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Principles and Developments in Mobile Satellite Communications

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Introduction

Having access to the internet whenever and wherever you go is no longer a luxury. When you're away from home, out of the workplace, or on a lengthy journey, Satellite Communication (SatCom) researchers are making it a reality to deliver you data, video, and audio services. The installation of a satellite communication antenna on mobile ground terminals is a need for effective connectivity. We cover the evolution of this type of antenna in its historical background in this study, as well as the significant scientific accomplishments of on-ground mobile terminals. Many eye-catching demonstrations and prototypes are examined to better understand new technologies and assess their potential for practical application. Future difficulties and trends are also examined. Although humanity has entered the era of broadband internet and optical fiber communication, satellite communications continue to fulfill the fundamental telecommunication needs of many countries due to their promise of global coverage and diversity. As of May 2015, communications satellites made up 60 percent of the almost 3,600 spacecraft in operation. Satellite consumer equipment, including mobile satellite terminals, rose 22% in 2014, according to the TAURI group of the Satellite Industry Association (SIA). Mobile satellite services (voice and data) gained 6%. According to this analysis, Mobile Satellite Communication (MOST) has emerged as a crucial growth driver for the total satellite business, which grew by just 3% in the same year. Satellites are used to keep people in aircraft, ships, and other land vehicles connected at all times and in a cost-effective manner. In-flight connectivity would assist passengers using a smartphone or laptop to surf the internet or watch streaming media. To stay in touch and make critical calls, passengers in fast-moving cars require ongoing communication. Crew access to the most up-to-date maritime information, such as chart updates, engine monitoring, and weather routing broadcast, may be beneficial to ship crews. To provide connectivity in difficult and emergent settings, the backpack terminals must be installed rapidly and reliably. To accomplish these tasks, systems based on terrestrial mobile communication infrastructures, such as Long-Term Evolution (LTE), are sluggish, costly, regional, and difficult to scale. Because of its improved dependability, cost-effectiveness, outstanding accessibility, and scalability, SatCom is an appealing choice. SatCom is always provided via antennas that modify Radio-Frequency (RF) carriers and broadcast and receive them across the absorptive environment. The major enabling payload on satellite terminals appears to be the uplink and downlink antenna systems. There haven't been many efforts done in the literature to comprehensively evaluate MOST antennas and keep up with new understanding in this sector. MOST antenna, on the other hand, is a thriving research topic that continues to draw business attention. This study examines SatCom antennas on mobile ground terminals, examines the market's mature product, looks back at the history of core design principles, assesses the application of developing technologies, and explores future trends and problems. The propagation latency of communication satellites is substantially longer than that of terrestrial communication networks like cellular or Wi-Fi. Furthermore, as the carrier frequency is increased, mobile satellite communications perform poorer than fixed satellite communications. For future applications, the Mobile

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Satellite Service (MSS) has not been aggressively pursued with lengthy latency at high-frequency bands. With different user mobility and Doppler-shifted carrier frequency, the negative impact of extended propagation delay in a traditional satellite system is explored in this study. The satellite network is modeled as a simple delayed feedback channel system, and the communication performance is examined using delayed Channel State Information (CSI) to determine the system's mobility feasibility.

During crises where terrestrial infrastructure systems have been disrupted, satellites can provide worldwide coverage and long-term communication services. Satellite communication systems are one-way or two-way Radio Frequency (RF) transmission systems based on local oscillators in deployed satellites that operate in the 1 to 30 GHz band across a large bandwidth range. In terms of resources needed, cost, transmission technology, and how they are deployed and operated, these systems are fundamentally different from terrestrial systems. Satellites, ground gateways, and network management stations, respectively, make up the space, ground, and control parts of the satellite network. Satellite systems are classed in general based on the altitude at which they are deployed and the services they deliver. The systems are divided into three groups based on their altitudes: low earth orbit (LEO; 200 km to 2000 km), medium earth orbit (MEO; 2000 km to 20000 km), and geostationary orbit (GEO; 2000km to 20000 km) (GEO; 36000 km). Fixed Satellite Services (FSS), Broadcast Satellite Services (BSS), and Mobile Satellite Services (MSS) are the three types of satellite services available. Data packet transmissions for Internet services have replaced TV broadcasting and telephony trunking as the primary intended applications. Recent advancements in 4G/5G technology have focused emphasis on the creation of satellite-terrestrial heterogeneous networks. Due to the expensive expense of sending large processing components into orbit, traditional satellite networks decide on user scheduling and data forwarding concerns at ground hub stations, and satellites have operated as bent-pipe relays depending on decisions made on the ground. The fast advancement of Application-Specific Integrated Circuit (ASIC) or powerful Central Processing Unit (CPU) technology is predicted to make the On Board Processing (OBP) method practical for usage in the sky. The total end-to-end latency of satellite systems can be reduced by eliminating the unnecessary roundtrip delay to receive the control signal, and valuable RF spectrum can be conserved by reducing the need for feeder links to the gateways if communication networking is facilitated in the onboard payload.

Furthermore, with the OBP method, satellite networks may handle larger throughput in many beams, and up/down connections, as well as possibly Inter-Satellite Links (ISL), which can make use of routing and scheduling schemes more effectively. This might lead to the development of a High-Throughput Satellite (HTS) capable of providing 100 Gbps services and facilitating a large amount of onboard computes using cutting-edge technologies.

The antenna's electrical performance must meet SatCom's fundamental mission criteria. (a)SatCom is a type of long-distance point-to-point radio link that operates in the line-of-sight mode. To focus on the communication object, a SatCom antenna must have good beam quality, which includes high gain, small beamwidth, suppressed sidelobe, and low cross-polarization. A high gain signifies a high Effective Isotropic Radiated Power (EIRP) of the transmitting antenna or a high gain/system noise temperature of the receiving antenna with a restricted electric power supply and a specified microwave route. Narrow beamwidth and suppressed sidelobe are essential for preventing signals from being sent and received in undesirable directions, which can cause multipath fading and unwanted interference to other SatCom systems. (b) SatCom's transmission medium is the absorptive atmosphere, which limits frequency utilization. Due to the scarcity of natural resources, the International Telecommunication Union (ITU) manages frequency allotment in various locations and services. Currently, the band is the most popular in civilian use. Band payloads were installed on more than 240 satellites in the sky. The utilization of very tiny aperture terminals, bandwidth availability, and worldwide coverage are all highlights. The band is mostly utilized in the military. Notably, more and more band satellites are being launched throughout the world, which might result in a higher data flow than the crowded band. (c) Polarization is a significant consideration. In SatCom, Linear Polarisation (LP) and Circular Polarization (CP) are often utilized. On the receiver side, the LP transmitter necessitates tight polarisation alignment. The CP signal is less affected by rain.

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