Final Degree Project

Budget

Study of end-of-life disposal options for highly-inclined geosynchronous satellites

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1. Budget

This document presents the estimated budget of the Study of end-of-life disposal options for highly-inclined geosynchronous satellites. The costs are divided into direct and indirect costs.

1.1. Direct costs

This study has been developed by a single engineer along a 4 months semester. Specifically, it has been completed in exactly 19 weeks. The average wage of an undergraduate engineer is assumed to be 15 €/hour. Table 1 illustrates the man hours required to carry out the study and the total cost of the engineering work, which can be estimated in 7680 €.

Concept	h	€ /h	Cost (€)
Introduction	16	15	240
State of art	18	15	270
Certifications and regulations	22	15	330
Description of the orbits	8	15	120
Characterization of the orbit	52	15	780
Operational environment	36	15	540
Possible types of propulsion systems	-	-	-
Chemical engines	12	15	180
Electrical engines	12	15	180
Possible end-of-life disposal strategies	-	-	-
De-orbiting	-	-	-
Uncontrolled de-orbiting	5	15	75
Controlled de-orbiting	5	15	75
Maneuvers to disposal regions	-	-	-
Impulse maneuver	36	15	540
Low thrust maneuver	122	15	1830
Detailed description of the maneuver strategy	-	-	-
Maneuver description	12	15	180
Cost and requirements of the propellant mass	32	15	480
Execution times	22	15	330
Simulation of the disposal maneuver	32	15	480
Report	50	15	750
Presentation	20	15	300
Subtotal of worked hours	**512**	**15**	**7680**

***Table 1** Engineering work cost estimation.*

1.2. Indirect costs

The hardware used to develop the study was a laptop (ASUS A55VD-SX408H) with a cost of 890 €. By considering a 50% of annual amortization (890 € in 2 years) and a period of 19 weeks of 52 weeks/year, the hardware cost can be estimated as:

$$\text{Hardware cost} = 890 \cdot 0.50 \cdot \frac{19}{52} = 162.60\ € \qquad (1)$$

The software used during the study sum up to a cost of 580 €. Table 2 illustrates an estimation of hardware and software costs.

Concept	Units	Criteria	Cost (€)
Hardware			
Laptop (Intel Core i7 610M @ 2GHz)	19 weeks	890 € in 2 years	162.60
Subtotal of hardware components			**162.60**
Software			
Matlab R2015a (Academic use)			500.00
Microsoft Windows 10 (Student)			0
ProjectLibre			0
Microsoft Office 2013 package			80.00
Mendeley			0
Subtotal of software licenses			**580.00**

***Table 2** Hardware and software costs.*

Considering the extensive processing time required by the project, the power consumption has also been included in the budget. With approximately 141 simulation hours, the electric power consumed corresponds to a cost of 15.51 €. Table 3 shows an estimation of the electric power consumption costs.

Concept	h	€ /h	Cost (€)
Simulation (Power consumption)			
Constellation construction	20	0.11	2.20
Ground track	16	0.11	1.76
Orbital perturbations	18	0.11	1.98
Impulse maneuver	22	0.11	2.42
Low thrust maneuver	65	0.11	7.15
Subtotal of simulation hours	**141**	0.11	**15.51**

***Table 3** Electric power consumption costs.*

1.3. Total costs

An overhead of 10% has been applied to the engineering work cost estimation and to the processing costs. No overhead has been applied to hardware and software expenses, as their cost is considered to be already established. The total cost is estimated to 9207.66 €.

Concept	**Cost (€)**
Subtotal of worked hours	7680.00
Overhead (10 %)	768.00
Subtotal of hardware components	162.60
Subtotal of software licenses	580.00
Subtotal of simulation hours	15.51
Overhead (10%)	1.55
Total	9207.66

Table 4 *Total cost estimation.*