Correlation of the CubeSat TestPod vibration test results with finite element analysis

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Abstract. One of the important verification steps before the launch of the nanosatellite developed at TUM (TUMnanoSAT) was vibration testing of the real model. These tests were carried out according to the requirements submitted by the Japan Aerospace Exploration Agency (JAXA) in collaboration with which the launch of our nanosatellite was possible [1]. Thus, in order to validate the structural integrity of CubeSat nanosatellites under launch loads, a 1U TestPod was designed and manufactured.

This work presents hands on experience of the vibration testing of the developed TestPod, the simulation of the modal analysis and the correlation of the obtained results. The testing facilities were provided by the Space Science Institute from Bucharest. Our test pod mounted on the test Jig is presented in figure 1, *a*. The attached accelerometer generates a voltage signal that corresponds to the amount of vibration and the frequency of vibration the machine is producing. Before the nanosatellite test, according to the requirements, the empty TestPod was tested on the Y and Z axes (for the X axis the nanosatellite can be repositioned inside the Pod). Acceleration data measured by modal survey are illustrated in figure 2. The blue line graph shows the response of the acceleration sensor.

The numerical calculation model was elaborated in ANSYS Workbench [2]. The meshed model in over 122800 elements is depicted in figure 1, *b*. The modal simulation results include the first 6 modes and contain values higher than the critical frequency of 140 Hz, reaching the level of 2000 Hz. The first

modes for the each axis are compared in the table 1. Results correlation is obvious.

Table 1. Experimental and numerical modal test results comparison.

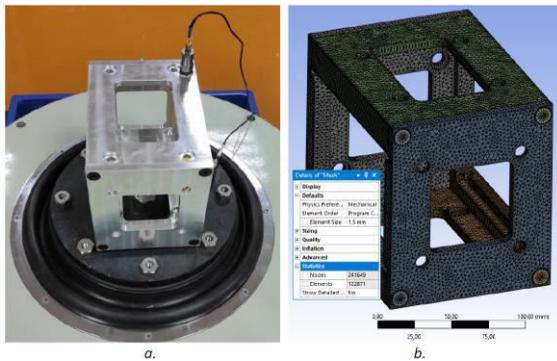| Axis	1ˢᵗ mode test freq., Hz	1ˢᵗ mode simulation freq., Hz	Difference, %
Y	325	328	0,9
Z	255	246	3,5

Fig. 1. CubeSat TestPod: *a)* real model; *b)* numerical calculation model.
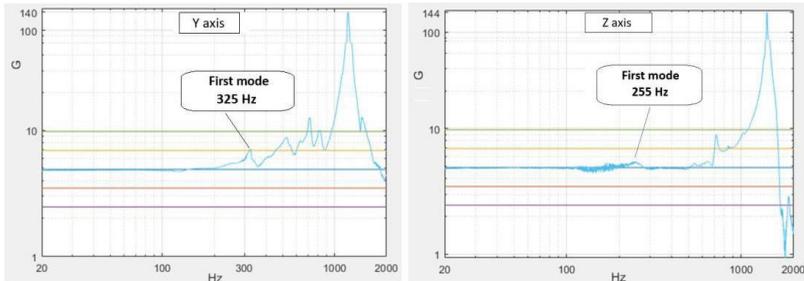

Fig. 2. Modal testing results.

References

[1] V. BOSTAN; N. SECRIERU; O. LUPAN și alții, Programul KIBOCUBE: Provocările și experiența Universității Tehnice din Moldova în dezvoltarea nanosateliților. – Ch.: Bons Office SRL, 2022, 259 p. ISBN 978-9975-166-65-2.
[2] S. Furger, Analysis and mitigation of the Cubesat dynamic environment. Master thesis, California Polytechnic State University, USA – 2013.