



UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

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

Titulació:

Grau d'Enginyeria en Tecnologies Aeroespacials

Alumne (nom i cognoms):

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Enunciat TFG:

Development of CFD codes for the numerical resolution of potential flow and the incompressible form of the Navier-Stokes equations

Contingut:

Budget

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Contents

| | | |
|----------|-------------------------------|----------|
| 1 | Introduction | 2 |
| 2 | Justification of costs | 2 |
| 2.1 | Direct costs | 2 |
| 2.2 | Indirect costs | 3 |
| 2.3 | Total cost | 4 |
| | References | 5 |

1 Introduction

In this document it will be presented the budget of this project according to the work load, the energy consumption cost and other related costs, where it will be separated into direct and indirect cost.

2 Justification of costs

In this section it will be presented the two different types of costs: direct costs and indirect costs.

2.1 Direct costs

The direct cost are the costs that are directly related to the project: the previous study, programming, verifying, the report writing...

Concretely, the direct cost will be specified in the following list:

- **Code's background:** this consists on the previous theoretical study of each case (potential flow, convection-diffusion equation and incompressible flow of the Navier-Stokes equations), the lessons that CTTC department offered for the understanding of numerical methods and code verifying, and the mathematical development (discretization of the equations).
- **Code elaboration:** the code elaboration can be divided into amplifying the knowledge on C++ (the most important thing is the use of dynamic memory) and the elaboration of the codes for every single case. In the case of potential flow it can be found the streamline method (it has been developed two similar codes in order to find the object's streamline fixing its circulation or fixing the velocity at one point) and the potential velocities method. In the case of convection-diffusion equation there is a single code because it has been developed the three problems treated on the same code. And in the case of the Navier-Stokes equations it has been developed two different codes, the general code where it has been treated the *Lid-Driven Cavity* problem and a concrete code where it has been treated the *Differentially Heated Cavity* problem.
- **Results analysis:** this consist on the plotting of the result obtained from the C++ programs, so it will be considered the time to elaborate easy codes so as to plot the solutions.
- **Documents elaboration:** a big part of this project has been to write all the documents (report, budget, appendix)

Having described all the direct cost, on the following table it is going to be presented the direct costs. According to *la Generalitat* [1], the average salary for a male engineer

Budget

is 19.87 €/h, however this project has been carried out by an under-graduated student, so it has been considered a hourly price of 15 €/h.

TABLE 1: Direct costs

| Concept | Time (h) | Cost/hour (€/h) | Cost (€) |
|--|------------|-----------------|--------------|
| Code's background | 36 | 15 | 540 |
| Theoretical study | 10 | 15 | 150 |
| Attended lessons | 6 | 15 | 90 |
| Mathematical development | 20 | 15 | 300 |
| Code elaboration | 188 | 15 | 2,820 |
| Amplifying C++ knowledge | 5 | 15 | 75 |
| Streamline method (fixing circulation) | 50 | 15 | 750 |
| Streamline method (fixing velocity) | 1 | 15 | 15 |
| Velocity potential method | 15 | 15 | 225 |
| Convection-diffusion equation | 25 | 15 | 375 |
| Navier-Stokes code (general) | 90 | 15 | 1,350 |
| Navier-Stokes code (Diff. Heated Cavity) | 2 | 15 | 30 |
| Results analysis | 20 | 15 | 300 |
| Document elaboration | 185 | 15 | 2,775 |
| Report | 180 | 15 | 2,700 |
| Budget | 2 | 15 | 30 |
| Appendix | 3 | 15 | 45 |
| TOTAL | 427 | 15 | 6,435 |

2.2 Indirect costs

The indirect costs are the costs that are not directly accountable to the project. There are two types of indirect cost: fixed or variables. However, in this budget it will not be differentiated these two types of costs.

In this project the indirect costs are specified on the following list:

- **Software:** this includes all program licenses needed to carry out the project. The C++ compiler is free so it will not be a cost. Although Matlab student license has a cost of 35€[4], since this license it is provided by the UPC, its cost will not be considered. For the documents writing, it has been used the web page *Overleaf*, which is a free $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ compiler.
- **Hardware:** the laptop used has not been bought uniquely for this project since it has been bought 2 years ago. Although it is not going to consider the whole cost of it, it will be considered an amortization of its use. Generally a laptop can have

Budget

around of 4 years of lifespan [2] [7] [5], and the laptop that it has been used has cost around 1100€, so the monthly cost for its use is around 23€. Since it has been worked during 4 months, the amortization cost has been 93€.

- **Power consumption:** the only power consumption that has been considered is the computer consumption. This consumption has been estimated as 0.1 kW per hour [3], and it has been estimated that the computer has been working every day on average 5 hours (including weekends) during 4 months. Knowing that the cost of kWh is around 0.12€/kWh [6], the total electricity cost is around 7€.

With that, the indirect costs are 100€.

2.3 Total cost

Finally, taking into account the direct and indirect costs, the total project cost will be of around 6,540€.

TABLE 2: Project costs

| | |
|---------------------------|-------|
| Direct Costs (€) | 6,435 |
| Indirect Costs (€) | 100 |
| Total Cost (€) | 6,535 |

References

- [1] Institut d'Estadística de Catalunya. *Salari brut anual i guany per hora. Per sexe i tipus d'ocupació*. [online]. 2018. URL: <https://www.idescat.cat/pub/?id=aec&n=398> (visited on 06/02/2019).
- [2] Chron. *The Average Lifespan for Laptops*. [online]. 2019. URL: <https://smallbusiness.chron.com/average-lifespan-laptops-71292.html> (visited on 06/07/2019).
- [3] Energguide.be. *How much power does a computer use? And how much CO2 does that represent?* [online]. 2019. URL: <https://www.energguide.be/en/questions-answers/how-much-power-does-a-computer-use-and-how-much-co2-does-that-represent/54/> (visited on 06/02/2019).
- [4] The MathWorks Inc. *New License for MATLAB Student R2019a*. [online]. 2019. URL: <https://es.mathworks.com/store/link/products/student/new> (visited on 06/02/2019).
- [5] Empower IT. *Laptops And Desktops: How Long Do They Last?* [online]. 2017. URL: <https://www.empowerit.com.au/blog/it-planning/budgeting/laptops-desktops-how-long-do-they-last/> (visited on 06/07/2019).
- [6] Selectra. *Precio de la luz por horas*. [online]. 2019. URL: <https://tarifaluzhora.es/> (visited on 06/02/2019).
- [7] TechGuided. *How Long Should A Laptop Last? Laptop Lifespan & Average Battery Life*. [online]. 2018. URL: <https://techguided.com/how-long-should-a-laptop-last/> (visited on 06/07/2019).