# S-BAND GROUND STATION VERIFICATION AND OPERATION FOR LEAN SATELLITE, HORYU-IV

**Department of Applied Science for Integrated System Engineering**
**Graduate School of Engineering**
**Kyushu Institute of Technology, Kitakyushu, 804-8550 Fukuoka, Japan**
**Name: BONSU Benjamin, Student No: 14350943**

**1. INTRODUCTION:** Lean-satellites is equivalent to small/micro/nano/pico satellites that utilizes untraditional risk-accepting development methodology to achieve low-cost and fast-delivery. Lean satellites mostly developed by universities are launched into Low Earth Orbit (LEO) with an altitude range from 400km to 900km. Communication between satellites and ground stations mostly utilizes Amateur VHF and UHF bands, with respective data throughput of 1200bps and 9600bps. The challenge in LEO satellites is limited time window of communication. Therefore, larger size data downlink requires several passes during communication. As lean satellite missions become sophisticated, demand for high-speed communication is arising.

**2. ABOUT HORYU-IV LEAN SATELLITE:** The Arc Event Generator and Investigation Satellite (AEGIS) also known as HORYU-IV was developed by Kyushu Institute of Technology (Kyutech). HORYU-IV was released into LEO on the 17$^{th}$ of February 2016 (18:17:34 JST) at an altitude of 575km to acquire images of the discharge occurrence phenomenon on the experimental solar panels onboard. To demonstrate this advanced scientific technology, S-band communication subsystem was implemented onboard with transmitter data throughput of 100kbps, BPSK modulation scheme, bandwidth of 120kHz and transmitter output power of 0.4W (26.4dbBm) to downlink packets of data to its dedicated S-band ground station.

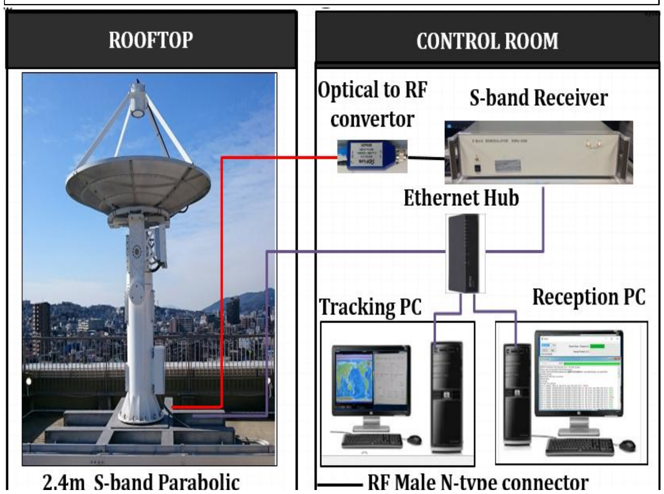
**3. S-BAND GROUND STATION:** A 2.4m parabolic dish antenna system (parabolic reflector, horn feed antenna, antenna drive system, and termination box) was installed at the Kyutech General Research building-1 rooftop. The control interface system (tracking and receiver computers) and customized S-band radio receiver were installed at the control room in the 8$^{th}$ floor of the same building. The development and installation of the S-band ground station was done by both Microlab and ELM Companies.

**4. RESEARCH PURPOSE:** My research purpose is to perform verification test on the S-band ground station installed and configured by Mircrolab and ELM and be able to operate the S-band ground station to receive downlink data during HORYU-IV operation.

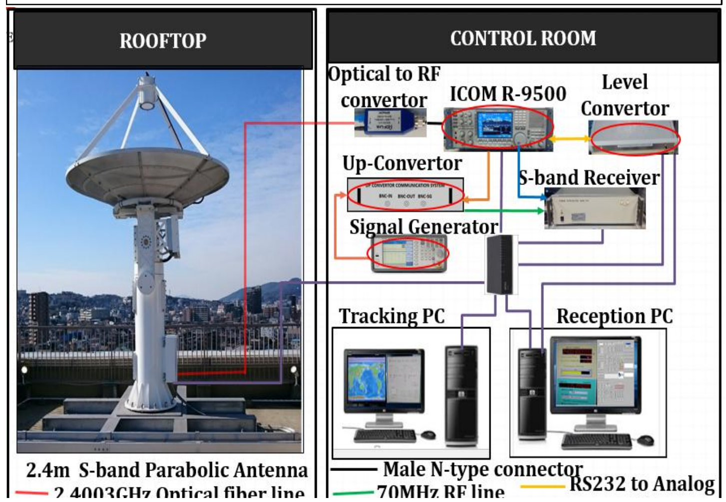
**5. VERIFICATION TEST AND RESULTS:**
Before HORYU-IV was launch, interference test performed on S-band ground station was free from WiFi signals and Mobile signal. End to End communication test results at a distance of 2600km (path loss of 168.3dB) between transmitter station and S-band ground station could able to satisfy the design requirement with a link margin of 20.2dB and data rate reception of 46kbps

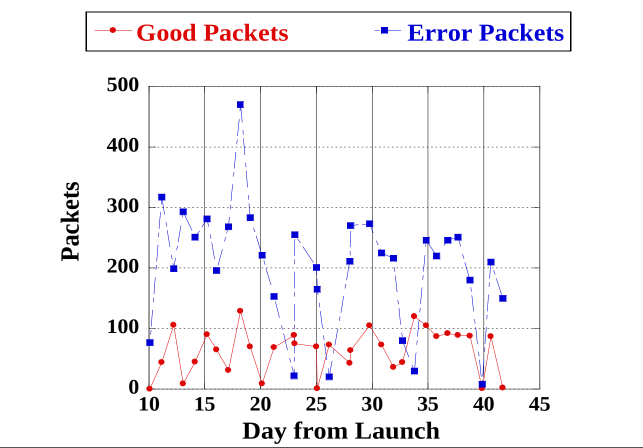
**6.OPERATION** : During HORYU-IV initial operations, the received data rate and link margin resuts could not satisfy the mission requirement. The two main anomalies detected that affected data rate reception and received signal strenth was doppler shift and attitude control. To mitigate these anomalies, doppler correction software was developed to interface with a commercial off the shelf radio receiver, (ICOM R9-500) and its hardware interface to control the frequency shift during HORYU-IV operation. After modification of S-band ground station and satellite stabilization, the downlink data rate reception could able to satisfy the requirements. Also after attitude control was able to stabilize

S-band ground station configuration before modification

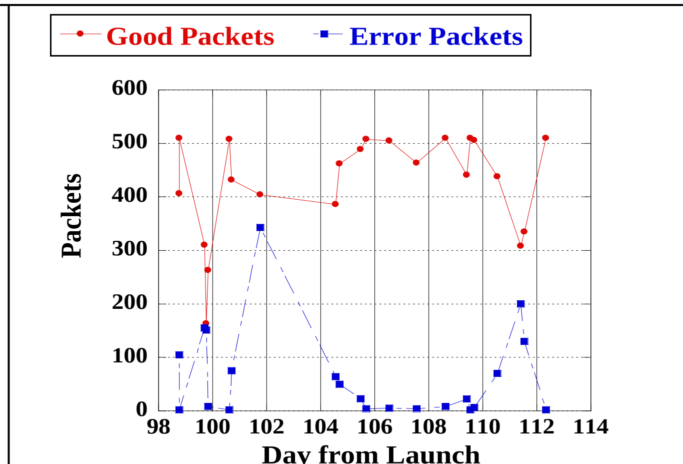



S-band ground station configuration after modification




Downlink packet data analysis results before S-band ground station modification




Downlink packet data analysis results after S-band ground station modification

**7. CONCLUSION AND FUTURE WORKS:** S-band ground station was successfully installed at Kyushu Institute of technology General Research Building 1. Before launch, verification test could satisfy the mission requirements. After HORYU-IV launch, it was realized that satellite attitude control and Doppler shift can greatly influence data reception. After modification of the S-band ground station configuration, the data rate reception could satisfy data mission requirement. From the lesson learned in this research, Doppler shift should be included in end to end communication test by performing real satellite operation with the ground station under test. Enough link margin should be set so that in case of attitude control delay, to stabilize the satellite, the S-band ground station can able to still decode the weak downlink signal. One general advise, is young communication engineers, should not rely on manufacturers documents regarding system specification but verification test should be performed to verify system performance.