



ESEIAAT



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Cubesat Constellation Astrea

Report

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1 Satellite design planning

Interdependency relationships among tasks, human resources and level of effort

ID	Work Package	Time (h)	Prelations
1. Preliminary design			
1.	Preliminary design	30	
2. Structure and mechanics			
2.1.	Structure	6	BF - 1
2.2.	Deployments	6	BF
2.3.	Thermal protection	9	BF
2.4.	Commercial availability	12	BF
2.5.	Choose option	6	BF
3. Electrical Power System			
3.1.	Solar arrays	9	BF - 1
3.2.	Batteries	9	BF
3.3.	Power management	12	BF
3.4.	Commercial availability	15	BF
3.5.	Choose option	9	
4. Propulsion Systems			
4.1	Motivations	12	BF
4.2	Commercial availability	15	BF
4.3	Choose option	9	
5. Payloads			
5.1.1.	Data Handling Systems	15	BF
5.1.2.	Antenna	12	BF
5.2.	Commercial availability	15	BF
5.3.	Choose option	15	
6. AOCS			
6.1.	Attitude determination	9	BF
6.2.	Attitude control	9	BF
6.3.	Orbital Control	12	BF
6.4.	Commercial availability	20	BF
6.5.	Choose option	4	

Table 1.1: Prelations and Time

2 Satellite design

2.1 Structure and mechanics

EMPTY

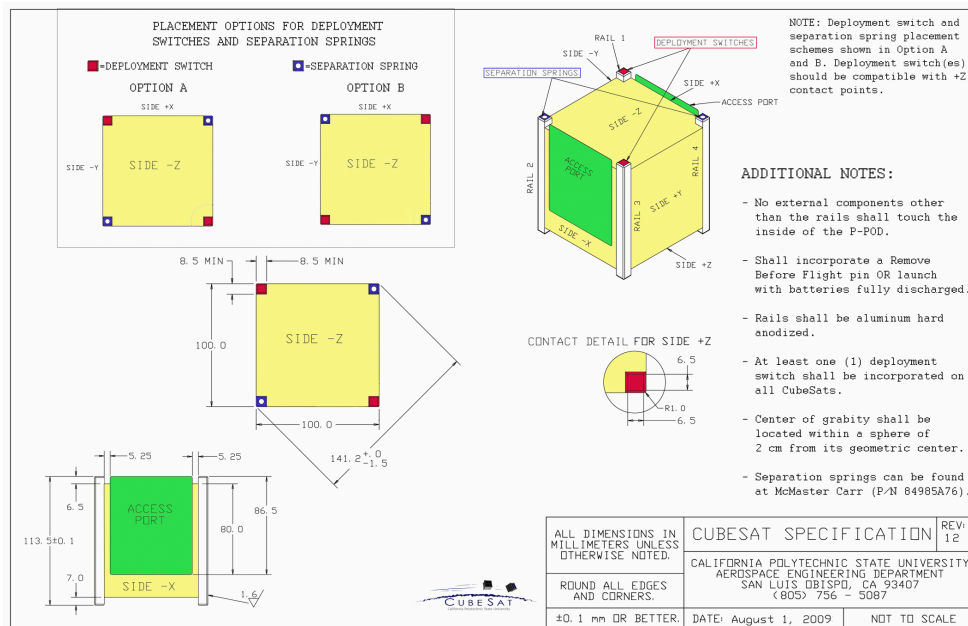


Figure 2.1: Dimensions of a 1U CubeSat [?]

2.1.1 Structure

EMPTY

2.1.2 Deployments

EMPTY

2.1.3 Thermal protection

The thermal protection system protect the CubeSat from thermal shocks. The satellite must remain in a optimal range of temperatures, despite the external temperature. It consists of various insulating materials and thermal conductors in order to maintain it within acceptable temperatures.

2.1 Structure and mechanics

2.1.4 Study of the commercial available options

EMPTY

2.2 Electrical Power System

Brand and model	Features and description	Money (€)
Solar Panels		
Fabricant 1	EMPTY	2000000
Chuscas 1	EMPTY	20000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 2.1: Options studied

Of all the options in 2.4, we have chosen the following options.

2.2 Electrical Power System

The Electric Power System of the satellite must provide and manage the energy generated efficiently in order to have all the systems operating under normal conditions. The Electrical Power System of a Cubesat is, probably, the most fundamental requirement of the satellite payload, since its failure would result in the mission failure. The functions of the EPS are to control and distribute power to the Cubesat, to supply a continuous source of electrical power for through the lifetime of the mission, to protect the satellite against bus failiures and to monitor and communicate the system status to the on-board computer. The role of the EPS is very diverse and the following subsystems have to be analyzed in detail.

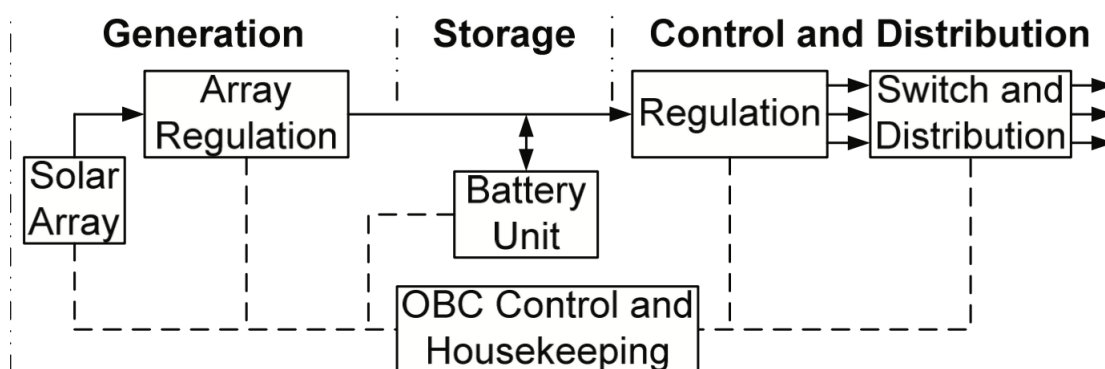


Figure 2.2: Basic schematics of the EPS [?]

2.2.1 Solar arrays

The primary source of electrical power has to be photovoltaic cells, given the size of the CubeSat. The photovoltaic cells will collect and convert the energy of the sun into electrical energy. Since they are main power source, they have to be correctly selected to prevent failure. Among the characteristics we seek for our mission, we are looking specially wheter the solar

2.3 Propulsion Systems

cell has a decent amount of power collection, low mass, protective radiation shield, deployment system, great temperature range and compatibility with the other systems.

The selected option for the Astrea mission will be a set deployable solar panels provided by EXA (Agencia Espacial Civil Ecuatoriana). These panels are low mass (135g each), have a protective radiation shield (NEMEA Anti Radiation Shield protects the solar panels of EM, High Gamma, X-Ray, Alfa, Beta and low neutron radiation), a very high temperature range (from -80 to 130°C), a gentle release and deployment with artificial muscles (developed by EXA) and provide a power of 16.8W each (19.2V@0.5A).

Every cubesat will have 6 deployable solar panels providing it with 100.8W of power to supply peak demands while it is operating. Additionally, it is worth mentioning that these solar arrays are compatible with the hardware used in each of the satellites.

2.2.2 Batteries

Batteries are vital for a proper mission operation. They will provide the spacecraft subsystems with the power needed when the solar arrays are working less efficiently or not properly. Astrea is looking for decent capacity batteries (because the subsystems will not usually require a peak power and the batteries are just an emergency system), operating at the desired voltages and currents and

2.2.3 Power management

2.2.4 Study of the commercial available options

Several commercial options have to be studied. The table provided below organizes some information about the different options purchased.

Brand and model	Features and description	Money (€)
Solar arrays	EXA (Agencia Espacial Civil Ecuatoriana)	17000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 2.2: Options studied

Of all the options in 2.4, we have chosen the following options.

2.3 Propulsion Systems

EMPTY

2.3 Propulsion Systems

2.3.1 Motivations

There is a big risk of a collision with space debris while a spacecraft is operating in Low Earth Orbits. The Inter-Agency Space Debris Coordination Committee recommended to the United Nations (section 5.3.2 ‘Objects Passing Through the LEO Region’): “Whenever possible space systems that are terminating their operational phases in orbits that pass through the LEO region, or have the potential to interfere with the LEO region, should be de-orbited (direct re-entry is preferred) or where appropriate manoeuvred into an orbit with a reduced lifetime. Retrieval is also a disposal option.” and “A space system should be left in an orbit in which, using an accepted nominal projection for solar activity, atmospheric drag will limit the orbital lifetime after completion of operations. A study on the effect of post- mission orbital lifetime limitation on collision rate and debris population growth has been performed by the IADC. This IADC and some other studies and a number of existing national guidelines have found 25 years to be a reasonable and appropriate lifetime limit.”

Thus, a proper propulsion system is needed both for maintaining the satellite’s orbit and for de-orbiting after the mission’s lifetime.

Given the size of the CubeSat, not many effective options are available and a committed solution has to be found in order to follow the recommendations by the IADC.

2.3.2 Orbit decay

Orbit decay prediction powered by the Bureau of Meteorology by the Australian Government.

To calculate the orbit decay the following parameters are used:

Solar Radio Flux at 10.7cm (F10.7). It is a clear indicator of solar activity and has proven very valuable in forecasting space weather. The extreme UV that impact the ionosphere also modify the upper atmosphere, thus F10.7 data is needed to account for these variations. The value used in this calculation is: 79.54. REF: <http://www.spaceweather.gc.ca/solarflux/sx-5-mavg-en.php>

Cubesat mass of up to 4kg.

The K-index, and by extension the Planetary K-index, are used to characterize the magnitude of geomagnetic storms. Kp is an excellent indicator of disturbances in the Earth’s magnetic field and is used by SWPC to decide whether geomagnetic alerts and warnings need to be issued for users who are affected by these disturbances.

2.4 Communication module

The principal users affected by geomagnetic storms are the electrical power grid, spacecraft operations, users of radio signals that reflect off of or pass through the ionosphere, and observers of the aurora.

The geomagnetic index used in this calculation is: 12.

RE-ENTRY EVERY 106.25 DAYS!

Calculations based on day 100, with an altitude of 400Km. Already lost 100Km:

2.4 Communication module

100kbps:

1mbps:

¿solo 9600bps?:

Links interesantes universidades:

2.5 Attitude and Orbital Control Systems

Attitude and orbital control subsystem is needed to enable the satellite to keep a specific position within its orbit and to control the antennas in order to remain oriented to assigned area, because the satellite tends to change its orientation due to torque. The AOCS receives telecommands from the central computer and acquires measurements (satellite attitude and orbital position) from sensors. We will also refer to the attitude control as ADACS (Attitude Determination and Attitude control system).

2.5.1 Attitude Determination

EMPTY

2.5.2 Attitude Control

EMPTY

2.5.3 Orbital Control

Thrusters

2.5.4 Study of the commercial available options

2.6 Payload

Brand and model	Features and description	Money (€)
Solar Panels		
Fabricant 1	EMPTY	2000000
Chuscas 1	EMPTY	20000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 2.3: Options studied

2.6 Payload

EMPTY

2.6.1 Communications systems

The communication system allows us to realize the reception and trasmission of data, voice signals, etc. It consists of a group of transponders, that are the combination of a transmitter and a receiver and whose functions are receiving, separating, amplify, process, reamplify and retransmit signals.

The telemetry subsystem analyses the information about the ground station and other sensors of the satellite in order to monitor conditions on board. It allows report to ground station about the conditions of the on board systems.

The command and control subsystem allows the ground station to control the satellite.

2.6.1.1 Data Handling Systems

EMPTY

2.6.1.2 Antenna

EMPTY

2.6.2 Study of the commercial available options

EMPTY

Brand and model	Features and description	Money (€)
Solar Panels		
Fabricant 1	EMPTY	2000000

2.6 Payload

Chuscas 1	EMPTY	20000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 2.4: Options studied

3 References