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Research on the development of artificial satellites

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Abstract. This paper aims to systematically explore the development history, current situation, and future trends of artificial satellites, and to comprehensively analyze the important role of artificial satellites in national science and technology, national defense, and economic construction. Firstly, the paper outlines the extensive applications of artificial satellites as an important component of modern aerospace technology in fields such as communication, navigation, meteorology, and earth observation, as well as their significant importance for national security and economic development. Secondly, this paper adopts the research methods of literature review and case analysis to systematically study the latest progress and achievements in artificial satellite technology in various countries around the world and deeply analyzes the key technological breakthroughs and current development status of China in remote sensing, navigation, communication and other fields. Finally, through an in-depth analysis of the development trends and challenges faced by artificial satellite technology, combined with the current development status of China's aerospace industry, strategies and suggestions for the future development of artificial satellite technology in China are proposed. This study can provide theoretical support for the research and application of artificial satellite technology in China, and help promote the sustained and healthy development of China's aerospace industry.

Keywords: Artificial satellites; Aviation; Space technology

1. Introduction

Man-made satellite is one of the important tools for human beings to explore and use space and are an important part of modern space technology. Since the Soviet Union successfully launched the first artificial satellite in 1957, the artificial satellite has become an important part of national science and technology and national defense construction, and its application scope has gradually expanded, including communication, navigation, meteorology, earth observation, space science research and other fields [1]. With the successful implementation of China's "two bombs and one satellite" and "manned spaceflight project", China has become a big country with independent launch capability and has made important progress in the fields of remote sensing, navigation, and communication. In the future, China will continue to strengthen the research development, and application of artificial satellite technology and constantly promote the development of China's space industry. This paper aims to systematically discuss the development course, present situation and future of artificial satellite, analyze its important role in national science and technology, national defense and economic construction, discuss its future development trend and challenges, and provide reference for the research and development and application of artificial satellite technology in China.

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2. Overview of artificial satellites

2.1. The composition of artificial satellites

A satellite is an artificial object designed, manufactured, and launched by human beings into the orbit of the earth or other celestial bodies. The structure includes a shell, bracket, and protective cover, which are used to protect the internal equipment of the satellite from the space environment [2]. The power system includes solar cells, battery packs, and other components, which are used to provide needed power for satellites. Communication equipment includes antenna, transceiver, modem, and other components, which are used for communication between satellites, and ground stations or other satellites [3]. The control system includes attitude control equipment, thrusters, and sensors, which are used to control the movement and position of the satellite. The load includes various scientific instruments, monitoring equipment, and communication equipment, etc., which are used to achieve the specific mission objectives of the satellite. The thermal control system includes a radiator, temperature sensor, and heater, which are used to control the internal temperature of the satellite to ensure the normal operation of the equipment [4]. The navigation system includes the Global position system (GPS), constellation positioning, and other components, which are used for satellite navigation and positioning. Logistics and safety system includes memory, backup system, early warning system, and other components to ensure the efficient and safe operation of satellites [5]. Satellites play a vital role in human society. They can provide support and services for communication, positioning, navigation, weather forecasting, resource management and scientific research, and promote the development, and progress of human society. With the continuous development of satellite technology, artificial satellites will broaden their application fields and bring more welfare and development opportunities to human society [6].

2.2. Operation of artificial satellites

Satellites first need to be launched by vehicles such as rockets, or space shuttles. After launch, satellites usually enter various orbits such as low earth orbit (LEO), medium earth orbit (MEO) or high earth orbit (GEO). Once in orbit, the satellite will continue to run along its predetermined orbit. The choice of orbit depends on the mission requirements and application fields of the satellite. For example, communication satellites are usually located in high earth orbit to achieve global communication coverage [7]. In order to maintain stable operation and correct positioning, satellites need attitude control. This includes using devices such as thrusters or reaction wheels to adjust the speed and direction of satellites and using sensors such as gyroscopes to measure and correct attitudes. Satellites are usually equipped with communication equipment for receiving, processing, and sending data. Through communication links with ground stations or other satellites, satellites can transmit information such as data, images, and sounds [8].

Satellites use solar panels to collect sunlight and convert it into electricity for satellite operation. Some satellites also use battery packs to store electric energy to maintain satellite operation at night or on cloudy days. Every satellite has its life expectancy. After a period of operation, the satellite may be terminated due to power exhaustion, component failure, or mission end. The termination methods include controlling re-entry into the atmosphere and burning, pushing it to a safe cosmic cemetery orbit, or moving it out of orbit away from the earth. Generally speaking, artificial satellites need to go through launch, orbit operation, attitude control, communication and data transmission, and power supply to achieve their design goals and provide various services for human society [9].

3. Trajectory of artificial satellite

3.1. Kepler's law

Kepler's law is the basic law describing the motion of planets and artificial satellites. It was put forward by the German astronomer Kepler in the late 16th century and early 17th century and is regarded as the foundation stone of modern astronomy.

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The first rule of Kepler's law stipulates that planets and artificial satellites orbit the sun or other celestial bodies along an elliptical orbit, in which the sun is located at a focal point of the ellipse.

The second law of Kepler stipulates that the speed of planets and satellites in their elliptical orbits is constantly changing. In places far from the sun, the speed is slow; When approaching the sun, the speed will increase [10].

The third law of Kepler stipulates that the square of the period of revolution of planets and satellites is directly proportional to the cube of their average distance from the sun. This proportional constant is called the Kepler constant.

According to Kepler's law, satellites are usually placed in elliptical orbits around the earth. By adjusting the speed and direction of the satellite, it can maintain the required orbital inclination and altitude. There are three common satellite orbits, LEO is between 200-2000 kilometers, and the period is about 90-120 minutes. This kind of orbit is usually used in meteorological forecast, scientific research, earth observation, and military investigations. MEO is between 2000 and 35786 kilometers, and the period is about 6-24 hours. This kind of orbit is usually used in GPS and other navigation satellites. The altitude of GEO is above 35,786 kilometers, and the period is about 24 hours. This kind of orbit is usually used for communication satellites because they can maintain a relatively static position to ensure a stable communication coverage.

3.2. Types of artificial satellites

Satellites can be divided into many types according to their functions and tasks. The following are the common types of artificial satellites.

3.2.1. Communication satellites. Communication satellites are used to provide global telephone, television, Internet, and data transmission services. Communication satellites are usually located in geosynchronous orbit (GEO) to maintain a relatively static position. Communication satellites are mainly used to provide global communication services, including telephone, TV broadcasting, Internet access, and data transmission. These satellites are usually deployed in GEO also known as Geostationary Orbit. Geosynchronous orbit is located on the equatorial plane, with a height of about 35,786 kilometers. Satellites orbit the earth along the same rotation period of the earth, keeping its position relative to the ground unchanged, thus achieving stable communication coverage. One of the advantages of geosynchronous orbit is that the satellite can be fixed in a fixed position relative to the ground without frequent orientation adjustment. In this way, users can communicate with the satellite on the ground only by using the antenna with a fixed orientation, and there is no need to adjust the orientation frequently. At the same time, geosynchronous orbit satellites have a wide coverage, and can provide continuous communication services. However, the geosynchronous orbit also has some limitations. Because of the high orbit height, the delay of signal transmission is be obvious, and it takes about 0.25 seconds to transmit the signal from the earth to the satellite and back again, which may have an impact on some applications with high real-time requirements. In addition, geosynchronous orbit resources are limited and can only accommodate a limited number of satellites, so there is competition for spectrum resources.

3.2.2. Meteorological satellites. Meteorological satellites are used to collect and transmit earth meteorological information, including cloud pictures, temperature, precipitation, and other data, in order to support meteorological forecasts and research. Meteorological satellites are usually in LEO or polar orbit. A meteorological satellite is a satellite used to collect and transmit the earth's meteorological information, so as to help weather prediction, research, and weather disasters. Images taken by meteorological satellites include cloud images of the earth's surface, ocean, land, and atmospheric components. These images help meteorologists understand weather patterns and climate change, and predict future weather conditions. Usually, meteorological satellites are deployed in LEO or polar orbit to obtain images with the highest resolution (such as 1 km) as possible. Meteorological satellites in low earth orbit need to rotate around the earth at a relatively high speed on a regular basis in order to cover

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different regions of the world. Meteorological satellites in polar orbit can also provide global meteorological data, and can also provide higher resolution data for medium and long-distance meteorological events. The data and images provided by meteorological satellites can help weather forecasters to monitor global meteorological phenomena in real time, improve the accuracy and accuracy of weather forecasting, and have an important impact on people's lives and property safety.

3.2.3. Navigation satellites. Navigation satellites are generally distributed in MEO, forming a satellite network covering the whole world. Navigation satellites provide accurate positioning and navigation services on a global scale. GPS is a very famous navigation satellite system, which is maintained and managed by the US Air Force. A navigation satellite system is usually composed of multiple satellites, which help users to determine the position of the receiver and provide direction and speed information by transmitting signals and receiving signals from the receiver. By connecting multiple satellites simultaneously, the navigation system can provide more accurate positioning and navigation services. At present, GPS navigation technology is widely used around the world, from automobile navigation and logistics transportation to unmanned aerial vehicles and maritime navigation, etc., all of which make use of the precise positioning and navigation services provided by navigation satellite systems. In the future, with the continuous development of technology, the application prospect of navigation satellite systems in traffic, safety, and other fields is still very broad.

3.2.4. Earth observation satellites. Earth observation satellites include optical remote sensing satellites, synthetic aperture radar satellites, etc. They are usually located in LEO. Earth observation satellite is a satellite system used to monitor and study changes in the earth's surface, climate change, environmental pollution, and natural disasters. Optical remote sensing satellites can capture visible light, infrared light, and other electromagnetic radiation on the earth's surface by carrying optical sensors, such as cameras or imaging spectrometers. These satellites can provide high-resolution images to help scientists observe and monitor the characteristics of the surface, land use changes, vegetation growth, urban expansion, and so on. In addition, they can also be used to monitor the changes in ocean surface temperature, marine ecosystem, and atmospheric composition. Synthetic aperture radar satellites use radar technology to transmit microwave signals and receive signals reflected from the surface. This technology can be used for surface observation during day and night, under the cover of clouds and smoke. Synthetic aperture radar satellite plays an important role in measuring surface elevation, surface deformation, glacier movement, forest cover, and crustal activity. They can also be used to monitor the occurrence and evolution of natural disasters such as floods, earthquakes, volcanic activities, and ocean eddies.

4. Comparison of artificial satellites

A man-made satellite is a device that human beings launch into space in order to achieve different goals. There are differences in their functions, orbital types, application technologies, quantity and layout, launching and deployment methods, life span and renewal period, etc.

According to their different functions, artificial satellites can be divided into communication satellites, navigation satellites, earth observation satellites and scientific research satellites. Communication satellites are used to provide global communication services, navigation satellites are used for positioning and navigation, earth observation satellites are used to monitor changes in the earth's surface, and scientific research satellites are used to carry out various scientific experiments and explorations. According to different orbital heights and inclinations, satellites can be divided into GEO, LEO, MEO, PO and so on. Geosynchronous orbit satellites maintain synchronization with the earth's rotation speed above a fixed position, while low-earth orbit satellites orbit around the lower altitude of the earth.

Number and layout: Different countries or organizations may have different numbers and layouts of artificial satellites. For example, the GPS is composed of multiple satellites, forming a satellite network to provide accurate positioning and navigation services.

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Launching and deployment mode: Satellites are launched into space by rockets, and can also be deployed by the space shuttle or the International Space Station. The launch and deployment method depends on the type and requirements of the satellite.

Life span and renewal period: The life span of an artificial satellite varies with its design, operating environment and mode of use. Some satellites are designed for long-term operation, while others need to be replaced and updated regularly.

These are just some key summaries in the comparison of artificial satellites. Different types of satellites play an important role in different fields and provide a wide range of services and support for human society.

5. Conclusion

This paper mainly studies the important role of artificial satellite technology in national science and technology, national defense, and economic construction, as well as the latest progress and development status of countries around the world in this field.

Through a comprehensive analysis of relevant literature and cases, it can be concluded that artificial satellite technology has broad application value in fields such as communication, navigation, meteorology, and earth observation, and plays an important role in national security and economic development. The competition in artificial satellite technology among countries around the world is extremely fierce. China has made some important technological breakthroughs in remote sensing, navigation, communication, and other fields, but it still needs to strengthen core technology research and development and talent cultivation. In the future, China should strengthen international cooperation, improve its independent innovation capabilities, promote the rapid development of artificial satellite technology, and achieve sustained and healthy development of China's aerospace industry.

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