Distribution measurement of Nano-Satellite components for shock level estimation

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1. Backgrounds & purposes

Of recent, universities and research institutes across the globe are focusing on Nano-Satellites. Typically, the weights and sizes of Nano-Satellites are within 50kg and 50cm respectively. Unlike large spacecraft, Nano-Satellite's development has attributes of low-cost and fast delivery. Most Nano-Satellites are made from non-space qualified and commercial –off - the –shelf (COTS) components. However, the biggest issue is on the testing to verify the reliability of the COTS and non-spaced qualified components that are used. The biggest worry of the developers and customers of Nano-Satellites is the approach for the implementation of environment testing. There is the test standard for Large/Middle satellites but there is not the one for Nano-Satellite. The test costs for Large/Middle satellites are so high. The costs are not suitable for Nano-satellite. Therefore, it is necessary to establish Nano-Satellite test standard because of providing an environment which can be developed efficiently at low cost.

In this paper, we focus on shock test, which is one of the environmental tests. Satellites are tested to ascertain whether the satellites can withstand the harsh environment at the time of launch rocket. Shock test of large satellites require a pyrotechnic facilities and a large place but the test method is not practical in terms of cost and time for Nano-Satellites. In order to provide a practical test for Nano-Satellite, we have developed shock test machines.現在、Shock test ha two problems. First is not to be a reproducible shock machine for nano-Satellite. Next is not clear the shock response level of the satellite components.

In this paper, it is described that the shock distribution of bombarding to the satellite and the development process of the shock test machine

2. Test Specimen

We used Dummy Satellite as a test specimen. It is shown in the Fig. 1. Dummy Satellite has a weight of approximately 50kg which is the largest of the Nano-Satellite. This satellite is suitable as an example of a test satellite for internal acknowledgment because the components included flight quality.

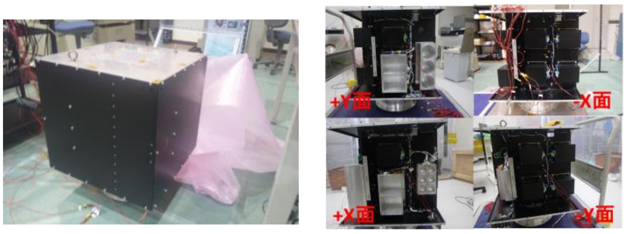

Fig.1 Overview and Inner Panel of Dummy Satellite

The dummy satellite was developed to acquire data for the specification of the environmental test standard and its main structure is based on QSAT-EOS having 4.5 tatami structure (yojohan).The satellite's structure is shown in Fig.2

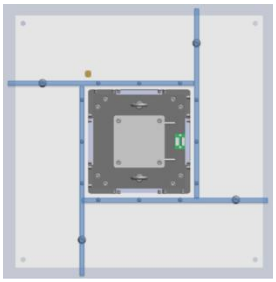

Fig.2 Top view of yojohan of the internal structure

3. Test Device

3.1 Shock Machine

We use the Copy shock machine which JAXA devised. The machine is shown in Fig.3.

Satellite is bolted to the base plate. The base plate is supported by hangers. We have fixed the base plate by fixing belt. Weight tool is fixed to the upper machine. We bombard the machine using pendulum. The points that have been changed from the first machine are shown in Table 1

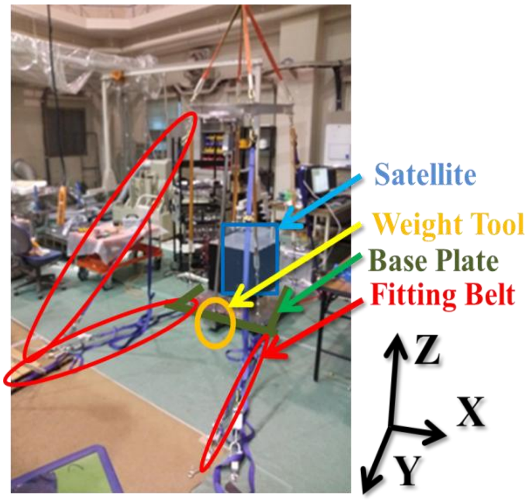

Fig.3 Overview of Shock Machine

Table 1 Comparison of Shock Machine

Machine	Original	Improvement
Weight Tool	Brass:7.7kg	Iron:10kg
Interface	Size:800×600×10cm^3 Weight:12kg	Size:1200×800×100cm^3 Weight:23kg
Fitting	Label Rope, Shelf	Tie-down belt, Bolt Anchor
Shock Absorber	-	✔
Note	-	・Positioning Tool ・Adapter

3.2 Analysis and Evaluation of Shock

Shock waveform is generated by SRS (Shock Response Spectrum) analysis. First, the shock acceleration is fast Fourier transformed on the time axis. Second, we plot the maximum absolute value of acceleration for each frequency. The graph is a SRS waveform. Shock reference levels are provided on rockets. It is determined whether a shock level exceeds the reference level in the graph. In this paper, we use the reference shock level of the H-IIA rocket. Shock test's configuration is shown in Fig.4.

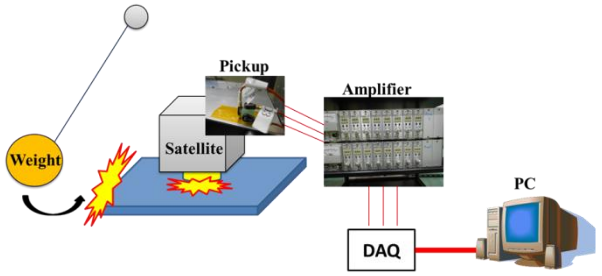

Fig.4　Test Configuration

4. Test Result

4.1 SRS Waveform

Our shock machine can do simultaneously the horizontal and vertical shock reference level. The waveform is shown in Fig.5.

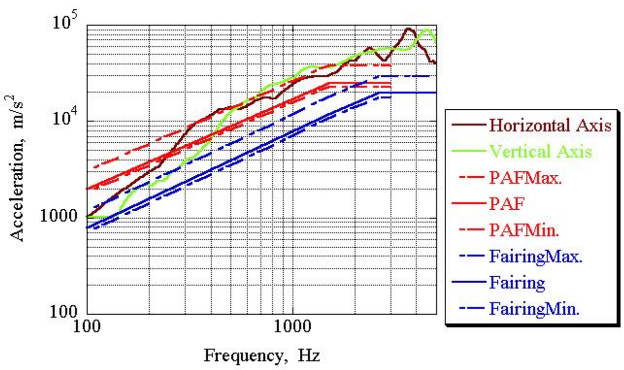

Fig.5　The Waveform of Shock Test

4.2 Shock Response Survey

Shock responses of Dummy Satellite are shownin Fig.6 and Fig.7. The shock responses difference decreases the frequency increases. In short, the internal responses are similar at high frequencies.

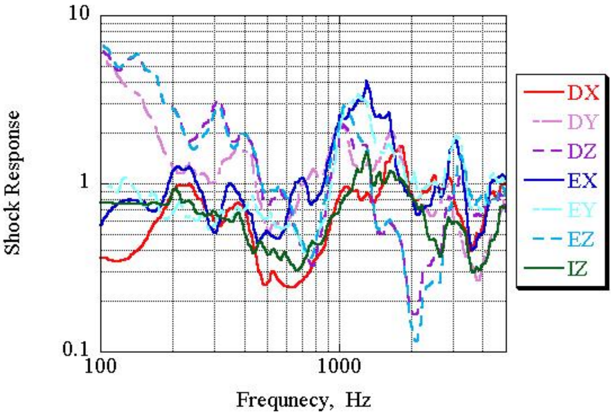

Fig.6　＋X Panel Shock Response

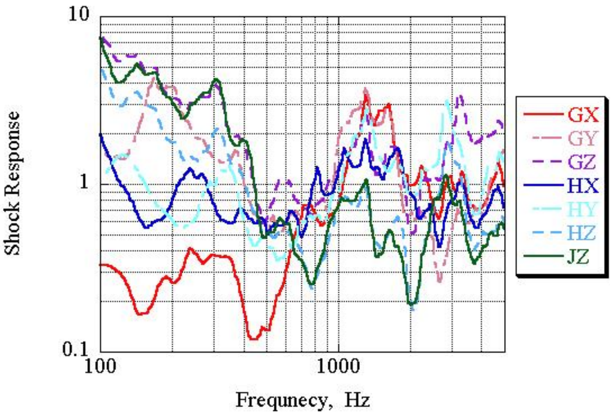

Fig.7　＋Y Panel Shock Response

It has become possible to estimate the shock level of Dummy Satellite's components by these results.

5. Future Plan

Hit to the impact face of the weight tool of our machine is not stable. The hit affects the shock level. I design the machine to lead the tool to the impact face because of changing into stable the hit to develop a reproducible machine.

We get the data of the shock responses for each some satellites and summarize shock responses in size and structure.

Reference

1) Japan Aerospace Exploration Agency: Guidebook for Small Sub-satellite Application to Carpool to the H-ⅡA　Rocket, 2010.

2) Japan Aerospace Exploration Agency:Shock Test Handbook ,2006.