Space Japan Club

-Record of the man who sweated for satellite communications-

Mr. Masaaki Shimada

Senior Engineer, Aerospace Research and Development Directorate
Japan Aerospace Exploration Agency

– *Mr. Shimada has been engaged in technology development of satellite communications for many years. I heard that you joined the Radio Research Laboratory (RRL, now, National Institute of Information and Communications Technology (NICT)) at first, and then you moved to the National Space Development Agency (NASDA, now Japan Aerospace Exploration Agency (JAXA)). Would you introduce your career by yourself?*

In view of a full-size model of H-II rocket behind him at the Tsukuba Space Center of JAXA

I was assigned to Kashima Branch of RRL, Ministry of Posts and Telecommunications in 1978. I engaged in experiment of the millimeter wave (about 35 GHz) radio propagation using the Engineering Test Satellite-II (ETS-II) and preparation for the experiment of the millimeter wave satellite communication by using the Experimental Communications Satellite (ECS). Since both of ECS satellite launched on February 6, 1979 and ECS-b one launched on February 22, 1980 were failed in geostationary orbit injection, I carried the experiments of site diversity communication using the Medium Scale Experimental Communication Satellite (CS. Sakura) and an experiment of rain dispersion using remodeled ECS facilities as a substitute experiment of ECS.

After I had worked at Kashima for about 4 and a half years, I conducted the pilot experiment by the Communications Satellite 2 (CS-2) at Koganei Headquarters of RRL, development of CS-3 satellite control facilities at the Telecommunications Satellite Corporation of Japan (CSTJ) where I was transferred form RRL, development of ETS-VI (Kiku-6) onboard equipment (millimeter-wave transponder). Then I was transferred to the NASDA in 1991, and I engaged to develop the onboard equipment of inter-satellite communications and 21 GHz satellite broadcasting missions for the Communication and broadcasting experiment and test engineering satellite (COMETS, Kakehashi).

I prayed for success of launching COMETS as a member of satellite control team at the time of its launching in February 1998, but the communication experiment became hopeless because the satellite was not put into the planned transfer orbit due to shorter combustion time of the second stage engine of the H-II rocket than a plan. However, to carry out every possible communication experiment, we had examined the most suitable

orbit choice in a cooped up state for about a week . For the appropriate choice of orbit, repetition of orbit calculation was necessary while taking in a complicated condition, but quick analysis work by Mr. K, NICT (in those days, Communications Research Lab.) was very effective. Finally the satellite was injected into the orbit of about 17,700 km apogees, 30 degrees inclination after seven times of orbit change. The orbit made us unexpected presents. The apogee of the orbit moved to the Southern Hemisphere from the Northern Hemisphere day by day and it reached over Australia in March 1999. Since the usual elevation angle to the geostationary satellite at central Japan, is a little less than 50 degrees, the radio propagation is blocked by a high-rise building in the urban region and the satellite communication is disturbed. However, the elevation angle for COMETS at Sydney is about in zenith at this time. An experiment of mobile satellite communications on the Ka/millimeter wave band was performed by making a experiment vehicle run in city center of Sydney where high-rise buildings stand at both sides of road that is not wide. I think now it was the experiment that was ahead of quasi zenith satellite system.

From 1999 to February 2001 I had engaged to develop the S band mobile satellite communications system and its communication equipment onboard ETS-VIII (Kiku-8) at the Advanced Space Communications Research Laboratory (ASC). ETS-VIII was launched in December 2006 and its two large-sized deployable antennas of tennis court size successfully. However, abnormality occurred in power supply system of low noise amplifiers of the reception system, and it became impossible to recover receiver function. As a person concerned at the time of development, I still feel very regrettable.

Since March 2001, I had engaged to develop a communication mission for the Wideband InterNetworking engineering test and Demonstration Satellite (WINDS, Kizuna) that was a joint project by JAXA and NICT.

Imposing image of WINDS in a geostationary orbit !

A general introduction of WINDS:

JAXA's, No. 016, Oct. 1, 2007 http://www.jaxa.jp/pr/jaxas/backnumber_j.html

Technical introduction of WINDS:

“Special Issue on Wideband InterNetworking engineering test and Demonstration Satellite (WINDS)”, Journal of the NICT, Vol.54, No.4, December 2007, http://www.nict.go.jp/publication/shuppan/kihou-journal/journal-vol54no4.htm

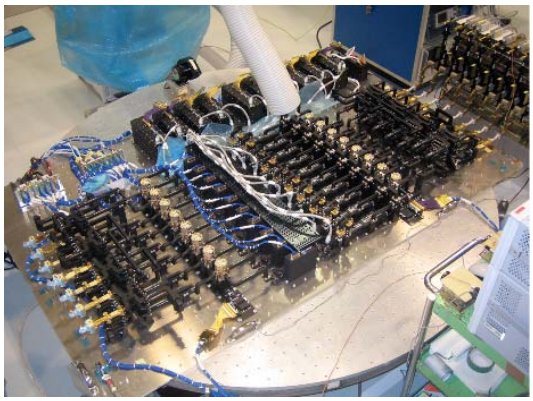
Space Japan Review, No.56 June / July 2008, http://satcom.nict.go.jp/56/index.html

– *Mr. Shimada, I think that you had a hard time to take charge of development of communication mission for the Japanese super-high-speed Internet satellite, WINDS, launched in 2008 and I think that there had been difficulty in longtime development. Would you talk about a story focusing on development of WINDS?*

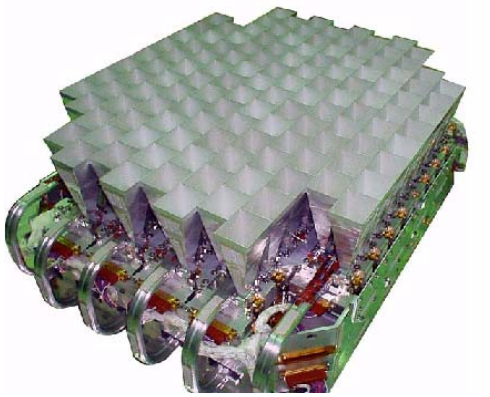
The mission equipment onboard the WINDS consists of multi-beam antennas (MBA) covering Japan and East Asia, high output multi-port amplifier (MPA), active phased array antennas (APAA) that can direct beams to arbitrary direction (in approximately earth field of vision), and a lot of wide band transponders (1.1 GHz bandwidth). A large number of high frequency radio devices of uniform characteristic are required, because a lot of numbers of beams and transponders are needed. I think that the people of manufacturer had to work hard for a long period from designing these onboard equipment, producing them and testing them to launching the satellite. Essentially, performance of the high frequency radio equipment can not be obtained only by making it. The targeted performance can be obtained as a result of warm-hearted electronic adjustment for each device. In particular, since the MPA and the APAA work by phase composition of signal, variation of gain and transition phase among devices deteriorate the whole characteristic of the MPA or the APAA directly. Therefore, people of manufacturer and we reviewed a production process and an adjustment process from a part level to achieve uniform gain, phase and temperature characteristics. The manufacturer explained the process in the factory casually and lightly, because it seems to concern to know-how, but I can image easily that there was serious hardship in development under cost constraint.

For JAXA side, there was some sweat, not just sweat but cold sweat, namely terrified matters. The next episode is the whole story of malfunction that happened to be found.

In NICT, special issue on the satellite is published in a bulletin "Review of the NICT" before its launch. JAXA was requested to write a paper about WINDS onboard equipment. The happening was occurred when I wrote an introduction on the whole WINDS communication system and individual equipment. A signal level diagram in transponder is important information for planning communication experiments. Just a signal level diagram is enough usually, but I wanted to introduce the thermal noise for the broadband transponder besides signal. I asked the manufacturer to submit level diagrams of signal and noise of the transponder. I found that the noise level had a little inconsistency in the transponder mode



18 GHz band MPA of eight ports: From the left, signal power divider, amplifier, power combiner.



18 GHz band transmit APAA: Rightly under 128 pyramid horns, solid state power amplifiers, phase shifters, etc. are implemented in high density.

using the APAA as a reception system, when I checked it as a double-check. I had a feeling that the ability of reception G/T (an index to express reception performance) of the APAA might not be demonstrated, because thermal noise was large unexpectedly. Therefore, I reinvestigated C/No (ratio of signal power to noise power density) data provided by a radio wave emission test in a combination of the APAA and the satellite main body that had already finished. Then my feeling changed to conviction because it became clear to be low C/No data compared with ability of inherent G/T performance of the APAA. The cause of unexpected large thermal noise was an attenuator that was inserted between the output of the reception APAA and the transponder for adjustment of signal level. An attenuator itself generates thermal noise depended on the attenuation value. But in the analysis on G/T, the effect of the attenuator can be neglected if gain of an amplifier put in a preceding section of the attenuator is sufficiently high. But gain of the APAA was not so high, and the cause was marginal level diagram in this case.

When the cause was found, it seemed to finish measure only by moving an insertion position of the attenuator, but, actually, it was not easy to solve it. The satellite was a flight model, so it was impossible to open new holes to change the position of wave guide equipments. The attenuation was redistributed so that the transponder performs without the non-linear operation and the thermal noise is suppressed, and it was able to be implemented. But there was not already any opportunity of the radio wave emission test that could confirm the repair result. The combination test of the APAA and the satellite main body together was conducted at the launch site (Tanegashima Space Center, JAXA) that was the last chance, and noise power was confirmed to be in near analysis value. Then the satellite was launched. I was really relieved when C/No was measured to be near calculated value in check-out in orbit after launching.

A state of a radio wave emission test

Before launching; "Get it, Oh!"

–After hard time of many years, you finished to launch the satellite, to put it into geostationary orbit, and to conduct its check-out successfully. Would you please tell us your frank impression about that?

I have been concerned in geostationary satellites mainly. But, no satellite that I concerned reached to the geostationary orbit or worked its expected function as my career shows. I resigned myself nearly to “All of satellites I concerned do not go well". But since WINDS arrived at the geostationary orbit and has functioned as expected, I feel like I have been liberated from the jinx for the first time. In the initial check-out, there was some malfunction, but, fortunately, big influence does not appear.

The lift off just before launch window closes at 17:55 on February 23, 2008.

– Would you tell me finally the future prospects of WINDS experiment and your own opinion and impression related to satellite communications development by Japanese government?

Please forgive me for saying a personal view. For an example of earth observation mission, its development result is returned to people through earth environment is monitored after satellite launch, a cause of earth environment change is pursued based on acquisition data, and environmental safeguard measures is taken. In the case of communications satellites developed as technology proof, the communication experiment is carried out for three to five years after its launch and its mission comes to a tentative end,

but I think that it is obscure under the present situation how the development result returns to people. Even if individual element technology is as high as world top-level, I do not think that the development results are returned if people does not accept them as a total system of satellite communications (space segment + ground one) from its cost and convenience of utilization.

"Contribution to digital divide free communication society" is one of the development purposes of WINDS so that it can offer possible Internet communication environment in anywhere since Internet already becomes one part of life. Using a very small aperture terminal of antenna diameter 45 cm which can be installed at a porch of usual home, people can receive high speed data of 155 Mbps via WINDS. It may be said that the development result is able to be returned only after the development result of WINDS are succeeded to new satellite communications system that people wants to use at reasonable charge.

There are application experiments, that the Ministry of Internal Affairs and Communications invited public participation and conducted selection, besides fundamental experiments by JAXA and NICT which are development organizations of WINDS. The application experiments will be started from this autumn under participation of people of universities, research organizations and communication industries in Asian countries as well as in Japan. I would like to make an effort still more so that development result leads to be returned.

–Thank you very much.

(Interviewed by Y. Suzuki, Editorial Adviser, August 2008)