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CubeSats

Introduction

A movement towards smaller nano- and pico-satellites began two decades ago when Bob Twiggs, a professor at Stanford University and a group of his students created the first pico-satellite. The first pico-satellites were used by Aerospace Corporation as an initiative to test the feasibility of launching several smaller satellites into orbit. Shortly after, Twiggs began developing the CubeSat. Six years after its development, CubeSats have become known as the standard for small satellites. They are now being used at over 60 different universities and high schools as well as programs initiated by the US Air Force and National Science Foundation [1]. NASA has also recently began a CubeSat Launch Initiative where twelve CubeSat payloads were selected for launch. This initiative will allow educational institutions across the country the opportunity to launch nano-satellites into space for research purposes [2].

Commercial Applications

CubeSats are nano-satellites used specifically for research. They are characterized by the dimensions "Units" or "U" which are 10 x 10 x 11cm [3]. CubeSats can measure 1U, 2U, 3U or 6U in size. CubeSats weigh approximately 1.33 kg per U. In addition to their small size, the appeal of these nano-satellites is their significantly lower cost. The cost of a CubeSat launch starts around $100,000 [4]. This is significantly cheaper than launching large geosynchronous orbits (GEO) satellites which can cost between $200-$500 million [5]. CubeSats are cheaper because they do not require a dedicated launch vehicle. Additionally, CubeSats are built with electronic circuit chips like microprocessors and radio frequency transmitters and receivers that are also used in smart phones and other small electronics. The miniaturization of electronic devices has helped with the creation of nano-satellites.

CubeSats have been used in a plethora of research application areas ranging from fundamental biology and environmental sensing to testing flight systems. NASA has utilized CubeSats in Astrobiology research because of a desire to gain access to interplanetary conditions in low Earth orbit. NASA has launched two CubeSats between 450 and 550 km above the surface. GeneSat was launched in 2006 to

study space's effect on bacteria and PharmaSat was launched in 2009 to study the effect of various anti fungal agents on yeast in space [1].

Technology for CubeSats

While CubeSats have provided many organizations and institutions with access to space due to lower cost satellites, they are limited by the power and range of the communication antennae. The antenna use radio frequencies in the VHF, UHF, L-, S-, C-, and X- band. Specifically at low Earth orbit, CubeSats use antennas for communication at the UHF and S-band [6]. CubeSats rely on the interaction between the satellite and the ground. An onboard computer (OBC) is essential for this communication. It is developed around a microcontroller and performs all computing tasks. The OBC also organizes payload data before downlink [7].

When CubeSats were first created they used Salvo RTOS embedded software on microcontrollers. As CubeSats became more commonly used, a CubeSat kit was created that includes both hardware and software components. The CubeSat kit hardware uses Pumpkin's satellite architecture and allows support from multiple processors. It implements a motherboard as well as a development board that can be used for laboratory work. The CubeSat kit also includes software libraries that allow the CubeSat to enable and control the transceiver interface, USB interface, SD card interface, power switching and shut down for minimum power consumption. Lastly, the CubeSat kit runs Pumpkin Salvo Pro RTOS Software which is a framework for multitasking applications [8].

References

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