



ESEIAAT



Escola Superior d'Enginyeries Industrials,  
Aeroespacial i Audiovisual de Terrassa

UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Cubesat Constellation Astrea

---

## Report

**Degree:** Aerospace Engineering

**Course:** Engineering Projects

**Group:** G4 EA-T2016

**Delivery date:** 22-12-2016

### Students:

Cebrián Galán, Joan

Foreman Campins, Lluís

Fuentes Muñoz, Óscar

Herrán Albelda, Fernando

Martínez Viol, Víctor

Pla Olea, Laura

Puig Ruiz, Josep

Tarroc Gil, Sergi

Urbano González, Eva María

Fontanes Molina, Pol

Fraixedas Lucea, Roger

González García, Sílvia

Kaloyanov Naydenov, Boyan

Morata Carranza, David

Pons Daza, Marina

Serra Moncunill, Josep Maria

Tió Malo, Xavier

**Customer:** Pérez Llera, Luís Manuel



# Contents

List of Tables	ii
List of Figures	iii
<b>1 Satellite design planning</b>	<b>1</b>
<b>2 Satellite design</b>	<b>2</b>
2.1 Structure and mechanics . . . . .	2
2.1.1 Structure . . . . .	2
2.1.2 Deployments . . . . .	2
2.1.3 Thermal protection . . . . .	2
2.1.4 Study of the commercial available options . . . . .	3
2.2 Electrical Power System . . . . .	4
2.2.1 Solar arrays . . . . .	4
2.2.2 Batteries . . . . .	5
2.2.3 Power management . . . . .	5
2.2.4 Study of the commercial available options . . . . .	5
2.3 Propulsion Systems . . . . .	5
2.3.1 Motivations . . . . .	5
2.3.2 Orbit decay . . . . .	6
2.4 Communication module . . . . .	6
2.5 Attitude and Orbital Control Systems . . . . .	7
2.5.1 Attitude Determination . . . . .	7
2.5.2 Attitude Control . . . . .	7
2.5.3 Orbital Control . . . . .	7
2.5.4 Study of the commercial available options . . . . .	7
2.6 Payload . . . . .	7
2.6.1 Communications systems . . . . .	7
2.6.1.1 Data Handling Systems . . . . .	8
2.6.1.2 Antenna . . . . .	8
2.6.2 Study of the commercial available options . . . . .	8
<b>3 References</b>	<b>9</b>

## List of Tables

1.1	Prelations and Time . . . . .	1
2.1	Options studied . . . . .	4
2.2	Options studied . . . . .	5
2.3	Options studied . . . . .	7
2.4	Options studied . . . . .	8

## List of Figures

2.1	Dimensions of a 1U CubeSat [?]	2
2.2	Basic schematics of the EPS [?]	4

# 1 Satellite design planning

Interdependency relationships among tasks, human resources and level of effort

ID	Work Package	Time (h)	Prelations
<b>1. Preliminary design</b>			
1.	Preliminary design	30	
<b>2. Structure and mechanics</b>			
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
<b>3. Electrical Power System</b>			
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	
<b>4. Propulsion Systems</b>			
4.1	Motivations	12	BF
4.2	Commercial availability	15	BF
4.3	Choose option	9	
<b>5. Payloads</b>			
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	
<b>6. AOCS</b>			
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

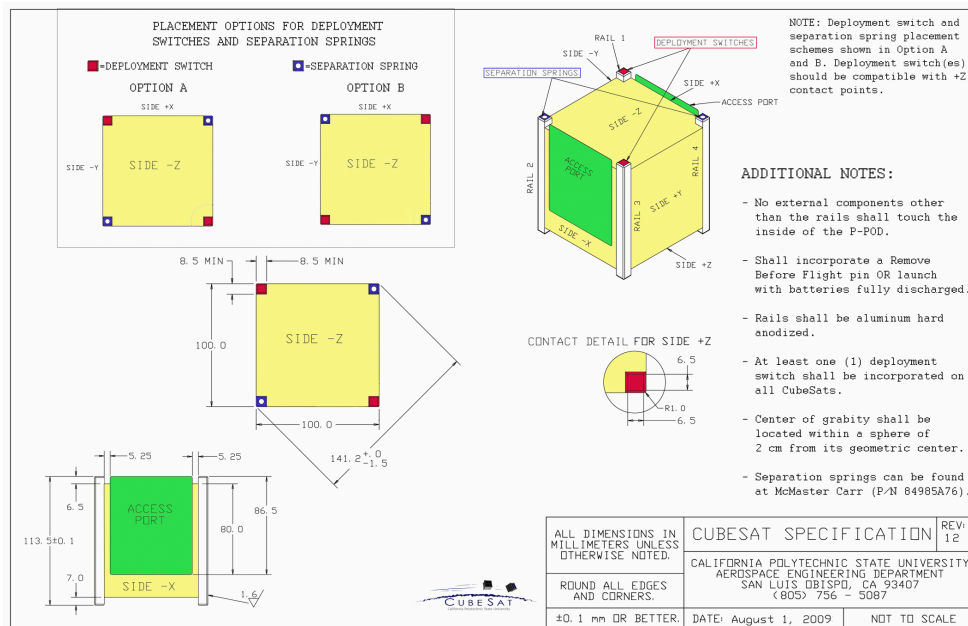


Figure 2.1: Dimensions of a 1U CubeSat [?]

#### 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 (€)
<b>Solar Panels</b>		
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 a failure of it results in a mission failure. High level functions of the EPS are to control and distribute power to the Cubesat, to supply a continuous source of electrical power for the duration of the mission or the service provided by Astrea, 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.

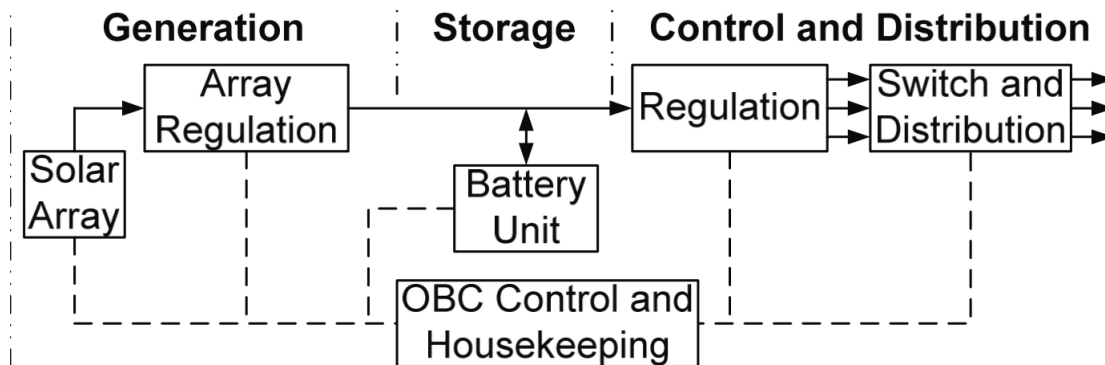


Figure 2.2: Basic schematics of the EPS [?]

### 2.2.1 Solar arrays

The primary source of electrical power has to be photovoltaic cells, given the size of the CubeSat.

## 2.3 Propulsion Systems

### 2.2.2 Batteries

Batteries give power the different subsystems when solar arrays do not, due to not receiving sunlight

### 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 (€)
<b>Solar Panels</b>		
Fabricant 1	EMPTY	2000000
Chuscas 1	EMPTY	20000
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

### 2.3.1 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.”

## 2.4 Communication module

---

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.

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!

## 2.4 Communication module

100kbps:

1mbps:

¿solo 9600bps?:

Links interesantes universidades:

## 2.6 Payload

---

### 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

Brand and model	Features and description	Money (€)
<b>Solar Panels</b>		
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

## 2.6 Payload

---

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 (€)
<b>Solar Panels</b>		
Fabricant 1	EMPTY	2000000
Chuscas 1	EMPTY	20000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 2.4: Options studied

## **3 References**