Overview of Standardization Activity on Integration of Satellite and Terrestrial Communication Systems

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This paper summarizes the international standardization activities on the integration of satellite and terrestrial communication systems. On the system issue, regulations are approved in the Europe and the U.S. in the 2000s. After that, the discussions have been held on the standardization at the Asia-Pacific Telecommunity (APT) and the International Telecommunication Union Radiocommunication Sector (ITU-R). As for the radio interface issue, the radio interface for satellite communications corresponding to the terrestrial fourth-generation mobile communication has been discussed, and the ITU-R Recommendation has been approved.

1 Introduction

Traditionally, in satellite communication systems, solely satellite-based transmission systems have been the central focus. In contrast to this, communication systems that have two wireless interfaces, for terrestrial and satellite, called dual-mode or hybrid systems, have been standardized and are being put to practical use. Further, in recent years, advanced communication forms that integrate terrestrial and satellite systems, called integrated Mobile Satellite Services (MSS), have been proposed, and activities for making regulations and international standardization[1] of systems has been carried out in addition to international standardization of radio interfaces[2]. The Satellite/Terrestrial Integrated mobile Communication System (STICS), also, is a type of integrated MSS.

With a view to the future implementation of STICS, this article sums up and discusses information on movements toward international standardization of integrated MSS systems. After this in Section **2**, movements toward making regulations and standardization of the system as a whole will be categorized. In Section **3**, movements in standardizing radio interfaces will be categorized. Section **4** will provide the conclusion.

2 Movements in making regulations and standardization of integrated MSS systems

In regard to integrated MSS systems, coming into the 2000s, communication systems that complementarily use terrestrial systems on the same frequency band as mobile satellite communication systems were drafted in Europe and the United States by satellite operators. This terrestrial system is called Ancillary Terrestrial Component (ATC) in the United States[3] and Complementary Ground Component (CGC) in Europe[4], but they are both based on the same concept and both aim at improving transmission services by operating complementary services through terrestrial base stations (ATC/CGC) on the same frequency band as MSS. In the U.S., it was approved by the Federal Communications Commission (FCC) in 2003[3]. Several plans were drafted by multiple satellite operators for MSS/ATC systems using the L/S band, and in the period between 2008–2010 satellites were launched[5]–[7] (commercial service not yet begun). In Europe, the company Solaris Mobile launched the satellite Eutelsat-W2 A in 2009 with the aim of S band mobile communication services that unify terrestrial and satellite system mobile phones (development of a 12 m diameter S band antenna yet to be achieved)[8]. Recently, the company Inmarsat proposed a satellite/terrestrial S band frequency-sharing mobile communication service for aircraft use in Europe, called Aviation CGC (ACGC), and is making progress in activities toward obtaining an S band CGC license for within the European Union (EU) region and is developing satellites, aircraft-mounted transmission devices, and terrestrial systems (as of writing, September, 2014)[9].

In the Asia-Pacific region, an international organization specializing in telecommunications, Asia-Pacific Telecommunity (APT), has been carrying out discussions between member countries through the APT Wireless Group

(AWG), which has the aim of maximizing, spreading, and further encouraging wireless communication systems in the Asia-Pacific region. Firstly, results of R&D for STICS were recorded in the report "Studies for the Efficient Interoperability Between Satellite and Terrestrial Services in the Area of Disaster Mitigation and Relief."[10] Further, at the 2013 AWG14 meeting, the "Questionnaire on APT Frequency Usage of the Bands 1980–2010 MHz and 2170–2200 MHz in Asia-Pacific Region" was proposed, and usage surveys were carried out for shared S band MSS/MS[11]. Also, at the same meeting "Studies within the Architecture and Performance of Integrated MSS Systems and Hybrid Satellite/Terrestrial Systems below the 3 GHz Band" was approved, and technology studies were begun for integrated MSS systems and dual-mode hybrid systems[12]. In these studies, STICS R&D results were recorded, and were established through a 2014 report[13].

In the International Telecommunication Union Radiocommunication Sector (ITU-R), at the February 2014 ITU-R WP4B meeting, a Question was proposed for studying the system architecture and performance aspects of integrated MSS systems[14], a new research area was established, and at the June 2014 meeting a working document was proposed for drafting a recommendation/report[15]. This working document studies integrated MSS systems on issues such as: service and system architecture, implementation scenarios, technological constraints, performance evaluations, and enabling technologies for performance improvements, etc. Based on this working document, discussions on integrated MSS systems are planned to be held at ITU-R.

3 Standardization of radio interfaces

Dual-mode communication systems (or hybrid systems) running on a single terminal device with two wireless interfaces for use on terrestrial and satellite systems are actualized via dual-mode devices in conjunction with Global System for Mobile Communications (GSM), an international standard for terrestrial system Second Generation Mobile Communications (2G). The satellite radio interface is set to GEO-Mobile Radio Interface Specifications (GMR); and, Thuraya, for example, uses GMR-1[16] and ACeS uses GMR-2[17]. Further, GMR-1 3G, which corresponds to terrestrial Third Generation Mobile Communications (3G), is now authorized to connect to the core network of Universal Mobile Telecommunications System (UMTS), an international standard for third generation in Europe, in addition to GSM[18]. In ITU-R, under the international standard concerning the IMT-2000 radio satellite interface[19], which is a third generation standard, GMR-1 3G is treated as an external standard. Further, in 2012, the company Qualcomm proposed a system that connects terrestrial 3G with Long Term Evolution (LTE), which equates to terrestrial 3G or 3.9th generation, in dual mode using Enhanced Geostationary Air Link (EGAL), a wireless Third Generation Partnership Project 2 (3 GPP2) interface[20].

Through integrated MSS systems, it may be possible for devices to be equipped with a wireless interface more advanced than that of dual-mode in the form of a single wireless interface made up of a terrestrial wireless interface expanded for satellite systems. These sorts of proposals for radio interfaces are being carried out as a part of standardization efforts for mobile satellite communication systems, referred to as IMT-ADVANCED-SAT, that are compatible with Fourth Generation Mobile Communications (4G). IMT-ADVANCED-SAT standardization began at the November 2010 meeting at ITU-R WP4B, and was enacted in 2013 in ITU-R Recommendation M.2047 (IMT-Advanced-SAT)[21] and ITU-R Recommendation M.2279 (SAT-IMT-Outcome)[22]. In the Recommendations, Chinese (BMSat) and Korean (SAT-OFDM) proposals were approved. Both were proposals for altered LTE radio interfaces and the proposals make adjustments in order that they harmonize with satellite-specific large delay environments and requirements for low energy, etc. For example, in dealing with large delay environments, the Chinese proposal puts forward the HARQ method, referred to as Virtual Hybrid ARQ, which does not rely on ACK/NACK feedback. And, in dealing with low-energy requirements, the Korean proposal puts forward a method called Narrowband RB uplink transmission. Under this method, because terminal device transmit power is restricted, the number of transmit sub-channels per terminal device is greatly decreased in order to increase transmit power per frequency bandwidth.

4 Conclusion

Above we reported on the general situation in international standardization of mobile communications systems that integrate satellite and terrestrial systems. In regard to integrated MSS systems overall, coming into the 2000s, after regulations were made in Europe and the United States, discussions were carried out at APT and ITU-R, etc. In regard to radio mobile communication interfaces that use satellites, dual-mode type radio interfaces were realized through international standards for terrestrial 2G mobile communications, and ITU-R recommendations for international standards for 3G were established. Further, as a radio interface with advanced terrestrial/satellite integration, an ITU-R Recommendation was established for a satellite system radio interface that is equivalent to terrestrial 4G. In the future, too, moves toward integrated MSS system international standardization and implementation by Japan and other countries will be watched with interest.

Acknowledgments

This research was conducted under the auspices of the Ministry of Internal Affairs and Communications' "Research and Development of Satellite/Terrestrial Integrated Mobile Communications System" research contract.

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