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CUBESAT MISSION WITH TECHNOLOGICAL DEMONSTRATOR PAYLOAD FOR HIGH DATA-RATE DOWNLINK AND HEALTH MONITORING

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ABSTRACT

A phase–A study has been performed on a Cubesat design. The HyperCube payload will be composed by two different technological experiment, an high data-rate C band antenna, and a demonstrator for a remote structural health monitoring system. The first one has been thought with the aim to give Cubesats the capability to download an high quantity of data; it could be useful either if the data requiring the high data-rate downlink is on-board generated or simply retransmitted. The applications for which this payload could be used are several; an example for the first category of application is to download the data generated by another payload; the high data-rate capability could be necessary due to the narrow visibility window with the ground station, affected also by the absence of an active AOCS subsystem, which makes difficult the alignment of the on board antenna with the ground one. But the C band antenna could also be used to act as a "space–repeater", downloading up–linked information. The second payload is related to the need to take under strictly control the health of the structures (not only the ones strictly belonging to primary structures, but also that of any subsystem component). In order to do that, smart materials are integrated into the structural component that need to be monitored; in particular, piezoelectric patches are used as sensors. As the structure is stressed, and the integrated piezoelectric sensors are subjected to mechanical deformation, they produce an electric signal; acquiring and properly studying the produced signal it is possible to monitor the mechanical condition of the structures. The health monitoring system is completed by a MicroController Unit which acquires, samples and stores the signal produced, and a transmitting system, which could be the C band antenna, or the TT&C antenna which each satellite needs.

INTRODUCTION

The HyperCube project involves a preliminary study to define the scientific and technological mission to carry out and objectives to accomplish, and to size the satellite subsystems, identifying the critical aspect of the designing process related to the payloads chosen for the mission. The aims of this project were several; first of all the educational objectives, principal purposes for every university respect to its students; educational objectives should be listed as:

- to provide the best possible education in space engineering through team work, hands-on experience, designing and testing of a real spacecraft;
- to get the students in Engineering involved into a real space mission;
- to create a "space conscience" in students.

Secondly the technical aspect, either related to sizing of satellite subsystem, for example the definition of a strategy for the attitude determination and/or control, or focused on the satellite components testing and integration. But also technological aspect must not be neglected. In fact two technological experiments has been chosen to be the satellite payload among several possible experiments identified during a preliminary brainstorming activity. The first decision to take before starting the preliminary design process was the one related to the experiments to mount on board satellite; in fact it's this first step that defines the mission and system requirements. The trade-offs made to determine the more appropriate, feasible and affordable payloads lead to decision to try to mount the following two payloads on board satellite. The first one is related to the heritage on the smart structures and its usage as sensors and actuators; it has been decided to mount on a satellite internal platform a certain number of piezoelectric sensors in order to monitor the vibration which the satellite face during the launch phase. The geometric position and the dimensions has been caught up by a previous work on this thematic. The vibration of the platform will be sensed by the piezoelectric material, acquired as an electric signal by the microcontroller unit (MCU), stored in its internal memory, and, finally, once the satellite is in orbit, and a first link with the ground station has been established, downloaded to ground. The second payload to mount on board satellite will be a C band antenna. This kind of antenna provide the possibility to guarantee an high data rate link between the CubeSat and the ground station, in order to allow the satellite to manage an elevate quantity of data, atypical for a satellite of this size. This type of antenna could be useful either if the data requiring the high data-rate downlink is onboard generated or simply retransmitted. The applications for which this payload could be used are several; an example for the first category of application is to download the data generated by another payload; the high data-rate capability could be necessary due to the narrow visibility window with the ground station, affected also by the absence of an active AOCS subsystem, which makes difficult the alignment of the on board antenna with the ground one. But the C band antenna could also be used to act as a “space–repeater”, downloading previously up–linked information, working as a Data Relay Satellite.