ESEIAAT

Escola Superior d'Enginyeries Industrials, Aeroespacial i Audiovisual de Terrassa
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Cubesat Constellation
Astrea

Report

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Contents

List of Tables

List of Figures

1 Satellite design planning

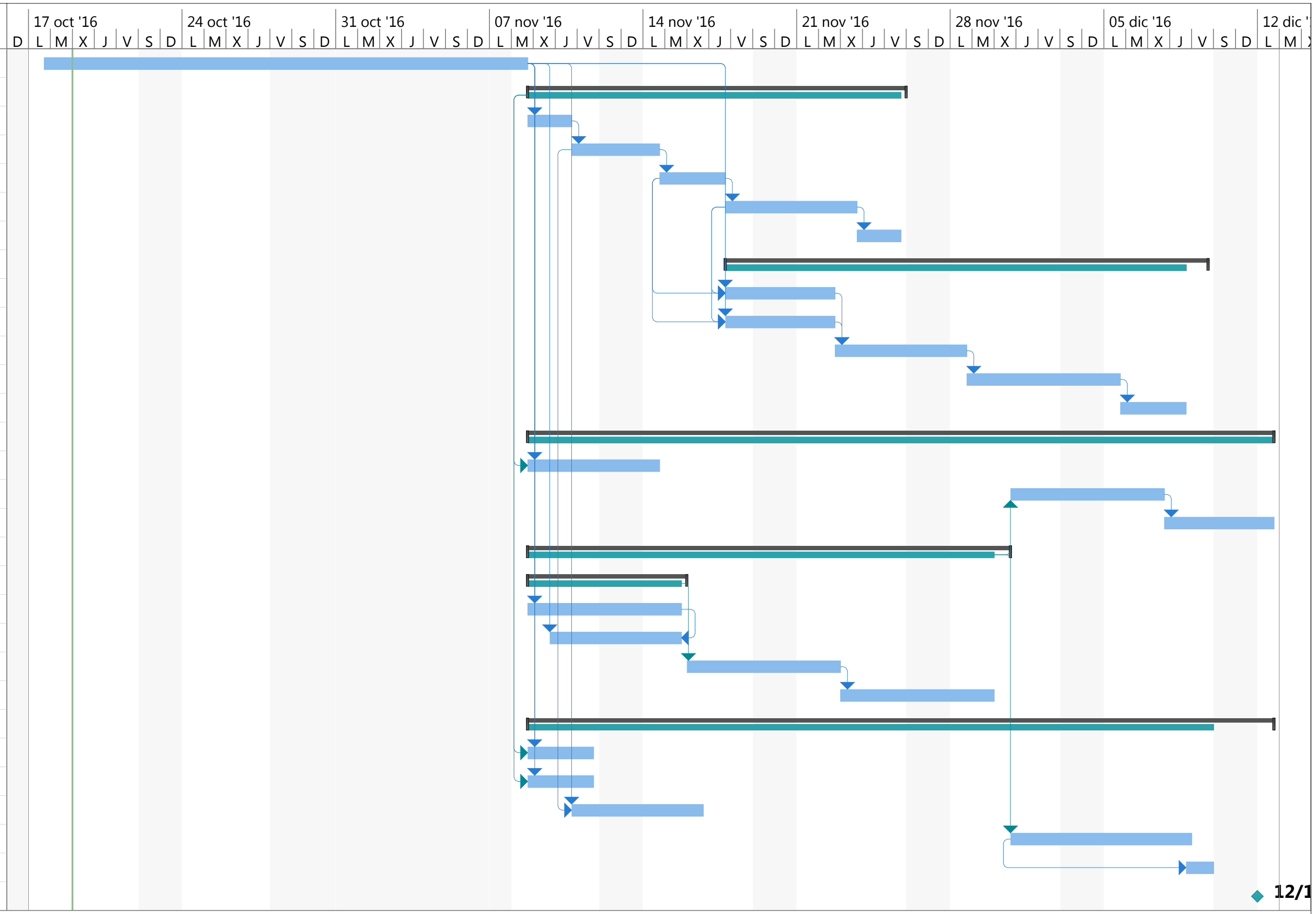
Interdepency relationships among tasks, human resources and level of effort

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 - 2.1.
2.3.	Thermal protection	9	BF - 2.2.
2.4.	Commercial availability	12	BF - 2.3.
2.5.	Choose option	6	BF - 2.4.
3. Electrical Power System			
3.1.	Solar arrays	9	BF - 1, BB - 5, 6
3.2.	Batteries	9	BF - 1, BB - 5, 6
3.3.	Power management	12	BF - 3.1, 3.2
3.4.	Commercial availability	15	BF - 3.3.
3.5.	Choose option	9	BF - 3.4.
4. Propulsion Systems			
4.1	Motivations	12	BF - 1, BB - 2
4.2	Commercial availability	15	BF - 5
4.3	Choose option	9	BF - 4.2.
5. Payloads			
5.1.1.	Data Handling Systems	15	BF - 1
5.1.2.	Antenna	12	BF - 1, FF - 5.1.1.
5.2.	Commercial availability	15	BF - 5.1.
5.3.	Choose option	15	BF - 5.2.
6. AOCS			
6.1.	Attitude determination	9	BF - 1, BB - 2
6.2.	Attitude control	9	BF - 1, BB - 2
6.3.	Orbital Control	12	BF - 1, BB - 4
6.4.	Commercial availability	20	BF - 5
6.5.	Choose option	4	BF - 6.4.

Table 1.1: Prelations and Time

2 Gantt of the section

Id	EDT	Nombre de tarea	Duración	Comienzo	Fin
1	1	PRELIMIARY DESIGN	28 horas	lun 17/10/16	mar 08/11/16
2	**2**	**Structure and mechanics**	**5 días**	**mar 08/11/16**	**vie 25/11/16**
3	2.1	Structure	6 horas	mar 08/11/16	jue 10/11/16
4	2.2	Deployments	6 horas	jue 10/11/16	lun 14/11/16
5	2.3	Thermal protection	9 horas	lun 14/11/16	jue 17/11/16
6	2.4	Comercial availability	12 horas	jue 17/11/16	mié 23/11/16
7	2.5	Choose option	6 horas	mié 23/11/16	vie 25/11/16
8	**3**	**Electrical Power System**	**6 días**	**jue 17/11/16**	**vie 09/12/16**
9	3.1	Solar arrays	9 horas	jue 17/11/16	mar 22/11/16
10	3.2	Batteries	9 horas	jue 17/11/16	mar 22/11/16
11	3.3	Power management	12 horas	mar 22/11/16	lun 28/11/16
12	3.4	Comercial availability	15 horas	lun 28/11/16	lun 05/12/16
13	3.5	Choose option	9 horas	lun 05/12/16	jue 08/12/16
14	**4**	**Propulsion Systems**	**9 días**	**mar 08/11/16**	**lun 12/12/16**
15	4.1	Requirements	12 horas	mar 08/11/16	lun 14/11/16
16	4.2	Comercial availability	15 horas	mié 30/11/16	mié 07/12/16
17	4.3	Choose option	9 horas	mié 07/12/16	lun 12/12/16
18	**5**	**Payload**	**6 días**	**mar 08/11/16**	**mié 30/11/16**
19	**5.1**	**Communication systems**	**2 días**	**mar 08/11/16**	**mar 15/11/16**
20	5.1.1	Data Handling Systems	15 horas	mar 08/11/16	mar 15/11/16
21	5.1.2	Antenna	12 horas	mié 09/11/16	mar 15/11/16
22	5.2	Comercial availability	15 horas	mar 15/11/16	mar 22/11/16
23	5.3	Choose option	15 horas	mar 22/11/16	mar 29/11/16
24	**6**	**AOCS**	**9 días**	**mar 08/11/16**	**lun 12/12/16**
25	6.1	Attitude Determination	9 horas	mar 08/11/16	vie 11/11/16
26	6.2	Attitude control	9 horas	mar 08/11/16	vie 11/11/16
27	6.3	Orbital Control	12 horas	jue 10/11/16	mié 16/11/16
28	6.4	Comercial availability	20 horas	mié 30/11/16	jue 08/12/16
29	6.5	Choose option	4 horas	jue 08/12/16	vie 09/12/16
30		FINISH	0 horas	lun 12/12/16	lun 12/12/16



Proyecto: planning
Fecha: mié 19/10/16

Tarea	Resumen del proyecto	Tarea manual	solo el comienzo	Fecha límite
División	Tarea inactiva	solo duración	solo fin	Progreso
Hito	Hito inactivo	Informe de resumen manual	Tareas externas	Progreso manual
Resumen	Resumen inactivo	Resumen manual	Hito externo	

3 Satellite design

3.1 Structure and mechanics

EMPTY

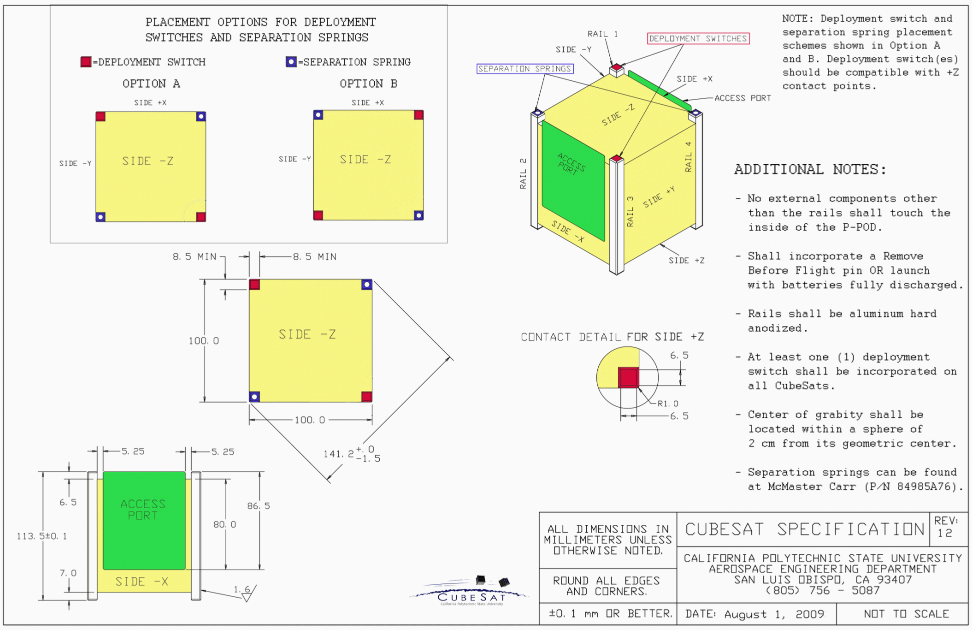


Figure 3.1: Dimensions of a 1U CubeSat [?]

3.1.1 Structure

EMPTY

3.1.2 Deployments

EMPTY

3.1.3 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.

3.1.4 Study of the commercial available options

EMPTY

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 3.1: Options studied

Of all the options in 4.4, we have chosen the following options.

3.2 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 suppy 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.

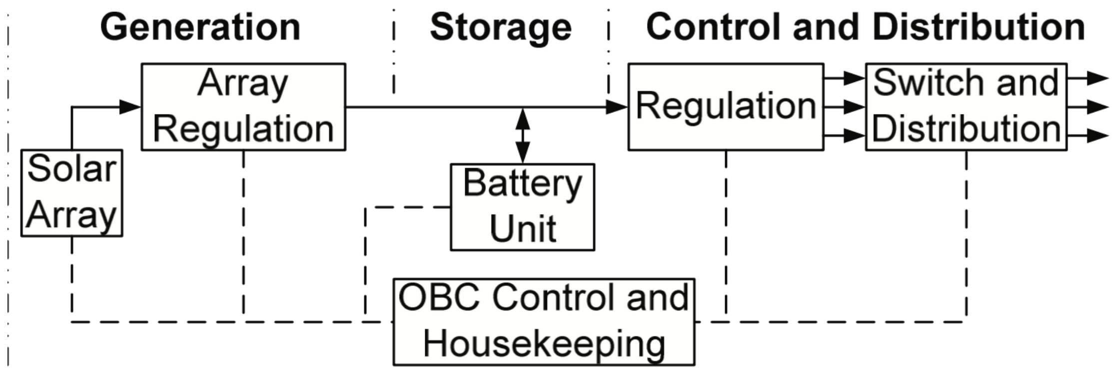


Figure 3.2: Basic schematics of the EPS [?]

3.2.1 Solar arrays

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

3.2.2 Batteries

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

3.2.3 Power management

3.2.4 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 Panels		
Fabricant 1	EMPTY	2000000
Chuscas 1	EMPTY	20000
Truñaas 1	EMPTY	20000
Cuescas 1	EMPTY	20000

Table 3.2: Options studied

Of all the options in 4.4, we have chosen the following options.

3.3 Propulsion Systems

EMPTY

3.3.1 Requirements

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.

3.3.2 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!

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

3.4 Communication module

100kbps:

1mbps:

¿solo 9600bps?:

Links interesantes universidades:

4 Antennas

Antennas are a fundamental part of the communication subsytem and their principal work is transmit and receive electromagnetic waves. There are three main types of antennas: XXXXX. The main parameteres must fulfill meet certain requirements to ensure correct operation.

The frequency range is one of the most important parameters, because it must take into account satellite-satellite and satellite-earth communication. The initial requirement of the antenna frequency range is that it should be between 1-10 GHz. This is due to limitations in satellite-ground communication due to atmospheric conditions. Finding an antenna that meets this stringent requirement is very complicated, and a margin must be given to find an optimal market option.

The bandwidth is the frequency range where the highest power of the signal is found. The higher this bandwidth the better performance we will have.

The gain of an antenna is the ratio between the power density radiated in one direction and the power density that would radiate an isotropic antenna. The best option is to have a high gain.

Polarization is the orientation of the electromagnetic waves when leaving the antenna. There are three types of polarization: linear, circular and elliptical.For better perfomance, an antenna that receives and an antenna that transmits must have the same polarization. In project case, the best option is circular polarization because it is able to keep the signal constant regardless of the appearance of different problems such as movement with respect to the ground station.

The weight of the antennas should be as small as possible because the total weight of the cubesat should not exceed 4 kg. Most of the antennas of the market have a similar weight and does not cause us an extra problem when choosing the antenna of the project.

The power consumption parameter is an important requierement because most of the power is consumed by the different subsystems. The stage of greater power consumption due to the antenna corresponds to its deployment, while once it is deployed, consumption is greatly reduced. In most cases, the power required for deployment ranges from 2-10 W.

The operational temperature range is important to the correct work of the antenna, because if the antenna was in a temperature outside this range, it would not be able to perform the communication of optimal form. An habitual temperature range use to be between XXXX

After a market study, the antennas chosen to perform the communication have been a Microstrip Patch Antenna developed by Antenna Development Corporation and a turnstile antenna ANT430.On the back and lower face of the cubesat will be implemented turnstile antennas, while on the lateral sides will be implemented the antennas patch.

On the lower face of the cubesat is necessary to use an antenna turnstile because a thruster must be incorporated.

The following table shows the main parameters of those antennas.

PACTH ANTENNA	
PARAMETERS	**VALUE**
Frequency range	1-2 GHz
Bandwidth	20 MHz
Gain	6 dBi
Polarization	Circular
Maximum power consumption	10 W
Impedance	50 Ohms
Operational temperature range	-65ºC to +100ºC
Mass	<250 grams

TURNSTILE	
PARAMETERS	**VALUE**
Frequency range	400-480 MHz
Bandwidth	5 MHz
Gain	1.5 dBi
Polarization	Circular
Maximum power consumption	10 W
Impedance	50 Ohms
Operational temperature range	-40ºC to +85ºC
Mass	30 grams

4.1 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).

4.1.1 Attitude Determination

EMPTY

4.1.2 Attitude Control

EMPTY

4.1.3 Orbital Control

Thrusters

4.1.4 Study of the commercial available options

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 4.3: Options studied

4.2 Payload

EMPTY

4.2.1 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 subsytem 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.

4.2.1.1 Data Handling Systems

EMPTY

4.2.1.2 Antenna

EMPTY

4.2.2 Study of the commercial available options

EMPTY

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 4.4: Options studied

5 References