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# Cubesat Constellation Astrea

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## Budget

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## **Part I**

# **Astrea's Budget**

# 1 | Introduction

The aim of a budget is to provide reliable information about the estimation of the expenses required in order to start and carry out a new company such as Astrea.

Astrea's situation is kind of unusual, due to the fact that the company is not selling a defined physical product, but a service. To do so, a widespread constellation of cubesats is deployed around the whole Earth. This situation obviously requires of a certain maintenance and eventually a complete renewal. In other words, over the years, some other investments must be carried on.

In particular, in the year 0 of Astrea's life (this is, the planning and beginning) there are many different costs such as the engineering hours, the communications' first investment, the satellites building and launching, amongst many others. Nevertheless, 5 years from that point (this is, year 5) the life of the satellites is expected to be getting over, and in order to prevent fails on the service, a replacement strategy is done. In year 4 new satellites will be built and in year 5 they will be re-launched, so as to fill the constellation again. This will mean that a second budget is done for the year 4, including both building and launching. Again, in year 9, the same phenomenon will occur, and so on.

Therefore, two different budgets are going to be explained. The first one is the initial budget, and the second one is the periodic budget, which must be invested every 5 years from the beginning of Astrea's life.

All the costs stated in this document are in €.

Without further ado, let's state the different costs of the project.

## 2 | Costs

### 2.1 Manpower

The engineering hours were stated in the Project Charter together with the Gantt Chart. They are again synthesized in the following table. It must be taken into account that the salary of an Astrea's engineer is of €per hour.

Engineering hours budget	Hours	Labor cost (€)
<b>MANAGEMENT</b>		
Meetings documentation		
Meetings	340	6800
Meetings preparation		
Agendas	10	200
Minutes	10	200
Task Tracking and scheduling		
Project Charter	170	3400
Team tasks monitoring	20	400
WBS and Gantt update	10	200
<b>SATELLITE DEVELOPMENT</b>		
Spacecraft subsystems	180	3600
Payload		
Antenna	40	800
PHDS	50	1000
<b>ORBITAL DESIGN</b>		
Constellation geometry	220	4400
Orbit parameters		
General parameters	120	2400
Drift	100	2000
Legislation	50	1000

Engineering hours budget	Hours	Labor cost (€)
<b>LAUNCH SYSTEMS</b>		
Vehicle	60	1200
Satellite deployer	10	200
Replacement strategy	100	2000
<b>OPERATION</b>		
Communication protocol	100	2000
Ground station	80	1600
End of life strategy	80	1600
<b>FINANCIAL PLAN</b>		
Costs		
Fix		
Maintenance and cost analysis	10	200
Insurance cost analysis	15	300
Administration cost analysis	15	300
Taxes cost analysis	25	500
Variable		
Manufacturing cost report	10	200
Launching cost report	10	200
Income		
Price analysis	25	500
Revenue forecast	25	500
Economic feasibility report	40	800
Marketing Plan	20	400
<b>PROJECT EXHIBITION</b>		
Constellation simulation	30	600
<b>TOTAL</b>	<b>1975</b>	<b>39500</b>

## 2.2 Communication Costs

The communications costs include the costs of building the Ground Stations and the Mission Control Center, and also the costs of maintenance and operation of them.

### 2.2.1 Initial Investment

The investment required for building each Ground Station is of 356000 € and the Mission Control Center of 3000000 €.

	Cost
GS Canada	356000
GS Malvines	356000
GS Scotland	356000
MCC Spain	3000000
<b>Total</b>	<b>4068000</b>

### 2.2.2 Maintenance and Operation Costs

The following costs are associated to operation resources and general maintenance:

Concept	MCC	GS Canada	GS Scoltand	GS Malvines
Energy	20540	4550	9100	9100
Maintenance	7500	7500	7500	7500
Internet	660	660	660	660
<b>Total</b>	<b>28700</b>	<b>12710</b>	<b>17260</b>	<b>17260</b>

And also the costs associated to salaries of the operators:

Concept	Cost
Salaries GS Canada	381500
Salaries GS Scotland (UK)	226400
Salaries GS Malvines	81800
Salaries MCC	429900
<b>Total</b>	<b>1119600</b>

Nevertheless, those costs are annual, so they are not to be taken into account when estimating the budget, since they are not included in the initial investment. They will be subtracted from the profit of the company.

## 2.3 Satellites Costs

The costs of the satellites can be splitted into two big groups: the costs associated to building each satellite and the costs associated to the assembling of them.

Let's start with the building costs for each satellite:



Component	Units per satellite	Costs (unit)	Cost (satellite)
Structure	1	3900	3900
Thermal protection	1	1000	1000
Electric power system			
Solar arrays	4	17000	68000
Batteries	2	6300	12600
Power management	1	16000	16000
Payload			
1st Patch Antenna	1	18000	18000
Patch antenna	7	7000	49000
Antenna deployment	1	3000	3000
Transciever inter-satellite	3	8245	24735
Transciever space to ground	1	5500	5500
Data handling system	1	5000	5000
Variable expenses	1	4000	4000
AOCDs			
Thruster	1	50000	50000
CubeSpace ACDS	1	15000	15000
<b>Total</b>			<b>275735</b>

Taking into account that there are 189 satellites in Astrea's constellation (21 satellites per plane, and 9 planes), the total building cost is:

Cost of each satellite	Total cost
275735	52113915

There are also the assembling cost of the satellites:

Concept	Cost per unit	Cost per constellation
Individual Assembling	20000	3780000
Constellation Assembling		150000
<b>Total Cost</b>		<b>3930000</b>

The conclusion is that the global cost of the satellites are:

Concept	Costs
Building	52113915
Assembling	3930000
<b>Total</b>	<b>56043915</b>

## 2.4 Launching Costs

There are 9 different planes of satellites orbiting the Earth. Each plane requires a different launcher. Therefore, there is a cost associated to each launcher. Moreover, a fee must be paid too for every satellite carried on in the launcher.

Consequently, the launching costs are:

Concept	Individual cost	Number of units	Total cost
Launcher	5361774	9	48255966
Satellites in launcher	16000	189	3024000
Total			51279966

## 2.5 Other costs

There are some other costs which are not taken into account when calculating the budget. Those costs are the salaries of the Ground Stations and the Main Control Center operators, the annual insurance cost, the administration cost, the supplies and the maintenance of the host for the website, amongst some others. Those costs are to be paid annually, and therefore they are not included in the different investments. They will be subtracted from the profit of the company.

## 3 | Budget

As the introduction of the Budget has already explained, there will be two different budgets. The first one is the initial budget, required at the beginning of the project, and the second one is the periodic budget, required every 5 years from the beginning of the project.

### 3.1 Initial Budget

This budget is for the beginning of the project (year 0). At that point, the project is designed, the Ground Stations and the Main Control Center is designed, built and started, the satellites of the first cycle of the constellation are built and assembled and eventually launched. Therefore, the costs that must be taken into account are:

- Manpower (engineering hours): 395000 €.
- Communications Initial Investment: 4068000 €.
- Satellites building and assembling: 56043915 €.
- Launching costs: 51279966 €.

Adding all those quantities, the initial budget turns out to be of 111786881 €.

### 3.2 Periodic Budget

This budget is for every 5 years once the project is started (this is, year 4, 9, 14 and so on). At that point, the only cost is the one derived from the requirement of renewal of the constellation. Therefore, the costs are of building and assembling the satellites and launching them again:

- Satellites building and assembling: 56043915 €.

## Periodic Budget

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- Launching costs: 51279966 €.

Adding all those quantities, the periodic budget turns out to be of 107323881 €.

This budget could mean another investment required but also could come from the wide benefits that Astrea provides by time time. For further details, check the Feasibility Study.