Introduction to the IEEE Open PocketQube Kit

Thanks to the introduction of the CubeSat standard in 1999 by professors J. Puig-Suari (California Polytechnic State University) and Bob Twiggs (Stanford University's Space Systems Development Lab) in the past two decades, the number of satellites launched has increased exponentially. CubeSat's were initially defined in a configuration called a 1U, that is equivalent to a cube of 100 mm side, with a mass of roughly 1 kg. However, recent revisions of the standard (Available here) increased the 1U mass to 2 kg, and allowed the possibility of different 1U combinations for 1U, 1.5U, 2U, 3U, 6U and 12U. The softer requirements of a CubeSat as compared to other conventional satellites has allowed organizations and institutions with limited resources to be able to launch their own payloads, operate their own missions, and reduce the mission required development time.

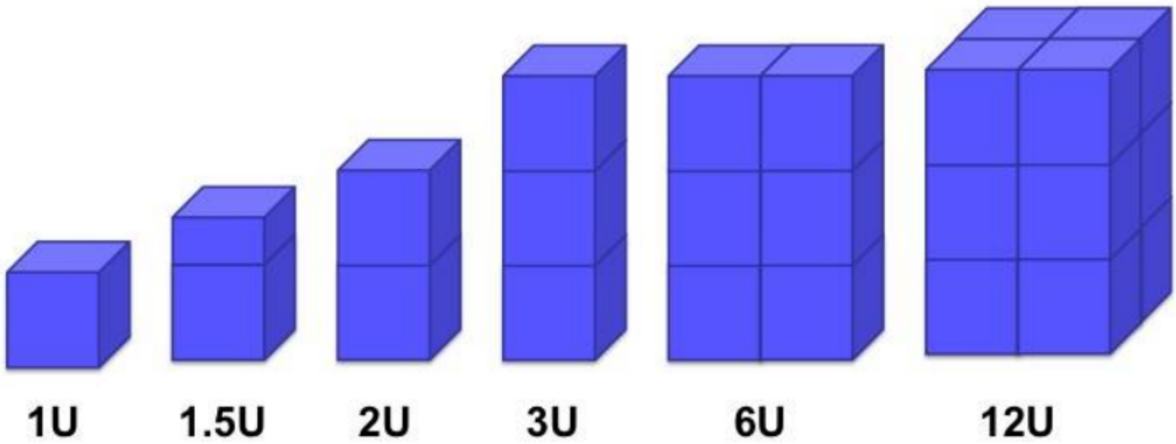

Figure 1.1 CubeSat Sizes. Illustration by NASA

Despite the reduced complexity of a CubeSat as compared to a conventional satellite, the difficulty in developing a CubeSat is still a barrier for some organizations that do not have the required facilities or knowledge, and cannot afford its cost. For this reason, the PocketQube specification was introduced in 2009, which proposed a pico-satellite with dimensions of 50x50x50 mm called a 1P unit, that is half the side or the eight of the volume of a CubeSat, with a mass smaller than 250 g. The first PocketQube was launched by the Morehead State University in collaboration with the

Sonoma State University in 2013.

The objective of the PocketQube was to further reduce the spacecraft cost and complexity, while trying to maintain as much functionality as possible. This has been possible thanks to the improvement in commercially off-the-shelf (COTS) components. Despite not being specifically designed for space applications, they have shown to be fairly durable to space environmental conditions, as shown by the number of recent missions launched. Their mass production has also led to a reduction in cost, which favors the adoption of the PocketQube standard.

After the introduction of this new and smaller form factor, several companies and institutions have started using this new type of spacecraft for applications that have been mainly focused on IoT and EO, and it has also served as an educational tool for academic institutions and associations. The two leading companies in the use of PocketQube's for space missions have been Alba Orbital and FOSSA Systems.

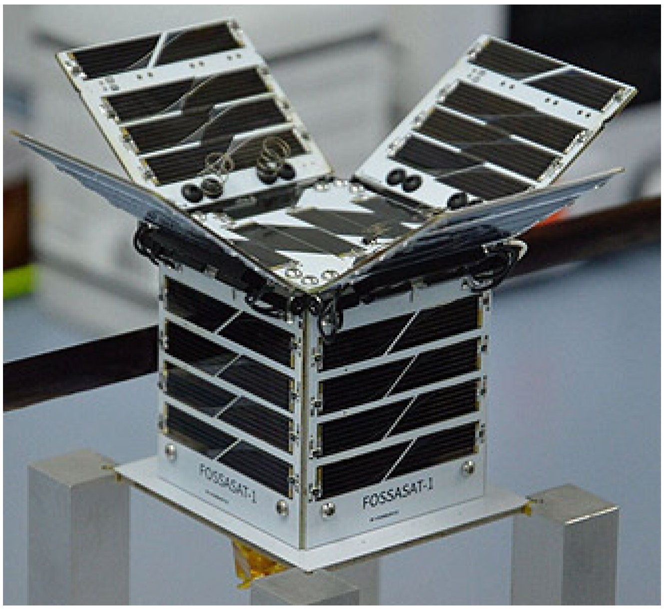

Figure 1.2 FossaSat1 [Fossa Systems]

Furthermore, the space harsh environment conditions make that not every solution is feasible. Spacecrafts experience high levels of radiation because of the lack of the Earth's atmosphere that degrade materials at a higher rate and means that not all materials can be used, big temperature gradients stress materials and can damage electronics critically, single-event upsets can hang the on-board computer or corrupt memory, and the extreme vibrations experienced during launch can affect the structure and connectors.

These inconveniences combined might require a knowledge level and a number of resources that cannot be surmounted by some organizations that otherwise might want to design a spacecraft mission, turning into a barrier for new-comers to the space sector. Therefore, the GRSS-IEEE procured the development of the "IEEE Open-PocketQube Kit" as an educational initiative for all interested organizations that want to pursue a PocketQube and might not have the means to start.

For compatibility with commercial deployers, the PocketQube developed in this project follows the PocketQube mechanical standard. The standard specifies that the dimensions for a 1P pocket have to be of 50x50x50 mm, and that it has to be placed over a 64x58 mm interface board that will be used to hold the PocketQube inside its deployer. Despite that, the standard does not however specify the inner structure of the satellite. As a result, the “IEEE Open PocketQube kit” has been proposed as an alternative to reduce the entry barrier.

The “IEEE Open-PocketQube Kit” is an educational initiative proposed by the IEEE GRSS society to develop an open-source PocketQube kit to facilitate the entry barrier to organizations and institutions to space. Its design started in Spring 2020, and it has been carried by previous PAE and TFG students that worked in the development of the PocketQube that preceded this project.

The need to create an open-source PocketQube kit comes from the requests of new-coming institutions in the space sector that want to launch a satellite, but do not have the means to start their design from zero. The kit should provide the design resources necessary to be capable, for any unexperienced organization, to reproduce the structure and subsystems of one 1P PocketQube, and be able to integrate a custom payload. These includes the subsystems schematics, layouts and bill of materials, documentations and guides needed to elaborate a PocketQube.

Within the “IEEE Open PocketQube kit” project three different payloads will be developed and tested in three different PocketQube’s:

- ^{Po}Cat 1: carries a VGA camera,
- ^{Po}Cat 2: carries a L-band RFI monitoring payload,
- ^{Po}Cat 3: carries a Ka-band RFI monitoring payload to measure the possible interferences caused by the 5G communications system deployment.

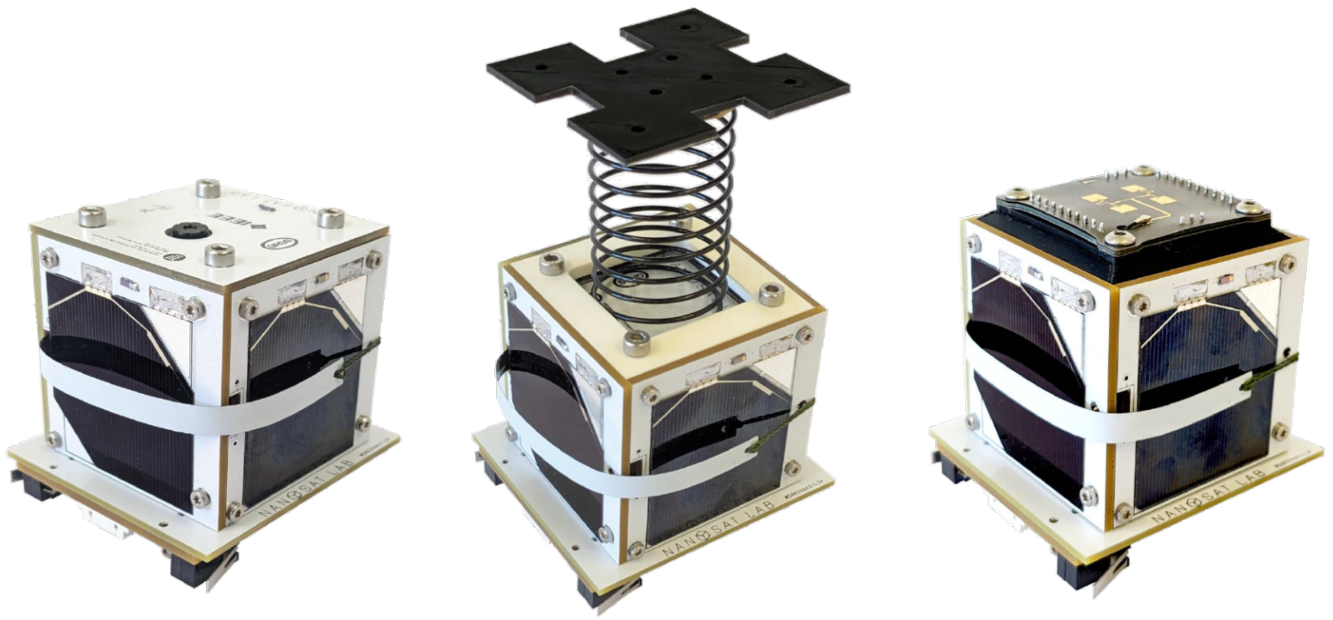

Figure 1.3 ^{Po}Cat 1, ^{Po}Cat 2 and ^{Po}Cat 3, the PocketQubes developed in the context of the *IEEE Open PocketQube Kit project*.

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