Reports on attending IAC2010

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Fig. 1. International Congress Centre in Prague

1. Introduction

The 61st International Astronautical Congress (IAC) was held in Prague, Czech Republic between Sep. 27 and Oct. 1, 2010. This paper reports the Conference, featuring the technical symposium on space communications and navigation (SCAN).

2. Opening Session

The 61st IAC was held at International Congress Centre in the city of Prague (Fig. 1), in which 160 sessions were organized and more than 2,800 participants assembled. This was the first IAC in Czech Republic in 33 years since 1977, and its opening ceremony was highlighted with a congratulatory speech delivered by V. Remek, the first Czechoslovak in space who is also the first cosmonaut from a country other than the Soviet Union or the United States (Fig. 2). The festive mood was highly raised by the stage of traditional Czech music and dance, and the audience was especially attracted by the performance of other countries' folk tunes in Czech style (Fig. 3).

Fig. 2. Speech by Czech Cosmonaut V. Remek

3. SCAN Committee

I attended the SCAN Committee on the IAC as one of its committee members. The Committee held a meeting on Sep. 28 and discussed subjects such as confirmation of cancelled presentations, renewal of the membership list, planning of the next year's plenary session in Prague, and the appointment of chairpersons. Considering the fact that 10% of the total 75 submitted papers to the 2009 IAC SCAN Symposium were not accepted, and that only 66% of average 68 papers per symposium were actually presented thus far in the previous sessions, we found it exceptionally striking that the B2.1 Session of this year symposium was scheduled to deliver 12 presentations out of 12 submitted papers (100%). We also discussed a new program for the next IAC, in which guest speakers will be invited for plenary lectures in each session to draw many participants with such a highlight.

Fig. 3. Entertaining performance in IAC2010 opening ceremony

The next SCAN Committee meeting is now scheduled to be held in Paris, France in the week of March 21, 2011.

4. Sessions in Space Communications and Navigation Symposium

The outline of each session is as follows:

B2.1 Advanced Systems

Robert Prevaux from the US and Ryutaro Suzuki of NICT from Japan served as chairpersons, and I, Morio Toyoshima as rapporteur for this session. 12 presentations out of 12 submitted papers were delivered in this session, which was the first perfection since this SCAN symposium started.

Electronics and Telecommunications Research Institute (ETRI) from Republic of Korea made a presentation on a satellite converging four missions of communications, broadcasting, positioning and Earth observation. The company is planning a 18 m deployable antenna for Ground Based Beam Forming (GBBF), and the satellite requires the mass over 7 tons and the power over 15kW. For power resource assignment, each 7kW is allocated to the two missions of communication and broadcasting respectively, and the rest is to the other two missions. **Gazprom Space Systems** from Russia presented its study on a satellite system on the high-elliptic orbit that can back the high-latitude region. This system includes three types of satellites, one called "ARCTICA-M" for meteorological observation with infrared scanners, one called ""ARCTICA-MC for communications, and the other called "ARCTICA-R" which is a sun-synchronous low Earth orbit (LEO) satellite equipped with a Synthetic Aperture Radar (SAR). **OHB-System AG** from Germany reported on development of a satellite system to detect Automatic Identification System (AIS) signals. The aircraft of this mission, with a mass of 327 kg and average power consumption of 240W, is designed to maintain in orbit for 7.5 years and provides a downlink at a data rate of 42.4Mbps. **European Space Agency (ESA)** challenged the issue of throughput degradation with increasing traffic in satellite internetworking, and proposed the way to enhance the throughput by mapping Frequency Division Multiplex Access (FDMA) and Time Division Multiplex Access (TDMA) in a two-dimensional matrix.

Fig. 4. Scene from Exhibition (DLR's booth)

Tohoku University from Japan introduced its study on an effective route control method on multi-layered satellite networks. In its simulated network with satellites of LEO at the altitude of 780 km and Middle Earth Orbit (MEO) at 10,000 km, the method it proposed can reduce a packet drop rate to half in the optimal route to minimize the hop count, compared with the existing Dijkstra's shortest path (DSP) method. **ESA** also presented the high capacity hybrid feeder links using the Q/V band and the optical band. In its report, the agency observed that the Optical Ground Station (OGS) is small in cost and large in capacity but needs site diversity at the same time. **Centre National d'Etudes Spatiales (CNES)** from France reported on the Alphabus program that is involving commercial partners such as Inmarsat. The agency remarked that European satcom industry successfully established its position in the world high-power telecom market. **Graz University of Technology (TU Graz)** from Austria announced its upcoming experiment to measure Q/V band propagation using the Alphasat satellite to be launched in 2012. For the ground terminal, a high power amplifier with output of 400 W and a Software Defined Radio (SDR) system for the receiver will be assumed. **Jet Propulsion Laboratory (JPL)** from the US presented optical link demonstrations between a ground station at Table Mountain in California and the Optical Inter-orbit Communications Engineering Test Satellite (OICETS). Four beacons and three communications laser beams were uplinked through a 1 m telescope and the downlink was received in a 20 cm telescope. The Agency reported the test results validated its link models.

National Institute of Information and Communications Technology (NICT) from Japan made a presentation on the results of the optical communications experiments between OICETS and the world's four OGSs. The agency developed a common analysis program to analyze the propagation data obtained at

each OGS, and for further steps, is prepared for free distribution of the program to any possible users for research-only purposes, which will contribute to the establishment of the future free- space propagation model.

B2.2 Fixed and Broadcast Communications

Twelve presentations were programmed including five cancelled in this session.

The first presentation was delivered by **Thales Alenia Space Italia** from Italy on the High Definition TV (HDTV) broadcasting satellite system in Ka-band. Despite some drawbacks of using Ka-band such as a propagation loss higher than Ku-band in present use, transmission in Ka-band is one of the solutions to increase the orbit-spectrum resources. **Devas Multimedia Pvt. Ltd.** from India is planning satellite multimedia services in mobile environments. Designed to provide all IP-based services, its satellite system employs two satellites of GSAT-6 and -6A with five spot beams that are stationary and on S-band around 2.5GHz. **Sirius Satellite Radio** from the US reported optimizing the system performance of Satellite Digital Audio Radio Services (SDARS) which came into operation in North America in 2000. The system is comprised of eight satellites; five GEOs and three Highly Inclined Elliptical Orbits (HIEOs).

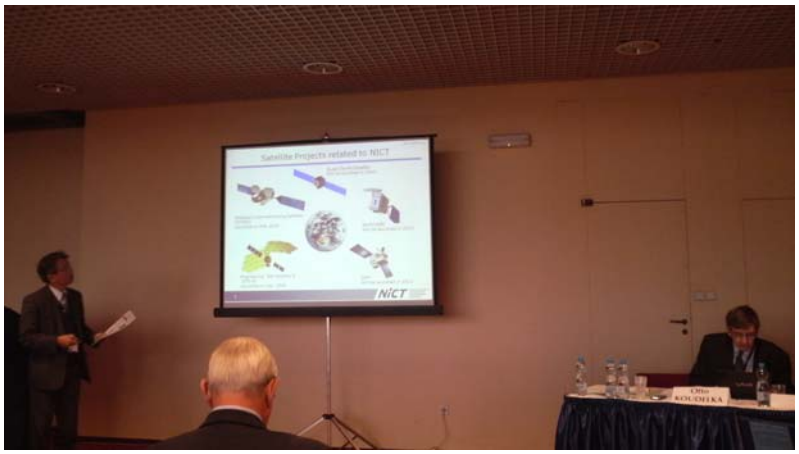

Fig. 5. Scene of B2.2 Session.

NICT made a presentation on survivability application demonstrations via Wideband InterNetworking engineering test and Demonstration Satellite (WINDS). In the presentation, discussed are various experiments for the survivability applications in a disaster, such as helicopter satellite communications systems, wireless ad-hoc connections using the IP phone, and airborne synthetic aperture radar (SAR) data connections. The agency carried out the demonstration of disaster communications combined with the IP network on the ground, which successfully resulted in less than 1 second delay in reply talk maintaining a good voice quality, and also the good performance of video data transmission. Fig. 5 shows the B2.2 Session. **LIQUIFER Systems Group** from Australia reported on analysis of the Chinese and Indian satcom markets. It observed that satcom applications in China are strongly influenced by the government and the military, and direct satellite reception to home TV is generally forbidden. Furthermore, it referred to necessary provisions of multiple channels even for a single satellite to cope with different languages spoken in the country, where many ethnic groups exist and the domestic demand seems greatly upward.

B2.3 Mobile Satellite Communications and Navigation Technology

Thirteen presentations were programmed including six cancelled in this session.

Korea Aerospace Research Institute (KARI) from the Republic of Korea made a presentation on the simulation of GPS based positioning control of a formation flying vehicle. The result was that formation flying vehicles at an along-track separation of 100 m can be maintained with a mean position error of approx. 0.2 m. **Dnipropetrovsk National University** from Ukraine reported on the modeling communication sessions between Ukrainian students' nano satellite and the GlobalStar System. The university studied the optimal height and inclination angle of the satellite's orbit for the maximum communications duration in transmitting sound signals. **ESA** presented the IRIS program, a satellite communications program for air traffic management. A launch in 2014 and system validation by 2015 are scheduled to start operational use by 2020. A launch of a backup satellite is also scheduled in 2018. **Universidad Politécnica de Madrid** from Spain reported its study on a software receiver for Galileo. The university has developed a FPGA based software receiver and showed the measurement results of E1 signals of 1575.42 MHz received from

the Giove-A and Giove-B satellites.

NICT introduced the current R&D status of the Satellite/Terrestrial Integrated Mobile Communication System (STICS). Specifically discussed are developments of a high linearity S-band GaN amplifier (SSPA) and a high linearity low-noise amplifier (LNA), technologies of low sidelobe, super multibeam and reconstruction of resource allocation. **ESA** presented scientific research with the Global Navigation Satellite Systems (GNSS). Scientific applications of GNSS under study are monitoring of ionosphere, monitoring of tropospheric delay, crustal deformation and earthquake studies, measuring the Earth's rotation, volcano studies, monitoring of glaciers, geodesy, tropospheric and ionospheric profiling by occultation, and so on. ESA has set up the GNSS Science Advisory Committee (GSAC) to evaluate and select the research themes.

B2.4 Space Navigation Systems and Services

This session program initially included a presentation on Quasi-Zenith Satellite-1 "Michibiki" of Japan, which was unfortunately cancelled.

Surrey Satellite Technology Ltd (SSTL) from the UK reported on development of the Galileo satellites. Following the launch of the Galileo test bed satellite called GIOVE-A of which development the company was involved in, it is engaged in part of the development for the in-orbit operational phase where the system reaches full operational capability with 30 satellites including three backups. The launch scenario is that each two Galileo satellites will be launched by each 5 Soyuz launchers, and four by Ariane-5. **Delft University of Technology** from the Netherlands introduced development of an emergency system for LEO to transmit emergency signals using Galileo GNSS to swiftly cope with the contingency. **Space System/Loral** from the US made a presentation on the implementation of European Geostationary Navigation Overlay Service (EGNOS) on the Sirius 5 satellite. Sirius 5, now on track for a launch in the fourth quarter of 2011, is equipped with a navigation payload of C- and S- bands providing the L1 and E5 signals. Another presentation of **Delft University of Technology** is about simulations of a deep space navigation system using pulsar radio emissions. The results show that navigating is possible by observing and processing Doppler shifted pulsar signals even though the received signals are very weak. **Beijing Aerospace Automatic Control Institute** from China reported the mapping on the computer vision with Speeded Up Robust Feature (SURF) algorithm for precise navigation of lunar landers. **Harbin Institute of Technology** from China introduced the methods of optimal synchronization of formation flying spacecrafts by pulsar timing.

B2.5 Near-Earth and Interplanetary Communication

RUAG Space from Switzerland made a presentation on a technology development roadmap for future interplanetary communications. Classifying interplanetary missions into two principle types: one is science and exploration missions and the other is infrastructure ones, the company examined an each case with various mission targets such as the Moon, the Lagrange point L2, the Mars, the inner and outer planets, and the Asteroids. **Japan Aerospace Exploration Agency (JAXA)** from Japan presented development of a Ka-band transponder. The agency is studying its Ka-band demonstrations in the Hayabusa-2 mission starting after 2014, and also in the science missions such as solar observations and Mars and Lunar explorations starting after 2017. **JPL** reported on Ka-band telemetry system upgrade for NASA's deep space network. The initial Ka-band operational support is required for the James Webb Space Telescope in 2014, and the upgrade has been implemented into the 34-meter antennas of its ground stations in the network. Another presentation of **RUAG Space** was about the potential of laser communications from interplanetary distances to Earth. The study is concluded with feasible communications at a date rate of 500Mbps from a lunar orbiter to a 1m ground telescope, and at 50Mbps and 5Mbps respectively from the libration point L2 and a Mars orbiter to a 15m ground telescope.

NICT made a presentation about a small optical transponder on board a small satellite. The agency is now developing an engineering flight model (EFM) with the mass of approx. 5 kg and power consumption of about 20W, and plans to execute satellite-to-ground laser communications demonstrations at a data rate

of 10Mbps.

Budapest University of Technology and Economics from Hungary reported on development of a new protocol of data transmission with sensors forming an ad-hoc network on the surface of a distant planet. **Johns Hopkins University** from the US proposed the routing algorithm based on graph theory for interplanetary communications. It reported how this graph routing algorithm operates to build an optimal network path. Another report from the university is about its developed software-defined radio which supports multiple frequencies and is capable of dual-band (X/Ka or S/Ka) transmit. Another development of a delay tolerant network for interplanetary communications was introduced by **University of Luxembourg** from Luxembourg. It presented the analysis results on the efficient routing for data transmission from the Mars to the Earth. **JPL**'s 2nd presentation was about the optimization methodology to maximize both the coverage of the Moon surface and the total amount of data transmitted for the robotic exploration of the Moon. The network consists of four lunar landers, a relay satellite between the landers and the Earth and the 34m dish system on the ground. **Graz University of Technology** from Austria presented an Internet-to-orbit gateway called HERMES that is provided by the ESA for educational use and enables Internet users to receive signals from a spacecraft in orbit. It reported that this gateway performed an important role during the event of the February 2010 near-miss collision between Iridium-33 and the Swiss cubesat.

Fig. 6. Famous Charles bridge (Karlův) in Prague

B2.6 Advanced technologies

Boeing Space and Intelligence Systems from the US reported development of on-demand satellite systems which can be swiftly provided for a launch such as in the event of emergency. This possible rapid deployment is contributed by recent technological innovation in which space capabilities previously afforded only for larger satellites are now able to be offered to small satellites. **Budapest University of Technology and Economics** made a presentation on its study of quantum-based satellite communications. The university examined the quantum dense coding and the BB84 quantum key distribution protocol's performance in which bit rates in the range of 10-100kbps can be achieved. **University of Dundee** from the UK presented development of SpaceFibre which, evolving from SpaceWire, is capable of data transmission at a rate of 2.5Gbps. The university plans to consolidate the specification of SpaceFibre ready for implementation as an official standard in the next two years. Also, its interface IP core will be developed to be implemented. **Technical University of Berlin** from Germany reported an S-band transceiver for small satellites with capabilities of MIMO and adaptive data rate technologies. The simulation results showed the maximum data rate of 4 Mbps from an orbit of 800 km to a 1.8m ground telescope.

Fig. 7. Estate Theatre (Stavovské divadlo)

John Hopkins University presented the experimental results of determining the spin axis for the NASA Radiation Belt Storm Probes (RBSP) mission by using RF Doppler signals re-

ceived on a 18 m ground station. **Graz University of Technology** reported a new telemetry system design for future nanosatellite missions, mainly consisting of a UHF uplink for commanding a spacecraft and an S-band downlink for which FPGA is employed. **State University of Londrina** from Brazil made a presentation about development of error-correcting codes which was started after the unfortunate event of data corruption in the transmission of telemetry data during the Platform for Acquisition of Acceleration Data (PAANDA) mission. Originally this mission was executed to obtain micro-acceleration data in a close-to-zero gravity environment on a microgravity platform launched by a sounding rocket named Cumã II. **University of Bremen** from Germany presented the satellite dynamic simulator called "Luvex", which is capable of floating freely by the help of a propulsion system composed of 3 thrusters connected to 4 air tanks filled with compressed air to hover the vehicle and 6 thrusters to move it with possible one-hour operation.

5. Information of Host City: Prague

The city of Prague is easily accessed and about 30-minute distant from the airport by taxi. We unexpectedly and luckily had a chance to enjoy an opera performance in the Estate Theatre (or Stavovské divadlo), one of famous historic spots in Prague, where Amadeus Mozart himself conducted the world premiere of his "Don Giovanni". This beautiful and classic theatre remains in my mind as a good memory of this city.

Fig. 8. Audience of "Don Giovanni" in the Estate Theatre

6. Acknowledgment

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