



Space From Perspective of National Security

Ulusal Güvenlik Açısından Uzay

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Özet

Ülkelerin refahı ve güvenliği için uzay önemli bir varlıktır. Uzay, çevre ve hava durumu izleme, tarım, iletişim, navigasyon, bilim ve keşfe kadar çeşitli alanlarda dikkate değer faydalar sağlar. Özellikle günümüzde güvenlik konuları daha da ön plana çıktığı için uzay teknolojisine olan talepler tüm dünyada artmaktadır. Geçmişin aksine, ulusal güvenlikleri tehdit eden örgütlenmemiş veya örgütlü, belirsiz, öngörülemez failler olduğu için güvenlik sorunları bugün dramatik bir şekilde değişmiştir. İnsan kaynaklı tehditlerin yanı sıra iklim değişikliği gibi doğal afetlerin etkileri daha fazla hissedilmekte ve ülkeler beklenmedik ve garip etkiler yaşamaya başlamıştır. Birçok ülke ve kuruluş, bir süredir ulusal güvenliğe yönelik tehditlerle başa çıkmak için uydu teknolojilerini etkin bir şekilde kullanıyor. Bugün, ulusların gelecekteki refahı için uzay teknolojilerine ve yetenek geliştirilmesine yönelik yatırımların önemli ölçüde artacağı açıkça görülüyor. Bu bildiride uydu teknolojilerinin sağladığı faydalar ulusal güvenlik perspektifinden ele alınmaktadır. Ayrıca, ulusal güvenlik için uzay alanında daha da öne çıkacak yeni teknolojiler de tanıtılmaktadır.

Abstract

Space is a significant asset for prosperity and security of countries. Space brings noteworthy benefits in various areas from environment and weather monitoring, agriculture, to communications, navigation, science and exploration. Demands for space technology is increasing all over the world since particularly security issues are becoming even more prominent. Contrast to past, security issues are dramatically changed today since there are unorganized or organized, uncertain, unpredictable perpetrators that are threats to national securities. In addition to man-made threats, the effects of natural hazards such as climate change are felt more and countries have started experiencing unexpected and strange impacts. Many countries and organizations have been using satellite technologies effectively to cope with threats to national securities for a while. Today it becomes apparent that investments in space technology and capability development will dramatically increase for the future prosperity of the nations. In this paper, benefits brought by satellite technologies are being articulated from the perspective of national security. In addition, emerging technologies that will become more prominent in space field for national security are also being introduced.

1. INTRODUCTION

Security has been the first priority of humankind throughout the history and national security still has been the top concern for the modern states. In the past, security basically means protection of nations against military attacks. Generally, wars were taken place between regular armies however, in the 21st century it was realized that threats may not only be regular armies but unorganized, unpredictable, uncontrolled perpetrators as well.

Nowadays the definition of national security is changed a little bit and it becomes more extensive (ESPI Report 80, 2022). It includes reacting to and recovering from natural and man-made disasters; preventing and investigating crime due to organised or unorganized hybrid attacks, terrorism, conflicts and mass destruction; improving border security; protecting infrastructure against natural and man-made threats including cyberattacks; digital security, privacy and data protection. For that reason, the national security approach of the modern world should be arranged in a way to tackle with modern threats.

Threats may be classified as man-made and natural hazards or intentionally or unintentionally. For countries, there are always unexpected emerging threats. Hence, nations have to prolonged monitor not only borders but must be prepared for possible threats emerged from within the country. In this context, security concerns seem to be most relevant to air, land and naval domains however persistent surveillance from space brings benefits and complements to other domains.

Space technologies help nations with border and maritime surveillance, environmental monitoring, situational awareness, emergency services, transport safety, telecommunications, civil protection and crisis management. One of the most important problems faced today is climate change that effects daily lives on Earth. Space-based assets with earth monitoring services provide critical information for early warning, reaction and mitigation actions.

Recently there is a growing interest for space technologies all over the world. Moreover, this growth is also mutually triggered by the establishment of new space agencies. Over the past five years, more than ten countries have already established their national space agencies (ESPI Report 79, 2021). Thus, space activities have been exponentially increasing in the last decades. For example, Turkish Space Agency was established with Presidential Decree on December 13, 2019 and National Space Program, which includes ten major objectives, was declared on February 9 2021.

However, meanwhile a number of nations are also developing counter-space and anti-satellite systems. For example, Russia, China, India, North Korea and Iran are developing such kind of systems and performing very risky activities in space that can give harm to space assets. In particular, non-kinetic activities such as jamming, dazzling, blinding and kinetic destructive activities such as anti-satellite missile systems, laser and electro-magnetic systems can be given as examples (Samson, 2021).

Recently, we also witnessed the impacts of the use of space technologies in the war between Russia and Ukraine. Briefly, it is obvious that space technologies are strongly effective on security of nations.

This paper elaborates benefits brought by space technologies by first stating space and relevant terminologies and then giving relevant examples and claims. Emerging technologies are also articulated that will be used with space technologies.

2. TERMINOLOGY

There may be different space terminologies. In this article, NATO space terminology is taken as reference since the main objective of NATO is to ensure security of nations particularly of its allies (NATO, 2022).

Space is defined as the volume beyond approximately 100 km (Kalman Line) above sea level (Reding 2020). Basically, a space system is composed of the space segment (satellites or spacecraft) and the ground segment (control stations). According to NATO nomenclature, data links (uplink and downlink) and user segments are also included in space system definition.

NATO defines the space functional areas as Space Situational Awareness (SSA), Intelligence Surveillance and Reconnaissance (ISR), Positioning, Navigation and Timing (PNT), Satellite Communications (SATCOM), Meteorological Services (METOC), Shared Early Warning (SEW). From the perspective of national security, use of space services and products in these areas are inevitable (NATO, 2022).

Resilient and responsive space systems are other definitions widely used in space and defence realm. Indeed, these terms are highly interrelated to each other. Resiliency is defined as the ability of a system architecture to continue providing required capabilities in the face of system failures, environmental challenges, or adversary actions (Pawlikowski, 2013). In this context, abilities of rapid response or rapid constitution of disabled abilities is becoming more important. For example, responsive space capability can facilitate rapid deployment of space assets in orbit and thereby enabling resiliency. In this regard, launch capability is the main pillar for responsive space (Perry, 2021).

The last term defined in this section is “spacefaring nations”. It can be defined as nations that are capable of independently building and launching spacecraft to space. Today, due to the dramatically increasing number of private launching companies both countries and corporations can be referred to as spacefaring. Within the frame of this section, Rocket Lab may be a good example for a spacefaring company since Rocket Lab's Responsive Space Program enables launch, reconstitution and augmentation of space assets on rapid timelines and hence delivers confidence and resilience to customers (Rocket Labs, 2022).

Finally, emerging spacefaring nations can be defined as countries that continue increasing their capabilities to become more autonomous in space activities. For example, Türkiye, Malaysia, United Arab Emirates and South Korea etc. are among the emerging spacefaring countries.

3. SPACE FOR NATIONAL SECURITY

Space is a strategic asset contributing to better human life, independence, security and prosperity of the countries. Enormous advantages have been achieved in different fields. For example; observation from space makes available protect environment, forecast the weather and disaster management that includes mitigation, preparedness and response and recovery. Figure 1 summarizes examples of uses of space technologies in different areas.

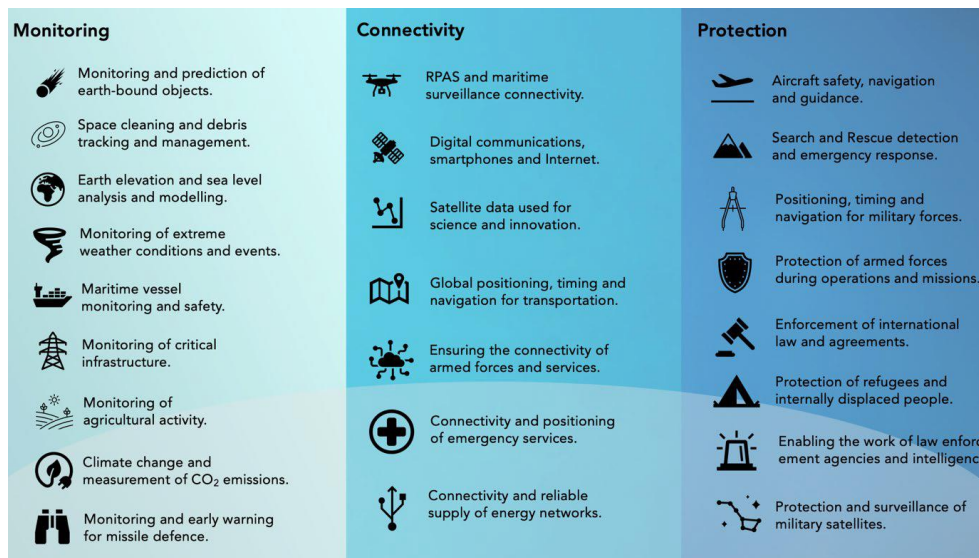


Figure 1: List of the Uses of Space (Fiott, 2020)

Based on the satellite database given in (USC Satellite Database, 2022) more than 5400 satellites are currently orbiting Earth and the distribution of these satellites with respect to countries is given in Figure 2. NATO Science & Technology Trends report (Reding, 2020) presented some results about operational satellites as of September 2019. Similar analyses were carried out and presented in this study. Due to mega constellations, especially Starlink, there is an explosion in the number of low-orbiting satellites in the last few years. Figure 3 and 4 show the charts of operational satellites against countries, users and orbits upon data on May 1, 2022.

As seen from Figure 3 there is a growing interest for commercial space activities. Smallsats and new launcher technologies have changed conventional space business paradigm and commercial satellites become to dominate space business market. On the other hand, with increasing use of space in wide range of applications, threats to space assets are also developing.

Security is one of the most significant challenges in the 21st century. While advances in technology and innovation may seem to make our lives easier on Earth, their malicious use can also endanger lives, harmony, peace and thus the security of nations (Hamourtziadou, 2019; UKEssays, 2018). Hence, it is vital to make smarter preparation for defence. In this regard, space will be the crucial area alongside air, naval and land for security of nations (İnce, 2008; NATO, 2019).

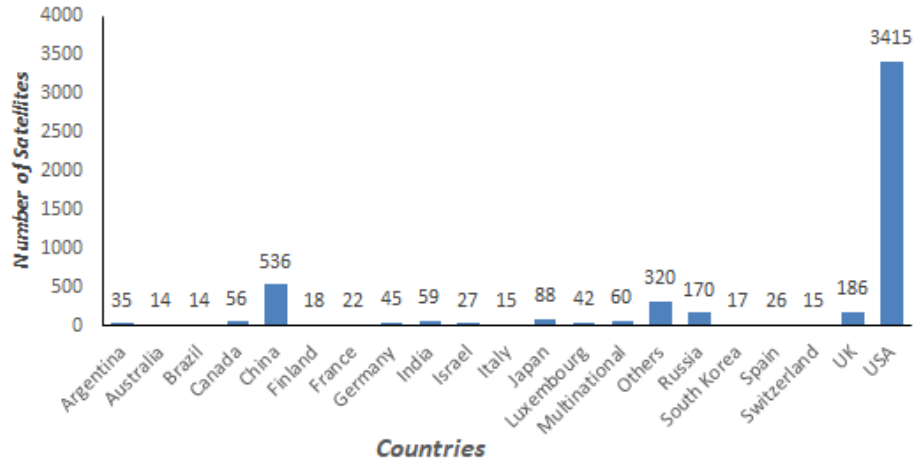


Figure 2: Operational Satellites versus Countries

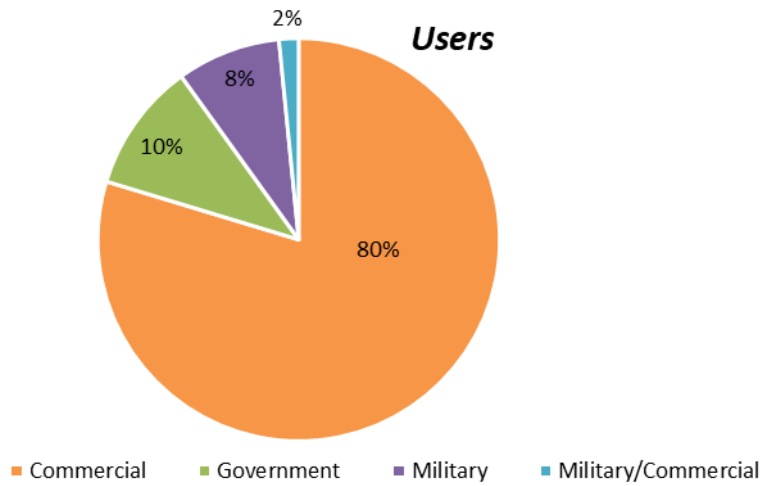


Figure 3: Operational Satellites versus User Diversity

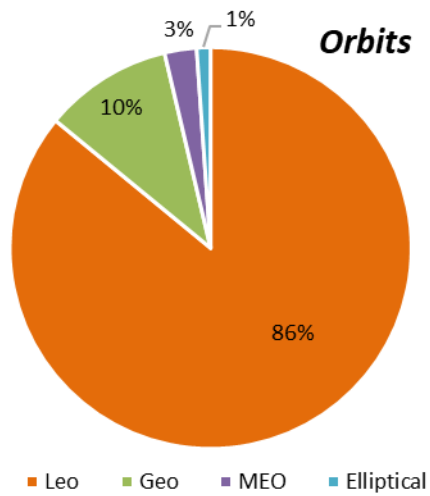


Figure 4: Operational Satellites versus Orbits

Space technologies provide to national security with important advantages over conventional technologies such as global coverage, fast and instant services that are independent of terrestrial infrastructure, temporary network solutions that result in rapid delivery of the services.

Furthermore, satellites could provide forecasts and images to security authority. Security departments and emergency managers need vital and very latest information for disaster preparedness, response and recovery in order to protect the nation's critical infrastructure and natural resources, and reduce the loss of lives.

Nowadays national security operations for defence systems can be like an uninterrupted operational theatre, starting from the very surface of the territorial lands and seas reaching out to highest altitudes of the space above or far away from territory as depicted in Figure 5 (Airbus, 2020). Security authority needs to deploy interconnected, interoperable and coherent network with in this operation scenario. In this case satellite communications could meet all these requirements.

Also, space based observation systems provide the monitoring of the intended area without geographical limitations. The use of space domain improves the ability to foresee threats and respond and react to them within shorter time, more effectively and more accurately.

Satellite technologies facilitate the monitoring of activities on ground and at sea. The combination of data acquired by space based radars and optical satellites helps authorities monitor and track people and goods at borders. Illegal human trafficking, illegal immigration or refugees and drug trafficking can be surveilled and then prevented.

Similarly, with the space based AIS system identities and locations of ships are broadcast so that maritime authorities become aware of ships especially in the open sea. These data are then distributed to avoid collisions and illegal fishing and to help search and rescue operations, and pollution control and to monitor migration. Hence, space technologies will significantly contribute to maritime safety and security.

Recently ballistic missile activities are dramatically increasing all over the world. New generation hypersonic and low-flying missiles are being developed by some countries and it becomes difficult to detect and track such kind of missiles by ground based radars, and this reduces the ability to generate alert signals instantly (Starling, 2021; Stone 2022). Figure 6 depicts an exemplary of ballistic missile and hypersonic missile trajectories. In such cases, satellites can be thought as eyes in the sky, they can surveil ongoing activities without geographical limitations, and thus relevant authorities can become aware of potential trouble before it arises. Indeed, the United States have started developing space-based missile warning systems a long while ago. These systems mostly include multiple satellites and embark infrared optical payloads in order to detect ballistic missiles and track them on their path and alert the relevant authorities early enough.



Figure 5: Exemplary Image of Interoperability of Space, Air, Land and Naval Assets

Today the use of unmanned platforms is increasing dramatically and unexpectedly. As well known, formation flight of unmanned air platforms requires precise position data from satellites and communication with each other. When they fly away from their territory, they cannot be controlled from their ground stations so that they need to be controlled from satellites. Moreover, surveillance data should be transferred to the ground. Communication satellites facilitate uninterrupted data links.

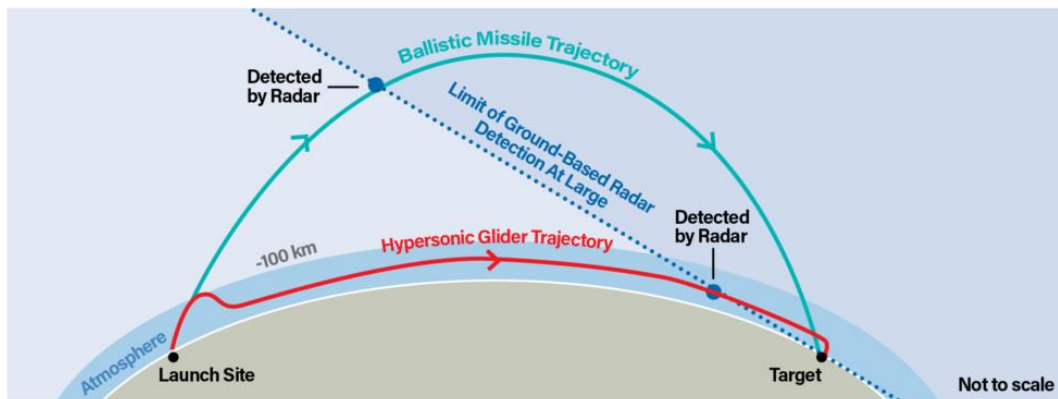


Figure 6: Exemplary of Missiles Trajectories
(Stone, 2022)

Therefore, we could say that integrated use and application of satellite communication and satellite navigation solutions with space-based observation systems and with related non-space systems could make nations better secured and better protected against natural and man-made threats.

The Gulf War, which took place in 1991, is considered the first space war although there was no real war in space. Satellite-based global positioning systems (GPS) played a critical role in the conflict when US lead coalition drove Iraqi troops out of Kuwait (Greenemeier, 2016). Since the GPS satellites changed the course of warfare, space has become vital for navigation applications.

Another example of the use space technology can be given from the war between Russia and Ukraine. Maxar Technologies, a US company, provided high resolution satellite images taken from Russia-Ukraine conflict (Satnews, 2022). These images are also shared with the media and the conflict can be

watched from TVs and smartphones. The images are acquired by one of Maxar's WorldView constellation of satellites.

Similarly, last February Starlink satellites, belonging to SpaceX, started providing internet services disrupted by Russian invasion in Ukraine. More than 2000 satellites are orbiting the Earth and providing seamless communication with thousands of terminals on the ground (Vinion, 2022).

In summary, from earth observation to communications and to navigation, space is becoming an indispensable domain for all countries. However, emerging technologies and the number of actors in space field do not only bring opportunities but also challenges and nuisance.

Recently, more nations and even commercial companies are sending more satellites to space. It naturally increases the probability of creation of more space debris and collision to space assets. With the increasing use of space, threats to space assets are also developing as well. Some space fairing countries develop their technologies for counter-space and anti-satellite activities. In particular, Russia and China already conducted some dangerous experiments in space. On January 2007, China tested a direct ascent anti-satellite weapon against one of its own satellites and thereby creating the largest number of space debris in history. Similarly, on November 2021 Russia deliberately hit its satellite so that there were a lot of debris occurred. This may be very harmful even for International Space Station (ISS). Therefore, today space situational awareness is no longer a luxury but it is rather a necessity for secure and safe space domain.

There are also unorganized, non-state, unpredicted perpetrators or terrorist groups that are also threatening the use of space by using jamming and cyberattacks. Although cybersecurity is not a physical domain capability should be improved against cyberattacks. Cybersecurity tools are vital for protecting systems both in orbit and on the ground against cybercrime.

Most of military missions and even daily lives on Earth rely on position, navigation and time data. Today, countries or non-state actors deliberately interfere GNSS (Global Navigation Satellite Systems) signals thus resulting in loss of location and synchronization of systems. Therefore, more resilient Positioning, Navigation and Timing (PNT) space systems are being researched, and even some of private companies and agencies have already started developing such kind of satellites. For example, ESA plans in-orbit demonstration with new low orbiting navigation satellites. This project aims at delivering more accurate, robust and available PNT data everywhere (ESA LEO PNT, 2022).

Countries started to accelerate their space activities in order to maintain their pre-eminence in space and protect their satellites and space assets. In particular, space fairing countries such as USA, China, France make significant financial investment in space domain (Brunner, 2021). In addition, USA and France established space forces to enhance their defence capabilities in 2019. Similarly, UK Space Command was set up on April 2021. NATO created a space centre at Allied Air Command in Ramstein to monitor space and satellites as well as to collect data on possible threats in 2020. On January 2021, NATO

established a new Centre of Excellence dedicated only to space according to French proposal. The centre of excellence will conduct doctrinal and standardization work, training, exercises, analyses, concept development and experimentation (Chapeaux, 2022).

On the other hand, the Russian Space Forces, a branch of the Russian Aerospace Forces, were originally formed on August 1992, alongside the creation of the Russian Armed Forces. Then several reforms were made and finally on August 2015, Russian Air Force and Russian Aerospace Defence Forces were merged to re-establish the Russian Aerospace Forces (Russian Space Forces, 2022). The world's other largest space power belongs to China and is called the People's Liberation Army Strategic Support Force, which is also China's cyber power (Pollpeter, 2017).

National security cannot be thought without international security. Countries come together and establish alliance for mainly considering their international security. For example, NATO is one of the best examples for establishing an alliance for international security since NATO aims at ensuring security of nations particularly of its allies (Brunner, 2021). In 2019, NATO officially declared space as an operational fifth domain alongside land, air, naval and cyber domains. At the beginning of 2022, NATO released a detailed new Space Policy by defining space related threat environment, NATO's approach to space, principles and tenets. It is obvious that space is essential for the operation of NATO. The operation needs timely, rapid, effective and accurate information. Since the members are located in different parts of the world the way of sharing of information can be vital for the success of the operation. In this case, satellite communication can be only solution for connection and data transfer.

Regarding space, NATO has identified its objective very clearly as NATO Secretary General Jens Stoltenberg said, "Space is extremely important for all civilian and military activities, for communications, for navigation, for the transmission of data, so of course, space and satellites are of great importance for all NATO Allies. We will not weaponize space, we will not deploy weapons in space, but we make sure that the assets there are available in peace, crisis and conflict." (Samson, 2021).

Similarly, European Union works on to develop space and defence technologies. In recent years, special attention has been given to space technology. Space has been integrated into the European Defence Agency's (EDA) Capability Development Plan (CDP). One of the main objectives is to achieve coherent European space capability within members of Union. In 2018, particular topics were identified as capability priorities from a defence perspective (Space-EDA, 2022): Satellite Communications (SatCom), Space-Based Earth Observation (SBEO), Positioning, Navigation and Timing (PNT) and Space Situational Awareness (SSA).

European Commission published An EU Approach for Space Traffic Management (STM) in February 2022 since space becomes more congested and contested particularly in LEO. Since there is no fully internationally agreed consensus about regulatory framework and STM it is aimed to establish common understanding of STM terminology and contribute to the security and defence scopes of the EU in space. Therefore, based on exhaustive studies STM was defined as the means and rules to access, conduct

activities in, and return from outer space safely, sustainably and securely (An EU Approach for Space Traffic Management, 2022).

In recent years, NATO-EU cooperation has become very close as ever before for defence and security. With space technologies both EU and NATO can respond to crises with greater speed, effectiveness and precision (Csepregi, 2021). In the 2021 European Parliament (EP) resolution on EU-NATO, space is emphasized as a critical domain and that new technologies are rapidly enabling its use for defence.

Also, other countries have commenced to revise or update their policies based on the growing importance of space to national and international security interests. As states increasingly rely on space, protecting these assets becomes more and more critical.

Another important issue in space activities, which also affects security issues, is that there is still no common ground between countries on how to respond to threats in space. United Nations continue working on the development of space laws including resolutions, treaties, procedures, etc. The Outer Space Treaty-1967 draws the general framework about international space law. The following main principles are covered: peaceful use of space including Moon and other celestial bodies; not subject to national appropriation; prevents the placement of weapons of mass destruction in orbit, on the Moon and celestial bodies. On the other hand, but it does not fully define activities against if weapons are placed or target space assets. In December 2020, the resolution (UNGA Resolution 75/36) was adopted by the United Nations General Assembly in order to reduce space threats through norms, rules and principles of responsible behaviours (UNGA Res. 75/36, 2020). However, there are still remaining works to be done for space security in order to tackle space threats challenges.

4. EMERGING TECHNOLOGIES AND BUSINESS APPROACHES

In the past, space activities were different from today. Although space activities have been emerged and gained more momentum during the cold war, nowadays space technologies provide invaluable contributions to communications, navigation, safety, environmental issues particularly climate monitoring and countless scientific explorations.

As technology is evolving very rapidly but unfortunately, threats to security are also emerging. In order to tackle with the current security challenges at national or international level new emerging technologies should be incorporated with satellite technologies.

In coming years, unmanned and automated systems, robotic technologies, IoT, artificial intelligence and quantum technologies are becoming widely spread. For example, European Union plans to invest in quantum technologies as well as establishment of a full Quantum Information Network (QIN) by 2034 in order to have more secure, robust and reliable communications. Although cybersecurity was not spoken too much today it will become vital for almost all technology areas in coming years (Mahnamfar, 2022).

In the past, the use of space technologies was mostly dominated by a few countries all over the world. However, due to increasing number of private companies, particularly in the last decade space become more accessible and affordable for other countries as well (New Space). It should also be noteworthy that space leading countries still continue to allocate huge budgets and make investment in space technology.

Small satellites are becoming cheap enough even for emerging countries to buy and operate such kind of satellites. Due to advancement particularly in electronics technologies payloads also become smaller. Moreover, these satellites are supported by cheap and responsive launch capabilities. All these advancements incorporated with demands for low latency, high resolution images and more revisit times, constellations of hundreds or thousands of satellites start to be evolving. These capabilities make space domain more appealing for defence communities as well as civilians and hence it is expected that actors in space will increase unpreventably and the world will become dependent on space applications.

With small satellites, defence community has been gaining the ability to reconstitute their system rapidly and survive under various kind of attacks. Due to the large number of satellites in the constellation, loss of one or multiple satellites may not cease providing services, even the space system may still continue working at degraded performance. Today distributed or fractionated space systems seem to become more common, all of which facilitate increased resiliency of space systems.

Recently, space is no longer an indicator of privilege for countries as it is more accessible and affordable. Due to increasing trend for mega constellations we expect that in coming years there will be enormous number of satellites in space. However, this also increases space debris and risk of collisions. Therefore, the space traffic management should be seriously considered in coming years.

The importance of space situational awareness is increasing and higher technologies are used in both space and ground. For example, in a conflict, satellites may be attempted to be disrupted by using jammers, lasers or other advanced technologies or arms. Therefore, more powerful optical, radar and intelligence systems (electronic/signal intelligence, communication intelligence) will be used commonly in coming years.

Another trend in the space business is returning to the phenomenon of vertical integration, where a company can control their supply chain. Many mass production companies, in particular, have faced long schedules for the delivery of chips during the Covid 19 pandemic. A company can accomplish vertical integration by purchasing or establishing its own suppliers, manufacturers, distributors rather than outsourcing them, thus having predictable and shorter delivery time, more efficient and effective development phase, higher quality and lower risk. Despite the capital initial investment, greater efficiency, lower costs and greater control throughout the production or distribution process may be attained (Hayes, 2022). SpaceX and Blue Origin can be a good example for companies that use vertical integration in their business (SpaceX, 2022; Blue Origin, 2021).

5. CONCLUSION

In 21st century, both threat and security concepts are changed. As technology evolves new threats also emerge, hence nations have to cope with threats in a smarter way and react in shorter time with better precision. It is obvious that space technologies play a key role in ensuring and promoting national security. The use of integrated space based communication/navigation/observation technology and infrastructure will become more common for prediction and early detection of emergencies and alerting populations.

As expected with 5G or higher communication technology the world becomes more connected. Network operators will be able to complement their 5G services with satellite connectivity. The complementarity of the satellite capabilities with terrestrial infrastructure and services will provide more secured and protected nations.

The race among space fairing countries is undeniably growing due to increasing dependence and reliance on space technologies in security perspective but other countries regardless of whether they have internal capabilities also put more endeavours to enhance their space capabilities through international cooperation, technology transfer etc. As of today, it seems that technologies posing threats will continue to evolve and security issues will become more challenging all over the world. Therefore, countries should continue to improve their internal space capabilities as well as international cooperation. States should soon become ready for an agreement on the common security and defence policy to struggle against new space security threats. All nations should agree on the use of space for peaceful purposes in the first place and should develop a common approach to fill existing gaps in international agreements.

Briefly, concrete links among space, security and defence are vital for security of nations. Space technologies will undoubtedly continue to provide enormous opportunities to combat security threats at large scale.

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