (ESA) is the example of non- EU governmental structure agenda in its envoy, where EU acts as its primary procurer to provide more active initiatives that can work as a guidance to GOVSATCOM as the tailored applications dedicated to the global security of the European Region, including The United Kingdom of Great Britain.

The institution works in the space agency status performing the task of independent entity with a peaceful development of the outer space projects promoting the European scientific industrial ventures for the global security with 22 member countries, taking in account Poland, too. The paper reveals a brief description of the satellite communications evolution, as well as, the market analysis of current and emerging trends which clearly indicate that the small satellites and their constellations are presumed to remain the largest and the fastest growing segment both for the structured institutions of European Members in the governmental and military area, but also for an independent entity with the example of ESA. This institution performs the solution for innovative R&D projects and in more independent perspective acts with the business domain or administrative diplomatic efforts to create the balanced synergy in undertaken projects for worldwide security factor. A short, non-technical description of a set of general requirements of civil and military users for the satellite communication is also presented in this Paper.

Aim of this study is to present the satellite communications evolution, as well as, the market analysis of current and emerging trends which clearly indicate that the small satellites and their constellations are presumed to remain the largest and the fastest growing segment.

Finally, authors try to answer the question: if the satellite communication services and applications provided by the configuration of small satellites are able to fulfill the governmental and defence sector needs providing the added value as a supportive or complementary solution to the current communication trends?

1. The current and emerging trends in satellite communications – The new age of large LEO constellations

The world's national affairs have been transformed into more global instruments of actions and practically there is no any part of the globe and air which is not exploited by the human. Consequently, the satellite-based systems play a crucial role in providing the economical and crisis management solutions to connect the unconnected areas, assisting in saving life in emergencies and shield our nations, contribute critical information concerning the protection of expected climate changes, including serious fires of forest in the Mediterranean Sea region in summer 2021, Australian huge inland fires caused by the extremely high temperatures in 2020, or the dynamic reports of COVID–19 Pandemic currently spreading around the world (Kołodziejczak, 2020, pp. 239–252).

Since 1957, which can be considered as the beginning of the space era, when the first satellite was launched into space, the space race has begun. Every year hundreds of satellites are launched into Earth's orbit for different purposes ranging from communications and Internet of Things (IoT) and global internet services, to environmental monitoring and border security.

In 2020 there have been more than 6000 satellites distributed into orbits around the Earth, and that number keeps growing, of which less than half (3000 satellites) were operational. It shall be stated that more than 3200 defunct satellites are still orbiting the planet as a space junk that corresponds to the result of 60% satellites launched into space so far. According to the index of the Union of Concerned Scientists (UCS) database more than half of Earth's operational satellites have been launched for commercial purposes. They are dominated by communications satellites (about 61%) providing the communications services starting from the satellite TV and Internet of Things (IoT) connectivity to global Internet. The second largest number of satellites reflects the amount of 27% as the commercial satellites that have been launched for Earth Observation (EO) purposes, including the environmental monitoring and border security (Visual Capitalist, 2020). The increased demand for the satellite data and services causes that those hundreds of satellites are launched into Earth's orbit every year. This result is estimated by Euroconsult in the amount of 990 satellites that will be launched every year in the future and it will be more visible in the coming decade.

It proves the fact that by 2028 there could be approximately 15000 satellites in orbit (Union of Concerned Scientists, (2022). The Table 1 finds the breakdown of number of commercial satellites by purpose and Table 2 presents numbers of operational satellites by its type (Visual Capitalist, 2020).

Table 1. Number of commercial satellites by purpose

Commercial Satellites by Purpose	**Number of Satellites**
Communication	1007
Earth Observation	446
Navigation/GPS	97
Tech Demonstration and Development	87
Other	9
All Commercial Satellites	**1646**

Source: Wood, 2021

Table 2. Number of operational satellites by type

Operational Satellites by Type	**Number of Satellites**	**% of Operational Satellites**
Commercial	1440	54
Government	436	16
Military	339	13
Civil	133	5
Combination (Other)	112	4
Combination (Commercial)	206	8
Defunct Satellites	**3200**	**-**

Source: Wood, 2021

The satellites play a vital role in the systems of modern communications providing links between various points on Earth and expanding effective wireless interconnection via terrestrial wireless and satellite communication possibilities. What is more, the increased development and use of manned or unmanned space systems which are intended to explore the outer space requires reliable and improved space communications systems as a critical protocol for the success of international missions. Initially, in the 60's, the satellite communications were designed as some kind of the passive reflectors of radio waves which duplicated long-distance terrestrial links. These solutions have provided capabilities which are not present in the terrestrial networks, namely: a long-range and large coverage broadcasting; wide bandwidth capability; quick setup and ease of reconfiguration. Currently, with all these capabilities, satellites are able to provide the services in telecommunication around the world providing global scale broadcasting for the large populations, supporting the mobile communication and providing the services to airplanes, cruise vessels, and high-speed trains. Nowadays, the connection is also achievable with the help of cellular network and fiber combination (e.g. support of cellular networks and mobile communications). Furthermore, the hard-to-reach places or areas with poorly developed terrestrial communication infrastructure demonstrate satellite communication advantage and deliver its services for these zones as well. Additionally, it is very important and it cannot be ignored that there is a crucial need of the satellite services when swift deployment is critical (e.g. in disaster relief operations) or in the situation when the government/military communication systems play strategic role in the performed actions. Typical satellite communication services and applications are shown in the Figure 1. In the meantime, the state-of-the-art technologies in the development of satellite telecommunication has gone through a long evolution.

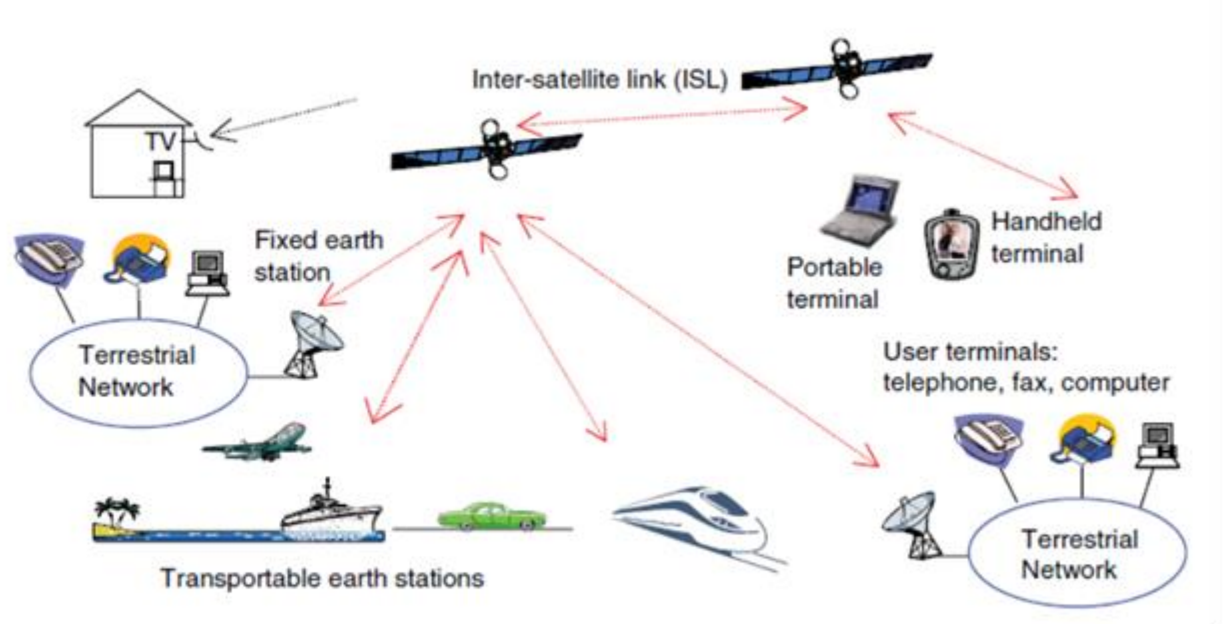

Fig. 1. Typical satellite services and applications

Source: Sun, 2014

In 1965, when the first commercial satellite (Intelsat I) started its operation, high level of requirements in the satellite technologies have enabled the satellite telecommunication to expand its services. Starting initially with the point-to-point multi-channel services for the analogue voice and television to the current solutions provided by telecommunication satellites e.g. digital audio and video broadcasting, mobile communications, on-demand narrowband data services, broadband multimedia and internet services (Maral et al., 2009). The wide spectrum of service will continue to change significantly in the future.

Fig. 2 shows the evolution of satellite communication technologies since the beginning of the satellite communication era.

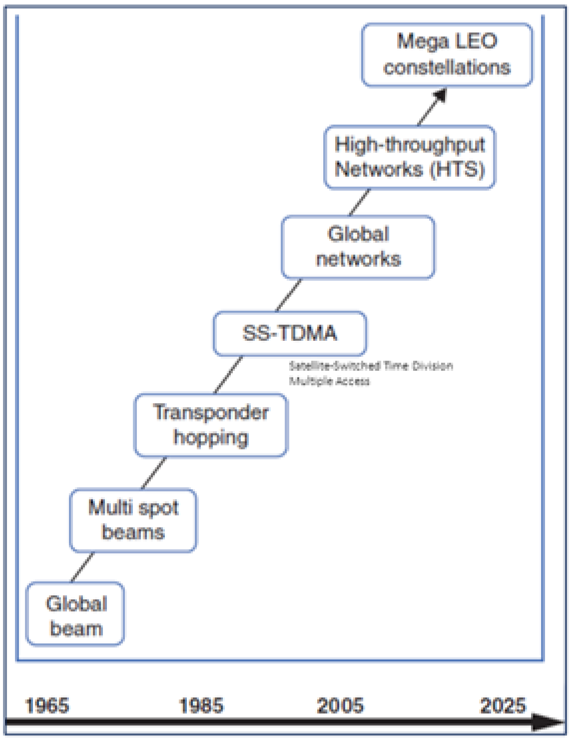

Fig. 2. The evolution of satellite communication technologies

Source: UCS Satellite Database, 2022

Among all the varieties of satellites purposes, since the early 1990s communication, a new solution of the satellite constellations have been proposed. Depending on the orbit, where they are located, the following classification can be listed:

1. Low Earth Orbit (LEO) constellations (with altitude from 160 km to 2000 km) which provide unique characteristics in the comparison to higher orbits (MEO, GEO):

- low latency (transmission time with only ~13.3 ms) (Ali, I. et al., 2002).
- high bandwidth which results from the need to deploy more satellites to ensure global coverage. The overall network capacity of a LEO constellation is usually higher than MEO and GEO constellations, therefore each user can be allocated with more network resources(Ali, I. et al., 2002).
- less signal transmission loss, due to the fact that the signal travel length is much shorter comparing to MEO and GEO. However, the main drawback of LEO constellations is the high satellite mobility which would result in frequent disturbances among satellites when communicating with Earth terminals. For a steady Earth user, the communication time length with a satellite is shorter than 20 minutes (Ali, I. et al., 2002).

2. Medium Earth Orbit (MEO) satellites (rate from 2000 km to 35786 km) which are located in the space between GEO and LEO. It is worth noting that compared to GEO satellites these systems are less complicated to manufacture and to launch in comparison with LEO satellites

and in the result of this fewer MEO satellites are necessary to provide global coverage. Therefore, these types of constellations are commonly used for a variety of purposes, including communication but also navigation. (Yang, 2019, p.28).

3. Geostationary Earth Orbit (GEO) satellites (altitude of 35786 km located exactly above the equator).Due to the special orbit height, which results in an unchanged position between the GEO satellites and the Earth, we have a great superiority for data transmission. What is more, GEO satellites provide the significant advantage by their high coverage. In theory, the high altitude of the satellite location makes it possible to provide global Earth's coverage with only three GEO satellites. It means that the higher altitude at a satellite is located, the larger coverage it has on the Earth, Figure 3 illustrates the concept (Yang, 2019, p.28).

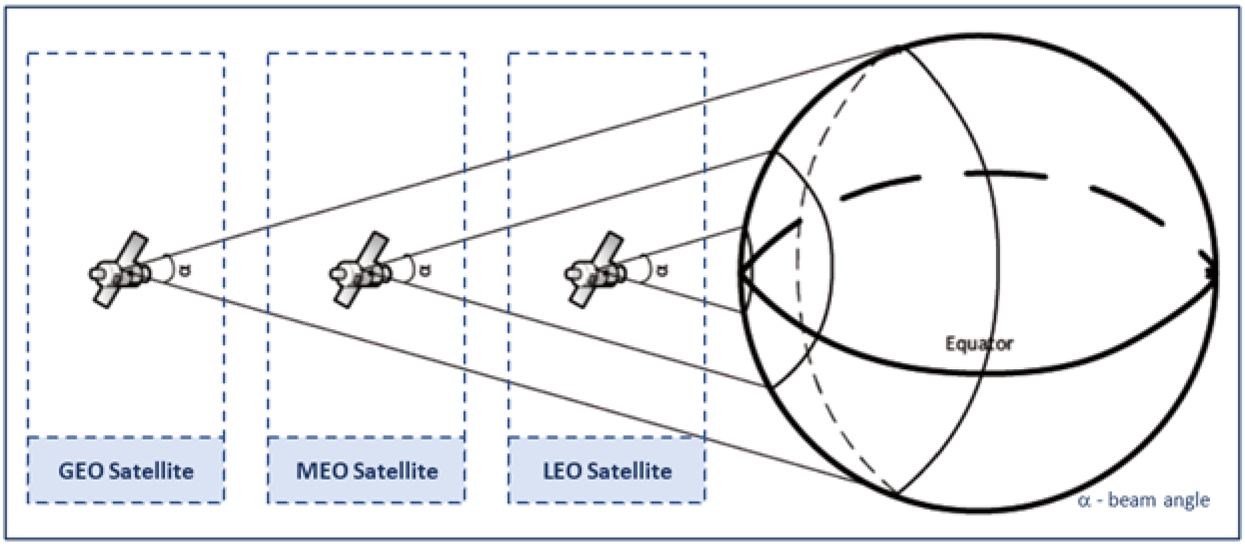

Fig. 3. The correlation between the coverage of the Earth's area and the height of the satellite's orbit
Source: Yang, 2019

Traditionally, communication satellites are usually placed into the GEO orbit to achieve the best coverage and the minimal movement in relation to the Earth. However, in comparison to MEO and LEO satellites, which are operated at a shorter distance, GEO satellites are bigger and more difficult to be manufactured. In recent years, MEO and especially satellites placed in LEO orbit, are becoming more advantageous for communication purposes primarily due to the rapid progress in the development of a small technologies.

The development trends of small satellite constellations can be clearly observed, and the main of which are listed below:

- lower altitude: definitely observed trend of launching modern communication satellites to low orbits (LEO and MEO), (European Space Agency, 2021)

- greater mobility: lower altitude for satellites orbiting in LEO results in much greater movement relative to the Earth, (European Space Agency, 2021)
- higher transmission frequency: provides higher communication bandwidth, which offers the potential for the latest high-bandwidth applications, tu
- increasing satellite number and constellation complexity: necessary conditions to cover the same area, which in consequence requires a greater number of satellites in the LEO orbit compared to the number of satellites in the MEO or GEO. (European Space Agency, 2021)

Recently the satellite industry has shifted from the manufacturing big, massive high costly satellites (>5000 kg, hundreds of million dollar) to the new generation of various million-dollar small satellites (<500 kg). For example, in 2016 more than 120 satellites were launched of which nearly 45% were CubeSats. Moreover, although the number of launched satellites has increased by more than 54% in the time of 2015 and 2019, this is due to the small satellites (<1,200 kg) in LEO orbit (Secure World Foundation, 2019).

There is a clear downtrend of GEO satellites orders which dropped from between 20-25 on average annually to just 17 in 2016. The following years were even worse for GEO satellites and finalized with seven commercial orders for the large geostationary communications satellites in 2018 and with an unexpectedly low order of five in 2019. This is a consequence of the fact that even the manufacturers continue to win new contracts, the satellite operators withhold their purchases, waiting for breakthrough advances in a high-throughput technology and assess the potential of small-satellite constellations. This situation is also favored by the conditions resulting from the systematically growing government funds and support for private entities, as well as the constant demand for satellite research and development purposes. This phenomenon will lead the vend to the need of small satellite industry to a global level of the government and military high-tech requirements.

It is estimated that the increasing popularity for a low-Earth orbit is the main factor of the retail growth for 2018-2028. Even though the market may face challenges concerning the prompt development of processing and assembling techniques, it will result in a lower enlargement and operational costs. According to the retail analyzes, it is expected that small satellites are presumed to remain the largest, as well as, the fastest growing segment throughout the forecasted period. In 2017, the share of this segment in the revenue of the entire market was approximately 41% and the small satellites segment will continue to grow, especially in the communication services. It is predicted that the global market for small satellites will grow tremendously over the next decade. Basing on the assessment provided by the Future Market. Insights, global small satellite market revenue totaled about $3 billion in 2020 is expected to reach $12.9 billion by 2031. The small satellite market is expected to grow at a CAGR of 18.5% during 2021-2031. Although it is foreseen that the nano-satellites are presumed to stay dominant, the security and defence sector will continue to generate the highest demand for small satellite over the next few years. It is forecasted that, as so far, North America will be the dominant venue, but Western Europe and Southeast Asian Countries (SEA) and others of Asia-Pacific Countries (APAC) are also seen as participants of robust growth. All regional retil for small satellites are anticipated to exhibit healthy growth at promising double-digit CAGR values over the forecast period of 2021-2031 (Future Market Insights, 2021). Global small satellite market by region is presented in Figure 4 below.

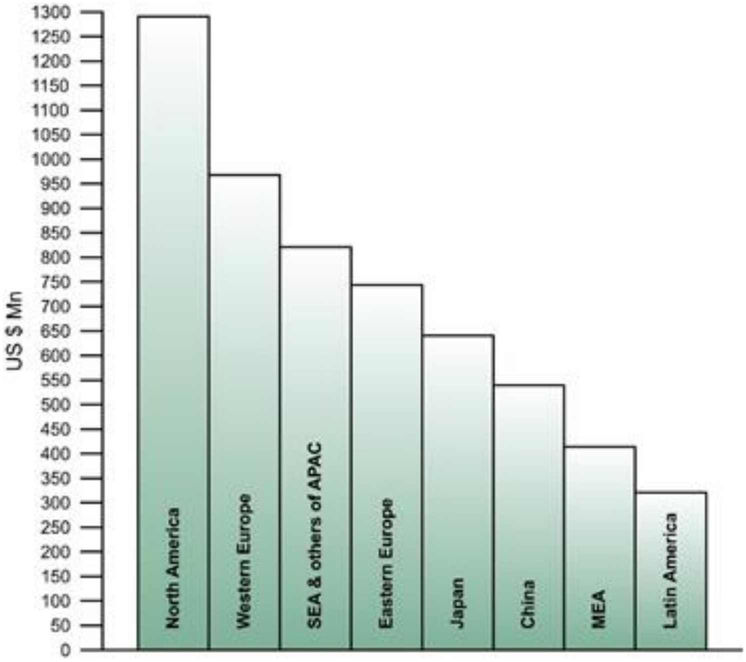

Fig. 4. Global small satellites market by region

Source: Future Market Insights, 2021

2. GOVSATCOM – critical tool for governmental and security actors

In the context of ensuring European Region security, prosperity and competitiveness, when confronted with the era of cyber threats and potential incidents, the space sector and in particular satellite communications (SatCom) become a strategic asset which is closely linked to the national security, what seems to be increasingly critical nowadays. All these issues are in the consensus that the satellite communication today is a key facilitator for the civil and military missions recognized as one of the best and most reliable ways to establish communication links with a complete set of new and evolving IT services. What is relevant in the specific circumstances is the fact, that all satellite communications are crucial and indispensable in the situation when ground infrastructure does not exist (maritime, air, remote areas) or it is undependable, discontinuated and destroyed by the natural disasters, crisis situations or conflicts. Additionally, the security of critical missions and operations (e.g. crisis management) and the transmission of security-sensitive information (e.g. institutional diplomatic official communication for administrative purposes) requires both highly guaranteed access and multilevel protection against interference, interception, intrusion, and cybersecurity risks. The secured satcom has multiple advantages in this regard (European Commission, 2018). In the above context, the diplomatic mandate of EU recognized its major role in ensuring the securityand resilience of Europe for the unpararelled challenges and endangers from outside of the structure. The regional conflicts, cyber threats, acts of terrorism and growing migration pressures are recognized as a huge challenge for the European Continent that should face them currently. So, being powerful and having more autonomous power on the intercontinental scene to strengthen common security with defence capabilities shall be a priority envoy for all international structures with mandate to establish peaceful resolutions on the Earth, but more frequently with help of the outer space management instruments.

Therefore, the development of space sector and its relevance for the European citizens have been addressed in several EU high level records connecting the experience of ESA which recognizes and enhances the role of outer space in the concept of the satellite communications in European security, prosperity and competitiveness as a priority for the future generations. From a certain moment satellite communication has been also recognized as a critical drive for the governmental security actors, such as: police, border guards, fire fighters, and civilian and military crisis managers that were necessary to protect European Area against threats and ill-intentioned acts of satcom. The demand for satellite communication has been also located between the highly robust and secure military satcom (MILSATCOM) with the commercially executed satcom services of (COMSATCOM) for EU mandatory structures that have been growing in the demand.

Finally, the operational needs performed in Europe were not always fulfilled under the current circumstances of the high technical demands with a confidential protocol.

In this perspective, as mentioned before, there was a need to establish an entity called the Governmental Satellite Communications (GOVSATCOM) that would work as an example of the structured instrument to perform the task directed by the European Commission (EC)

Space Strategy for Europe, European Defence Action Plan for 2016, as well as, the EC draft Space regulation for 2018 in which GOVSATCOM component has been proposed as a part of the future EU space programme. In this context the European Defence Agency (EDA) together with contributing Member States gathered operational defence needs and developed EDA GOVSATCOM Pooling and Sharing Demonstration project (GSC Demo) for the security requirements. It is also worth emphasizing that the first notion of governmental satellite communication was raised in the European Council Conclusions in December 2013 and it was eventually elaborated in December 2014 by Competitiveness/Space Council and next in May 2015 the results were presented in the Foreign Affairs Council. The EU Governmental Satellite Communication legislative proposal was initially part of the Commission's 2017 Work Programme, and now it is part of the "Regulation establishing the EU Space Policy Programme" for the Multi-annual Financial Framework 2021-2027 (European Commission, 2018).

Taking into consideration only technical aspects, GOVSATCOM is the first initiative under the common umbrella of the European Union (EU) of such large scale with EDA and bilateral work of European Space Agency (ESA). It should be stated clearly that ESA apart of the described above governmental structured projects for Europe is involved in the innovative solutions with industrial entities. Definitely, this connection will carry on ambitious plan to guarantee reliable, secured and cost-effective satellite communications services for European Region and domestic public authorities that are supervise security of the critical missions and infrastructures (Borek, Hopej and Chodosiewicz, 2020). The task is not an easy undertaking, especially when these expectations are broad and they must be efficient for the civil or military GOVSATCOM user and its communities that have identified the high-tech solution with a security protocol at European and national level. Taking into account the above considerations in the context of the implementation GOVSATCOM component to enhance civil and military cooperation with defence capabilities, the question should be asked: whether the unavoidable and increasing development of small satellites constellations will meet the challenges and strictly defined requirements of the governmental and military sector to support the development of GOVSATCOM Project and non-EU structured institution, like ESA?

The most important requirements that shall be considered by the future communication satellite systems which intend to participate in the process of secured and guaranteed communication protocol with information exchange module for the civil and military users with continuously growing high-tech requirements for a quick access with the sufficient bandwidth can be divided into specific groups which are listed below:

1. Level of following risks acceptance:

- assured access (users are required to ensure that the satellite communication service or resources are guaranteed and cannot be pre-empted by non-governmental users or third parties) (Bielawski, 2020),
- jamming and interference (services must be resistant to interference and should offer technical and procedural means enabling a quick remedy without any disruptions to the service) (Bielawski, 2020),
- interception and intrusion (guaranteed protection against any attempt to intrude into connected IT systems or intercept the transmitted data and information that is required), (Bielawski, 2020),
- space operations (from the respective satellite operator users require services which are critical to reducing the risk of any in-orbit hazard, such as space debris and space weather phenomena. In this context, the EU Space Observation and Tracking Program (EUSST) established under Decision No 541/2014 / EU, may be used to support space operations (Bielawski, 2020),
- cybersecurity risks (users expect effective and proven implementation of countermeasures to ensure the provision of services, and communication links are not the entry point for cyber-attacks) (Bielawski, 2020),
- dependence on third parties (this specific requirement takes into account the risk of technological dependence, space and terrestrial dependence at components, subsystems and systems as well as in manufacturing and accreditation and certification bodies, which in consequence may hamper the autonomy of the EU and its Member States)(Bielawski, 2020),

2. Common Needs (another important group of requirements which must be taken into account):

- interoperability and standards (relevant standards, both for satellite communication and those related to interoperability with the existing terrestrial infrastructure), (EEAS, 2021)

- terminal needs (as essential elements, user terminals should undergo a defined functional and security accreditation process to certify that the use of the terminal does not pose any threats to satellite communication systems), (EEAS, 2021)
- training and concept of use (to confirm that civil and military personnel are adequately qualified to manage, operate or use the systems, with any training that will be required). (EEAS, 2021)

3. Communication service for the crisis management (it will be able to contribute sufficient guaranteed power for initial deployment and it should be scalable if additional capacity is required; services should be also obtainable for practicing and training of the various security and defence forces). (EEAS, 2021)

The above recorded three basic groups of requirements for the governmental and military satellite communication do not end the broad spectrum of expectations which should be performed with these instruments.

3. Current Opportunities for European Region

Coming to the complexity of the market and the needs of high-tech requirements of the satellite constellation for military and non-military entities, UK as one of the example of European Community responds globally to different needs in the fieled of the aerospace, defence, space and security industry. The example of such aforementioned commercial initiative may be found in Airbus Corporation performance with local revenues of £6 billion, apart of ESA above undertaken initiatives.

The Airbus Corporation has created The Aerospace Growth Partnership (AGP) that with its programme is able to secure the future of the UK aerospace industry being connected with the numerous international, domestic projects and community undertakings supported by the government and governmental institutions, among them: The Royal Aeronautical Society or The Royal Academy of Engineering. Such a multi - leveled cooperation can not only create a path for innovations, but also it can clearly define the needs for the commercial and military market taking into account competitors of this sector in a global format with the security issues as priorities.

Despite of Brexit all the provisions of agreements done by UK are executed with help of SKYnet systems working as the connected tissue of military communication satellites operated currently by Airbus Defence and Space on behalf of Ministry of Defence of The United Kingdom (Airbus in the United Kingdom, 2021). Due to such cooperation the network of communication satellites is able to provide a strategical and tactical communication protocol for the military purposes, like NATO, British Armed Forces, some UK government departments and agencies, but also to the allied governments, as a diplomatic solution of the confidential institutional communication in a critical information protocol that is needed between the international organizations such as: EU, UN or NATO with the mandate of community credibility to sustain the global safety.

It shall be also stated that the EU initiative of GOVSATCOM is developed under the EU Space Regulation. Despite the mutual character of its vision directed to EU members, also non-EU institution are involved in its preparatory actions, as with the example of ESA. In this perspective ESA is an independent institution, but still working with the EU space structures as the innovation oriented entity. UK experience in these scientific solutions can be still processed in the issues of global communication, security in the space management (plan for debris collection), satellite space tracking or global navigation systems services for a worldwide community. Additionally, UK as the example of the leader country with a wide experience of establishing the scientific exchange institutions and providing the standards of security strongly underlines the importance of synergy in achieving positive results for European Region in the space management on the European Continent as the balanced competition for China or Russia.

Besides, UK as a member of the Agency being involved in preparatory actions, like GOVSATCOM precursor activities (PACIS 1 to 6) within ESA optional programme Advanced Research in Telecommunications Systems (ARTES) ("THE EUROPEAN SPACE AGENCY," 2021) can seize the opportunity and continue its involvement in the tools or mechanisms which will be established after PACIS projects.

ESA will be probably accountable for the R&D in GOVSATCOM projects and preparation of the roadmap for the system. It has been not decided yet if the future system is based only on GEO assets, especially looking at the new approach to the satellite communication that is revealed through mega constellations put in LEO. It should be expected that the future system will be a combination of possibilities in GEO and LEO because they both have their own specific technical advantages and disadvantages. Then, there would be also a place for the space emerging countries which still do not have the potential in building a large telecommunication satellite, but they have achieved some experience within the state-of-the-art components.

It should be born in mind that the new opportunities of bilateral development may also develop at EU level a potential chance to join the European countries with emerging technical solutions of the scientific activities contributed with overseas countries under the umbrella of global protection of geopolitical trends. As with the US example that sees the European Defence Fund as a threat to its exports to Europe, so there is a debate to allow non-EU companies to benefit from the tool (The governance of the European Defence Fund, 2021). The answer will come with an intense debate during the negotiations of the regulation that is coming out this year.

4. Forecasted assumptions for the development of UK Satellite Constellation Market

The communication solution for dedicated government networks and missions demanding a rapid deploy ability; military-grade network security; flexibility and the ability to scale is performed by the OneWeb's network, as the next example, that supports Air, Land, Sea, and Space communication network in these zones. The consortium behind OneWeb led by the UK Government and the Indian mobile network operator Bharti Global may offer the unique chance for the government sector to bring digital inclusion to millions of personnel through fibre-like connectivity for the first time (LeoSat - Satellite Communication Redefined, 2021). In July 2021 OneWeb has announced the successful completion of its 'Five to 50' mission and with this crucial milestone the entity is ready to deliver connectivity across the U.K., Canada, Alaska, Northern Europe, Greenland and the Arctic Region. The latest launch sends OneWeb's in-orbit constellation to 254 satellites of forecasted number of 648 LEO satellites that will provide high speed, low-latency global connectivity which is planned to work in 2022. The following example of the United Kingdom's effort which considers a LEO constellation to support the military, civil government, and commercial segment users with low-cost options for reliable data is the LeoSat satellite communication service. The company is increasing a constellation of up to 108 joined low-earth orbit communications satellites to ensure totally secure network, the first commercially accessible, enterprise grade, exceedingly speed lightening and protect data service worldwide.

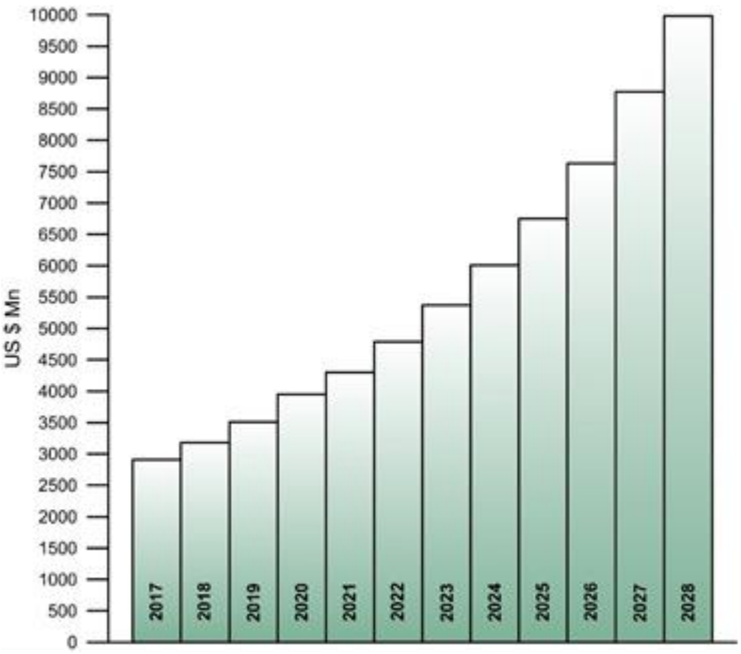

Fig. 5. U.K. Satellite Communication Market forecast

Source: Grand View research, 2021

Definitely, the list does not close a wide range of entities, manufacturers and operators participating in the development of communications based on the commercial scale integrated in the constellations of satellites and its services with the high-tech requirements that shall be provided. Indeed, in the context of the governmental and defence sector there are needs for the satellite communication characterized by the strictly defined and stringent requirements, like example of (GOVSATCOM) solution with a very high level of availability, security, anti-jamming capabilities and robustness that reflects the requirements that shall be completed to keep the protocol of confidentiality and a high-tech processing for the military and governmental needs. The question shall be asked then: Are the services of satellite communication and applications from the growing outer space market sector but delivered by the commercial satellite operators are able to meet these requirements? The answer possibly will be positive, especially that LEO constellations for communication proceeds to evolve and grow at high rates to satisfy the need for the collection, processing and placement of the large amounts of data and information with low-latency bandwidth for the national and international needs supported at the same time by technological breakthrough or the disclosure of new business models or increased funding. Furthermore, the situation is favorable due to the fact that military and governmental users are increasingly looking for commercial systems as the capabilities which provide their satcom needs what creates the competition among big private and institutional players of a high- tech solutions.

What is more, LEO constellations can offer some significant advantages over GEO among, which we can even specify: considerably lower latency, potentially truly global coverage, variable communications geometry which may reduce susceptibility to downlink jamming, mobility whilst communicating using omni antennas, anti-jam and robustness benefit due to coverage constraints and beam isolation from strategic threats, potential significant reduction in the cost of reusable rockets deployment. But still, in order to be fully complied with defence and security sector, the requirements are prioritized. The main requirement is that constellation of the small communication satellites and services must include among others the transparency of commercial systems by using sovereign, 'militarized' waveforms and ground segment; potentially widely distributed with the coverage over globe, even with a limited number of relatively constrained geographical areas. Simultaneously, a full LEO constellation has required providing a continuous service availability in coverage areas, even in the situation when the most of their LEO's orbit would not be providing any useful communication. To overcome all the problems associated with the remote operative scenarios in a real-time and 24/7 communications is an enormous challenge. To perform the above requirements there should be found a response to the expectations of military and government users with a strong interest to use complementary and enhanced communication satellite services in the right spot.

Looking in the future, the foreseeable technology improvement is not the leverage of swap for the satellite communications industry. Parallelly to the technology development, it is essential to strive for a completely fulfilled new service of demands and requirements in both civilian and defence related markets. Although, communication is based on a broad number of small satellites still they face numerous challenges. The LEO constellations become inevitable, they are strongly targeted at the global broadband markets and finally they are well positioned for the governmental, security and defence users. What promotes and supports the use of small satellites more is the fact, that most of the existing satellite communication capability is based on the traditional GEO orbit that does not provide adequate coverage for areas at the Earth's poles. It approaches with the a low speed, high costs and functioning challenges. The inaccessibility of reliable communication in these regions is also, among others, the reason for the lack of interest in carrying out investments. These regions were building cable networks that now are hardly feasible from an economic perspective. They are usually not connected to the global fibre-optic cable network and in order to promote the digital services in these remote locations it seems to be a big challenge for the governments and commercial organizations. Therefore, the operators of small satellites are expanding their capabilities, seeing the LEO constellations, as the chance to provide wireless, broadband connectivity to these regions. Consequently, the list of telecommunications satellite operators and manufactures searching for new opportunities of LEO and MEO constellations is constantly growing, as the example, a few of them can be mentioned: OneWeb, SpaceX and LeoSat, Japan-based Sky Perfect JSAT, SES, O3b Networks, Russian Satellite Communications Company (RSCC), Space Systems Loral (SSL) and Surrey Satellite Technology Limited (SSTL).

5. Summary

The Satellite Communications technologies have achieved substantial breakthrough in the regulation and immense of the high-tech processing of performance in nearly a half century. However, we can observe increase of " remarkable new technologies that can be still developed in terms of the space-based satellite constellation, among them: more powerful processors, new encoding capabilities and a new user terminal capabilities that can make user systems more mobile, more versatile, more personally responsive, more powerful in terms of performance, and yet lower in cost". (The Next Thirty Years, 2003, pp. 188–190; Pelton, 2017) that are ready to be used for the governmental and military purposes, but also for monitoring the climate change, recovery process in the post COVID-19 economy, unexpected natural disasters, like floods hitting western Europe in the summer of 2021 or still developing new digital technologies.

The abovementioned issues are no more connected with one country or one institution of the international mandate as EU, NATO or UN to provide the worldwide standards of security and order. In spite of developing technologies and competitiveness in faster data processing even in the outer space technology requirements, there shall be remembered that space is at the crossroads of the global changes nowadays. In this spectrum Europe as one Region has the best space potential of "knowhow" to monitor its zone for a climate change, stability in energy transmission or health dynamics with all reports. There shall be taken into consideration the solution of bilateral cooperation of EU institutions and non- structured EU entities under the common agenda of European investment in the space technologies and science as the resilient structure to strengthen European Continent as the global actor and expert in the government and military requirements of the current space communication trends.

References

Ali, I. et al. (2002) Doppler Applications in LEO Satellite Communication Systems.

The International Series in Engineering and Computer Science, SECS, volume 656, doi: 10.1007/b117718.

Bielawski, R. (2020) Bezpieczeństwo bezzałogowych systemów powietrznych w środowisku zakłóceń. O Bezpieczeństwie i Obronności, 5(2), pp. 193–212. doi: 10.34739/dsd.2019.02.12.

Borek, R., Hopej, K. and Chodosiewicz, P. (2020) 'GOVSATCOM makes EU stronger on security and defence', Security and Defence Quarterly, pp. 44–53. doi: 10.35467/sdq/118743.

Future Market Insights. (2021) Small Satellite Market - Analysis, Outlook, Growth, Trends, Forecasts. London. UK. REP-GB-3298. pp. 125-132.

Grand View Research, Inc. Report (2021) Satellite Communication Market Size, Share & Trends Analysis Report By Component (Equipment, Services), By Application (Broadcasting, Airtime), By Vertical, By Region, And Segment Forecasts, 2021 – 2028. ID: GVR-4-68038-975-3.

Kołodziejczak, M. (2020). The Emergency States Guarantee the Functioning of the Country during the COVID-19 Pandemic: The Case of Poland and the Republic of China (Taiwan). European Research Studies Journal, XXIII (Special Issue 3), pp. 239–252. doi: 10.35808/ersj/1880.

Maral, G. and Bousquet, M. (2009) Satellite Communications Systems. John Wiley & Sons, Ltd. doi: 10.1002/9780470834985.

Pelton, J. N. (2017) 'Trends and Future of Satellite Communications in Handbook of Satellite Applications. Cham: Springer International Publishing, pp. 679–704. doi: 10.1007/978-3-319-23386-4_24.

The Next Thirty Years" (2003) in Satellite Communications in the 21st Century: Trends and Technologies. Reston. VA: American Institute of Aeronautics and Astronautics, pp. 169–202. doi: 10.2514/5.9781600866692.0169.0202.

Wilson, K. (2019) Impact of Newspace and Data Revolution. Secure World Foundation. Geospatial World Forum. Amsterdam, Netherlands. pp.2-5. Available at: https://swfound.org/media/206437/gwf_april2019_kw.pdf

Yang, X. (2019) Low earth orbit (LEO) mega constellations - satellite and terrestrial integrated communication networks. Institute for Communication Systems. University of Surrey. UK. doi: https://doi.org/10.15126/thesis.00850382.

Electronic sources

Airbus in the United Kingdom (2021). Available at: https://www.airbus.com/en/who-we-are/our-worldwide-presence/airbus-in-europe/airbus-in-the-united-kingdom

European External Action Service EEAS. Avaliable at: https://eeas.europa.eu/topics/common-security-and-defence-policy-csdp_en

European Space Agency ESA. Avaliable at: https://www.esa.int/ESA_Multimedia/Images/2020/03/Low_Earth_orbit

European Commission (2018) Executive summary of the impact assessment – GOVSATCOM. SWD(2018) 328 final. Brussels. Belgium. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2018:0328:FIN:EN:PDF

LeoSat - Satellite Communication Redefined (2021). Available at: https://www.leosat.com.

The governance of the European Defence Fund, European Issues, 592 (2021). Available at: https://www.robert-schuman.eu/en/european-issues/0592-the-governance-of-the-european-defence-fund.

Union of Concerned Scientists (2022). Available at: https://www.ucsusa.org/resources/satellite-database

Visual Capitalist (2020). Available at: https://www.visualcapitalist.com/visualizing-all-of-earths-satellites/