Satellite Communications and I

“Satellites are huge products created by many technicians and engineers in various fields.”

Mitsubishi Electric Corporation

Kamakura Works

Futaba Ejima

“ Five, four, three, two, one, zero! ” There were orange flame and white smoke emitted from rocket’s engine with a roaring sound. The rocket left from a launcher, took off straight into a blue sky to the space. At 5:20 pm, September 10, 2002, H-II A F3 rocket loading two satellites, DRTS and USERS, was launched from Tanegashima Space Center. I have been engaged in DRTS (Data Relay Test Satellite) program, one of the 2 launched satellites, for 7 years. I said to DRTS, “Bon voyage!” with excitement and kept an eye on the moment of the launch. At that time, I felt like I could see DRTS through the rocket’s faring. After that, the rocket had a smooth flight, succeeded in separating satellites and placing them into their orbit. September 10 became an unforgettable day for me.

DRTS FM (December, 2002)

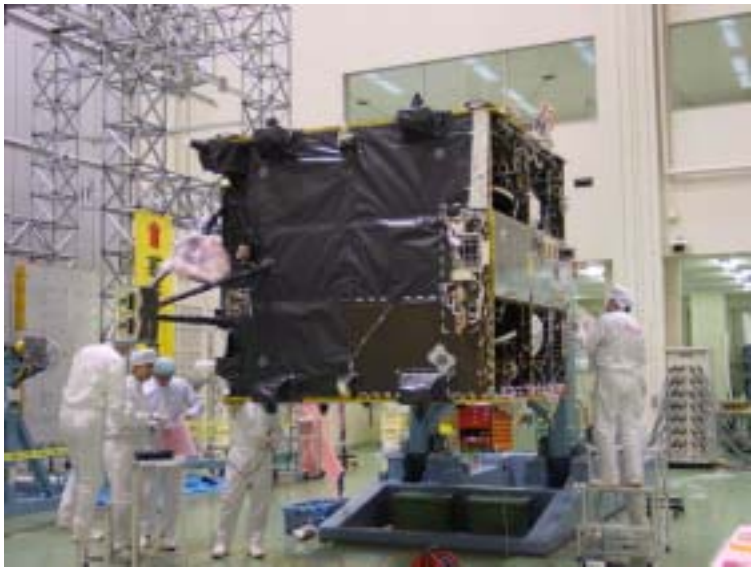
DRTS mission is an experiment of an inter-satellite communication. DRTS receives data from LEO (low-earth-orbit) satellite and transmits them to the earth station. By relaying data, we can have much broader range of communication on the earth. I am an engineer specialized in electrical and communication engineering and was in charge of ICE (Interorbit Communication Equipment) subsystem which plays the prominent role in DRTS system. I have been involved in designing, manufacturing, performance test and evaluation of ICE.

I remembered preparing a proposal in making a bid for DRTS with my boss soon after I had joined Mitsubishi Electric Co. (MELCO) in 1994. After completing and submitting the proposal, I enjoyed a little bit of relief but not enough before my boss told me suddenly, “Ms. Ejima,

we have been awarded an order of DRTS!" I replied in surprise, "Really!?" I still remember the moment when I heard the good news. However, I had too little experience at the time to understand the real meaning of "winning the order of one satellite". At all events, I couldn't help feeling happy because everyone seemed happy.

In normal satellite development procedure, we begin developing EM (Engineering Model) first and don't begin manufacturing FM (Flight Model) yet until we finish evaluating the performance of EM. Therefore, it takes considerable amount of time and indeed took us from 1996 to 1998 for development of EM, and from 1998 to 2001 for assembly and test of FM. The satellite system is divided into 2 parts, mission system and bus system. The mission of DRTS is ICE and the bus system consists of some subsystems such as ACS (Attitude Control Subsystem), EPS (Electric Power Subsystem), TTC (Telemetry Tracking and Command), UPS(Unified Propulsion Subsystem). Consequently, various sections of MELCO were involved in DRTS development. In addition we cooperated with other companies such as NEC and Toshiba (currently NTS), and IHI. I realized that it was a really big project to build such a satellite with so many suppliers and vendors joining us.

I describe below what I experience and learned through ICE project that I was in charge of. We started to design whole of ICE first and fixed the specification of components such as transmitter, receiver, frequency converter and filter. The components were designed, manufactured and tested appropriately to meet the specification. In the meantime, we investigated the layout of these components on the panel with system engineers. In this work, mechanical engineers and electrical engineers in various fields were involved to discuss each other to meet a performance of all components because the equipment have to meet the requirement of all aspects of electrical, thermal, and mechanical performance as well as reliability standpoint. The design of cables and harnesses, which are to connect the components on the panel, is another job that can not be overlooked. It was difficult to design cables around a motor. Other cables which were wired from the top of the antenna to the main body of satellite needed to meet a special specification so that they could survive under severe environment of the space with respect to wide temperature variation or radiation effect.



Assembly at Tsukuba Space Center

After said steps, the components were completed and delivered one after another. There

were many integration works as follows. The components were installed on the satellite panel, then DC integration took place to check the electrical interface of command and telemetry line, followed by RF integration in which the level and frequency of RF signal line were confirmed. Finally, these components were connected with RF cables or harness. All the process was taken care manually and the collaboration and harmony of assembly and test team was indispensable.

An author (left) during performance test at Tsukuba Space Center

When we proceeded to the assembly and test of satellite to some extent at Kamakura Works, we shifted our work site with the satellite to the Tsukuba Space Center where certain facilities are available for some test that can not be conducted at Kamakura Works. We stayed at a hotel near the Space Center. Though ICE is one of the subsystems, it takes about 80% of whole system test period to confirm the performance of ICE. ICE has some communication routes with the frequency of S-band and Ka-band, and each frequency band has bi-directional communication link of forward line (from earth station via DRTS to LEO) and return line (from LEO via DRTS to earth station) where the forward line has slightly higher frequency. We test and evaluate the characteristics of all the routes. We often worked until late in the night because the test schedule was always tight. Whenever any technical problems occurred, we had to trace them to their cause, investigate them and take appropriate corrective actions to make sure the problem had been resolved. While I didn't get used to the trouble shooting, I became very nervous and felt like crying because of the pressure, however, after learning a lot from the experience and advice my boss and experts provided, I gradually managed to solve the problems step by step with composure.

I felt a lot of tension when I actually dealt with the hardware because when I make a mistake in analysis or simulation I can try again and correct it, yet if I made a mistake in dealing with hardware they would be damaged or even broken. It was always necessary to think carefully, make quick and cautious judgment.

In contrast to these hard days, I have some peaceful and funny episodes that I had during my off-duty days. I used to take a walk along the pond near the SITE (Spacecraft Integration and Test Building) for breakfast, and a duck appeared from nowhere and chased after me so often, which I still can not figure out why. To commute between my

hotel and the Space Center, I rent a bicycle one day. Unfortunately, its saddle was set too high for myself and I fell down into the thicket after I lost the balance and landed awkwardly. My colleague watched my poor circumstance teasingly. I have too many episodes to write here.

I felt very happy when DRTS EM was completed, but at the same time we had to start manufacturing FM immediately. Though there was no design difference between EM and FM in principle, but there were some problems found on FM that we did not have on EM. I have learned in a hard way that the performance of FM was not necessarily the same as EM because the performance of parts or workmanship of the product might not always be the same.

In April 2002, DRTS, with full of memories, was transferred from Tsukuba to Tanegashima by a ferry. In May, four months before the launch, I made a business trip to Tanegashima Space Center to participate in the final performance test at the last stage. DRTS was ready for launch and waiting to be placed in a rocket's fairing. I could not resist feeling this would be the last time I could see DRTS. The test was completed successfully and finally September 10 came, and DRTS left the earth for space.

At Tanegashima Space Center (May, 2002)

In December, 2002, another rocket called H-II A F4 loading ADEOS-II satellite was launched. ADEOS-II, so to speak one of the friends of DRTS, was to perform a first experiment of an inter-satellite communication with DRTS. We wouldn't be able to achieve the experiment without success of both satellites. Ultimately ADEOS-II sent data and DRTS relayed them successfully and we managed to receive an image data of India and neighbor. I was very impressed with the picture and realized the significance of my job for the first time.

After the DRTS project, I am currently in charge of developing components for MTSAT-2 (succession of a weather satellite Himawari) and other future satellites. Satellites are huge products created by many technicians and engineers in various fields and there are dreams and bright aspect in there whereas there are continuous and steady works varying from designing little substrates to satellite integration. I am fascinated to the feature of satellite business by such aspects. ***(The End)***