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Space Technology
and its Implications on National Security

Introduction:

Space has always been an area for scientific revolution, the effects of which have reflected on both civilian and military life, providing advanced countries with information in all fields. In peacetime, satellites scan the regions of countries, map them, discover natural resources, and monitor weather conditions. They also play a key role in navigation. In the military field, they are used to assess offensive operations, identify and distinguish military targets, and provide information during crises, intelligence gathering, eavesdropping, communications, and more. Additionally, the role of space technology in achieving sustainable development goals has become essential and indispensable in many matters, including but not limited to climate and weather monitoring, access to healthcare and education, water management, transportation and agricultural efficiency, peacekeeping, security, and humanitarian aid. The list of space applications affecting Earth is countless, and many other valuable contributions are still under development and research.

Space exploration operations, which have been successful, have always been linked primarily to a political, military, and technological system. Had it not been for these sovereign motives, the USA, Russia, China, England, France, Japan, and others would not have ventured to send their citizens into space. Despite the fact that the primary driving force for countries to join the international space club is military and technological superiority, we cannot ignore the numerous benefits that have and will continue to return to humanity from uncovering the secrets of Earth and the surrounding world in light of the drastic depletion of natural resources and energy sources. Outer space has become the future; these words sparked a frantic race towards space, especially since space programs take on many missions that far exceed what traditional military tools can accomplish. Therefore, this research will present a study on the impact of space technology on national security.

Research Objective:

To understand the origins and development of space science and technology, as well as study the role of space technology in achieving sustainable development goals. It also aims to study and analyze the impact of space technology on Egyptian national security.

Research Methodology:

This paper primarily relies on:

- **Theoretical approach:** which depends on studying references, scientific books, and credible websites on the international network, and everything related to the subject.

- **Descriptive approach:** to study and classify the modern technologies in the field of space technology and their relationship with achieving sustainable development goals.
- **Inductive approach:** to study the impact of space on Egyptian national security.

First: Conceptual Framework of the Study

1. Definition of Space Science and Technology

A- Space Science [1]: Space science is one of the oldest sciences to have been recognized. It is defined as the study of stars, planets, and space. Space refers to the void between celestial bodies, and the term "outer space" is used to distinguish it from the atmospheric space around Earth. Space can also be defined from a physical perspective as a three-dimensional region in which objects take a relative position and direction. Due to the developments in space science, it has become a science concerned with studying the universe, how it originated, and the possibility of its development. Space science also aims to explain events that arise in the universe and find logical reasons for their occurrence. It relies on analysis and observation. In short, space science is defined as a body of scientific knowledge related to space exploration, which depends on traditional sciences such as physics, chemistry, biology, and engineering, and also requires conducting specific research related to it.

B- Space Technology [2]: Space technology refers to the technology used in outer space, or in space travel (space navigation), or other activities outside Earth's atmosphere, for purposes such as space missions, space exploration, and Earth monitoring. Space technology includes satellites, space stations, and orbital launch vehicles. It also includes communication equipment in deep space, space propulsion technologies, and a wide range of other technologies, including supporting infrastructure equipment and procedures. The space environment is sufficiently unique, as working within it often requires new tools and technologies. It relies heavily on many everyday services used on Earth, such as weather forecasting, remote sensing, satellite navigation systems, satellite television, and some long-range communication systems. Astronomy and Earth sciences benefit from space technology. Often, new technologies emerging from space-related endeavors or accelerated by them are exploited in other economic activities.

2. History of Space Science and Technology

Extensive research in the field of space has led to the establishment of an independent science, known as space science and technology. This field has contributed to the emergence of a new economy associated with the space economy, and new technologies developed in space research are often exploited or accelerated in other economic activities, improving human life on Earth. Space technology is the practical application of scientific and engineering theories and facts in exploring outer space and utilizing its many diverse applications. Space constitutes a new environment that requires new tools and techniques to operate in. Space technology is defined as technology developed by space science or the space industry for use in space flights, satellites, or space exploration. This space technology includes spacecraft, satellites, space stations, supporting infrastructure, equipment, and procedures. The technologies discovered through space research, such as NASA's studies on exploring new horizons for humanity, are now applied in daily activities. To study the history of space technology, we must first understand the history of space science.

A- History of Space Science

Space science, also known historically as astronomy, is one of the oldest and most important sciences known to humanity. Space science has played a fundamental role in human life, with humans relying on space for various aspects of life. Since ancient times, humans have strived to learn astronomy to keep up with the demands of life. Space science began in prehistoric times by tracking the movements of stars and planets in organized cycles. The first thing that intrigued humans was the apparent, recurring motion of the sun and the moon, from which they were able to create calendars to document events in their lives. Space science has rapidly advanced with the use of simple astronomical instruments and the construction of astronomical observatories, which were used to observe various celestial phenomena such as solar eclipses, lunar eclipses, and star observations(3). In the modern era, space science has evolved alongside advancements in modern technology, with astronomers recently using technology, such as software and devices, to travel into outer space and study the universe around us. This includes launching spacecraft controlled from Earth and deploying space observatories to monitor solar phenomena like solar storms that directly affect Earth, giving us time to take necessary precautions before they reach Earth.

B- History of the Development of Space Technology

The first country to launch any technology into space was the Soviet Union, which sent the "Sputnik 1" satellite into orbit on October 4, 1957. Weighing around 83 kg, its mission was to orbit the Earth. After that, the first probe to impact the moon's surface was the Soviet "Luna 2," which landed on September 14, 1959 (4). Then, on October 7, 1959, the Soviet "Luna" probe became the first to photograph the far side of the moon. The first successful human spaceflight, called "Vostok 1," carried Soviet cosmonaut Yuri Gagarin into space in April 1961. The entire mission was controlled either by automatic systems or by ground control. On December 24, 1968, the "Apollo 8" crew, sent by the United States, became the first humans to enter lunar orbit and see the far side of the moon. Later, the United States sent "Apollo 11," landing the first human, Neil Armstrong, on the moon on July 20, 1969, where he walked on its surface. This mission was followed by other missions, including Apollo 12, 14, 15, 16, and 17. Apollo 13 faced a malfunction in its service module but passed around the far side of the moon at an altitude of 254 kilometers above its surface, setting the record for the farthest humans had traveled from Earth in 1970. On November 17, 1970, the first robotic lunar lander, the Soviet "Lunokhod 1," touched down on the moon. The last human to walk on the moon was Eugene Cernan, who did so as part of the Apollo 17 mission in December 1972. Following Apollo 17, many uncrewed interplanetary missions were managed by NASA. One notable interplanetary mission was "Voyager 1," which became the first artificial object to leave the solar system and enter interstellar space on August 25, 2012. It is currently the farthest artificial object from Earth, having crossed the solar boundary at 121 astronomical units and now stands at 145.11 astronomical units (21.708 billion kilometers) from Earth as of January 1, 2019.

3. Space Technology Tools:

There are numerous tools used in space technology, including (5):

A- Rockets

Rockets are used to propel spacecraft, satellites, or any object out of the Earth's atmosphere, defying Earth's gravity. There are various types of rockets, each designed for a specific use (6). Some rockets are single stage, while others are multi-stage, all working to push objects upwards to the desired altitude.

B- Spacecraft

A spacecraft is a capsule containing astronauts, equipment, and supplies necessary for their life. It is usually attached to the top of the rocket, and each spacecraft has its own specific orbit. The term "spacecraft" is generally used to refer to the combination of the rocket and the capsule. Examples include the "Mercury," "Gemini," and "Apollo" spacecraft (7). There are also uncrewed spacecrafts that carry only measurement instruments and observation devices, traveling through space to distant planets without a crew, fully controlled from Earth, such as the "Voyager" and "Galileo" spacecraft.

C- Satellites

Satellites are similar to uncrewed spacecraft, but they do not travel to distant places (8). Instead, they orbit the Earth in specific trajectories. Satellites come in many types and classifications, as follows(9):

• Types of Satellites by Movement:

- Geostationary Satellites: These satellites orbit in synchronization with the Earth, with an orbital period matching the Earth's rotation period. They return to the same position in the sky every 24 hours. The "geostationary satellite" is a special type of satellite that orbits in a fixed geographical position directly above the equator. Another type is the "Tundra Orbit," an elliptical geostationary orbit used by certain satellites.

- Moving Satellites: These satellites orbit the Earth dozens of times in a few hours and appear as small stars moving noticeably across the night sky. They often shine due to reflecting sunlight, and they are equipped with reflective mirrors to make them easier to observe.

• Types of Satellites by Services Provided (According to the International Telecommunication Union):

o Type of Satellite

- Amateur Satellites (AMATEUR-SATELLITE)
- Broadcasting Satellites (BROADCASTING-SATELLITE)
- Earth Exploration Satellites (EARTH EXPLORATION-SATELLITE)
- Fixed Services Satellites (FIXED SERVICES SATELLITE)
- Inter-Satellite Communication Satellites (INTER-SATELLITE)
- Meteorological Satellites (METEOROLOGICAL-SATELLITE)
- Mobile Satellites (MOBILE-SATELLITE)
- Radio Navigation Satellites (RADIO NAVIGATION-SATELLITE)

Types of Satellites Based on Frequency Band Used:

o Frequency Band

- L-Band 1 - 2 Range (GHz)
- S-Band 2 - 4 Range (GHz)
- C-Band 4 - 8 Range (GHz)
- X-Band 8 - 12 Range (GHz)
- Ku-Band 12 - 20 Range (GHz)
- Ka-Band 20 - 40 Range (GHz)

Types of Satellites Based on Orbits Used:

o Orbit Type

- Low Earth Orbit (LEO) Low altitude orbits
- Medium Earth Orbit (MEO) Moderate altitude orbits
- Geostationary Orbit (GEO) Fixed orbit, aligned with Earth's rotation

Types of Satellites Based on Use:

o Satellite Type

- Military Satellites Includes reconnaissance and imaging satellites, and other military uses such as inspection, monitoring, research, and electronic surveillance.
- Communication Satellites Used for communication purposes.
- Nuclear Explosion Detection Satellites Used for detecting nuclear explosions.
- Interception and Destruction Satellites Includes "killer hunter" satellites and orbital bombs for interception and destruction.
- Civilian Satellites for Military Use Civilian satellites that may be repurposed for military purposes.
- Air Navigation Satellites Used for navigation in air traffic.
- Weather Prediction Satellites Meteorological satellites for weather forecasting.
- Orbital Laboratories Laboratories in orbit for research and experiments.

D - Space Shuttle (10):

The space shuttle closely resembles an airplane, but it is launched with the help of some propulsion rockets. However, it returns to Earth after performing its mission and lands on any runway at an airport or airfield without issues, like an airplane. The United States has five generations of space shuttles: Columbia, Challenger, Discovery, Atlantis, Endeavour. After the explosions of both Challenger and Columbia, only three remain [11]. The space shuttle is used for conducting special scientific experiments in various fields that require the absence of Earth's gravitational influence, such as space agriculture, the assembly of certain medicines that do not require gravity, or the production of certain metal alloys that also require the absence of microgravity. The shuttle is also used for launching satellites, as well as funding and building other orbital space stations, transporting astronauts and equipment to and from them.

E - International Space Station (ISS):

The International Space Station (ISS) is a multinational construction project and is the largest single structure ever placed in space by humans. Its main construction was completed between 1998 and 2011, although the station continues to develop with new missions and experiments. It has been continuously operational since November 2, 2000. The ISS is not owned by a single country; it is a "cooperative program" involving Europe, the United States, Russia, Canada, and Japan, according to the European Space Agency (ESA). The operating cost of the ISS is about $3 billion annually for NASA, which is nearly a third of the human spaceflight budget, according to the agency's Inspector General (12).

Second: The Impact of the Study on National Security Areas:

1-The Role of Space Technology in the Civilian Sector and Achieving Sustainable Development Goals

Space is used to achieve sustainable development as it positively contributes to various fields, including climate and weather monitoring, healthcare and education access, water management, transportation efficiency, agriculture, peacekeeping, security, and humanitarian assistance. The list of space applications positively impacting Earth is nearly endless, and many other valuable contributions are under development or research. By adopting the three main international frameworks in 2015 for the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction 2015-2030 (13), and the Paris Agreement on Climate Change, the international community committed to addressing the greatest challenges threatening our era. Space technologies are playing an increasing role in accelerating these commitments. The use of outer space not only promises humanity but also contributes to improving "life on Earth" for all living creatures through monitoring ecosystems, protecting wildlife, and raising awareness about addressing forest and desertification issues to conserve natural resources and halt biodiversity loss.

Since the dawn of the space age, effective international cooperation has been essential to ensure the safe, secure, and sustainable use of space. Space governance, described as the most expansive global commons for humanity, is becoming increasingly mature due to the growing number of governmental and non-governmental actors, as well as new technologies and approaches like public-private partnerships and private funding initiatives. In addition to providing direct services that all serve sustainable development goals, such as:

A - Television Broadcasting, Radio, and Communications:

A quarter of satellites are dedicated to television and communications services. Over sixty years ago, the United States started the first satellite broadcast, followed by Europe ten years later. Today, more than half of TV viewers rely on a dish on their rooftops to watch their favorite channels. In the late 1950s and early 1960s, the technology through which signals were received from Earth by a satellite and relayed to another ground station was announced. In 1962, American Telephone and Telegraph Company, at the request of NASA, launched the first communication satellite "Telstar" (14). The original use of communication satellites was to transmit voice, video, and data from a relatively large antenna to a distant second antenna, with the communication being distributed via terrestrial networks.

B - Positioning, Navigation, and Timing (15):

In 1957, scientists tracking the first satellite "Sputnik 1" discovered that they could precisely plot the satellite's orbit by analyzing the Doppler effect on its transmitted signals relative to a fixed location on Earth (16). They realized that if the orbits of many satellites were known precisely, it would be possible to determine positions on Earth using information from those satellites. The importance of locating submarines carrying ballistic missiles led both the United States and the Soviet Union to develop satellite-based navigation systems. In the 1960s and early 1970s, although these systems did not provide highly accurate information and were difficult to use, both countries developed second-generation systems: The U.S. GPS "Navstar" and the Soviet Union's GLONASS satellite navigation system. These systems were originally intended for military activities but continued to operate under military control while serving various civilian uses. The U.S. GPS system is now a global tool offered free of charge to all users, with the U.S. government committed to maintaining and upgrading it indefinitely. In the late 1990s, Europe began developing its own satellite navigation system, Galileo, which began operating under civilian control in 2016.

C-Protection of Ecosystems:

Space technology is used to protect and enhance the sustainable use of terrestrial ecosystems, sustainably manage forests, prevent and reverse land degradation, combat desertification successfully, reduce deteriorated natural sites, and end biodiversity loss. Space technologies can be used for the following:

- Monitoring the geophysical biological surface of the Earth.
- Monitoring terrestrial biodiversity.
- Monitoring illegal hunting and identifying smuggling methods.
- The Global Navigation Satellite System (GNSS) has been widely adopted to track animals.

Understanding animal movement is vital for biodiversity research, predicting hotspots to take necessary measures, identifying human-animal conflict areas, rebuilding and preserving fish stocks and productive ecosystems, and understanding the spread of diseases and invasive species.

D- Meteorology [17]:

Predicting the weather is not easy, and it often feels inaccurate. Despite some mocking of these predictions, their accuracy has improved fifteenfold since the use of satellites for this purpose. It has now become possible to predict the weather for up to two weeks. Meteorologists initially believed that satellites would primarily be used to monitor cloud patterns and provide warnings of impending storms. They did not expect space observations to be essential for improving weather forecasting overall. As satellite technology became more sophisticated, satellites were called upon to provide three-dimensional features of additional atmospheric variables, including temperature, humidity, and wind speed. These data have become important for modern weather forecasting. Many countries' defense ministries have developed similar satellites for military use aimed at taking various measures to address climate change and its impact on the country. Space technologies play a central role in climate change monitoring, weather forecasting, disaster management, search, and rescue operations. In response to climate change challenges, the United Nations Office for Outer Space Affairs (UNOOSA), in cooperation with key space, Earth observation, civil protection, and regional and international organizations, launched the Global Partnership Using Space Technology Applications for Disaster Risk Reduction (GP-STAR) [18]. GP-STAR aims to promote the adoption of space technology applications, including Earth observation, global navigation systems, and satellite communications to reduce disaster risks according to the Sendai Framework for Disaster Risk Reduction 2015-2030, by enhancing existing mechanisms and expanding the use of Earth observation technologies and related space technologies at all levels, thereby contributing to better-integrated and wider use of these technologies in disaster risk reduction worldwide.

E-Scientific Research:

Space technology plays a significant role in advancing scientific research, providing an opportunity to conduct studies and uncover the mysteries of the universe that would have been impossible to reveal through traditional methods. For example, missions such as measuring Earth's gravity, the height of mountains, or sea level are simple tasks carried out by satellites, analyzed by specialized space technology systems. Moreover, space technologies have enabled humanity to observe distant places in the universe and monitor stars and the Sun. Significant scientific research is also conducted in areas related to space science and technology, such as those carried out at the International Space Station.

F- Space Mining:

Resources available on the Moon and other bodies in the solar system, especially asteroids, represent additional potential targets for commercial development. The value of the mineral wealth in the asteroid belt between Mars and Jupiter is estimated to be worth hundreds of billions for individuals on Earth (19).

G-Establishing Sustainable Cities and Communities:

Cities are hubs of ideas, commerce, culture, science, productivity, and social development, which has enabled people to progress socially and economically. As such, there are many challenges to maintaining cities in a way that continues to create job opportunities and prosperity without overburdening land and resources. Space technologies are used for the following (20):

- Urban planning to determine structures and reference points for spatial and urban planning purposes.
- Smart cities, through the application of global navigation satellite systems, Earth observation, and satellite communications.
- Improving city services, such as smart waste management systems.
- Monitoring air quality.
- Disaster management.
- Monitoring infrastructure.
- Search and rescue operations.
- Satellite data helps support and plan human migration and movement, either in human migration between different regions of the world or within urban centers, and aids in planning for disasters and emergency response.

H-Commercial Space Transport:

The boom in the space communications sector has led the private sector to be willing to pay significant amounts to launch their satellites. Initially, satellites were launched into space aboard vehicles managed by the U.S. government. When the space shuttle was launched in 1982, it was the only American launch vehicle providing such services (21). However, after the Space Shuttle Challenger explosion in 1986, the shuttle was prevented from launching commercial payloads, which created an opportunity for the private sector in the U.S. to use existing launch vehicles such as Delta, Atlas, and Titan as commercial space transporters. The U.S. commercial space transport industry emerged in the 1990s, and now Space Exploration Technologies (SpaceX) has entered the market, offering launch services using the Falcon 9 rocket to clients worldwide. In 2008, NASA contracted with SpaceX commercially to deliver cargo to the International Space Station (ISS) instead of managing these launches themselves. In 2010, this approach was expanded to include transporting astronauts to the space station. The first commercial cargo delivery agreement to the ISS was made in May 2012, with the SpaceX Dragon capsule; operational cargo flights began later that year, and commercial crewed missions to orbit began in 2020.

2-The Impact of Space Technology on National Security

In an era where the final frontiers are the next boundaries of global military dynamics, the strategic importance of space technologies to national security and defense cannot be overstated. As nations increasingly rely on space to enhance their military and strategic capabilities, those nations that fail to adopt space technologies find themselves facing multifaceted risks. Therefore, there are several significant risks and vulnerabilities that countries face when neglecting to develop space technologies and integrate them into their security and defense frameworks, such as the following examples:

A- Strategic Deprivation and Global Isolation

One of the most urgent and dangerous consequences of not benefiting from space technologies is the strategic disadvantage that results on the global stage. For example, space capabilities such as satellite communications, reconnaissance, and missile warning systems offer unparalleled advantages in terms of information dominance, situational awareness, and global access. Without these capabilities, nations are not only blind to the activities of potential adversaries, but also to global crisis dynamics that could affect national security. This strategic disadvantage extends to diplomatic isolation. As alliances and partnerships increasingly rely on shared space capabilities and data, nations that lack space technologies find themselves excluded from important security alliances and discussions. This isolation undermines their ability to influence international security policies and participate in collective defense mechanisms, making them vulnerable to coercion and external threats.

B- Increased Exposure to Attacks

The absence of space assets significantly increases any country's exposure to both conventional and asymmetric threats. Satellite imagery and signals intelligence play critical roles in early warning systems, detecting and tracking missile launches, troop movements, and other potential threats. Without these capabilities, nations are at a disadvantage in identifying and proactively countering threats to their security. Moreover, reliance on terrestrial communication and navigation systems, which are more susceptible to disruption and attack, can cripple military operations and critical infrastructure. In contrast, space technologies offer flexible alternatives that can operate even when terrestrial networks are compromised.

C- Dependency and Threatened Sovereignty

Countries that do not develop their space capabilities often find themselves dependent on other nations or commercial entities for critical information and services. This dependency can harm national sovereignty, as access to data and services may be restricted by the geopolitical interests of the service provider. Moreover, this dependence exposes nations to the risks of espionage and manipulation, as control over the flow of information and its integrity remains in the hands of external parties.

D- Economic and Technological Stagnation

Neglecting space technologies not only affects military and strategic capabilities but also hinders economic and technological development. The space industry drives innovation across many sectors, including communications, navigation, and Earth observation, contributing significantly to national economies. Failing to invest in space technologies means missing out on the benefits of this high-growth sector, including job creation, technological advancement, and economic diversification.

E- Military Use of Space Technology

Since the dawn of history, humans have fought and struggled across all geographical terrains, from plains, valleys, and mountains, to all bodies of water such as seas, oceans, and rivers, and in their depths using submarines armed with torpedoes. Even the space between the Earth and the sky has been exploited for combat and bloodshed, using kites and balloons in ancient history, and relying on fighter jets and bombers from World War I until today. Finally, far from Earth's gravity and outside the atmosphere itself, outer space has become a theater for an accelerating arms race, heralding an anticipated space war. This has led to the emergence of the term "Space Militarization," which has its roots in the early Cold War of the 1940s. This field is concerned with the development of weapons and technologies for military purposes in outer space. Perhaps the most famous example of these technologies is the Global Positioning System (GPS), which, before being allowed for civilian use, was strictly reserved for military purposes, such as accurately pinpointing targets for bombing with smart bombs, cruise missiles, and enhancing the control and command of ground forces in operational theaters.

As a result of the immense military importance of satellite-based positioning systems, and U.S. control over them, many nations hastened to establish and launch similar systems, such as Russia, which currently has a completely independent system called "GLONASS," China, which has a similar system called "BeiDou," and even European Union countries, which now have their own system called "Galileo." The scope does not permit a detailed explanation of the existing or planned military space uses, but among them are: secure military communications, enemy reconnaissance satellites, precise mapping satellites, electronic jamming, and others. In general, the weapons intended for use in future space wars or perhaps those already deployed can be divided into three main categories:

First: Earth-to-space missiles, which will be launched from ground bases to destroy enemy satellites used for espionage or for target location and control of ground troop movements.

Second: Space-to-Earth missiles, which will be launched from satellites to destroy enemy forces on Earth, similar to bombers and cruise missiles, and in this case, the missile bases will be outside the gravity field. Some major military powers are seeking to use high-powered lasers to achieve the same goal.

Third: Space-to-space missiles, which will be launched from satellites, targeting enemy satellites.

1) Applications of Space Technology in the Military Field:

Space technology is used in several digital communication applications in the military field worldwide, such as:

• Global Positioning System (GPS)

The system is used in navigation applications and location determination for land, sea, and air forces, as well as in fire control systems for artillery and ballistic missiles, providing location, observation, navigation, and meteorological information.

• Automatic Vehicle Locating (AVL) [22]

The system is based on equipping vehicles with tracking units that determine the vehicle's location and plot its route. The system relies on the Global Positioning System (GPS). Information about the vehicle's movement is sent from the tracking unit to the AVL control center either in real-time (On-Line) or after gathering the data (Off-Line). The AVL system then analyzes and compares the actual route with the planned route and generates detailed reports on the vehicle's status, including stop durations, travel times, speed, number of passengers, door openings, and other detailed information.

• Global Hospital and Medical Center Connectivity System

The system is limited to medical consultation, enabling the exchange of expertise between doctors and their involvement in complex surgical operations through videoconferences. It also facilitates the transfer of medical information for educational purposes.

• Very-Small-Aperture Terminal (VSAT)[23]

The VSAT system complements military digital communication systems and serves as an alternative in case of threats and active adversities. It offers several advantages, including extensive coverage without being affected by geographical conditions, flexibility in network configuration, and the easy and quick establishment of new VSAT stations within the service area. It enables rapid and straightforward communication over long distances without restrictions and facilitates the addition of more subscribers and channel capacity adjustments.

• Espionage

Satellites monitor the Earth in real-time. The resolution and clarity of satellite images reach ten centimeters per pixel, allowing satellites to photograph military targets, monitor compliance with arms control and disarmament treaties.

• Warfare

A war can also be fought in space. The U.S. and Russia are actively working to equip their satellites with missiles. Despite the denials from both governments, the day when satellites carry intercontinental ballistic missiles is approaching. Many countries are also developing anti-satellite missiles and using satellite-guided munitions.

• Early Warning

Early warning satellites detect intercontinental missiles such as ballistic missiles and submarine-launched missiles, which need several minutes to reach and strike their targets. Therefore, there is a growing need to detect and assess nuclear attacks as quickly as possible, as well as estimate the damage caused by air or nuclear bombings.

• Electronic Reconnaissance

Used to identify air defense positions, defensive missile radars of adversary countries, eavesdrop on enemy military communications, secure long-range encrypted wireless communications between command centers and field unit leaders in operational theaters.

Third: Study Results / Proposed Response

1. There are several trends driving the increasing importance of space for national security:

A. Increasing Militarization of Space:

China, Russia, and other competitors are striving to acquire space weapons to counter U.S. space systems, such as anti-satellite missiles (ASAT), lasers, jamming devices, and cyber weapons. Both China and Russia have demonstrated anti-satellite weapons and have formed military space forces in recent years. The U.S. responds by enhancing space resilience and developing offensive space control capabilities.

B. Expansion of Space Powers and Capabilities:

Dozens of countries and commercial companies now possess local space capabilities. More than 70 countries own or operate satellites. The reduced costs and the advent of small satellites allow more players to access space, creating a more crowded and competitive space environment with increased risks of collisions, radio frequency interference, and potential hostilities.

C. Emergence of New Space Applications:

Advancements in small satellites, in-orbit services, and lunar space exploration are creating new opportunities for space activities. However, dual-use technologies, such as rendezvous and proximity operations, can also serve military purposes. As human activities expand to the Moon and beyond, space will become even more strategically important.

D. Increasing Dependence on Space Infrastructure:

Military, governmental, and commercial sectors heavily rely on space systems for critical missions. The ability of the U.S. military to project global power depends on space support. Satellites enable global communications, financial transactions, transportation, emergency response, and more. Loss of access to space would cause tremendous disruptions.

2. Mitigating Risks Through Global Cooperation and Policy Reform

To mitigate space-related risks, countries need to adopt comprehensive space policies focused on developing local space capabilities and establishing international partnerships. Cooperation with other nations and participation in multinational space projects can provide a path to acquire space capabilities without the expensive costs of independent development. Moreover, international rules and agreements play a crucial role in ensuring that space remains a safe and sustainable environment for all. By engaging in diplomatic efforts to promote responsible behavior in space, countries can contribute to global stability and security while developing their space capabilities.

As the pace of the space arms race accelerates, some treaties aim to slow it down or at least limit it, such as the Outer Space Treaty, which prevents signatories from placing nuclear weapons or other weapons of mass destruction in Earth's orbits, outer space, or on the Moon and other celestial bodies. This treaty has been ratified by 98 countries, including the United States, Russia, and the United Kingdom, with 27 other countries signing it without ratification. While this treaty only prevents the placement of nuclear weapons and weapons of mass destruction in space, it does not prohibit the militarization of outer space relying on other conventional weapons.

3-Steps of Egypt in Acquiring Space Technology for Development

Egypt has had a dream to establish its interest in space sciences through the "Egyptian Space Program" since 1960, but it stopped in 1967 due to the setback. After that, Egypt became a pioneer in the Arab world in the field of space by launching the Egyptian satellite "NileSat 1" in April 1998. This was the first tangible step into the world of satellite technology and cooperation with friendly countries such as Ukraine, Kazakhstan, and Russia to train Egyptian cadres. The first Egyptian satellite, "NileSat 101," was launched on April 28, 1998, making Egypt the 60th country to enter the space field. Then, the "NileSat 102" satellite was launched on August 17, 2000, and officially began operating on September 12, 2000, for telecommunications purposes on the "Ariane 4" rocket from the French Guiana spaceport to transmit hundreds of television channels. Egypt's space activities continued but without a clear plan or law regulating the sector. In 2004, the "NileSat 103" satellite was launched, an Egyptian communications satellite, also known as "Atlantic Bird 4." Then, the "EgyptSat 1," Egypt's first remote sensing satellite (currently out of service), was launched. The satellite was developed in cooperation with the Egyptian National Authority for Remote Sensing and Space Sciences and the Ukrainian Yuzhnoye Design Office. It was launched on April 17, 2007, aboard a "Dnepr-1" rocket from the Baikonur Cosmodrome in Kazakhstan. Communication was lost on October 22, 2010, and it was replaced by "EgyptSat 2." Since 2014, Egypt's political leadership has provided unprecedented attention and support to space technology as one of the promising sectors for future industries. For instance, the Egyptian state has done the following:

A. The Egyptian Space Agency was established as a public economic body with legal personality under the presidency of the Republic, pursuant to Law No. 3 of 2018. The decision to establish the Egyptian Space Agency was aimed at realizing the dream of Egyptian scientists working in this field, which had often faced setbacks. The Egyptian People's Assembly and a group of specialized ministers had approved its implementation back in 2001, but it had not materialized. The goal of the Egyptian Space Agency, built on approximately 123 acres in the New Administrative Capital, is to create, transfer, localize, and develop space technology and to acquire the capabilities for manufacturing and launching satellites from Egyptian territory.

B. In February 2019, the Egyptian satellite "EgyptSat A" was launched from the Russian Baikonur launch site to support scientific research, remote sensing, and various fields of sustainable development in the country, including (agriculture, mining, urban planning, and the environment), as well as monitoring natural hazards such as (desertification, sand dune movement, and floods).

C. Three "CubeSat" satellites were launched, designed and manufactured entirely without foreign expertise, contributing to the development of local space technology.

D. As a result of Egypt's scientific and technical efforts in this field, Egypt was chosen to host the headquarters of the African Space Agency, demonstrating Egypt's ability to use the agency to serve the continent in the fields of remote sensing and space sciences, and to advance national and regional African development efforts, in line with Africa's Agenda 2063.

E. The Egyptian Space Agency opened a satellite and space debris tracking station affiliated with the National Institute for Astronomical and Geophysical Research. This station is responsible for tracking the movement of satellites in various orbits and monitoring space debris that could affect satellite operations.

F. In 2023, the Egyptian Space Agency announced the completion of the integration, assembly, and testing center at the agency, the largest of its kind in Africa and the Middle East. It was established as part of the strategic partnership between Egypt and China.

G. On December 2, 2023, the Egyptian Space Agency announced the successful launch of the "MisrSat 2" satellite from China. The satellite was assembled and tested at this center and is a significant project implemented with Chinese grant funding, amounting to 92 million dollars. The project was part of a strategic partnership agreement signed in 2014, marking a new phase in Egyptian-Chinese cooperation.

H. Egypt is the first country to implement satellite cooperation with China as part of the joint development of the "Belt and Road Initiative." In December 2014, Egypt and

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China signed a cooperation agreement for remote sensing satellites, and in January 2019, they signed an agreement for the "MisrSat 2" satellite. The "MisrSat 2" satellite serves Egypt's sustainable development goals by using space technology in critical areas, such as agriculture, mineral exploration, surface water resources identification, and studying the impacts of climate change on the environment. This contributes to supporting Egypt's economy and strengthening its leadership role by providing training programs for specialized personnel in Africa and the Middle East and supplying them with satellite data.

I. Egypt is currently preparing to launch the "NexSat 1" satellite by the end of this year from China, as announced by the Egyptian Space Agency. It is the first experimental remote sensing satellite developed in collaboration with the German company (BST), representing a significant achievement in localizing satellite manufacturing technology in Egypt.

This illustrates Egypt's awareness of the importance of space technology and its continuous efforts to develop this sector to join the ranks of advanced nations and achieve not only societal welfare but also national security.

Conclusion:

Space has become an integral part of modern warfare and the global economy. With the growing competition among major powers in this field, Egypt and all Arab nations must take urgent actions to secure their vital interests and enhance stability in space. This will require substantial investments, policy innovation, and international collaboration in the coming years. Ultimately, the goal should be a sustainable, peaceful, and open space environment that benefits all humanity. However, achieving this future first requires Arab countries to robustly defend their national security against increasing threats in space today.

Countries and organizations with military forces deployed abroad have realized the significant benefits of space systems in military operations. They have developed their military space systems to enhance the effectiveness of their land, air, and naval forces.

The space sector is increasingly recognized as a crucial arena for national security and global stability. As such, failing to adopt space technologies poses significant risks, ranging from strategic deficiencies and global isolation to increasing vulnerabilities and economic stagnation. In facing these challenges, countries must balance the development of local capabilities with active participation in international cooperation and space management. The future of national security is closely linked to space, and countries will not be able to ensure their security, prosperity, and status in the international community without recognizing the inevitability of space technologies and acting accordingly.

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Space Technology and its Implications on National Security

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Abstract:

With the launch of the first artificial satellite into space, for more than seventy years, the space arena witnessed a huge technological leap, which made the Earth a small space in which a person could move between its limbs in minutes through a screen displaying information from satellites floating in space and covering all activities throughout the Earth. Modern space science arose with scientists looking to fly spacecraft beyond Earth's gravity to continue discovering the secrets of the universe. Space has also become a critical area of national security. For some time now, many major countries have been accelerating to militarize space, as major powers view it as a battlefield and are developing advanced space capabilities. At the same time, the world has become increasingly dependent on space systems for military, civilian, and commercial missions, creating new vulnerabilities. As a result of the great benefits that space technology brings to the countries that possess it, as well as the great risks of this technology to national security, losing access to space capabilities would lead to a severe deterioration in the state's ability to project power and defend its interests. In this research, the definition of science, technology, history of space technology science, and space technology tools will be reviewed, and we will present a study on the role of space technology in the civil sector and in achieving sustainable development goals and its impact on national security.

Keywords: technology - space - national security - the fourth industrial revolution

تكنولوجيا الفضاء وانعكاساتها على الأمن القومى

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المستخلص :

مع إطلاق أول قمر اصطناعى للفضاء وعلى مدى أكثر من سبعين عامًا، شهدت الساحة الفضائية قفزة تكنولوجية هائلة، جعلت من الكرة الأرضية حيزًا صغيرًا ينتقل الإنسان بين أطرافه فى دقائق من خلال شاشة عرض لمعلومات الأقمار الاصطناعية التى تسبح فى الفضاء وتغطى جميع الأنشطة فى أنحاء الكرة الأرضية. لقد نشأت علوم الفضاء الحديثة مع تطلع العلماءِ إلى التحليق بمركبات الفضاء خارج نطاق الغلاف الجوى لاستكمال اكتشاف أسرار الكون. كذلك أصبح الفضاء مجالا بالغ الأهمية لِلأمن القومى. ومنذ فترة تتسارع العديد من الدول الكبرى لعسكرة الفضاء، حيث تنظر القوى الكبرى باعتباره مجالا للقتال، وتقوم بتطوير قدرات فضائية متقدمة. وفى الوقت نفسه، أصبح العالم يعتمد بشكل كبير على الأنظمة الفضائية فى المهام العسكرية والمدنية والتجارية، مما أدى إلى إيجاد نقاط ضعف جديدة. ونتيجة للفوائد الجمة التى تجلبها تكنولوجيا الفضاء للدول التى تمتلكها، وكذلك مخاطر هذه التكنولوجيا الكبيرة على الأمن القومى، فإن فقدان القدرة على الوصول إلى القدرات الفضائية من شأنه أن يؤدى إلى تدهور شديد فى قدرة الدولة على إظهار القوة والدفاع عن مصالحها. فى هذا البحث سيتم استعراض التالى: تعريف علوم وتكنولوجيا وتاريخ علوم تكنولوجيا الفضاء، وأدوات تكنولوجيا الفضاء، وسوف نقدم دراسة عن دور تكنولوجيا الفضاء فى القطاع المدنى وفى تحقيق أهداف التنمية المستدامة وتأثيرها على الأمن القومى.

الكلمات المفتاحية : تكنولوجيا، الفضاء، الأمن القومى، الثورة الصناعية الرابعة.