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**Title:**

# *Optimization study of dynamic vibration absorbers parameters and distribution for its application on railway tunnels for the reduction of railway-induced vibration*

**Document content:** BUDGET

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# Contents

# List of Tables

# 1. Introduction

This annex presents the budget of the *Optimization study of dynamic vibration absorbers parameters and distribution for its application on railway tunnels for the reduction of railway-induced vibration*.

This section gives an overview of the items covered in the budget.

- **Labour** (human costs), expenses related to the hours worked by the corresponding engineer.

- **Hardware**, expenses related to the costs of the hardware used to develop this study as well as to run the code and its amortization.

- **Software**, expenses related to the costs of purchasing the software used to develop this study, mainly MATLAB, the corresponding *Toolbox* and its amortization.

- **Energy**, expenses related to the consumption of energy.

The final relation of costs is presented in table 1.1.

| **Labour costs** | Amount | Amort. period | Power / Unit time | Price / Unit time | Quantity | Total |
|---|---|---|---|---|---|---|
| Aerospace Engineer | | | | 30 €/hour | 540 hours | 16,200 € |
| **Software costs** | | | | | | |
| MATLAB R2014a | 2,000 € | 12 months | | 166.7 €/month | 4 month | 666.7 € |
| Parallel Computing Toolbox | 1,000 € | 12 months | | 83.3 €/month | 4 month | 333.3 € |
| Optimization Toolbox | 1,150 € | 12 months | | 95.8 €/month | 4 month | 383.3 € |
| Global Optimization Toolbox | 1,000 € | 12 months | | 83.3 €/month | 4 month | 333.3 € |
| **Hardware costs** | | | | | | |
| Working computer | 1,200 € | 24 months | | 50 €/month | 4 month | 200 € |
| **Energy costs** | | | | | | |
| Computing energy costs | | | 0.30 kWh | 0.13 €/kWh | 400 hours | 15.6 € |
| **Total** | | | | | | 18,132.2 € |

Table 1.1: Final relation of costs.

# 2. Detailed concepts

This chapter presents a more detailed explanation of the budget, than the included in table 1.1.

## 2.1 Labour costs

This concept includes the wage of the engineer in charge of the study. It has been estimated the dedication of labour time in table 2.1:

| Activity | Amount of hours | Percentage | Cost |
|---|---|---|---|
| Research | 90 hours | 16.67% | 2,700 € |
| Formulation | 150 hours | 27.78% | 4,500 € |
| Programming | 300 hours | 55.55% | 9,000 € |
| **Total** | | | 16,200 € |

Table 2.1: Labour hours dedicated.

## 2.2 Software costs

These costs include the not free software which has been used in this study. The software costs include the standard *Software Maintenance Service*, supplied by *MathWorks*. This subscription should be renewed yearly and includes the chance to obtain the latest updates to MATLAB products – with releases twice a year and access to technical support from specialized engineers.

There are four commercial produts needed to purchase:

1. **MATALB R2014a**: 2,000 € for a one year period (666.7 €).

2. **Parallel Computing Toolbox**: 1,000 € for a one year period (333.3 €).

3. **Optimization Toolbox**: 1,150 € for a one year period (383.3 €); this toolbox is mandatory in order to use the next one.

4. **Global Optimization Toolbox**: 1,000 € for a one year period (333.3 €).

The total software cost with its amortization is 5,150 € for a one year period (1,716.6 €).

## 2.3 Hardware costs

This part includes the price of the hardware used along the study. A unique computer has been used for all the tasks: research, formulation, programming and computing, the model Acer Aspire Ethos 5951G. It has been considered to have a life of two years, taking into account that a computer older than two years presents a considerable reduction of its performance, so it will not be competitive anymore.

The total hardware cost is 1,200 € for a two years period (200 €).

## 2.4 Energy costs

It has been calculated the amount of energy spent into computing time. It has been considered an average value as electricity fee.

The total hardware cost is 15.6 €.