



ESEIAAT



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

UNIVERSITAT POLITÈCNICA DE CATALUNYA

Cubesat Constellation Astrea

Budget

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	iii
I Astrea's Budget	1
1 Introduction	2
2 Costs	3
2.1 Manpower	3
2.2 Communication Costs	4
2.2.1 Initial Investment	5
2.2.2 Maintenance and Operation Costs	5
2.3 Satellites Costs	6
2.4 Launching Costs	7
2.5 Insurance and administration	8
3 Budget	9
3.1 Initial Budget	9
3.2 Periodic Budget	10

List of Tables

2.1.1	Engineering hours cost (manpower)	4
2.2.1	Ground Stations and Main Control Center initial investment	5
2.2.2	Ground Stations' maintenance and operation cost	5
2.2.3	Salaries of Ground Stations and Main Control Center operators	5
2.3.1	Satellite cost (of each satellite)	6
2.3.2	Total satellites cost	6
2.3.3	Satellites assembling cost	7
2.3.4	Global satellites cost	7
2.4.1	Launching cost	7
2.5.1	Administration and insurance anual costs	8

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 Astrea, as a new company.

Astrea's situation is kind of unusual, due to the fact that the company is not selling a defined physical product like a plane, 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 periodically 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 4) 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 estimated. 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.

In order to be conservative, all the figures in this document will be approximated to the high closest thousand value.

All the figures in this document are **in €**, unless stated the opposite, apart from the final budgets, which are **in M€**.

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 (€)
MANAGEMENT		
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
SATELLITE DEVELOPMENT		
Spacecraft subsystems	180	3600
Payload		
Antenna	40	800
PHDS	50	1000
ORBITAL DESIGN		
Constellation geometry	220	4400
Orbit parameters		
General parameters	120	2400
Drift	100	2000
Legislation	50	1000

Engineering hours budget	Hours	Labor cost (€)
LAUNCH SYSTEMS		
Vehicle	60	1200
Satellite deployer	10	200
Replacement strategy	100	2000
OPERATION		
Communication protocol	100	2000
Ground station	80	1600
End of life strategy	80	1600
FINANCIAL PLAN		
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
PROJECT EXHIBITION		
Constellation simulation	30	600
TOTAL	1975	395000

Table 2.1.1: Engineering hours cost (manpower)

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
Total	4068000

Table 2.2.1: Ground Stations and Main Control Center initial investment

2.2.2 Maintenance and Operation Costs

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

Concept	MCC	GS Canada	GS Scotland	GS Malvines
Energy	21000	5000	10000	10000
Maintenance	8000	8000	8000	8000
Internet	1000	1000	1000	1000
Total	30000	14000	19000	19000

Table 2.2.2: Ground Stations' maintenance and operation cost

And also the costs associated to salaries of the operators:

Concept	Cost
Salaries GS Canada	382000
Salaries GS Scotland (UK)	227000
Salaries GS Malvines	82000
Salaries MCC	430000
Total	1121000

Table 2.2.3: Salaries of Ground Stations and Main Control Center operators

Nevertheless, those costs are operational costs (annual), so they are not to be taken into account when estimating the budget. They will be assumed from the profit of the company. They have been added to this document just as for informative purpose, but won't be taken into account when calculating the budgets.

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
Total			275735

Table 2.3.1: Satellite cost (of each satellite)

As it has been already mentioned, the costs are approximated to its high closes thousand value. Therefore, the cost per satellite is of 276000 €.

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
276000	52164000

Table 2.3.2: Total satellites cost

There are also the assembling cost of the satellites:

Concept	Cost per unit	Cost per constellation
Individual Assembling	20000	3780000
Constellation Assembling		150000
Total Cost		3930000

Table 2.3.3: Satellites assembling cost

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

Concept	Costs
Building	52164000
Assembling	3930000
Total	56094000

Table 2.3.4: Global satellites cost

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	5362000	9	48258000
Satellites in launcher	16000	189	3024000
Total			51282000

Table 2.4.1: Launching cost

2.5 Insurance and administration

There are some other costs which are not taken into account when calculating the budget, similar to the salaries of the Ground Stations and the Main Control Center operators, as has been mentioned. Those costs are the anual insurance cost and the administrarion cost. Those costs are to be paid anually (operation costs), and therefore they are not included in the different budgets. They will be subtracted from the profit of the company. Next it will be shown a summary of them. Again, they are shown just for informative purpose. For further information on those costs, such as their break down, refer to the Annex V.

Administration cost (anually)	259000
Insurance cost (anually)	2246000
Total	2505000

Table 2.5.1: Administration and insurance anual costs

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: 56094000 €.
- Launching costs: 51282000 €.

Adding all those quantities, **the initial budget turns out to be of 11184 M€.**

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: 56094000 €.
- Launching costs: 51282000 €.

Adding all those quantities, **the periodic budget (every 5 years) turns out to be of 107.38 M€.**

This budget could mean another investment required but also could come from the wide benefits that Astrea provides by that time. For further details, refer to the Feasibility Study (section 7 of the Report, or Annex V).