Report on Attending IAC2009

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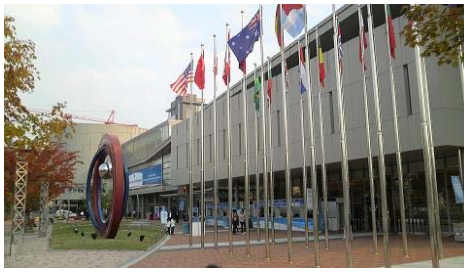
1. Introduction

The 60th International Astronautical Congress (IAC) was held at the Daejeon Convention Centre in Daejeon, Republic of Korea, from October 11 to October 17, 2009. Below is the report on the conference, mainly on the symposium of Space Communications and Navigation Committee (SCAN).



▲Conference Venue

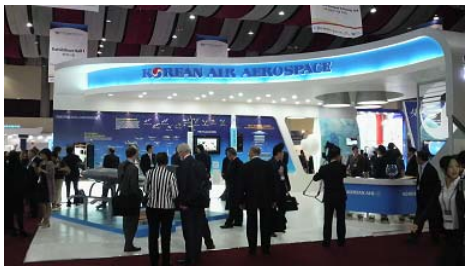
2. Opening Session

The 60th IAC was held with about 3,000 participants at the Daejeon Convention Centre in Daejeon, Republic of Korea. This was the first IAC in South Korea and was welcomed with such hospitality that President Lee Myung-bak delivered the congratulatory speech in its opening ceremony. In his speech, he mentioned about the launch of South Korea's first rocket, KSLV-1, in August 2009, which ended up with the rocket being thrown off course due to the malfunction of half of the payload's fairing that failed to separate; however, he clearly stated that the launch was not a failure but a great learning.

▲Speech of
President Lee Myung-bak

South Korea possesses satellites such as the KOMPSAT series and Communication, Oceanographic, and Meteorological Satellite (COMS) with the missions of communications and measurements. Korean Air Aerospace is currently undertaking space development as shown in the picture. What particularly interested me was a company named Satrec Initiative (SI), which was located in Daejeon City and was one of the sponsors of the 60th IAC. This company has an earth observing optical telescope with a high resolution of 1-m class as well as SI-200BUS and SI-100 BUS

▲ COMS Satellite



▲ Korean Air Aerospace

systems, and the company is also undertaking the wide range of satellite business from sub-components to an optical ground station. By getting to know this company, I recognized that Korea has a reliable company for space development.

3. SCAN Committee

I attended the SCAN Committee on the IAC as one of its committee members. The items discussed by the committee were on how to cope with the cancellation of presentations, renewal of the membership list, next year's plenary session in Prague, and the appointment of chairpersons. Regarding the cancellations, 23 expected presentations were cancelled out of the total of 67, that is, the rate of cancellations was 34%, and over 70% of all the cancellations were from China. The next SCAN Committee is now scheduled to be held in Paris, France, on March 22, 2010.

4. Sessions in Space Communications and Navigation Symposium

The outline of each session is as follows:

B2.1 Fixed and Broadcast Services

Gazprom Space Systems from Russia introduced a space informational system called "YAMAL," which provides video transmission service etc., for industrial companies; this system used twelve satellites. Dr. Fujino of **National Institute of Information and Communications Technology (NICT)** made a presentation on Satellite/Terrestrial Integrated Mobile Communications System for Secured and Safe Society (STICS). In response to a question from an audience on whether a receiving terminal can cope with polarized waves, he remarked that a problem had never occurred at the receiving end. **Devas Multimedia** from India reported on satellite digital multimedia (SDM), which is an interactive multimedia service using S-band. The examples of interactive hybrid satellite/terrestrial systems are those of ICO and Solaris Mobile. ICO G1 was launched in April 2008; it is based on the Loral 1300 standard bus and is now able to transmit an arbitrary waveform at 2-GHz band to North America over the bent-pipe mode. Solaris Mobile is a joint venture of Eutelsat and SES Astra, and it offers services of video and data transmission to mobile handsets and in-car stations in Europe.

China Academy of Space Technology (CAST) showed the calculated contour plots of antenna patterns by using the phased array for mobile satellite communications and that adaptive beam forming can contribute to the changeable users' requests in a day. **OHB** from Germany reported on the current development status of a satellite bus system for Small GEO (SGEO). Sixty people are presently involved in the project. The development of the satellite bus system entered Phase-C/D in 2009, and the HISPASAT mission in Phase-B in 2009 is scheduled to be launched in 2012. SGEO is an "ITAR-free" system, and it will be

supplied for EDRS and Heinrich Hertz systems, which are scheduled to be launched in 2013 and 2014, respectively. **Sona College of Technology** from India made a presentation about rainfall modelling, using data obtained from TRMM satellite in 2007 and 2008. They reported that heavy rainfall was observed in the areas up to 4S-8N° on earth and other elements such as lat/long data made it difficult to form a function. In response to a question about the effects on communications, they answered that the application was under study. **China Xi'an Satellite Control Center** presented their separation methods for geostationary orbit satellites, by controlling the collocation of four geostationary satellites with eccentricity and orbit inclination. They stated that these methods were useful for physical separation and radio frequency (RF) separation.

B2.2 Mobile Communications and Satellite Navigation Technology

Delft University of Technology made a presentation about the protocols of disruption tolerant networking (DTN), which is an approach to resolve the disruption of link between a low-earth-orbit (LEO) satellite and a ground station. Chosen as a case study was the satellite mission of Formation for Atmospheric Science and Technology Demonstration (FAST), orbiting the earth at an altitude of 650 km; this mission was a collaboration between the TU Delft and Tsinghua University of China. They succeeded in constructing the system that can work in the delay time of 6300–6700 s, while TOP/IP protocols cannot work under the same condition.

Seoul National University studied the Gaussian sum filter individual residual method (GSFIR) to measure the carrier phase precisely, and made a comparison with the methods of χ^2 distribution and Kalman filter. The simulation results showed that their method obtained the position error of approximately 1 cm, which is more accurate than the other methods with an error of a few centimetres. Similarly, **Korea Aerospace Research Institute (KARI)** proposed the method to resolve the integer ambiguity in carrier phase measurements on the Global Positioning System (GPS) and to increase its robustness. Another presentation of **Seoul National University** showed the GPS-like local area navigation system with locally installed antennas, which is necessary for rovers to move around in planetary exploration in the future. They showed that the system was able to measure a motionless object to an accuracy of approximately 1.5 cm (rms), and that of a moving one to 2.0 cm (rms). **Seoul National University** also proposed false alarm detection methods using the Kalman filter for the flying of two satellites, and reported the positive results in false alarm reduction. **KARI**'s another presentation was about a precision control system for automatic ground vehicles (AGVs) utilizing carrier-phase differential GPS (CDGPS). They succeeded in measuring a vehicle's position with an accuracy of approximately 0.3 m at a data transmission speed of 4 Hz.

B2.3. Mobile Communications and Satellite Navigation Systems

Politecnico di Torino from Italy made a presentation about the method for space navigation by using pulsars with a possible precision of about 150 m. This system is capable of performing position measurements anywhere in space; positions that are naturally available in the Earth's orbit as well. **European Space Agency (ESA)** reported on the Iris program for the air traffic management. This program, funded by ARTES 10, has been studied since 2007 following the well-reputed L-band mission of ARTEMIS. The scheme is to communicate with aircrafts using the L-band mission with 64-kbps forward link and 36-kbps return link. They aim to give its technical demonstration in 2015. **Japan Aerospace Exploration Agency (JAXA)** presented the Quasi-Zenith Satellite System, which is currently at the stage of proto-flight test (PFT) following the completion of satellite integration. The launch is scheduled in the summer of 2010.

B2.4. Near-earth and Interplanetary Communication Systems

Dr. Wittig of **ESA** presented about the communications to lunar explorers; a mission called Data Relay for Moon (DROM) that is planned to be launched in 2017 at the earliest and be operated until 2021. DROM is for communications between a ground station and a lunar exploration platform, and between a platform and a lunar lander. By using a 1-m optical ground station, a platform with a 26-cm telescope, and a lander with a 4-cm optical telescope, optical transmission at 100 Mbps can be carried out. If a hybrid communication system combining optics and Ka-band is adopted, it covers 99.9% time rate of the communications from the Moon.

Dr. Arimoto of **NICT** reported on the study of the optical communication system between Earth and Mars in the near future (around 2050), and on its feasible transmission speed of 10 Gbps. **JAXA/ISAS (The Institute of Space and Astronautical Science)** presented the development of a communication system for deep space activities. They introduced their newly developed engineering model by upgrading their formerly developed X-band digital transponder for their deep space mission to that of Ka-band. The X-band transponder will be provided with Planet-C in 2010.

Canadian Space Society made a presentation about the production of phased array optics using liquid crystals. The scheme appears to have just started and further investigation is likely required. They are developing a beam polarization device with no mechanical movable parts. Dr. De Paula of **NASA** presented the Ka-band for the deep space network that makes possible communications to the Moon and to L2 at 1–150 Mbps by using a cryostat and cooling a low-noise amplifier to 10 K. Its first support is scheduled for James Webb Space Telescope (JWST) in 2013.

B2.5. Advanced Technologies

Technical University of Munich made a presentation about the Ka-band antenna pointing mechanism. This system acquires two independent degrees of freedom, and it is capable of angular velocities between 0.05 deg/s to 5 deg/s. Their laboratory tests confirmed the qualities of its roller bearings, gears, and lubricating system. **Satrec Initiative (SI)** reported on the development of the Ka-band transponder for the COMS mission. The Ka-band transponder has been co-developed by Electronics and Telecommunications Research Institute (ETRI) and SI, and its frequencies are 30-GHz uplink and 20-GHz downlink. Its payload I/F is developed by ETRI, its control I/F by KARI, and its design by SI. It was originally scheduled to be launched in November 2009; however, is now likely to be postponed until 2010. **Korea Advanced Institute of Science and Technology (KAIST)** presented the development of a digital low pass filter using FPGA of Xilinx chip for the use of the communication subsystem of Science and Technology Satellite-3 (STSAT-3). They designed the digital processing system using 14-bits and 62-Msps analog-to-digital converter.

Sirius XM Radio made a presentation on deorbit from Highly Inclined, Eccentric Orbits (HIEO) currently in service. Their analyses showed that the disposal orbit was stable for at least 100 years at an orbital altitude of 31,000 km. **KARI** reported on the DSP-based GPS receiver using the Kalman filter, with an accuracy of around 17 m in position and around 0.094 m/s in speed. **University of Toronto** reported on their orbit determination of a nanosatellite using TLE, and stated that the accuracy of around 1 km was successfully achieved in the mission of CanX-2 launched on April 20, 2009.

University of Dundee from United Kingdom reported on Space Fiber, which is a data link literally using an optical fibre and it is able to increase data rates up to 2.5 Gbps for internal satellite bus communications. Professor Koudelka of **Graz University of Technology** made a presentation about the communication protocols of DTN in which a dedicated satellite that acts as a data relay for other satellites is implemented for data transmission of nanosatellites. **University of Aeronautics and Astronautics from China** presented the positioning and inter-satellite communications using x-ray pulsar.

B2.6. Advanced Systems

The chairpersons of this session are Dr. Robert Prevaux from USA and Dr. Ryutaro Suzuki of NICT from Japan; I was involved as a rapporteur. (See the picture on right where seated in the back is the rapporteur.)

Korea Air Force Academy reported on the improvement of the BER performance of

▲B2.6. Advanced Systems Session

Gaussian minimum shift keying (GMSK) by using multiple bits sampled at some points of the clock. **University of Dundee** introduced SpaceWire, which was capable of easy addressing by implementing remote memory access protocol (RMAP) and it has been adopted for 40 missions such as Lunar Reconnaissance Orbiter, Exso Mars, and Beppi Colombo.

Dr. Wittig of **ESA** presented satellite communications for disaster countermeasures, and reported that disasters in the last 8 years killed 2.3 million people, affected 5.4 billion people, and caused economic loss amounting to 164.2 billion US dollars. Satellite communications either at a high or low speed are highly versatile in terms of emergency response, peacekeeping, border security, etc. To my question on the estimated percentage of people who could be saved by using satellites, he replied that it would take his entire lifetime to answer that question. Mr. Croom of **Sirius Satellite Radio** reported that they have been providing satellite digital audio radio services (SDARS) by operating three geostationary orbit satellites with orbital inclinations, and launched a new satellite called SIRIUS FM-5 in June 2009 putting it into almost fully automated operations. All satellite operations are possible only through a Web browser. **Technical University of Munich** presented an autonomous antenna pointing control system using a 5-kg antenna aboard a 50-kg-class satellite. Their simulation showed the positive results of the posture error under 0.01° in 50 s and under 0.05° even in maneuvering.

Dr. Orikasa of **NICT** made a presentation of on-orbit evaluations of 31 elements of phased array-type far-field pattern (FFP) of the large deployable reflector antenna (LDRA), which is equipped on the engineering test satellite VIII (ETS-VIII). He stated the actual measurement results were a little different from the calculated ones owing to the mechanical distortion by solar heat input; however, correction should be possible at beam formation by appropriate temperature monitoring etc. **Instituto Nacional de Pesquisas Espaciais** made a groundbreaking report on the application of chaotic communication to satellites, of which the mechanism is to produce chaotic waveform at the side of the transmitter and then synchronize and demodulate it at the receiver, utilizing chaos dynamics with its property of sensitive dependence on initial conditions. The transmission experiment using a 120-km optical fibre was already executed and future applications are expected. **Institute for Space Studies of Catalonia (IEEC)** proposed the method of lossless data compression of which the performance is 2.5 times better than the conventional one.

Technical University of Berlin (TU Berlin) reported on the communication test results of the High Integrated S-Band Transmitter for Pico-Satellite (HISPICO) on a sounding rocket REXUS-4. The total mass of REXUS-4 is 1.175 kg comprising a payload mass of about 150kg. The REXUS program is an annual sounding rocket program mainly for university students, and REXUS-4 had six experiments—five by universities and one by DLR. The rocket flew to an altitude of 175 km and an experiment of 10 min duration was allowed. As for the communication mission, it successfully achieved a data rate of up to 1 Mbit/s with 1 W RF output power; the bit error ratio amounts to 10E-5 with a coding gain of 6 dB by

combining the Turbo code and DQPS modulation. This development is aimed at BeeSat-3 in 2013.

Vehicle-Type Optical Telescope

A transportable station equipped with optical telescopes was displayed in the venue. This vehicle with twin telescopes installed on the container was probably the property of South Korea's astronomical observatory, and appeared to have been developed in order to allow ordinary people to observe stars, moving around the nation. It made me evoke the image of a vehicle-type optical ground station in the future.

▲Vehicle with Twin Telescopes (top view)

▲Vehicle with Twin Telescopes (side view)

5. Information of Host City: Daejeon

Reaching Daejeon requires three hours from Incheon International Airport by a limousine bus, which felt rather distant. The security was beefed up around the venue because of the presence of President Lee Myung-bak in the conference. Checking ID cards, performing X-ray baggage inspection, and collecting plastic water bottles were some of the activities at the entrance hall, which were the same as those that took place at airports. With regard to the weather, we were told that it seldom rained during this season; however, in actuality, it rained during those days. We were provided with rain capes at the conference reception, which was quite a unique service.

In addition, a few awkward incidents occurred in the conference such as crosstalk of wireless microphones that consequently interrupted a certain presentation and the Internet services were disrupted in the conference hall. It seemed rather uncommon for these things to occur to such an international conference.

Finally, with regard to my personal trouble, I confess that my custom-made suit trousers were caught on the influenza detection ultraviolet equipments installed at both sides of the entrance path, which had them torn. I was forced to hurry to a local tailor to get them mended. Later in the day, a person from the security company rushed from the neighbouring town to me, and we reached a settlement on my travel insurance money. This was a good lesson and it taught me that I needed to be prepared for any contingencies while travelling.

Acknowledgment

The author is really grateful to Secretary, Ms. Emi Koma, for translating and editing this report.