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Recent Korean R&D in Satellite Communications

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SUMMARY The R&D in satellite communications in Korea has been driven mainly by KCC (Korea Communications Commission) but in a small scale compared to Korea space development program organized by MEST (Ministry of Education, Science and Technology). Public and civilian satcom sector R&D has been led mainly by ETRI with small/medium companies contrary to rare investment in private sector while military sector R&D has been orchestrated by ADD with defense industry. By the COMS (Communication, Ocean and Meteorological Satellite) experimental Ka-band payload, Korea pursues a space qualification of own technology for national infrastructure evolution as well as industrialization of space R&D results. Once COMS launched and space qualified in 2009, subsequent application experiments and new technology R&D like UHDTV will entail service and industry promotion. The payload technology is expected for the next Korean commercial satellites or for new OBP satellites. The COMS ground control system and GNSS ground station technologies are under development for COMS operation and enhanced GNSS services along with advent of Galileo respectively. Satellite broadband mobile VSAT based on DVB-S2/RCS (+M) and low profile tracking antennas have been developed for trains, ships, and planes. While APSI is developing GMR-1 based Thuraya handset functions, ETRI is designing IMT-Advanced satellite radio interface for satellite and terrestrial dual-mode handheld communication system like Japanese STICS, with universities' satellite OFDM researches. A 21 GHz Ka-band higher-availability scalable HD broadcasting technology and SkyLife's hybrid satellite IPTV technology are being developed. In near term Korea will extend R&D programs to upgrade the space communication infrastructure for universal access to digital opportunity and safer daily life from disaster, and to promote space green IT industrialization, national security, and space resources sovereign. Japanese stakeholders are invited to establish a collaborative R&D with Korea for mutual benefit of the future.

key words: *Korea, R&D, payload, satellite communication, satellite broadcasting, GNSS*

1. Introduction

Korea opened the satellite history by launching a small scientific satellite dubbed as KITSAT in 1992. The first commercial satellite, the KOREASAT1 invested by KT for telecommunications and broadcasting services was launched in 1995. It was inaugurated for complementing the terrestrial networks in the remote areas of peninsular or the area of lack of economy for terrestrial extension. The satellite digital broadcasting service was commenced only in 2002.

The KOREASAT2 was launched in the next year to back up the predecessor's launch failure and the follower KOREASAT3 brought Ka-band transponders to pioneer in cultivating broadband IP services besides Ku-band. The KOREASAT5 was launched in 2006 as a dual-use satellite carrying multiband transponders including Ku, X, and Ka. KT provides various satellite services like cable TV contents distribution, VSAT, TSAT, business TVRO, satellite Internet, and SNG. Most of transponders are occupied by DBS/DTH where SkyLife provides 155 SD and 41 Audio, 24 HD channel package. They have about 2.4M subscribers in total where 200k for H.264/DVB-S2 based multichannel HD service started from April 2008. In 2004, as a private sector investment, the satellite DMB service was deployed in Korea with MBSAT shared with Japanese Toshiba/MBCo. Albeit TU media manages to get the subscribers near to 2M but the business remains tough. This hardly gives a positive sign to satellite industry in spite of its relative success story against Japan's failure.

In remote sensing applications, MEST (formerly MOST) has led in investing to launch the multi-purpose satellites KOMPSAT series in a sequence from the year 1999. KARI and ETRI played the leading roles in developing and integrating these practical-use satellites for earth and ocean observation and scientific measurements. So far, the Korea space development has been highly oriented to these applications under the MEST policy. However, the R&D investment in communications areas has been made only by formerly MIC, now reorganized to KCC in terms of satcom, in a relatively small scale due to its nature of industry driven. Despite the satellite communications R&D have been limited to more or less ground equipment and service development, its industrial benefit has been gained than ever through non-interrupted funding for the new technology development. By this effort, Korea estimates itself to reach a world-leading group in some technology areas of satellite communications equipment like mobile VSATs, mobile antennas of Ku/Ka band, etc.

As a paradigm shift, Korea is now integrating a multimission GEO satellite, dubbed as COMS, carrying oceanographic, meteorological, and communication payloads [1]. The Ka-band transponders are developed by ETRI for a space qualification. From the strategic R&D approach point of view, this is the first experimental satellite in Korea because of its FM communication payload that had never been tried before. In the application areas of satellite communi-

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cations in Korea, ETRI leads the technology development in infrastructure and civil/public applications while ADD does R&D with big defense companies for military satellite and applications. Universities and small/medium companies are either supporting both R&D categories or making their own small researches. In contrast, private company's R&D investment seem very limited only to their business promotion cases.

In this paper, the summaries are presented on the recent R&D activities in the satellite communications, broadcasting, and navigation area. A near-term R&D plan prospects and collaboration proposal are presented as well.

2. Key Satellite Transmission Technology

The researches at universities in Korea related to key satellite transmission technology could be classified into two: One is the technology for imminent application such as satellite mobile Internet and the other is for mid-term or long-term needs. As an example of the former, WiBro (mobile version of WiMax, developed by Korea) can be incorporated into satellite network for mobile hot spots like high-speed train. OFDM waveform should be employed in this service but the non-linearity near HPA saturation point need to be cured otherwise the down link signal from satellite is likely distorted due to its high PAPR feature. Inter-Carrier Interference (ICI) due to Doppler frequency shift can be another to be addressed. For the latter case, the research themes are more or less dependent on the R&D policy represented by the "selection and concentration" policy that is similar philosophy of ESA's Telecommunications Long-Term Plan (TLTP) [2].

2.1 Satellite OFDM Nonlinearity Research

OFDM, a key technology of satellite WiBro, is well known to provide efficient implementation of transmission system with high spectral efficiency that is the ultimate requirement of 4G mobile communication. In spite of its robustness in multipath fading and high spectral utilization efficiency, it has two major serious drawbacks namely ICI caused by the frequency offset due to Doppler shift and PAPR problem caused by multicarrier transmission. The ICI can be relieved by the compensation techniques based on constellation estimation of received OFDM signal.

The PAPR problem turns out the most serious one in OFDM since it trails significant numbers of large peak resulting in high PAPR that causes a large fluctuation in input signal requiring the use of a highly linear amplifier. Due to the non-linear characteristics of the HPA used in the satellite, the peaks can be distorted non-linearly so that generates IM product causing both in-band distortion and out-of-band radiation.

To date, many techniques have been proposed for the remedial of the satellite PAPR problem that can be divided basically into four approaches: Firstly the signal distortion techniques can reduce the peak simply by nonlinearly distorting like clipping, peak windowing and peak cancellation. Secondly, special FEC code set can be applied. The third way is to scramble each signal with a different scrambling sequence then select the sequence that gives the smallest PAPR. The use of adaptive filters and pre-distorter prior to HPA serves as an alternative method.

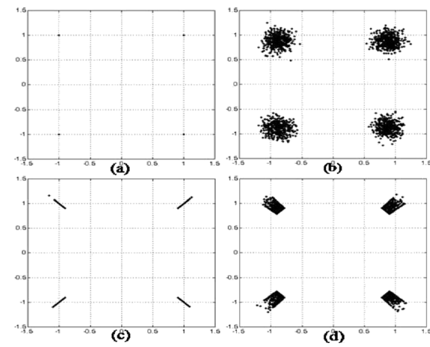

Fig. 1 (a) Original constellation (b) PC constellation (c) PR constellation (d) MPR constellation.

Also were proposed other techniques combining the above techniques to make the compensation more effective to the high PAPR problem. The published techniques or solutions have been effective in reduction, but most of them need to pay extra cost in terms of bandwidth, system complexity, or loss of critical signal though. In [3], a novel compensation technique to improve the linearity of the HPA was developed. They proposed a simple effective technique for PAPR reduction called Phase Realignment (PR) and its modified Modified-PR (MPR) resulting in high PAPR reduction. The PR and MPR constellations along with original ones are shown in Fig. 1.

2.2 Mid and Long-Term Research Themes

Research programs are expected to develop the state-or-art transmission techniques to increase the spectral efficiency including new waveform design, physical layer and MAC layer enhancement, cross layer optimization, multi beam operation, virtual MIMO or cooperative communication, and space-time diversity coding. In addition, rain fade mitigation, channel impairment countermeasures, Adaptive Coding and Modulation (ACM), and beam overlay etc. will be studied. For higher utilization factor, the terrestrial concept "cognitive radio" and "software defined radio" will be applied to the next generation satellite communications. These researches may be undertaken as a part of the system development projects or research programs for new satellite systems or service like IMT-Advanced satellite communication, VSAT, 3DTV/UHDTV, DMB and so on.

3. Satellite Communications and Navigation Infrastructure

3.1 Satellite Communication Payload System

ETRI has been developing a Ka-band communication pay-

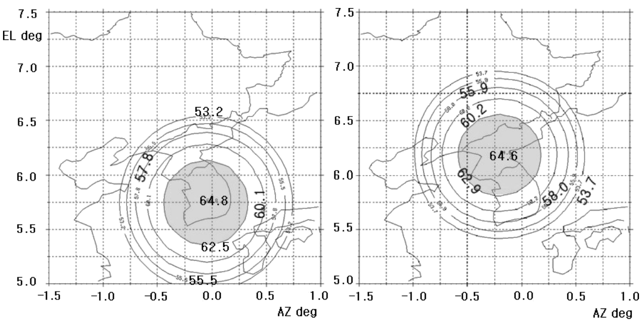

Fig. 2 COMS EIRP contours.

load system to get a space qualification through the government sponsored GEO COMS program. KCC sponsors the development of the Ka-band communication payload and satellite ground control system.

The Ka-band communication payload has been successfully designed and fabricated by ETRI with industry for last 5 years. It was delivered to KARI for integration into the COMS spacecraft supplied by EADS Astrium. After integration, the payload performance tests were conducted where the results showed a good agreement with the required specification. Currently, spacecraft undergoes the space environment test including vibration and thermal vacuum test. By completing all the checkouts, COMS will move to EADS Astrium and be ready for launch around Nov. 2009.

• Communication Payload Performance

The payload provides four 100-MHz channels (with one redundancy) covering the Korean peninsula. All channels are double-converted using S-band IF frequency and the two of three channels are able to be switched each other by multi-beam switching. The frequency plan of up/down is 29.6–30.0/19.8–20.2 GHz respectively. As major parameters' performance, G/T & EIRP measurement showed 15 dB/K and 62.1 dBW, which outperforms the requirements of 13 dB/K and 58 dBW respectively. The EIRP contours are depicted in Fig. 2.

• Transponder Test

The industrial partners consisting of local companies in Korea fabricated under ETRI the transponders. The transponders were tested under the test requirements generated from spacecraft guideline. After the equipment level testing, transponders were integrated to the payload system and integrated further into the spacecraft. The payload undergoes now the space environment test at the level of spacecraft along with the COMS test schedule. The required tests are EMC, launch vibration, thermal vacuum, and auto-compatibility tests. With a confidence from lower level tests, ETRI expects the transponders will meet the environment test requirements in terms of performance and spacecraft interface.

• Communications Antenna Test

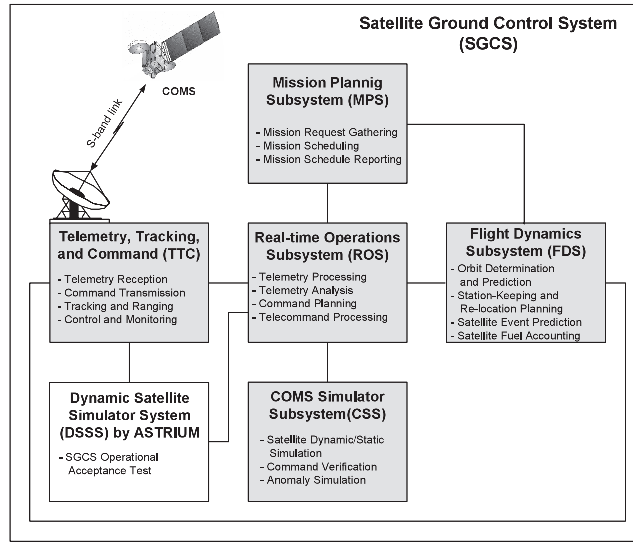

Fig. 3 Architecture of the COMS SGCS.

A Ka-band antenna performance test was conducted to verify the RF alignment of the antenna beams and antenna performance parameters such as beam pointing accuracy and other major parameters affecting the COMS spacecraft configuration. The east and west antenna assemblies were tested in a compact antenna test range. The Tx & Rx co-polarization pattern measurements of the antennas at 20.0 GHz and 29.8 GHz respectively show that the beams point towards the required direction and are well centered on their respective coverage as specified.

• Communications Experiments and Applications

After the IOT following the spacecraft check out in the orbit, the performance verification process will commence. Once the Ka-band payload proves qualified by the periodical measurements for a certain period, application experiments will start as in the case of WINDS in Japan. At that time, COMS will demonstrate its feasibility of Ka-band public service implementation including 21 GHz HD/3D satellite TV experiment, PPDR services, digital TV gap filling and so on. Besides, rain fade modeling and channel characterization research as well as R&D for UHDTV transmission around 21 GHz are under the planning.

3.2 Satellite Ground Control Systems (SGCS)

The SGCS for COMS has been developed by ETRI and delivered to KARI for end-to-end compatibility verification. In order to fulfill the operations requirement of three payloads and spacecraft bus, COMS SGCS performs telemetry reception and processing, satellite tracking and ranging, command generation and transmission, satellite mission planning, flight dynamics operations, and satellite operation simulation. With the proper functional allocations, COMS SGCS is designed and implemented as five subsystems as shown in Fig. 3. The SGCS software design was based on the object oriented analysis and design method-

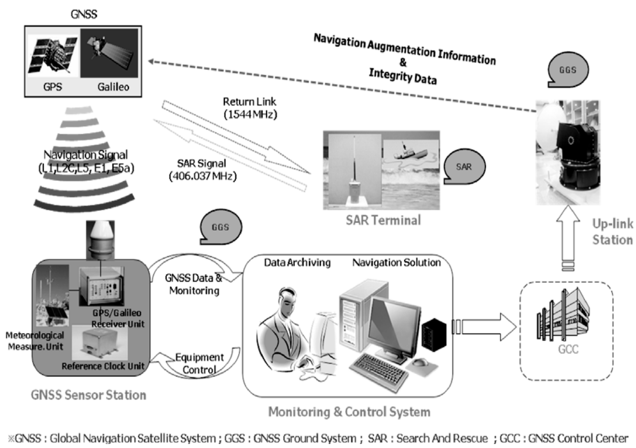

Fig. 4 Concept of the GNSS ground stations.

ology for maximum reuse of the codes and models. The SGCS programs were coded on .NET framework with C# programming language. All of the SGCS computer hardware is based on the Intel microprocessor and the operating system is Microsoft Windows XP or Server 2002.

The COMS SGCS has been functionally tested using DSSS (Dynamic Satellite Simulator System). The RF compatibility test and end-to-end TM/TC test have been completed with the COMS spacecraft (at ground) via RF link. Now, the COMS SGCS is ready for EADS Astrium acceptance and the preparation for the operation of COMS.

The SGCSs for the KOMPSAT (Korea Multi-Purpose Satellite) series have been also developed by ETRI and used for the successive satellites from KOMPSAT-1 [4]. Currently KOMPSAT-2 is being successfully operated by the ETRI developed Mission Control Element (MCE), or SGCS since its launch in 2006. The MCEs for KOMPSAT-5 and agile sub-meter electro-optical cartography mission satellite KOMPSAT-3 are also under development in ETRI for their operations in 2010 and 2011 respectively.

3.3 GNSS Ground Stations & Service Technology

Since Galileo, European commercial Global Navigation Satellite System, was announced to provide commercial GNSS service to the world, GNSS paradigm had been drastically changed. Korea, also, decided to join Galileo project in 2006 and launched some GNSS research programs based on national GNSS program. ETRI is developing basic technologies for GNSS ground infrastructure stations and SAR (Search and Rescue) distress beacon as shown in Fig. 4 [5]. The GNSS station models consist of three elements: sensor station, monitoring and control station, and uplink station. The sensor station monitors the signals from dual GNSS systems, GPS and Galileo, whereas the monitoring & control station manages ground facilities and performs navigation data processing. Uplink station carries out uploading GNSS augmentation and integrity data to the satellites. Throughout this technology development, high performance GNSS receiver technology can be achieved required for the multi- GNSS sensor station monitoring not only GPS (L1, L2C, L5) but also Galileo (E1 and E5a) signals. In addition, the SAR beacon system and user terminals will evolve to the second and the third generation models along with the Galileo fifth service.

In April 2008, EU launched GIOVE-B, the second experimental Galileo satellite that reported its successful signal transmission from May 2008. The signal was also monitored and processed by ETRI's prototyped receiver. In addition, GNSS signal generation S/W simulator and signal processors are under development in ETRI. It will provide tools and environment for verifying GNSS signal processing algorithm developed by industries of GNSS receivers or application systems.

Korean government established 78 GPS reference stations as National GNSS ground infrastructure. Through those stations, DGPS services have been provided through MF Beacon. Its R&D activities have been done by KORDI (Korea Ocean R&D Institute). KASI (Korea Astronomy and Space Science Institute) involved China-Japan-Korea joint research program on crustal movement in Easter Asia using GPS and research for GNSS meteorology related with assimilation of GNSS water vapor data for weather prediction (2006–2009) and 2D/3D regional ionosphere model for space weather monitoring.

Other major growing GNSS services are survey and GIS. Korean government established GIS and currently very fine three-dimensional map (15 cm level) is under construction. A big growth of market opportunity is expected when this accurate three-dimensional map can be combined to other application areas such as wireless communication network design, building construction, ecologies, high accuracy personal navigation, and environmental forecasting.

4. Mobile Satellite Communications

4.1 Satellite Broadband Mobile VSATs and Low-Profile Tracking Antennas

To meet the requirement of broadband interactivity and broadcasting services, European Open Standards DVB-S and DVB-RCS was developed in DVB in late 1990's. As technical provisions, ETRI appreciated the open standard approach and has been developing a number of broadband IP VSAT systems based on DVB-RCS evolutions since 2000 that enable to support IP-based satellite multimedia services in a fixed and mobile mode.

MSIA (Mobile Satellite Internet Access) system was developed in 2002 as a broadband mobile VSAT for providing a high-speed Internet and satellite broadcasting service. It was basically based on DVB-RCS MF-TDMA mode but the return link bursts were modified to be spread by the selected direct sequences in the assigned time slots. The design of spreading alleviated the interference problem posed by regulation at the cost of return link data rate. Only up to 384 kbps was provided for return link while forward remains max 45 Mbps capability. In this project a Ku-band micro-strip phase array antenna was developed. ETRI has tested this system with Japanese operator JSAT on the highway near Yokohama.

Next attractive and challenging work was the MoBISAT (Mobile Broadband Internet Satellite Access Technology) project for broadband mobile VSAT based on MF-TDMA again while using Ka-band frequencies instead [6]. ETRI tried to exploit the restriction-free Ka-band for the mobile system as well as to get higher data rate for return link for collective user applications. The system adopted the DVB-RCS standard but the return data rates target was set higher, for instance, 1 Msps for the terminal. In this system, ETRI focused on the development of a high-speed mobile VSAT and a low-profile tracking antenna. Some R&D results were reflected on the DVB-RCS guideline through standardization contribution.

A low-profile antenna was developed to have Ku/Ka dual band 2-axis mechanical stabilizer with its profile 30cm high. A public demonstration of MoBISAT system technology was held on a training ship in Busan, Korea in 2005. Various services including Internet, TV, and online network games on the ship were demonstrated successfully. The technologies were transferred to domestic companies for further commercialization to mobile VSAT product.

From 2006, ETRI has been developing a land mobile VSAT technology (XpeedSAT) applicable to high-speed trains by integrating satellite and terrestrial wireless access technologies for seamless IP multimedia service [7]. In this project, the forward link adopted DVB-S2 but the return link evolved to the DVB-RCS+M, denoting the mobile option of RCS, prepared by DVB TM-RCS WG and published by ETSI recently. In the new standard, physical layer techniques like spreading and robust synchronization, and upper layer techniques like link layer FEC were developed to cope with the channel impairment from shading, short period interruption, and Doppler shift etc. The system was designed to operate under LOS as well as NLOS like tunnel and railway station as shown in Fig. 5. To support seamless connection in tunnels, interactive broadband gap filler and packet diversity function were developed for a smooth network segment switching. In addition, terrestrial wireless interworking techniques have been devised for seamless access to WLAN and/or WiMax in the railway station.

A bigger version of low-profile tracking antenna whose profile dimension is of $1.4\,\mathrm{m} \times 50\,\mathrm{cm}$ (reflector aperture $-1.0\,\mathrm{m} \times 30\,\mathrm{cm}$) was designed to provide higher G/T: 11 dB/K and 12 dB/K for Ku and Ka-band respectively. EIRPs are 40 dBW and 49 dBW respectively. Azimuth & elevation tracking and linear polarization tracking is provisioned: azimuth rotation is unlimited but elevation angle covers $+15 \sim +57$ deg for worldwide market. A sequential lobbing of Ku Rx signal with the beam forming is employed for tracking. The tracking speed in azimuth direction is measured as 12 deg/s sufficient enough for a high-speed train. In order to reduce satellite acquisition and reacquisition time, the antenna has GPS module and dead-reckoning gyro sensors inside. The antenna and its installation on the G7 train are depicted in Fig. 6.

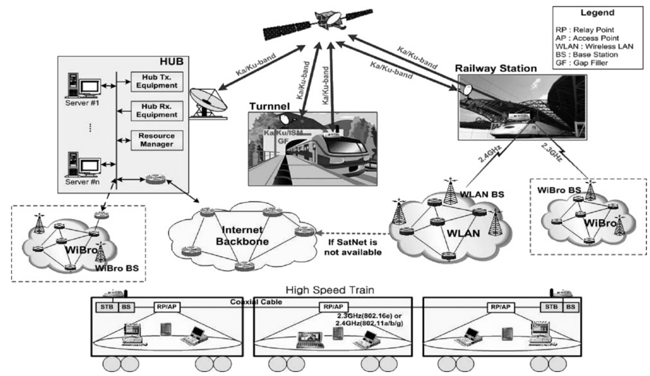

Fig. 5 XpeedSAT system configuration diagram.

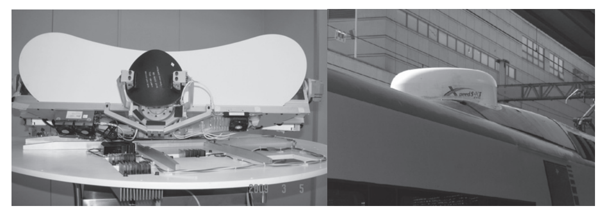

Fig. 6 XpeedSAT low-profile satellite antenna.

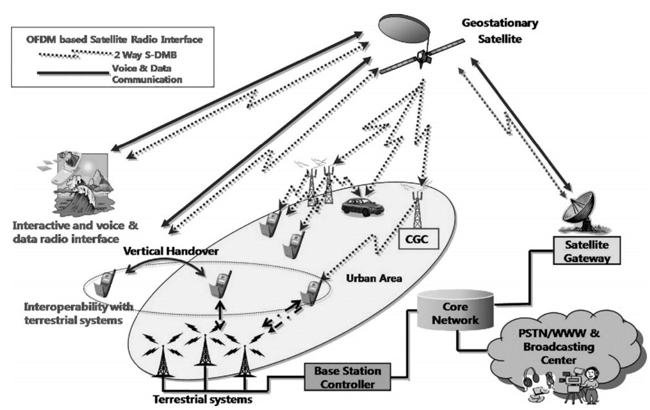

Fig. 7 IMT-Advanced satellite access concept.

4.2 IMT-Advanced Satellite Access Technology

ETRI is developing a satellite radio interface technology for IMT-Advanced, based on OFDM waveform. The work includes development of key core access techniques, implementation of link/system level simulator and development of detail specifications of satellite radio interface. The satellite component of IMT-Advanced considers largely two kinds of future mobile satellite service: terrestrial fill-in and MBMS (Multimedia Broadcast and Multicast Service) [8]. Figure 7 shows the IMT-Advanced satellite access concept as an integral part of global communication infrastructure.

The terrestrial fill-in service can be regarded as a coverage extension of terrestrial part with vertical handover. The IMT-Advanced satellite access provides services and applications outside terrestrial coverage under the inherent constraints imposed by power limitation and long round trip delay. In order to provide the fill-in service, a cost-effective vertical handover with terrestrial system has to be included. For this, satellite radio interface should be compatible and have a high degree of commonality with the terrestrial one. It needs to reuse terrestrial technology to minimize handset chipset and network equipment in terms of size and cost.

On the other hand, the satellite MBMS has advantage over terrestrial network in contents delivery. An advanced, high-quality interactive DMB service can be provided by an integrated network of satellite and complementary ground component (CGC). The CGC can be deployed in urban areas as collocated with mobile cell sites.

In addition, advanced communication techniques for performance enhancement and capacity increase are under consideration in this R&D. They include spectrum sharing techniques (through cognitive radio and cross-system interference suppression), cooperative transmission techniques (relaying and virtual antenna arrays), and ad-hoc networking, etc.

Regarding this study, standardization (with harmonization) is active on the B3G satellite system architecture in ETSI SES MSS WG. ETRI also undertakes as a Rapporteur to complete the technical report on the B3G satellite system architecture in the MSS WG. As ITU-R WP 4C gears up the study on the satellite radio interface of IMT-Advanced, ETRI contributed on visions and service/technical requirement for satellite component of IMT-Advanced in April 2009 [9].

4.3 GMR-Based Mobile Handheld Terminal

The current trend of the satellite mobile communication technology goes toward the GEO solution providing global mobile communications with a single ground earth station. For instance, Thuraya satellite system uses the GEO mobile radio (GMR-1) specification family. Recently, Thuraya GEO mobile satellite service has been launched by Asia Pacific Systems Inc. (APSI) in Korea. The GMR-based handheld terminals (SO-2510 and SG-2520) allow users to connect to Thuraya's satellite telecommunication services in more than 140 nations in Europe, Africa, and Middle East and Asia-Pacific region.

The terminal provides a two-way connectivity between user terminals and gateways, or single-hopped terminal-to-terminal (TtT) call connections between two user terminals in the same or different spot beams. Also, it provides always-on Internet connectivity as well as voice call. Figure 8 depicts the baseband processor implemented in a dual-core processor called TI OMAP and DALMA ASIC. For a strict synchronization of carrier frequency, phase, and symbol timing, initial synchronization scheme using dual chirp sequences was used. For frequency fine-tuning, a new frequency tracking scheme was applied in a combination with non-data-aided (NDA) estimation. Square time tracking scheme, uplink frequency offset and timing modules were added for accurate timing and frequency tracking. The terminal has been designed to support packet-data signals with variable number of slots, bandwidth, and coding rates to maximize data throughput.

5. New Satellite Broadcasting Technology

5.1 21 GHz Band Broadcasting Technology

The ITU WARC-92 had allocated frequency band ranging from 21.4 GHz to 22.0 GHz for potentially providing satellite HDTV or UHDTV services. However, since this band suffers a severe degradation in receiving signal quality under heavy rain, which can cause the video quality blazing or service outage, several methods have been studied to overcome the critical defect. Overlaying satellite transponders, increasing signal power or handling beams were tried but most trials cost very high. Instead of above approaches, ETRI is developing a scalable and flexible transmission system with the technologies of newly standardized H.264 Scalable Video Coding (SVC) and DVB-S2 Variable Coding and Modulation (VCM) that can achieve a rain fade adaptive solution with relatively low cost as shown in Fig. 9 [10].

HD video images are compressed and packetized to generate two interdependent but associated streams by H.264 SVC encoder system. One of streams sitting on base layer has SD-quality frame video plus audio data while the other stream riding on enhancement layer has additional

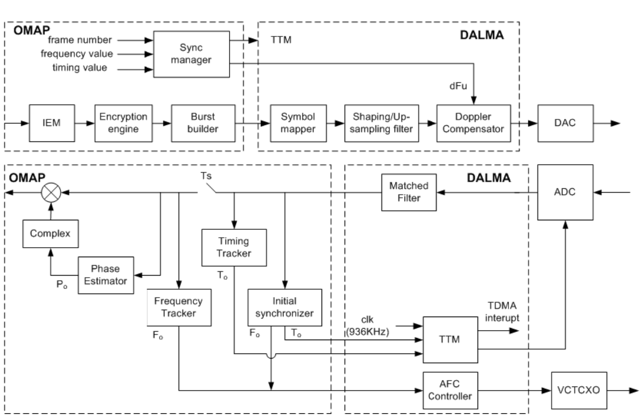

Fig. 8 Modem structure of GMR-based handset.

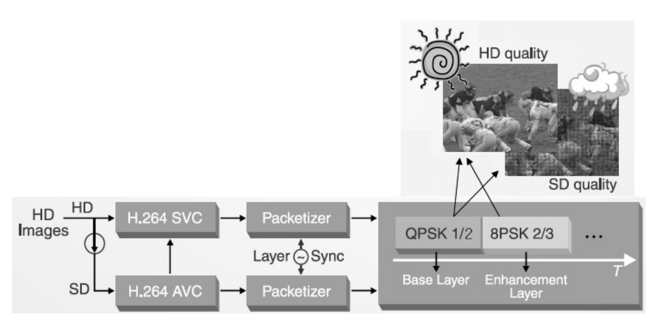

Fig. 9 Scalable HD broadcasting over satellite.

compressed information for complementing the HD video. Unequal FEC rate and different modulation scheme is applied to each stream. In DVB-S2, each BB frame contains information on modulation and FEC coding rate in its header. A VCM-capable demodulator decodes the header information to demodulate the received frames. ETRI aims to apply this technology to multi-channel HD in 21 GHz band firstly and extend to UHDTV in a near future.

With this technology, the system gets higher service availability than the conventional Ka-band satellite HD broadcasting service under the same link condition. Viewer can still watch SD quality even they have a heavy rain otherwise blacked out. Assuming use of the KOREASAT-3 Ka-band transponder and applying the parameters from ITU-R P.618-8 rain attenuation model, service availability of 99.8% can be achievable with 0.5 m sized receive antenna and 1.91 dB link margin [11]. Specifically, this separation and conditional quality delivery scheme can be implemented on the different RF links, to say Ku-band and Ka-band under the assumption of coexistence those transponders.

5.2 Satellite Hybrid IPTV Technology

SkyLife is carrying out a platform migration to H.264 and DVB-S2 from MPEG-2 and DVB-S to provide multi-channel HD service. Key technologies are as follows.

- Video Compression H.264 HP@L4
- Audio Compression Dolby 5.1
- Statistical Multiplexing
- DVB-S2 LDPC+BCH, 8PSK

Through this enhancement, SkyLife plans to provide 30HD channel package as of May 1, at least 45HD within this year, which will make it the biggest Pay TV operator in terms of the number of HD channel in Korea.

SkyLife is also developing the technology to launch the Satellite Hybrid IPTV service with KT from July 2009. Two-way connectivity is required for IPTV service but hardly implemented via satellite return link. In spite of well-deployed terrestrial network, due to QoS limitation, the coverage and lack of HD live contents need to be resorted to the satellite link for better IPTV. This situation facilitates IP hybrid business to complement two different media in order to enhance the strength of both companies at the maximum. Nationwide multi-channel HD via satellite is the most important factor of the success of hybrid service. In addition, 80,000 VOD contents from IPTV are another important feature of this service. SkyLife IP hybrid service subscribers can enjoy multi-channel HD contents from SkyLife via satellite and VOD contents from ISP's VOD platform through high-speed internet by a single hybrid STB. A QPSK-based live TV + IP based VOD hybrid service system configuration is shown in Fig. 10. The IP hybrid STB is under development by the global makers like Samsung Electric.

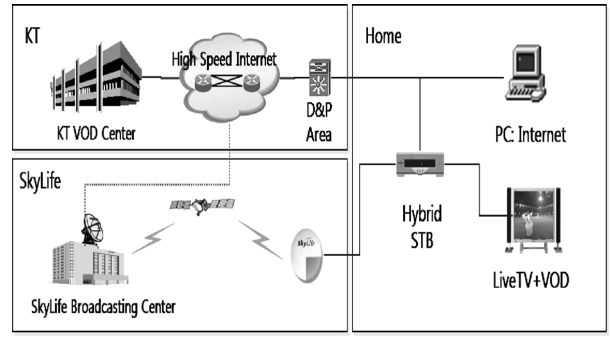

Fig. 10 Satellite/IPTV hybrid system configuration.

6. Conclusion

In this paper, a summary of recent R&D activities in satellite communication area in Korea is presented. In spite of its small scale, R&D has been carried out over a number of areas targeting at the upgrade of the national infrastructure as well as the service technologies, which was mostly led by public research institutes like ETRI. By the COMS project, as in the developed countries, Korea pursues the space qualification of new technology for the verification of the next generation service feasibility, space infrastructure upgrade, and space industry promotion. Once COMS gets qualified as a heritage, the payload technology may well be used for commercial satellites or for further technology evolution by either public or private investment, or in a form of PPP. In order to utilize the COMS Ka-band transponders, 21 GHz band UHDTV technology and satellite/wireless hybrid Public Protection and Disaster Relief (PPDR) communication technology R&D are already proposed.

Korea kicked off two public R&D projects of satellite communications this year: S-band satellite OBP technology development and next generation high efficient VSAT technology development. ETRI is going to develop a satellite & terrestrial dual mode handheld communication system technology based on IMT-Advanced satellite radio interface operating in 2 GHz band. This approach shares commonalities with the Japanese STICS program. Currently the project looks at the tailored 3GPP LTE specification as a candidate for the satellite radio interface for maintaining the maximum compatibility with terrestrial network. ETRI also participates in DVB-RCS Next Generation (NG) standardization aiming at a low-cost, highly efficient, lower power consumption Ku/Ka-band VSAT terminals for both consumer and professional markets of mobile/fixed applications.

KCC has recently prepared the radio promotion plan containing the near and mid-to-long term satellite communications promotion. Also KCC runs a study group to organize a mid-to-long term space communications promotion plan with the R&D plans for experimental or practical use satellites for constructing ubiquitous and disaster-proof communications infrastructure that is also green (environmentally-friendly and utilizing solar energy). Korea will continue with satellite communications to provide nation with a full digital opportunity of ubiquitous and universal telecommunication services for safer and more convenient society.

Finally, it is proposed that Korea and Japan be invited to establish some collaborative researches on the items both seem sharing common interests:

- S-band satellite & terrestrial dual mode handheld communication system and frequency sharing
- 21 GHz higher-availability broadcasting technology, UHDTV/SHV experiment with WINDS and/or COMS
- QZSS related technology for ground- and space- infrastructure

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