



Technical University of Civil Engineering Bucharest

Doctoral School

Research report no. 2

**Analysis of existing calculation, planning and
control methods for the overall costs of a
construction project**

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I. INTRODUCTION

The construction sector holds strategic importance for many countries around the world. It delivers the buildings and infrastructure needed by the economy and society.

Construction projects, in Romania and in the world, play a significant part in a country's economic and infrastructure development. In Romania, the population's needs are manifested by the lack of infrastructure works. Resources are generally limited, depending on the scale of needs. For this reason construction projects should be properly estimated to avoid unnecessary expenses and in this way to achieve the proposed objectives.

Much of the road infrastructure in our country is not in the best operational state. This is one of the factors where resources and efforts must be focused, in order to guarantee citizens a better quality of life and to take advantage of resources in an efficient way. Furthermore, road infrastructure must become a fortress that could serve to attract more foreign direct investment needed to increase the economic resources of the country.

Public assets such as roads must be maintained in good condition so that they can serve their primary function of transporting people and goods to different geographical points of the country in the best possible way.

Currently, roads are being used without the proper planning required by modern administration and on the contrary, public resources are being spent on unfinished works of poor quality, with poor control over materials, among others.

Planning and controlling the overall costs of a construction project are processes of defining, coordinating and determining the order in which activities must be carried out to achieve the most efficient and economical use of available equipment, elements and resources and to eliminate unnecessary diversification of efforts, processes that establish or define a work plan, which must be controlled throughout the project to know if the requirements are met or if they need to be revised or changed to meet the final objective.

In construction activity, cost estimation consists of two fundamental tasks such as determining the probable cost and time of the project. Both cost and time are probable because such an estimate is made before construction and provides an approximation of the actual cost of the project. However, in the stages of development and execution of construction projects, problems arise that result in additional costs and extensions of the previously established execution period, motivated precisely by the lack of correct professional technical criterion in preparing the project, thus causing problems in resource scheduling.

Developing a working budget as accurately as possible will favor cost estimation. To this purpose, it is important for the developer to have as much technical information as possible and consider all factors that influence the final cost of the project, even those not part of the technical knowledge of project engineering.

Global networks and infrastructure systems are under enormous pressure. In the face of the astonishing pace of urbanization, climate change and technological progress, it is not enough to just close the existing gaps. It takes a huge leap. By focusing the brightest minds, training and deploying more skilled employees, and using new digital tools, a better future can be created through infrastructure. The potential of high-quality infrastructure is transformative.

II. INFRASTRUCTURE PROJECTS

2.1 Definition of infrastructure projects

"A project is a temporary effort undertaken to create a unique product, service, or result" (PMBOK: 2017) [1].

A project consists of a series of temporary activities focused on creating a new and unique product, process or service (Project Management Institute: 2002) [2]. Temporality indicates that every project has a well-defined beginning and end, and this end will be reached by achieving the final objectives.

Construction projects can be classified, according to the financing entity, into two major groups: public projects in which the promoter is the state and private projects in which private entrepreneurs are the ones who promote the projects and whose basic purpose is to obtain an economic benefit. One of the main differences between the two is the value given to profitability as a decisive factor in making an investment decision. For public projects, the economic variable is not as decisive as the social one (Erossa Martín: 1998) [3].

Every construction project has goals related to obtaining a product, process or service that needs to be generated through various activities. Some of these activities can be grouped into phases, as they generally contribute to the achievement of an intermediate product, necessary to continue towards the final product and to facilitate project management. The conception of the phases to be executed, the order of the logical sequencing and the estimation of the nature and quantity of the resources to be used at any moment, require in-depth knowledge of the technologies involved in the project and an experience that allows to anticipate and overcome the difficulties that can usually arise in practice. Considerations such as the costs and resources required at the beginning of the project are normally lower than those in the intermediate phases and higher than those in the final stages (Bruzzzone: 1998) [4].

Infrastructure projects are important for the economic and social development of all countries. Through them, a country can count on greater physical capacity to facilitate the development of productive activities. Thus, having better roads can reduce logistics and transport costs, better ports can increase international trade, better airports results in increased tourist flow to the country, more power plants can improve the level of electricity service coverage to the population and, in general, with infrastructure works, the country will be able to significantly improve the provision of appropriate public services.

In many countries, the state is responsible for financing the construction of these works, as well as their operation and maintenance. However, it has been shown that the state does not have sufficient resources (human, knowledge and financial) to effectively manage the mentioned infrastructure. In developing countries, where service needs are many, governments should meet the primary and very urgent ones, such as health and education, by allocating their budgets for them. Infrastructure projects are large-scale projects that require very large amounts of money to finance investments.

2.2 Phases of a project

2.2.1 The need for the project

A project consists of a series of temporary activities focused on creating a new and unique product, process or service. Temporality indicates that each project has a well-defined beginning and end, this end being achieved by the completion of the final objectives.

Projects in general have a successive development in phases or stages closely linked, which start from the emergence of a need and until the completion of the final project, meaning that it meets the requirements of the need that gave rise to it. The project process is considered cyclic because, on the one hand, final outcomes may generate ideas for new projects that continue and complete the cycle, and on the other hand, each phase precedes another. This dynamic process incorporates new information with previous approaches and thus redirects the design process.

A phase is a set of related activities that aim to develop the project.

Each phase is defined by a set of externally observable elements, such as related activities, inputs (results of the previous phase, documents or products required for the phase, experiences related to previous projects), outputs (results to be used in the subsequent phase, experience gained, tests or results performed) and the internal structure of the phase. Figure No. 1 presents the general operation diagram of a phase with the mentioned elements.

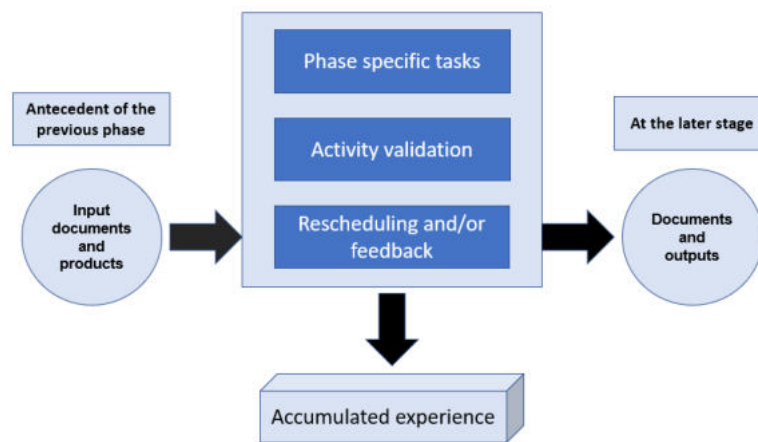


Figure no. 1. General operation diagram of a phase.

One of the recognized tools for improving the quality of investments is the application of the "project cycle" which consists of the set of phases used. In each general phase of a lifecycle model, a series of objectives and tasks characterizing it can be established. In this cycle, phases are clearly differentiated by means and purposes and are frequently accomplished in complete and sequential form.

In the construction sector, the linear lifecycle is the most widely used because it is the simplest, as it consists in decomposing the overall project activity into phases that follow one another in a linear manner, that is, each phase is executed only once, each phase is executed after the previous one and before the next one. With a linear lifecycle it is easy to divide tasks between teams and predict execution times.

Most construction projects begin with the recognition of a need; the beginning of the project will correspond to the generation of an idea, then continue with a growth and development related to the project's formulation, a maturity in the execution and operation phases, and finally, an end that coincides with the project's disappearance. The project cycle is represented in Figure no. 2.

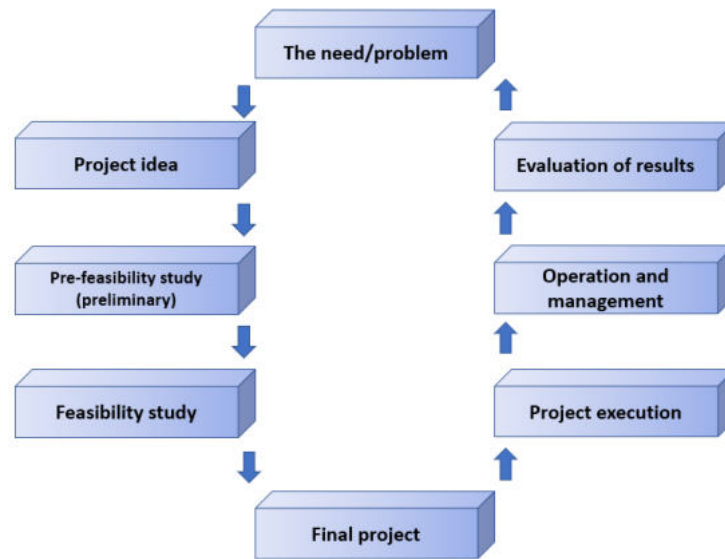


Figure no. 2. Project cycle.

The need for a project appears as a creative effort resulting mainly from identifying a problem, with the possibility of taking advantage of an opportunity and aiming to satisfy a need. Identifying the need involves the decision to perform an analysis to ensure the existence of a feasible alternative and the creation of the idea's profile, involving written formulation that will allow the idea's feasibility to be evaluated (Andrés: 2001) [5].

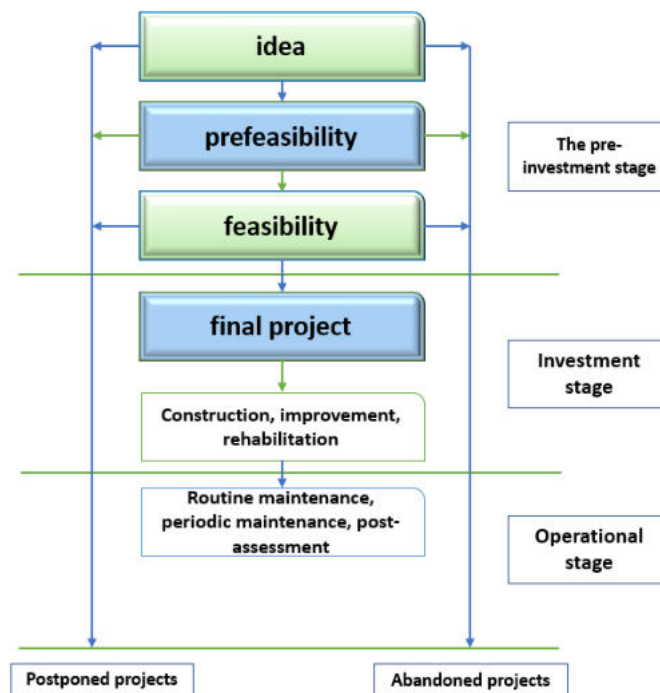


Figure no. 3. Project cycle.

2.2.2 Prefeasibility study

Prefeasibility constitutes the second level of analysis and aims to limit the alternatives identified at the project idea phase based on a greater content of information. In this phase, alternatives considered suitable are examined in detail, which were generally determined in the previous phase, the "project idea"

phase. That is, it decides the need to invest in studies that allow for a definitive decision. These studies will make it possible to determine their interest and priorities for the project, as well as technical, economic and social feasibility. Here the financing sources that will make the project possible are identified. The prefeasibility study includes a selection of technologies to be used, the location, size and period of the investment that allow a better definition of the project and its components.

With the prefeasibility study, it will be possible to determine whether the ideas identified in the "project idea" stage are technically, economically, socially and ecologically feasible and whether there is a viable strategic alternative that allows the achievement of the intended objectives and that justifies the implementation of more precise studies, namely the feasibility studies.

At the beginning of the prefeasibility stage, the problem (identified in the master plan) must be clearly defined. At the end of the prefeasibility stage, there will be clear evidence whether or not improving the project is worthwhile. Prefeasibility will usually identify which type of project might be convenient, verifying if the project is not premature and if it provides the necessary information for the feasibility study. Typically, this phase can identify "corridors" that require a new project.

A positive prefeasibility study will provide an advance warning of the financial resources that will be required for the future implementation of the project. The prefeasibility study may indicate that a proposed road improvement is not an effective way to solve a problem or that it should be considered in the future. In this case the process should be completed or postponed without incurring the high costs of a feasibility study.

At this stage, there is a high influence on the project's costs, that is, the level of uncertainty is high, but somewhat lower than in the "project idea" phase.

The prefeasibility study refers to the refinement of the problem identified in the previous stage and, on the other hand, to the technical and economic analysis of all the alternatives that may appear. In addition, it allows to reduce the margin of uncertainty by estimating socio-economic and private evaluation indicators for each alternative, which leads to the selection of the best decision regarding the project.

At the beginning of the prefeasibility stage, the transport-related problem (identified in the master plan) must be clearly defined. At the end of the prefeasibility stage, there will be clear evidence whether or not it is worth improving the project. In this case, prefeasibility will usually identify what type of project might be suitable, , checking if the project is not premature and if it provides the necessary information to request the feasibility study.

This study concludes with a prefeasibility report. To prepare it, the aspects identified in the project idea phase must be analyzed in detail, especially those that affect the feasibility and profitability of possible alternatives. Among these aspects, the following stand out: the market, technology, size and location of the project, as well as the institutional and legal conditions in the targeted area.

The prefeasibility report must include at least the following:

- ✚ the budget or economic profile of the project (order of magnitude of the project cost);
- ✚ the amount of technical and human resources, necessary at the macro level, that the project will have;
- ✚ environmental, social and cultural impact;
- ✚ possible location of the project;
- ✚ investment requirements;

- ✚ possible organization of the project;
- ✚ the report's conclusion: why it is necessary for this project to be further studied in depth and subsequently implemented.

2.2.3 Feasibility study

In this phase, the same points of the prefeasibility study are addressed, but a much more detailed study is carried out that involves a reduction in the level of uncertainty and a clearer quantification and definition in the aspects indicated in the previous study, that is, the uncertainties regarding risk factors are eliminated. By deepening the analysis and studying the variables affecting the project, the expected variation in project's costs and benefits is minimized.

The objective of this phase is to define the acceptance or rejection of the project. In the first case, measures are taken for its execution. Based on the recommendations made in the prefeasibility study, which were included in the terms of reference for the feasibility study, the requirements surrounding the concept of this phase are: preliminary engineering, technical effort of designing process alternatives, decision-making capacity and comparative economic studies. Among the technical aspects of the project that need to be defined should be: location, size, technology, execution schedule and launch date.

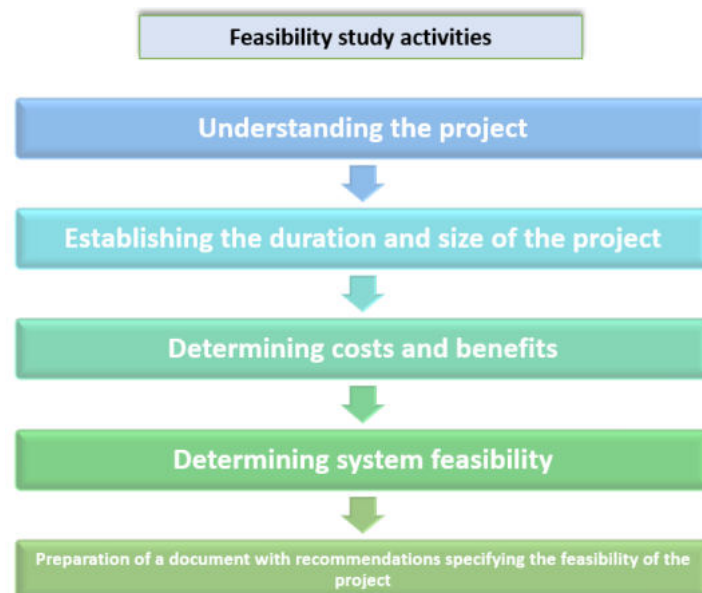


Figure no. 4. Feasibility study activities.

In this phase, the conditions that will affect the project are analyzed, the project engineering is carried out at the preliminary design level, satisfactory strategic alternatives are selected, the project objectives are more precisely defined, and the costs and benefits of the project are identified and quantified from three points of view: economic, social and environmental. Additionally, a plan for the organization, administration and management of the project is proposed, financing possibilities are analyzed: local, national or international, the legal framework is carefully studied and a multi-criteria evaluation of the project is carried out.

The objective of feasibility is to establish the fundamental technical aspects: location, size, technology, execution schedule, start-up and launch, organization, management and financial analysis, given a smaller range of variation in costs and benefits than the prefeasibility study.

The feasibility study should find the most appropriate improvement for a road infrastructure project by solving or helping to identify a transportation problem. To begin the study, the problem must be clear and with an expectation of how it can be solved by some type of road improvement so that it is economically, socially and environmentally acceptable. This expectation is supported by the obvious needs to justify the considerable costs of carrying out a feasibility study (identified through a prefeasibility study).

At the end of the study there should be a clear recommendation for a specific road improvement project. The study will provide evidence that this project should be carried out and the best solution to the problem, taking into account operational implications, benefits, economic and environmental impact. A detailed description of a preliminary engineering design, associated plans of the proposed project is provided to enable costing at a level of detail to facilitate funding decisions. The feasibility study should provide information for the budgeting process preparation, providing more details (than in previous stages) about the costs to be incurred and the project execution times.

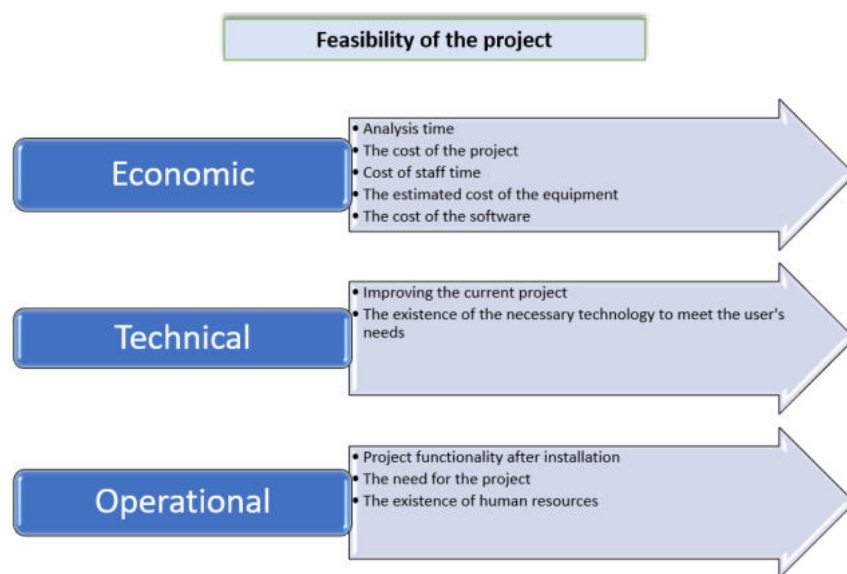


Figure no. 5. Feasibility of a project.

Operational feasibility refers to all those resources in which a certain type of activity (processes) intervenes, depending on the human resources participating in the project's operation. In this stage, all those activities necessary to achieve the objective are identified and everything required to complete the project is evaluated and determined.

Economic feasibility refers to the economic and financial resources needed to develop or carry out activities or processes. The basic resources to consider are the cost of time, the cost of execution, and the cost of acquiring new resources. In general, economic feasibility is the most important element because through it the other deficiencies of other resources are solved, it is the most difficult to achieve and requires additional activities when it is not possessed.

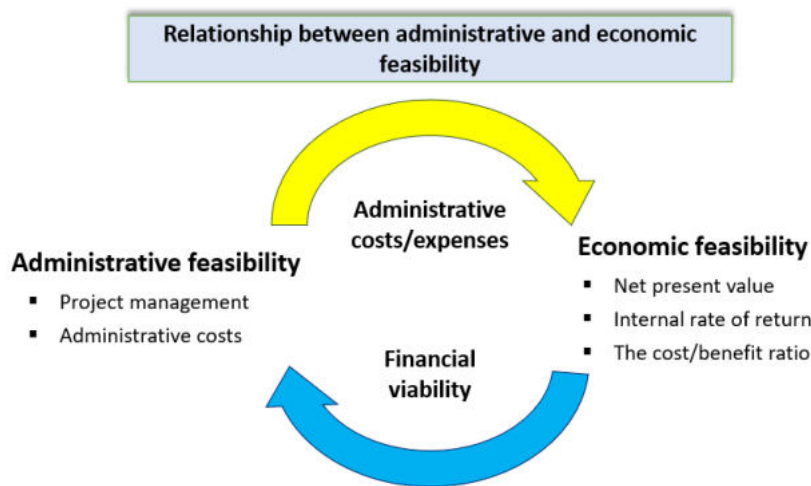


Figure no. 6. Relationship between administrative feasibility and economic feasibility.

Technical feasibility refers to the required resources, such as tools, knowledge, skills, experience, etc., that are needed to carry out the activities or processes required by the project. It generally refers to tangible elements. The project must consider whether the current technical resources are sufficient or should be supplemented.

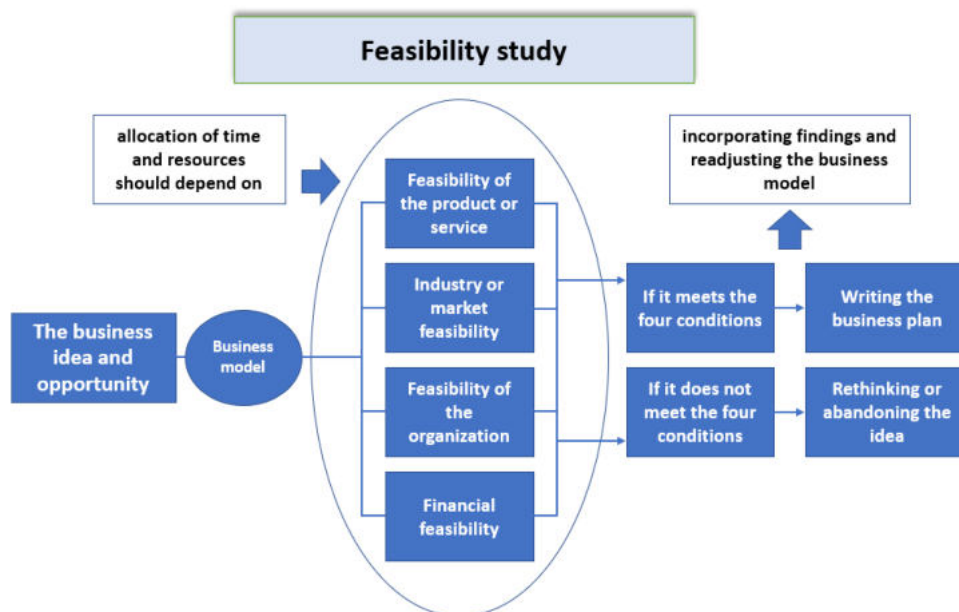


Figure no. 7. The feasibility study.

This study concludes with the feasibility report which is the culmination of the project's formulation and the basis of the decision regarding its execution. It also serves project promoters, financial institutions and those responsible for economic implementation. A feasibility study needs to be presented with all possible advantages, without neglecting any of the elements necessary for the project to work.

2.2.4 Development of the final project

After the project has been declared viable, the final study or detailed technical file is prepared, which consists of a set of technical, financial, socio-economic, environmental and organizational documents to ensure that the selected proposal for the project can be executed with a maximum of guarantees.

Each construction project culminates in the preparation of the technical file, taking into account the most important documents: descriptive memorandum, detailed memorandum, plans, specifications, technical specifications and budget. Each of these documents contains information and data that directly and indirectly intervene in the product quality of various construction processes.

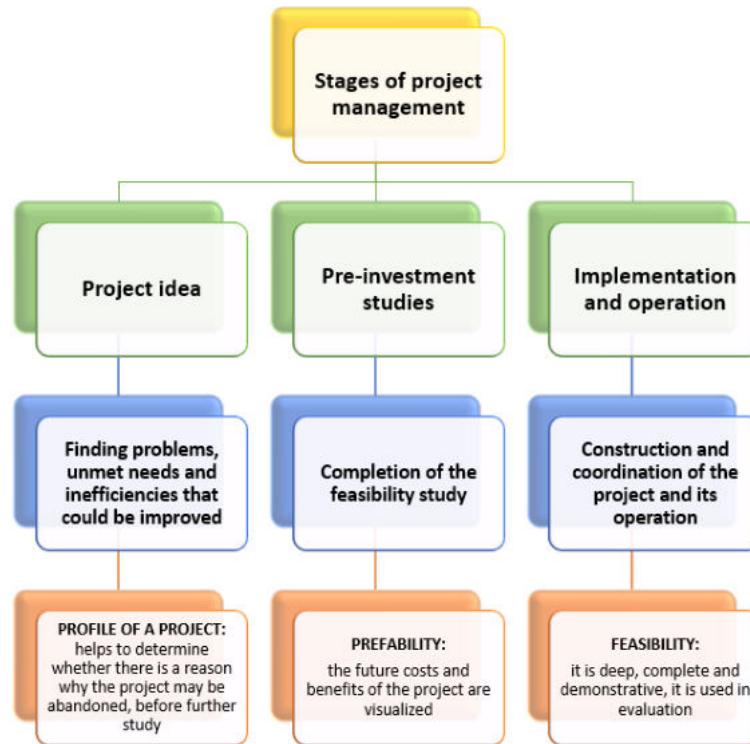


Figure no. 8. Stages of project management.

2.2.5 Project execution

This phase represents the set of tasks and activities that are involved in the realization of the project itself. This is when the physical execution of the investments begins with the tender for the works corresponding to whole or part of the project. It responds, above all, to the specific technical characteristics of each type of project and involves mobilizing and managing resources in the appropriate way to develop the project in question. Each type of project currently responds to its own technology, which is generally well known to those qualified in the field.

The project owner will designate an architect, engineer or a person experienced in construction management to take responsibility for conducting the construction inspection and approving changes. Field inspections are required to ensure that plans and specifications are followed and that construction materials are supplied in the quantity and quality specified.

Likewise, it continues with investment execution management and project execution control and monitoring. On the other hand, the execution will allow the identification of problems and obstacles derived from it. This stage requires a high capacity for management. The level of uncertainty is much lower than in the previous phases. The following figure highlights the reduction in the level of uncertainty in construction projects for each of the presented phases.

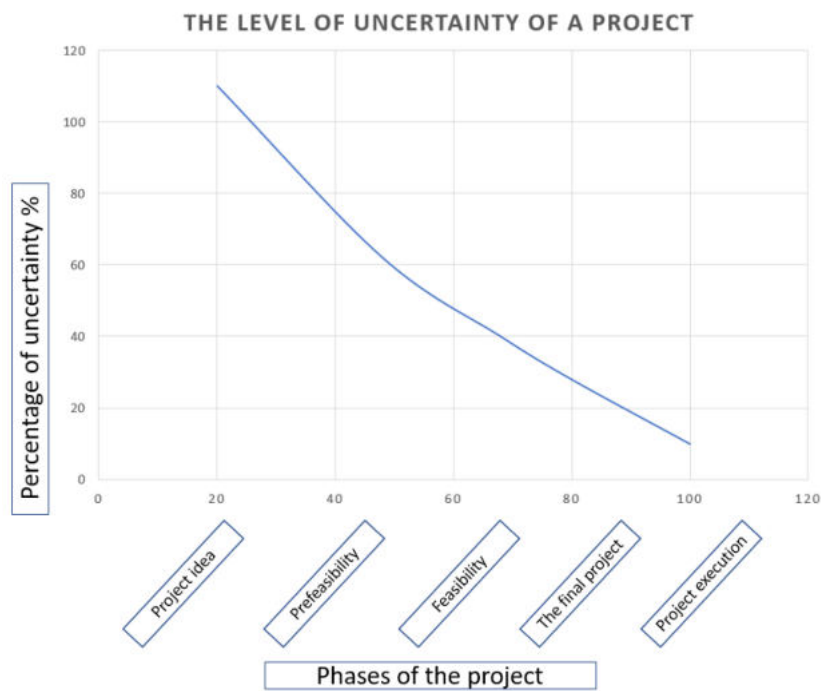


Figure no. 9. The level of uncertainty of a project in each of its phases.

In this phase it is important to develop a good project execution schedule using the estimated time for each task to determine the total time that will be required for its construction, taking into account all those factors that may at any given moment affect the adherence to the schedule, factors such as: weather conditions, land accessibility, delivery of materials by the distributor etc.

2.2.6 Project operation and management

This stage involves verifying the work done by analyzing the difference between progress and what was planned and initiating the necessary corrective actions. It also includes management, providing guidance to human resources, subordinates (including subcontractors) to do their jobs efficiently and on time.

Through project monitoring indicators, of various types, such as financial, technical, environmental etc., it is possible to examine the progress of the project throughout its lifetime. In this phase, decisions are made and, if necessary, objectives are redefined, so that the project development is adapted to reality.

2.3 Costs in infrastructure projects

2.3.1 Working budget

The working budget includes the company's total revenues expected to be received and expenses to be incurred. The budget is very important for the financial year of a company.

The budget is the forecast of expenses and income for a certain period. Budgets can be used by companies, organizations, households and government to effectively manage their finances (Rafi et al.: 2020) [6]. Budgeting can be thought of as a plan to take action according to the assessment. The term working budget can be defined as work in progress (Steininger et al.: 2020) [7]. It is also known as the game plan for the business. It is necessary to consider the functional financial budget from the moment the idea is generated by the entrepreneur to the moment it goes into operation. Without a working budget,

it is impossible to evaluate whether the project can be implemented or not. The working budget proves to be useful for evaluating the company's financial status, profit, loss and total revenues (Tuati et al.: 2021) [8].

Construction projects are large projects and need a huge budget for completion, however, the accuracy of such a budget matters a lot in project planning, so project managers in construction projects need to make an accurate cost estimate involved.

Automatic costs incurred in the mechanized construction of road infrastructure projects could certainly add up to 80-90% of the total costs, therefore the activities undertaken for road construction should be scheduled very carefully. By doing so, the desired equipment for the road infrastructure project is used efficiently and thereby minimizing unnecessary machine time. Costs for road infrastructure projects could fluctuate significantly, mainly depending on soil and terrain conditions, road principles associated with road construction, labor costs and equipment used, including the skills of the workers and operators involved.

The evaluation of the working budget in road infrastructure projects helps to implement the necessary changes to examine their progress, opportunities, challenges and risks (Aceves: 2020) [9].

Infrastructure projects refer to large-scale projects that focus on developing new facilities and systems or maintaining existing ones.

The scale of these projects makes the budget extremely important. The delicate nature of infrastructure development also needs a large upfront budget to manage the entire project successfully. Inefficient budget management can lead to delays in project completion, which increases the number of problems faced by the developer.

Therefore, construction costing is important in infrastructure projects. Major disputes associated with the cost and quality of highway projects are highlighted by researchers through the transportation factor that gains more and more publicity with technological advances and the passage of time.

Construction costs are usually underestimated, leading to a serious impact faced by developers (Sovacool et al.: 2018) [10]. The role of a well-established budget is to ensure that the developer knows the financial limits imposed on him, under which the project must be fulfilled. This helps establish both the scope of the project and its requirements. It serves as a performance measure, to test both pre- and post-project periods (Xenidis and Stavarakas: 2013) [11]. The main budget overruns are caused by late project delivery and fundraising issues. Thus, a budget established before the development of the project is essential (Lichtenberg: 2016) [12].

Road infrastructure costs are also increased due to several factors. The construction cost depends on the area, the material used and the labor force employed. Thus, the working budget becomes extremely important (Collier et al.: 2016) [13].

To better manage construction costs, developers try to forecast the budget provided. Once the costs involved in the project are understood, developers are able to implement policies and actions that help manage the established budget more effectively (Love et al.: 2018) [14]. Regarding public infrastructure projects, the responsibility lies with the government to decide and allocate a budget (Huang et al.: 2010) [15].

2.3.1.1 Budget types

A company's budget revolves around all aspects of its operations. When deciding on a budget, companies analyze certain factors. As such, the budget is divided into different types. For example, incremental budget refers to a company's approach to deciding a new budget by combining the previous year's budget of activity and adding or subtracting a percentage. Budget performance does not depend on incremental budget.

The sales budget refers to the estimated number of sales a company expects in a calendar year. It is used to forecast earnings by assessing the impact of costs. The sales budget is extremely important because it is the primary source of revenue generation. As such, it has an impact on the budget allocation of the entire company. The production budget refers to the manufacturing cost of a certain quantity of products. This is decided using the sales forecast along with the expected number of finished goods. The production budget serves as a regular cost, and any expansion of the firm's product line will increase it. It includes all facets involved in the production process - raw materials, labor and manufacturing overhead costs, supply chain cost, shipping costs, transportation and commissions (Isaac et al.: 2015) [16].

In capital expenditure budgeting, the focus is on purchasing fixed assets that the firm will use in the future. Examples of this could be machinery or property. A land purchased by a firm for construction purposes can be defined as a capital expenditure cost. It has a different nature because it is a long-term investment made by the company (de Souza Michelin et al.: 2020) [17]. Finally, a company's research and development budget refers to the cost reserved for the development of new directions. Before launching a project, it goes through several stages of research. This ensures that the project is ready for consumption (Guo et al.: 2018) [18].

Thus, the sales budget is mainly defined as the expected number or amount of sales that a company anticipates mainly in a calendar year. This proves to be useful for forecasting earnings by assessing the influence of costs. Sales budget is considered to be essential and extremely important as it is known to be the initial source through which revenue can be generated. On the other hand, the production budget is defined as the cost of manufactured products relative to a certain quantity. This is decided by using the sales forecast together with the expected quantity of finished goods. The production budget mainly acts as a regular cost, therefore if there was an expansion in the company's product line, then the budget would also increase. Moreover, the company also includes a capital expenditure budget which focuses on the acquisition of fixed assets by the company for future use, for example, machinery. The capital expenditure budget is different in nature, as it is a long-term investment made by the company (Isaac et al.: 2015) [16]. A company's research and development budget is known as the cost that has been retained for developing and manufacturing new goods. Also, before launching a product on the market, there are many stages of research, which ensure that the project is feasible. This is considered important as it is a long-term investment made by the company.

2.3.1.2 The role and importance of budgets in planning and control process

The budget guides the activities and operations of the company. Thus, it plays a vital role in a company's overall plan. Budgeting is also important because it helps a company track its expenses and save funds. Therefore, it can help managers make better business decisions (Shaikh : 2016) [19] .

Before starting design, a project budget containing indirect costs and direct costs should be developed. The more detailed and realistic the cost estimate, the less likely surprises will be as the project nears completion.

When the project reaches the construction phase, the designer will initially have a preliminary budget of his expenses prepared by the project engineer, architect or designer. The preliminary cost calculation is based on the costs of similarly designed projects built in the same city. If it is a public project, there may be actual cost records that allow the project manager to develop a calculated basis on a per-dwelling or per-structure basis and based on anticipated quantities.

Regarding the planning process, budgets provide companies with financial forecasts about plans (Bufan: 2013) [20]. These could include plans to expand or launch a new product/service. By ensuring a set budget, companies can better operate within it to ensure they do not face long-term problems. It also helps companies identify the resources needed for the project as well as the means of comparison.

In construction projects, changing the land on which construction is taking place or hiring additional labor could lead to an exponential increase in costs, making it necessary to have a contingency budget to meet this potential scenario.

The budget is the basis of all operations and activities that take place within the company, therefore it has a major role within it. In terms of the planning process, budgets basically provide firms with adequate and relevant financial forecasts. This could involve launching new products or services and plan to expand the existing product line (Guo et al.: 2018) [18]. By ensuring a set budget, companies can achieve better results within certain limits so that they do not face major problems or risks and also ensure that they do not face any problems in the project.

2.3.2 Direct costs, indirect costs and profit

Determining the cost of construction projects is a laborious process that must go through at least the following phases:

- ✚ Decomposing the work into activities that determine its analysis structure;
- ✚ Analyzing plans and specifications to determine the quantities of each of the defined activities;
- ✚ Studying the activities to determine the types and quantities of materials required, the characteristics and usage time of the staff who will be responsible for the execution and, finally, the necessary auxiliary equipment, including the characteristics and usage time;
- ✚ Investigate the costs of each material (including shipping and taxes), the typical wages for the type of workers that will be contracted, and the rental rates for the necessary equipment.

Direct cost is defined as the direct price that can be directly related to the development and manufacture of certain goods and services.

Indirect cost is known as the price that extends beyond the company's expenses it incurs, the expenses of manufacturing the products that are there to support the costs involved. Also, these additional costs are easily expected to be reduced after describing the direct cost.

Profit is defined as the financial benefit that can be assessed if the company's total revenues generated from various business activities exceed the expenses, costs and taxes.

These costs define both large segments of a project and the scope that a budget can have, but they have different ways of calculation because each includes differentiated acquisitions.

$$CT = CD + CI$$

where:

CT = total cost of construction project

CD = direct cost

CI = indirect cost

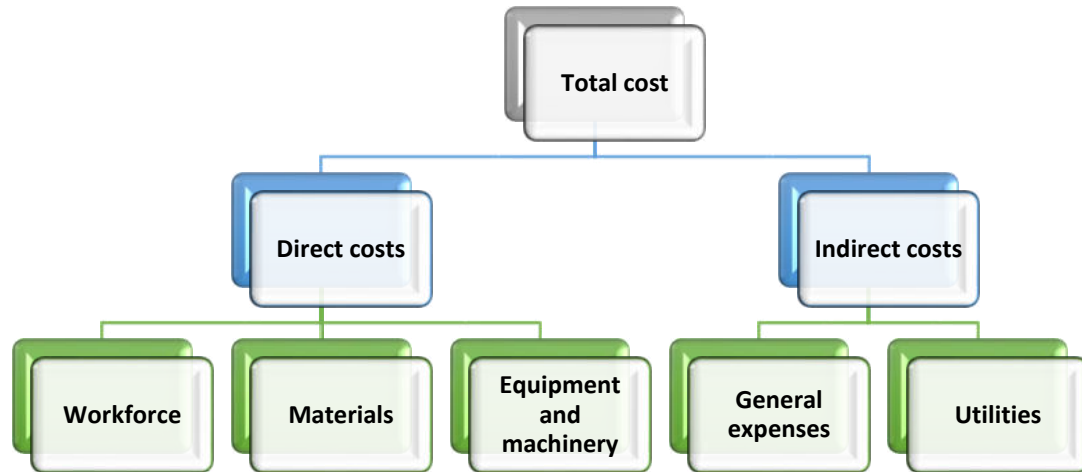


Figure no. 10. Classification of costs according to the method of distribution.

2.3.2.1 Direct costs

A direct cost can be defined as the price that can be directly related to road construction. Direct costs are often variable costs, so they can fluctuate at the same rate as the quantity and quality of the construction material.

Direct cost is the sum of the costs of materials, labor, equipment, tools, and all elements necessary to perform a work.

These direct costs which are analyzed for each of the elements that make up a work can have different degrees of approximation depending on the proposed interest. However, refining them does not always lead to greater accuracy, as there will always be differences between different cost estimates for the same item. This is due to the different criteria that can be assumed, as well as the experience of the engineer developing them.

Direct costs are calculated starting from the geometric analysis of the plans and are a very important source of information for subsequent budgetary control.

Direct costs are the expenses directly related to the construction work. Direct costs include: building construction costs, land acquisition, utilities including sewer, water, gas and electric lines, site grading, erosion and sedimentation control, street paving, gutter curbs and sidewalks etc.

2.3.2.2 Indirect costs

Indirect cost can be defined as the price that extends beyond the expenses that the company supports (Wang et al.: 2018) [21] . It can be shown that these costs are those remain after calculating the direct cost, although, the indirect cost proves to be more difficult to assign to a specific product compared to the direct cost. Examples of indirect costs include utilities, office computers, office equipment rentals, cell phones, and other supplies. Like direct costs, indirect costs can also be variable and fixed. Variable

indirect costs include fluctuating gas and electricity bills, and fixed indirect costs include payments such as rent.

Indirect costs are divided into overhead and utility costs. Overhead is divided into overhead that is not related to job execution time and overhead that is related to job execution time.

Indirect costs are included within a working budget, and represents the costs derived from its implementation in a social environment, such as taxes, insurance, service connections and professional fees, as well as the costs arising from the use of capital (financial costs) and the marketing of the final product (sales commissions etc.).

Determining this type of cost depends on a proper knowledge of the legislation in force and the application of the appropriate rates, although in the case of commercial costs it is also essential to apply financial techniques to determine them.

The control for these types of costs is a mix between those that apply to the previous two costs. Since some components are directly proportional to the work and can be controlled relatively easily (taxes), others, especially the financial ones, are highly time-dependent and become a problem when any delay in completing the project occurs.

The indirect cost corresponds to the general expenses necessary for the execution of the works not included in the direct costs carried out by the contractor or consultant, and includes among others: administrative expenses, organization, technical direction, supervision. In works budgeting practice, indirect costs are expressed as a percentage of direct costs.

Indirect costs are general expenses that allow the execution of works related to the construction project. Indirect costs include: administrative expenses, technical direction, organization, supervision, transportation of machines, contingencies, construction equipment, construction of general facilities, investment in advertising, etc.

To those indicated are added operating costs, among which we can mention expenses with consumables, be they: fuels, consumables etc., technical and administrative expenses, whether they are taxes, executive salaries etc. There are also indirect costs of the work office, among which we can mention: land fees, taxes, financing, among others. When talking about office expenses, it refer to the expenses of auction, stationery, copies and duplicates, post office, telephones, radio, electricity, gas and other consumptions etc.

2.3.2.3 Profit

Profit can be defined as the financial benefit that can be assessed when the total revenues of the company generated by the project exceed the costs, taxes and expenses involved in the activities carried out to complete the project. Profit can be calculated by subtracting total revenue from total expenses.

Business growth depends on its profitability. Therefore, some of the business people are dedicated to profitability, while others show interest in return before expenses or taxes. There are different types of profit which may include gross profit, net profit or operating profit etc. All types of profit are part of the profit and loss account. Each type of profit provides the researcher with more data regarding the company's performance and relates it to past performance and competitor performance.

2.3.3 Cost calculation

2.3.3.1 Distinctions regarding the notions of cost and expense

Expenses represent the consumption of purchased items, the overall operational cost that the company has incorporated to generate revenue. Expenses and costs are economic indicators through which companies can quantify the preparation of the decision-making procedure at the basis of general management within the economic entity (Zahorska et al.: 2021) [22].

2.3.3.2 Analysis and structure of expenses

The expenditure structure is based on the calculation of the gross domestic product (GDP) which includes investment, consumption, net exports and government expenditure (Baxodirovna: 2017) [23]. It focuses on everything that the private sectors, composed of private firms, consumers and government expenses, must add to the total revenue of products and services generated after a certain period (Baxodirovna: 2017) [23]. The expenditure method could be contrasted with the income approach for calculating GDP. Spending analysis provides accountability for where money is spent and on what things or processes. By doing so, huge potential gains can be realized in both allocative and technical efficiency, the 2 main constituents of the value of money.

2.3.3.3 Unit cost calculation procedures

A unit cost can be defined as the total expenses experienced by the company to store, sell and produce 1 unit of a particular service or product. The accounting measure includes all variable and fixed costs related to the manufacture of services and goods (Hanna and Dodge: 2017) [24]. Unit cost is identified as the essential measure of cost in the operational analysis of the company. Analyzing and identifying the company's unit costs is an effective way to check whether the company is achieving its efficiency objective. Unit costs can be calculated by adding fixed and variable costs and then dividing this figure by the total number of units required/created.

Unit cost is defined as the total amount spent by the company to produce, sell and store products in relation to one unit of it (Wang et al.: 2018) [21].

$$Unit\ cost = \frac{Total\ fixed\ costs + Total\ variable\ costs}{Total\ units\ produced}$$

Unit cost should decrease as the number of units produced increases, mainly because total fixed costs will be spread over a larger number of units. Therefore, the unit cost is not constant.

2.3.3.4 Cost analysis and calculation methods

Cost analysis is used to compare the cost of completing financial statements and controlling operations (Bozgulova et al.: 2019) [25].

$$CT = CF + CV$$

where:

CT = total cost of construction project

CF = fixed cost independent of production volume (depreciation, rent, utilities etc.)

CV = variable cost that depends on the production volume (raw materials, direct wages etc.)

For infrastructure projects, costs are calculated using the formula below:

$$\text{Project cost} = \text{Construction cost} + \text{Financial cost} + \text{Maintenance cost}$$

The following table shows the percentages occupied by each of the expenses involved in an infrastructure project.

Types of general expenses	Average percentage of project overhead
Staff	26,50
Mechanical installation	22,30
Access and scaffolding	18,00
Construction site	11,80
Energy	6,50
Cleaning and clearance of the construction site	4,80
Telephony	2,10
Temporary roads	1,80
Road signs	1,70
Surveillance and security	1,70
Insurance	1,70
Other items	1,30
Total	100,00

Table no. 1. The average percentage of overhead expenses involved in an infrastructure project.

It can be said that the budget is known as income and expert forecasts for a certain period. Budgets can be easily used by households, companies and government so that they can manage their finances effectively. The working budget mainly involves the company's total sales revenue that is expected to be taken into account as well as those expenses that are anticipated to be paid. The budgeting process can sometimes be really difficult for organizations, especially for those organizations that do not allow adequate time to assess costs or expenses, or when customers do not pay on time or revenue is found to be intermittent.

The nature of infrastructure development requires a huge budget to have proper and successful management of the entire project. Infrastructure development also requires a huge budget for successful management of the entire project. If the budget is not managed efficiently and in case of failure of its management, there can be certain delays in the project. It is very important for the development of large-scale infrastructure projects to decide on a correct budget (Xenidis and Stavarakas: 2013) [11].

To better manage expectations and budgets, it's important for developers to understand certain changes, as well as the factors that can lead to an increase in those changes. This may involve some unexpected delays that may occur due to environmental changes. If developers come to understand the budget correctly, then they will be able to execute actions and policies in a better way, which can contribute to the establishment as well as effective management of the budget (Love et al.: 2018) [14].

The techniques involved in road construction are comparable globally, reasonable estimates of construction costs can be easily derived when identifying the main aspects of custom based on the implementation of identical facts and comparable figures for road construction projects.

The construction cost for highway projects includes a diverse range of aspects such as design costs, supervision and technical assistance costs, secondary costs incurred for the location of road infrastructure projects, construction costs.

2.4 Planning, estimating and cost control

Complex projects are essential for the development of society and for a healthy economic environment. Investments in road infrastructure stimulate the economic structure of countries and positively influence citizens' lives. Road infrastructure helps the population to travel, work further from their homes; the existence of efficient road networks stimulates investments and directly influences job creation. In political terms, road infrastructure is one of the most visible and powerful achievements, and represents political success.

However, building infrastructure is an extremely complex effort due to the substantial costs involved, as well as the quite common unforeseen developments during the construction process and afterwards. Therefore, cost planning is the most relevant activity in the preparation of a road infrastructure construction project. In order to be successful in road infrastructure construction, it is necessary to reduce the risk and degree of uncertainty as much as possible.

Road infrastructure refers to any physical assets involved in the construction process, not only the road itself, but also all associated accessories such as artwork and all structures (buildings, bridges, sewers).

However, all infrastructure construction projects focus on service development. This does not only refer to road construction, but also to the facilities and systems and involves its maintenance as well. In this sense, building a profitable project should eliminate risks as much as possible, so that it deviates from the original plan as little as possible.

Project development costs refer to all capital expenses involved in the construction and development of mentioned project.

Cost control is the process of continuously collecting real-time actual costs in the project and comparing them to the project's budget. This process is necessary to keep track of project's expenses, to minimize costs where appropriate and to reveal areas where the contractor has exceeded the budget, to apply the necessary corrections during project's implementation in order to stay on time and in the budget.

The construction process itself follows a series of steps, which are quite specific to road development: land acquisition, clearing and excavation (and also prevention of erosion of cleared land), installation (ground is mounted, leveled, smoothed, pipes are laid), fine grading (surface preparation, which involves manual digging), aggregate base (placing crushed gravel or stone evenly), and finally paving.

As the works are carried out outdoors, they largely depend on external factors to the construction process, such as weather conditions, extreme natural phenomena, accidents, terrain issues etc.

Planning in such complex projects involves coordinating resources and stakeholders involved. Project planning involves the feasibility study - which answers the question of whether the project is feasible, realistic and likely to be completed.

2.4.1 Project cost planning

Project cost planning is essential to project effectiveness and development. The ability to accurately advance the total expenditure of a project can help eliminate the risks and dangers related to cost overruns, wastage of resources, labor and finances and can also help in proper budget control.

Planning for a budget requires the contractor (usually the one advancing the budget and cost planning) to properly understand all steps of project development. Project development costs are therefore all costs related to planning, development and design. These include all pre-project investigations, surveys, estimates, plans, specifications, official viewpoints etc.

In order for a contractor to be able to plan costs, to request a realistic budget, he must understand all project steps and be able to advance adequate amounts. Understanding the stages of a project helps the contractor to be more prone to the realistic calculation of all the financial resources involved. A contractor should be able to predict when specific types of materials are needed, in what quantities, what equipment and tools will be needed at a certain time, when labor is needed and when not, and be able to synchronize all these during the project's development.

To reduce costs, a contractor should be able to understand how certain external factors could slow down the project - such as delivery delays, shortages of certain raw materials, workplace accidents, labor health problems, natural disasters, inappropriate weather conditions. This is why project planning should also consider back-up plans, an emergency fund, back-up work teams and suppliers and include these in the contract as well.

In this sense, the contractor delivers a construction schedule and, through the use of software solutions, can coordinate real-time deliveries, materials, services, commercial works. These highly complex software programs can be managed in visual representation. An example is the critical path method (CPM), which can provide a realistic representation of site operations in real time and correlate activities.

This scheduling feature in construction is highly relevant because the budget and cost planning in road construction must clearly specify the periods to purchase or rent materials, equipment and services for certain time intervals in order to reduce costs.

A distinct and important point in budgeting and costing is the need to acquire land for the construction project and obtain the necessary approval and acceptance of the neighbors for the construction program, since the construction process itself can bring damage, objective and subjective, on the facilities or the population living in the immediate vicinity.

2.4.1.1 Characteristics of project cost planning

Cost planning requires detailed knowledge of the project and the environment in which it is to be executed.

Internally, it is necessary to have a clear definition of the scope in the form of a list of tasks, project schedule and resources. The latter should include a definition of the work packages to be outsourced and the required internal resources.

Regarding the environment, one must know the tax regulations of the place where the project will be developed, as this can affect the cash flow by introducing additional costs in the form of taxes.

Like other planning, cost planning is an iterative process because costs will be affected by actions defined in the risk management plan, and different iterations are usually required until the project approach meets the available budget.

In general, we can say that project cost planning includes the following information:

- ✚ The project budget. It is the total cost that the project will have for the organization and its division into the control packages that will be used in the monitoring and control phase.
- ✚ Cost curve. This comes from joining costs with the project schedule, showing expected cost evolution over time. Once approved, it becomes the cost baseline, which is vital to monitor and control the project.
- ✚ Project cash flow. It is the temporary representation of cash inflows and outflows during project execution. This study makes it possible to identify financing needs and guarantees that the project will be able to meet payment commitments.

The cost planning process for a project consists of the following main steps:

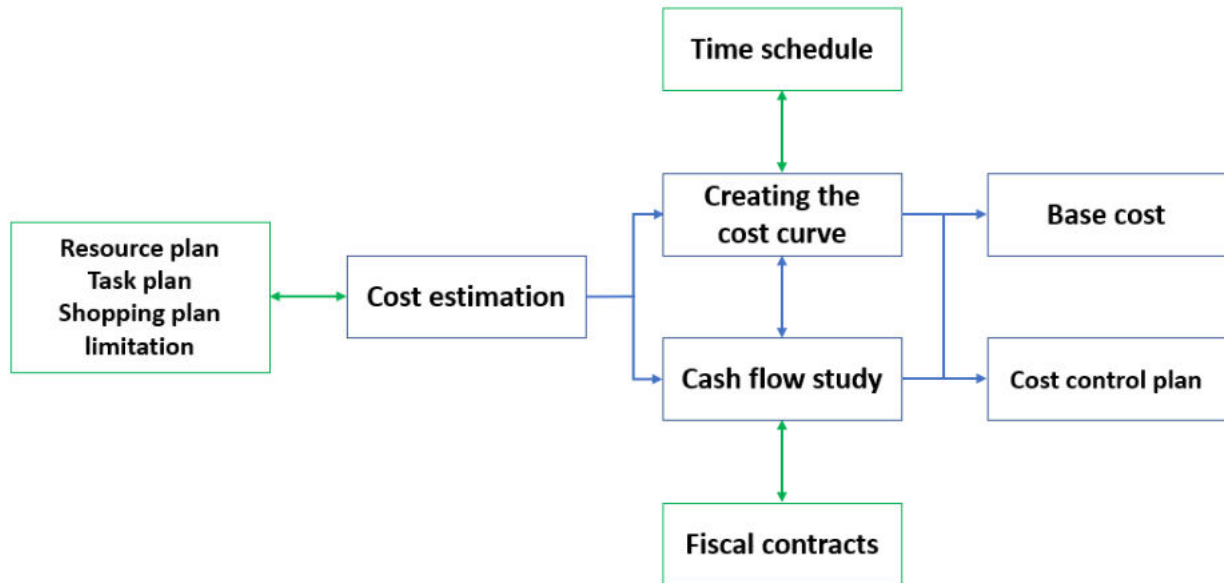


Figure no. 11. The cost planning process for a project.

Closely related to accessibility and transparency, cost planning should be visible to third parties so that all moving parts of the project understand the philosophy of project management and act as a team.

In addition to these features, planning should define how the builder will manage, control and communicate the costs of a construction project, as well as any developments that will affect the actual costs of activities on site, it should also include: o cost baseline; a project budget; a cost variation plan; a cost estimate; a cost management approach; a change and control process; a cost reporting and control process.

2.4.1.2 Tools and techniques for project cost planning

Before choosing a cost management tool, it is necessary to analyze the indispensable key features, thus the characteristics of effective project cost planning are as follows:

✚ **Cost and time estimation**

The main point of planning is to determine realistic financial costs and project time estimates; these are the principal elements of project management, especially project cost management, and there are several types of cost estimation (which translate into different types of contracts): fixed, variable, direct and indirect cost estimation.

Cost estimation can be done effectively with the help of specialized cost management software, so that it provides an accurate overview of how many financial resources the project will involve and how these resources will be used during the project implementation.

Project budgeting

After developing a realistic or unrealistic cost projection for the project, contract drafting will aim to approve a budget - organized by activities, sub-activities, on a daily, weekly, monthly estimate for expenses - so that the project never goes over budget. Specialized software, again, gives the contractor the option to set budget limits based on criteria such as time and financial resources.

When setting a budget, it is already complex and difficult; thus, cost management and planning should use an easy-to-use interface. The interface should be easy to access and help the contractor see faults and predict next steps easily, perhaps without requiring much analysis. This will increase productivity and allow the team to focus on the important aspects of their daily routine.

Project measurement tools

Measuring performance and efficiency enables timely adjustment of scope and activities so that project delivery is on time and within projected budget. Daily use of a dashboard helps the contractor keep up with construction activities. The dashboard should include the percentage of completion (and whether the level is within time), planned costs and actual costs of the project updated, schedule variance and more.

For project efficiency, the tool and reporting method that helps the contractor visualize cost management should be easy to use; building the report should not require the use of a manual or consultant and should provide full visibility to major stakeholders and parties involved to ensure real-time reporting. Cost management should be transparent and accessible.

Any project needs functional and accessible cost management and planning tools, so as not to stretch the budget more than necessary.

There are cost control techniques including: time management, project change control, budget planning, cost tracking and the use of earned value.

Recognizing the relevance of cost planning and the importance of sticking to the budget, there are several tools and techniques that can ensure that the budget is not exceeded.

To prevent the initial budget from being exceeded, contractors also provide a contingency budget, which is usually between 10% and 30% of the total expenses. This should cover the unforeseen difficulties of the project - delays due to weather conditions, delivery problems, accidents, natural disasters, health problems of the workforce, damage to equipment and tools and others.

2.4.2 Construction costs estimation

Construction cost estimation is the assessment of all direct and indirect costs distributed across the activities that make up the scope of the project. The objectives of cost estimation are: to define the economic magnitude of the project, and also to serve as a basis for project planning. It is important to underline that the cost analysis, which is done to estimate each project, must be adapted to the characteristics of each of them, taking into account aspects such as: the costs of materials, labor and equipment to be used, location and execution time, among others, which at some point could lead to an increase in project costs, such as: the construction system used, the complexity of the work, the degree of

detail of the planning, geographical location, policies in the employment of the staff, applicable laws etc. Economic estimation and analysis are closely related to the project cycle (from start to finish).

Early in the project life cycle, cost estimates are developed which, as more information is obtained, will be refined and detailed. To determine costs, the project must be simulated. It is necessary to quantify the materials indicated in the plans, to check their availability on site, available staff etc.

Cost estimation serves to provide an accurate idea of the final cost of the work, but only the end of the project shows its real cost.

In the construction sector, cost estimation consists of two fundamental tasks such as determining the likely actual cost and time of the project. Both cost and time are probabilistic because the said estimation is done before construction, therefore it provides an approximation of the actual cost of the project. The actual cost will be known at the end of the project, and the actual likely construction time depends on yields, crew sizes, equipment utilization levels and time allocated to each activity.

According to the PMBOK Guide, project cost management includes the following processes:

-  Cost estimation;
-  Budget determination;
-  Cost control (PMBOK: 2017) [1].

These three processes could be grouped into two, since cost estimation and budgeting in construction projects are done in a planning phase, and cost control is a more linear process that runs throughout the entire project.

Cost estimation is an important process in project planning that determines the financial impact of material, human and other resources for carrying out project activities. The characteristics of a cost estimation system include preparing estimates, creating costing options, developing the project budget, and control measures for executing the project within the allocated budget. The process validates the success of the project within the allocated budget, including completion of objectives and outcomes.

Given that one of the main errors in making estimates corresponds to the optimistic estimate of project costs, incomplete or inaccurate, without taking into account all the factors involved in the actual costs, such as the correct choice of materials, tools, equipment, cost change factors over time and unforeseen events that may occur during execution, especially in construction projects, the accuracy of the estimation is sometimes uncertain due to the complexity of the project and design changes.

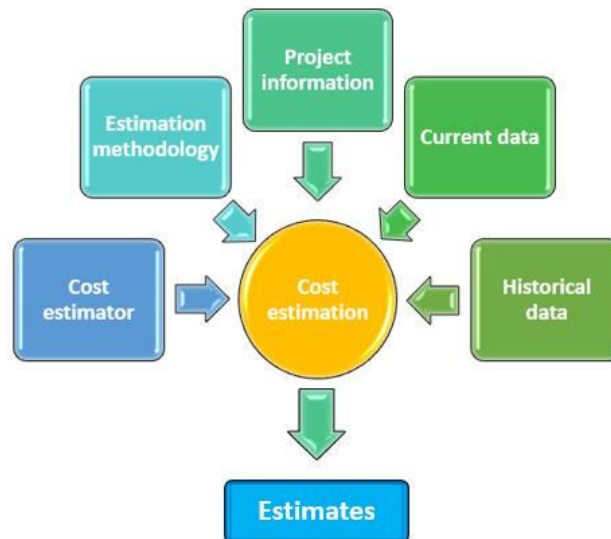


Figure no. 12. Critical elements of cost estimation (Kim et al.: 2012) [26] .

In the cost estimation process it is intended to develop an approximation of the financial (monetary) resources required to complete each activity of the project. The output of this process is the cost estimates of the activities and the estimate basis.

The basis of the estimates consists of the supporting documentation of the cost estimate, which should reflect a clear and complete understanding of how the cost estimate was obtained. The following figure presents the inputs, technical tools and outputs according to the PMBOK.

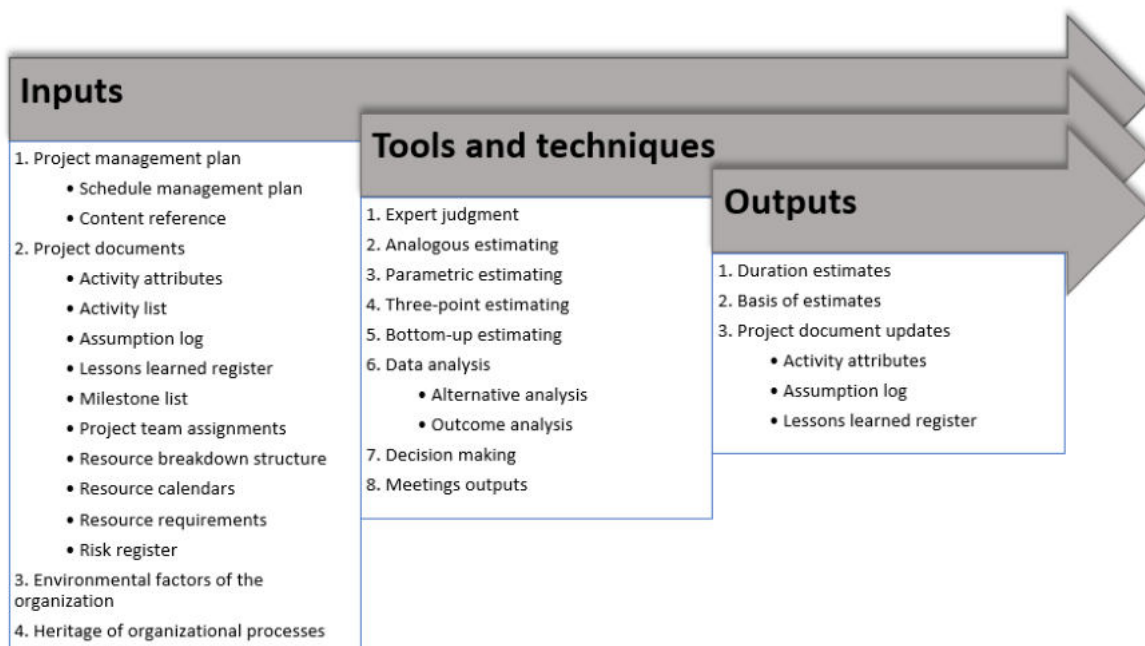


Figure no. 13. Budget determination: inputs, tools and techniques and outputs (PMBOK: 2017) [1].

2.4.2.1 Tools and techniques for estimating construction projects costs

The method of estimating construction costs depends on the level of detail of the project, that is for a rough budget, with little information, parametric estimation can be applied, and for a detailed budget,

an estimation based on unit costs can be applied. Some estimating techniques mainly use experience and judgment, while others place greater emphasis on the use of mathematics.

To determine the cost estimation of activities, different techniques and tools can be used: expert judgment, analog estimation, parametric estimation, bottom-up estimation, three-valued estimation, data analysis such as alternative analysis, reserve analysis and costs quality. Even though currently there are tools that can simplify the use of some cost estimation techniques and in this way facilitate cost estimation (cost estimation software applications, computerized spreadsheets and simulation and statistical tools), among those the most used cost estimation tools are the following:

- ✚ analog estimation;
- ✚ parametric estimation;
- ✚ three-valued estimation;
- ✚ bottom-up estimation;
- ✚ expert judgment.

Analog estimation uses the actual cost of previous similar projects as a basis for estimating the current cost of the project. It is frequently used to estimate a parameter when there is a limited amount of detailed information about the project. It is less expensive and requires less time than other techniques, but it is also less accurate. Analog estimation does not provide a highly reliable estimate. The advantages are that it is a process that involves less effort and costs are estimated by comparing with similar projects in the past.

Parametric estimation will use a statistical relationship between historical data and other variables to calculate a cost estimate for a resource in the scheduled activity, similar to analog estimation. This will use statistical data, which may or may not be accurate. It uses variables from other similar projects with similar profiles and applies them to the current project. Higher levels of accuracy can be achieved, depending on the refinement and the data being used. For example, in a road infrastructure construction project, the contractor will take the bitumen cost per cubic meter from a past project, estimate the amount needed for the present project, and multiply the values to record the result. This can give the total bitumen cost for asphalt paving, but if the prices considered are not accurate and realistic, the estimation will be inaccurate. This tool is, however, more accurate than analog estimation.

Three-value estimation, compared to the other previous estimation types, will reduce biases and uncertainties, but still evaluate the assumptions. Here, the contractor will determine the estimates of three variables, instead of one, and take the average to reduce uncertainty and risk. Three values are used to define an approximate range of costs for activity: the cost of the most likely estimate (M), the optimistic estimate (O) and the pessimistic estimate (P). The estimated (expected) cost of an activity is based on the following equation:

$$C_E = \frac{C_O + 4C_M + C_P}{6}$$

where:

C_E = estimated cost of the activity

C_O = optimistic cost

C_M = most likely cost

C_P = pessimistic cost

Three-value estimation calculates an expected activity cost (C_E), using the activity cost based on a realistic estimate of the required work effort and other expenses, the activity cost based on the best-case scenario analysis, and the activity cost based on the analysis of the most pessimistic possible scenario.

Bottom-up estimation is the most accurate, providing reliable results. The contractor will calculate the cost of each activity and subunit with the highest level of detail and include it in the total project cost. Each activity and stage of the project will be divided into components and small subunits, and the budget will be an aggregate of these subunit costs. This is the most time-consuming and expensive technique, but it will significantly reduce the risk.

Expert judgment involves providing information on labor rates, material costs, inflation, risk factors, the convenience of combining estimation methods and reconciling differences between them.

Asking an expert to evaluate the overall cost of the project can confer assurance, risk reduction, character and credibility to the project. Also, group decision-making techniques are based on the involvement of people who are going to actively participate in the project and thus obtain a more realistic estimate of the costs involved.

Instruments	Description	Advantages	Disadvantage
Analog estimation	A technique based on information and historical data of some completed projects, focusing on comparing the effort and extrapolating it between the object being analyzed and its analogue.	It is a quick and easy to understand technique. Reduced cost and application time. Possible application to the whole project or parts of it. Higher accuracy for greater similarity between activities.	It needs to be standardized to ensure accuracy. Estimates made are less accurate than other objective methods. Requires a historical base of previous projects
Parametric estimation	A technique based on a model, which is generated based on statistical relationships between historical information and the specific parameters of a project. Allows or generating "what if..." scenarios.	Very high accuracy is possible, depending on the refinement and the data used. Based on real observations and eliminates the dependence on subjectivity.	The entire analysis process must be documented, from data selection, settings, equation development, statistical analyses, to model validation and acceptance. Data collection and preparation are often difficult, expensive and time-consuming processes. Previous experience in the activities being estimated is required to generate the model.
Three-value estimation	A technique based on the PERT method, which uses a probability distribution and three estimates (optimistic, pessimistic and most likely) to calculate the expected cost of an activity.	The degree of uncertainty is reduced when determining the expected duration. Allows for normalizing subjective data.	Requires more work to perform the estimation, due to the fact that three estimates are used.
Bottom up estimation	The technique is based on decomposing the project into activities, and each activity and project stage will be divided into components and small subunits, with the budget being an aggregate of these subunit costs.	It is a reusable and intuitive technique. Allows for obtaining deterministic costs for activities, which are highly accurate. Allows for quick updates of estimates in case of lack of resources or in case of changes in the project scope.	Does not generate statistical confidence levels. The relationships between elements must be programmed by the analyst. Deterministic estimates prevent understanding the variability of a project's costs and hence the associated risks.
Expert judgement	A technique based on experience,	It is a widely applied methodology.	Purely subjective in nature, assumptions and assessment are

	knowledge and skills the expert.	Uses few resources and information. Saves time and application costs.	based on the analyst's knowledge and experience. Limited availability of highly experienced experts. Lack of a solid base to justify the estimate.
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Table no. 2. Comparative analysis of estimation methods.

2.4.2.2 Factors to consider in cost estimation

The final cost of a project is influenced by many variables that can significantly impact the estimated cost. In the case of project estimation, each value, the result of an estimate, corresponds to a possible outcome from the multiple variables and assumptions. These variables are not all directly controllable or absolutely quantifiable. The dominant assumptions that serve as the basis for most construction estimates relate to project scope, inflation, changes or unexpected situations, or project abandonment.

Project scope: The initially estimated project is often not the project ultimately built because there are inevitable changes in its development process. The changes result from an improved understanding of the requirements regarding the need for the project. The longer the construction of a project takes, the more likely changes to the scope will occur, including discretionary changes that add physical features to the project.

Inflation: Construction tasks range from simple to complex, with time and resources always being limited. The construction presents, as one of its main characteristics, a development in a certain time and according to the type of project; this characteristic makes the operating environment vulnerable to the inflationary effects of the economy. Material, labor and equipment costs change with inflation and this change should be taken into account when estimating costs.

Unexpected regular changes: The estimate can be made assuming that no changes will occur. However, there may be delays in construction processes or unexpected conditions at the project site.

Unexpected situations such as strikes or other uncontrollable events: If these situations occur, it would affect the construction project causing economic losses due to the resulting delays. In this way, the contractually agreed period to completion of the work would increase.

Abandonment of the project: The estimate must take into account the fact that political interests may hinder the progress and success of the project.

A project's cost estimate will vary throughout its development as engineering develops and uncertainty decreases. Depending on the type of project, the estimate will vary more or less.

Even though the construction projects vary greatly from each other, the estimation methods are "surprisingly" similar. The level of information available to make an estimate depends on the stage the project is at. That is, the level of uncertainty of the estimate will depend on the phase in which it is carried out. The following table summarizes this idea of the level of uncertainty in relation to the phase.

Level of uncertainty	Level of information	Engineering level	Project phase
95%	Defining the size and location of the project	Preconceptual engineering	Project idea
80%	Defining the main units of the project	Conceptual engineering	The prefeasibility study

50%	List of equipment and general plans	Basic engineering	Feasibility study
35%	Technical specifications and plans at 50%	Detailed engineering at 50%	The final project
5%	Technical specifications and plans at 100%	Detailed engineering at 100%	Project execution

Table no. 3. Level of uncertainty in relation to the phase.

2.4.3 Cost control

Cost control is an ongoing practice of identifying and reducing a project's expenses to increase profit and reduce overhead costs. Regular cost control within projects and businesses makes them more profitable by minimizing losses due to unexpected expenses from external factors.

The objectives of cost control are:

- ✚ determine the cost of each stage, activity, subunit and operation and compare these to the target costs/budget for the project, ensuring the project's delivery and maintenance within predetermined margins, when necessary;
- ✚ provide real-time alerts about budget overruns and the need to stay within the budget;
- ✚ provide relevant data on costs, parameters, causal reasons and factors and set standards for the future;
- ✚ to help assess variations that may occur during project delivery;
- ✚ promote cost awareness within the project team and ensure that the project philosophy has been internalized by all stakeholders and team members;
- ✚ to summarize the evolution and progress of overhead expenses.

A construction cost control system must focus on all cost elements of construction projects.

For a construction company, the cost elements to consider are:

- ✚ Material costs, which depend on the required quantities, corresponding market prices, and possible losses;
- ✚ Staff expenses (or workforce) depending on the activity performed, salary rates, costs associated with salaries, organizational structure and the performance or productivity of said staff;
- ✚ Construction equipment costs, depending on the work to be executed, fixed or ownership costs, variable or operational costs, and the performance or efficiency of using these equipment;
- ✚ Indirect costs, depending on the logistics costs of production support in the works and company's fixed costs, the latter being necessary to operate as a strategic business unit;
- ✚ Other costs, which include concepts that can ultimately be reduced to a similar treatment to any of the three elements initially mentioned.

Figure no. 14. highlights the place of cost control within the cost management of a project.

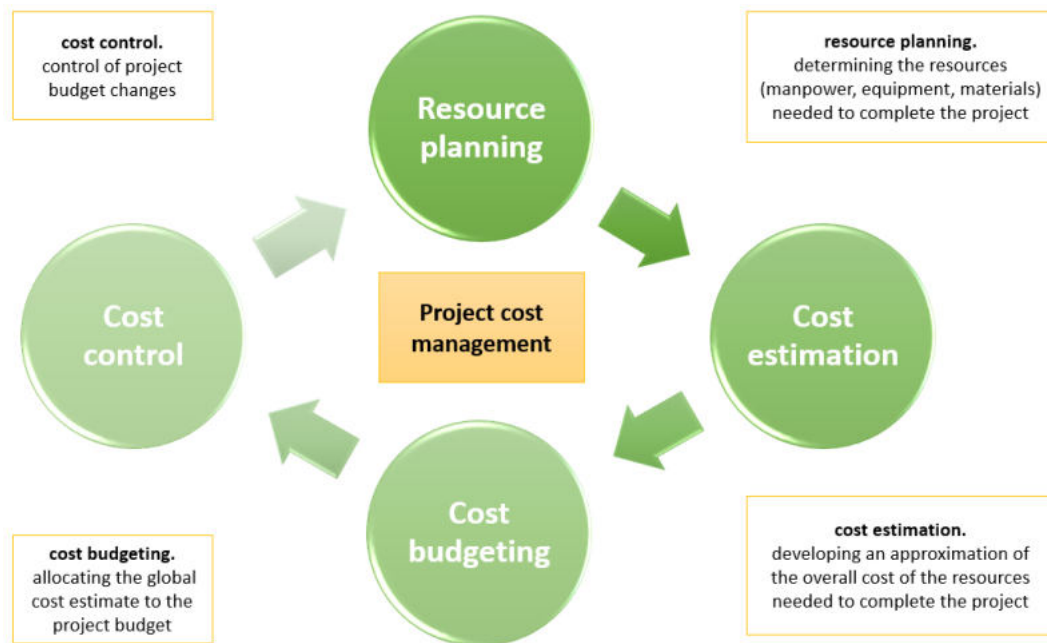


Figure no. 14. Project cost management (costmanagement.eu) [27].

2.4.3.1 The need to plan and control a project

There are visible and tangible advantages that result from ensuring proper cost planning and control activities for project development, especially for infrastructure construction projects, as follows:

- ✚ Planning and control ensure the development of a realistic and feasible budget;
- ✚ The project is ensured to meet the financial margins of the contract and consequently, is more likely to stay on schedule;
- ✚ Planning and control can warn of potential hazards, risks and uncertainties and therefore reduce their impact;
- ✚ These mandatory activities can increase the credibility of the project, the final outcome and the contractor;
- ✚ Both can ensure immediate or timely change of plans or corrections needed to ensure project delivery.

In a simplified manner, the impact of planning and control for an infrastructure construction project, which applies to all project developments in general, is exemplified in Figure no. 15.

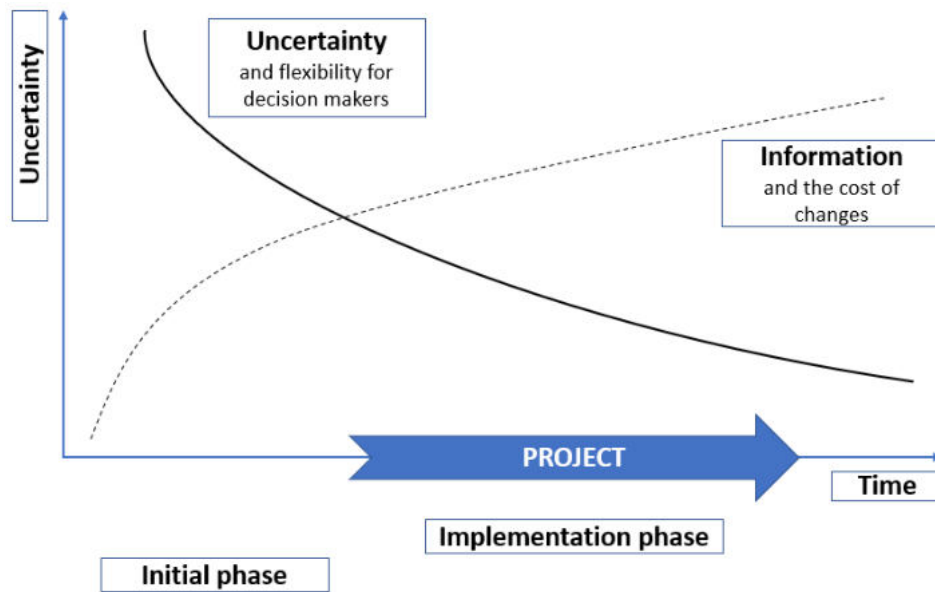


Figure no. 15. Impact of planning and control for an infrastructure construction project.

The first curve refers to the level of uncertainty, which is high at the beginning of the project. Lack of research, study, control and analysis would maintain the mentioned uncertainty. As the project develops, up to the implementation/construction phase, control is made and thus information about the project, conjuncture and context is provided, thereby reducing the level of uncertainty. Uncertainty is usually similar to the loss of financial resources, whereas, knowledge reduces that uncertainty, and thus the risk involved.

2.4.3.2 Stages of cost control and analysis

Cost control aims to reduce costs during the implementation of the project, namely during the pre-construction and construction period.

The stages of cost control are:

- ✚ Establishing a baseline/standard; this can be determined based on historical statistics/results or best case cost performance;
- ✚ Calculating the variance between actual results and the preset baseline; it is very important to focus on negative/unfavorable variances, to be able to correct when actual costs are higher than expected/budgeted ones;
- ✚ Investigating said differences; understanding how and why costs vary against budget in order to propose a solution that keeps the project on budget and on time;
- ✚ Taking action, according to the findings, and recommending the necessary corrective actions to reduce the risk or negative development.

2.4.3.3 Tools and techniques for construction project cost control and analysis

Control also requires evaluating the cost efficiency of each operation and the project as a whole. Various tools and techniques are used for cost control and analysis:

a. Earned Value Management (EVM)

Developed in the late 1960s as a financial analysis technique, it became popular over the following four decades as a project management technique. Today, it's also known as a program management technique.

EVM mainly covers the three most important knowledge areas of project management: scope, cost and time management unifying these areas within a common conceptual framework for mathematical representation of the relationships between them. Although EVM is weak in other areas of project management, such as stakeholder management, it can be used to greatly improve the project success rates when complemented with other project management techniques.

EVM is one of the most widely used methods for measuring project performance, integrating the scope baseline with the cost and schedule baselines to help the project team to measure progress.

EVM can indicate either a negative schedule variance, which means that the project is behind and over budget, or a positive cost variance, which indicates that it is cost-effective and that is under budget.

To measure performance with the Earned Value Management technique, a fundamental baseline is required, as all performance is measured against something previously defined (the baseline). In projects, the main references are the schedule baseline, representing the approved version of the schedule, the cost baseline, representing the approved version of the budget and the scope baseline, defined by the changes passing through the process of integrated change control. These three baselines are the main reference of the EVM technique. Once the benchmark is defined, the EVM will allow the project performance to be known for a specific analysis or deadline.

Thus, the EVM technique combines scope, time and cost measures to evaluate performance. And it can be applied to the entire project, a group of activities, or a single activity. Project progress and performance measurement are possible through the use of the following key dimensions:

- ✚ Planned Value (PV) - The authorized budget allocated for scheduled works in a certain period of time, the maximum planned value is the budget at completion or BAC;
- ✚ Earned Value (EV) - A measure of the work performed in terms of the budget for that work, that is, the actual progress of the activity at its budgeted price. The cumulative value of EV is the sum of the budgets associated with all activities or work elements implemented over a given period. Ideally, this value is close to the planned value;
- ✚ Actual Cost (AC) - The total cost incurred for the performance of the work measured by the earned value. Ideally, this value is close to the planned value.

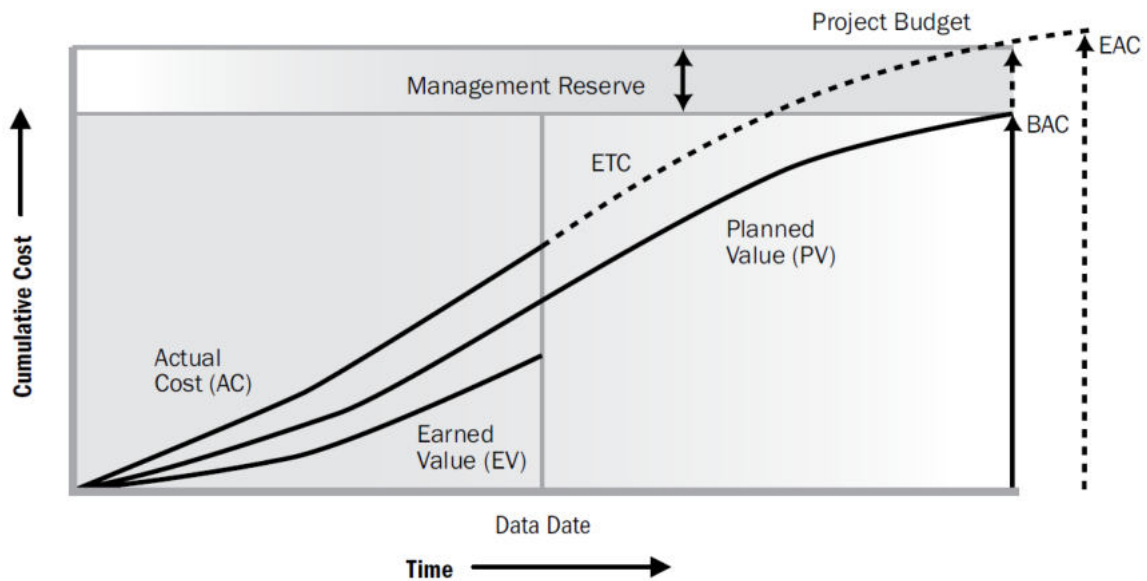


Figure no. 16. Earned value, planned value and actual costs (PMBOK: 2017) [1].

where:

AC - The real cost (Actual Cost) of the project;

EV - Earned Value of the completed works;

PV - Planned Value of the works;

BAC - Total approved budget value through the project budget (Budget at Completion);

ETC - Estimate to Complete the remaining works, respectively the cost required to complete the remaining works;

EAC - Estimate at Completion, respectively the total budget of the completed project.

With this type of chart, the trends followed by the three main variables of EVM can be observed. To analyze the project's schedule, cost variances and performance indices, knowledge of the following concepts is required:

- ✚ Schedule Variance (SV) - is calculated as the difference between earned value and planned value, it calculates possible temporal planning deviations; A negative value indicates that the project or activity is not following the plan and takes more time to implement, while a positive value indicates that implementation takes less time than initially expected;

$$SV = EV - PV$$

- ✚ Cost Variance (CV) - is calculated as the difference between earned value and actual cost. It calculates project performance and shows the extent to which the plan is met from the cost point of view, which is the calculation of the cost plan change; A negative value indicates a budget overrun, while a positive value indicates that the budget is underutilized;

$$CV = EV - AC$$

- ✚ Cost Performance Index (CPI) - represents how much profit each monetary unit invested in the project generates and is calculated as the division between the earned value and the actual cost. Calculates project performance and correlates planned costs with actual costs; A negative value indicates budget over-allocation, and a positive value indicates lower than planned costs;

$$CPI = \frac{EV}{AC}$$

If $CPI < 1$: the activity or project has a higher actual cost than the budgeted one.

If $CPI = 1$: the activity or project has an actual cost equal to the projected one.

If $CPI > 1$: the activity or project has an actual cost that is lower than the budgeted one.

- ✚ Schedule Performance Index (SPI) – is calculated as the division between the earned value and the planned value. It calculates the project's change index compared to the plan; A negative value indicates that the project is behind schedule, and a positive value indicates that the project is progressing faster than expected;

$$SPI = \frac{EV}{PV}$$

If $SPI < 1$, the activity or project is behind schedule.

If $SPI = 1$, the activity or project is on the planned path.

If $SPI > 1$, the activity or project is ahead of schedule.

Once the main concepts of EVM are defined, it can be said that this technique determines the variation and performance of schedule and costs for a deadline using mathematical calculations and using the performance measurement baseline as a reference. As a quick interpretation technique, it can be said that if the EV curve is above PV, the project is ahead, and if it is below PV, it is behind schedule, if the EV curve is above AC, the project is spending less than expected and if EV is below AC, the project is spending more than budgeted.

Every project needs control to be successful. Therefore, designing and planning are very useful measures in project management. EVM is an approach that provides additional information for successful project completion.

EVM is a method used to measure project performance in terms of cost and time. It effectively measures the time, cost required and cost consumed for a project by generating a warning signal. Key values are taken into account and calculated for forecasting. This helps the manager to define the project more accurately, having the success of work-based calculations. The EVM method can be considered a communication tool inside and outside the project, representing a technical and correct way of measuring and presenting progress and/or deviation from the schedule. This indicator includes the sum of the results obtained in the project up to a certain point of analysis, as well as the initial cost of obtaining these results.

In addition to the fact that EVM allows information related to how the project is progressing at a certain date, the method can also be used to make a projection of future performance, as well as project completion data and costs. Therefore, EVM provides two types of project performance measures:

- ✚ it allows measuring and representing, in a very reliable way, the performance of the project at a certain date;
- ✚ it allows for a projection of future performance, as well as project completion data and costs.

In short, Earned Value Management (EVM):

- ✚ Is a comprehensive technique for measuring project performance in an objective way.
- ✚ Allows:

- Measuring project progress and making a projection of the final cost and completion date;
 - Checking the status of the project, that is whether it exceeds or not the allocated budget;
 - Checking the project plan, respectively whether it fits within the schedule or not;
 - Taking measures to mitigate the impact of potential problems.
- ✚ It is a valuable communication tool, both for teams involved in project management and for management levels;
 - ✚ It provides management with the necessary information that allows them to continue the project or cancel it, request more funds or make other corporate decisions.

EVM can be applied to any type of project: large, medium and even small projects, being applicable to the entire project, any of its phases, or any activity within the project.

b. The To-Complete Performance Index (TCPI)

The To-Complete Performance Index (TCPI) is a relatively new forecasting tool. This excellent tool helps project managers calculate future project cost performance.

The value of the TCPI index can give a strong influence to the project manager regarding the urgency of the intervention that is required. The TCPI index is the calculated projection of the cost performance to be achieved for the remaining work in order to meet a specified management objective, such as BAC or EAC (PMBOK: 2017) [1].

TCPI shows the target cost performance index (CPI) that is required to complete the project within budget. In other words: the To-Complete Performance Index is the result of dividing the remaining budget according to the plan by the actual budget available (taking into account existing cost variances). The TCPI value is in one of the following three value ranges, each of which has a different meaning:

TCPI = 1: the project can continue with the current budget consumption rate;

TCPI < 1: based on the current cost variance, the project will be completed at a total cost less than budget;

TCPI > 1: if the project continues to operate at its current cost variance, it will complete over budget. In the future, the actual cost-performance index of the project should reach the TCPI value to allow the project to be completed within the approved budget.

In practice, TCPI is used mostly in situations where the actual cost exceeds the earned value (the third case). The To-Complete Performance Index indicates the factor by which future cost performance must be adjusted to complete the project within the planned budget.

To calculate TCPI it is important to know the inputs used in the calculation formula.

The TCPI formula requires 3 input parameters:

- ✚ Budget at Completion (BAC): The planned and approved cost for the project to complete its activity (before management reserve).
- ✚ Earned Value (EV): the amount of work performed up to the point of TCPI calculation.
- ✚ Actual Cost (AC): the cost incurred at the time the TCPI is calculated.

Budget at Completion (BAC)		
Budget at Completion (BAC)	BAC = Sum of all planned budgets	The planned and approved cost for the project to complete its work

Earned Value (EV)	EV = %work completed * budget	The amount of work performed up to the point of calculating TCPI
Actual Cost (AC)	AC = Total spent according to the budget	Cost incurred at the time of TCPI calculation
Estimate at Completion (EAC)	EAC = AC + BAC – EV	Total estimated cost to complete all work

Table no. 4. Summary table of parameter calculations for TCPI (PMBOK: 2017) [1].

With these values, the TCPI formula can be used to calculate the future cost performance of the project.

$$TCPI = \frac{BAC - EV}{BAC - AC}$$

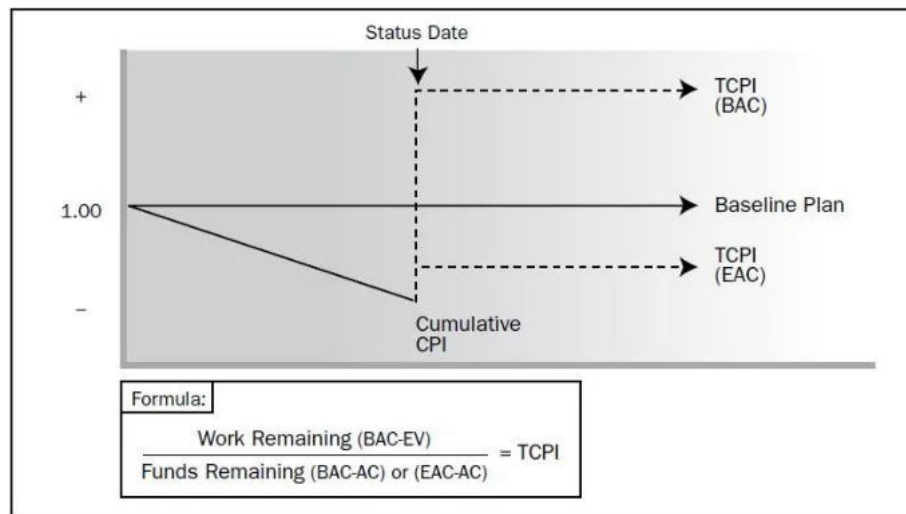


Figure no. 17. To-Complete Performance Index (TCPI) (PMBOK: 2017) [1].

During the execution of the project, forecasts can be made to estimate the final cost of the project, which may differ from the initial budget. When it is found that the allocated budget value is no longer feasible, an Estimate at Completion (EAC) of the project should be made.

Estimating involves analyzing conditions and events that may occur in the future, based on the information and knowledge available at the time of the estimate. Estimates are generated and updated based on project performance.

Based on project performance, two types of estimates can be developed:

- ✚ Estimate to Complete (ETC): the estimated expenses to complete the remaining work;

$$ETC = EAC - AC$$

$$ETC = BAC - EV$$

$$ETC = \frac{BAC - EV}{CPI}$$

- ✚ Estimate at Completion (EAC): the cost or amount of work required to complete all remaining activities until completion.

- the estimate based on the project being completed according to the allocated budget
- estimates that the remaining activities will be executed at the level of the amounts established within the budget;

$$EAC = AC + BAC - EV$$

$$EAC = AC + ETC$$

- the estimate based on the current performance rate – estimates that the current productivity will remain the same until the completion of the project;

$$EAC = \frac{BAC}{CPI}$$

Earned value analysis					
Name		Definition	Use	Equation	Result interpretation
PV	Planned Value	The authorized and allocated budget for the work in the execution schedule	The value of work planned to be performed at a certain time, usually at the current date or at project completion.	$PV = BAC * (Planned\ completion\ %)$	
EV	Earned Value	A measure of the work performed expressed in terms of the authorized budget for the completed work.	The planned value of all work performed at a certain time, usually at the current date. EV is a very important tool in evaluating project performance. Beyond helping the project team understand the health of the project, EV helps to get the project back on track in case of any deviations or variances from the plan.	$EV = BAC * (Actual\ completion\ %)$	The EV value cannot be greater than the authorized PV budget for a component or project.
AC	Actual Cost	Expenses incurred for the work performed during the planned period	The actual (real) cost for all the work performed at a certain time, usually at the current date, without reference to the actual costs.	$AC = \sum spent\ for\ performing\ the\ planned\ work$	AC is also called actual cost of work performed (ACWP) as it is the actual amount spent to perform the planned work
BAC	Budget at Completion	The sum of the budgets established for the execution of the project works	The total value of planned works, serving as a cost reference.	$BAC = Basic\ effort\ (hours) * Hourly\ rate$	
CV	Cost Variance	Value of the budget difference (±) at a given time, expressed as the difference between EV and AC	The difference between the value of works performed at a given time, usually the current date, and the actual cost at that date.	$CV = EV - AC$	CV= 0: project expenses are in line with the planned budget Positive CV: project expenses are below the planned budget (under budget)

					Negative CV: project expenses exceed the planned budget (over budget)
SV	Schedule Variance	Value of the budget difference (±) expressed as the difference between EV and PV	The difference between the value of works performed at a given time, usually the current date, and the value of planned works on that date.	$SV = EV - PV$	SV= 0: the project is progressing according to the planned schedule. Positive SV: the project is progressing ahead of schedule, implementation takes less time than originally expected; Negative SV: Project is behind schedule, may need more time to complete
VAC	Variance at Completion	Budget value projection (±) expressed as the difference between BAC and EAC. VAC is a forecast of variance, specifically cost variance (CV), at project completion.	The estimated cost difference at the completion of the works.	$VAC = BAC - EAC$	Positive VAC: The project will not fully utilize the entire planned budget by completion. VAC = 0: until the project is completed, the entire planned budget will be used. Negative VAC: The project will exceed the planned budget to completion
CPI	Cost Performance Index	Measure of the cost efficiency of budgetary resources expressed as a ratio between EV/AC	A CPI=1 value represents a project exactly within budget, with works performed exactly at the planned cost. Other values show percentages of cost above or below the budget value corresponding to the planned works	$CPI = \frac{EV}{AC}$	CPI < 1: the activity or project has a higher actual cost than the budgeted one CPI = 1: the activity or project has an actual cost equal to the projected one CPI > 1: the activity or project has an actual cost that is lower than the budgeted one
SPI	Schedule Performance Index	Measure of efficiency of execution planning expressed as a ratio between EV/PV	An SPI=1 value represents a project exactly on schedule, with works performed exactly within the planned cost. Other values show percentages of cost above or below the budget value corresponding to the planned works.	$SPI = \frac{EV}{PV}$	SPI < 1: the activity or project is behind schedule. SPI = 1: the activity or project is on the planned path SPI > 1: the activity or project is ahead of schedule
EAC	Estimated at Completion	The total estimated cost at the	If the CPI is expected to remain at the same value	$EAC = \frac{BAC}{CPI}$	

		completion of the project works expressed as the sum of AC and ETC	in the project, the EAC is calculated with the formula: If future work will be performed at the planned rate, the formula used is: $EAC = AC + BAC - EV$ If the initial planning is no longer valid, the formula used is: $EAC = AC + ETC$ If both CPI and SPI indicators influence the remaining works to be executed, the formula used is: $EAC = AC + \frac{BAC - EV}{CPI * SPI}$		
ETC	Estimated to Complete	Estimated cost to complete the remaining work	Assuming that the work is carried out as planned, the cost of the remaining work can be calculated with the formula: $ETC = EAC - AC$ The re-estimation of the remaining works "from the bottom up" is expressed as $ETC = Re - estimation$		
TCPI	To-Complete Performance Index	Measure of the cost performance to be achieved with the remaining resources to meet the specified management objective expressed as a ratio of the cost to complete the work, within the available budget.	The efficiency that must be maintained to carry out the work as planned $TCPI = \frac{BAC - EV}{BAC - AC}$ The efficiency that must be maintained to fit into the current estimated cost (EAC) $TCPI = \frac{BAC - EV}{EAC - AC}$		TCPI = 1: the project can continue with the current budget consumption rate TCPI < 1: based on the current cost variance, the project will be completed at a total cost less than budget TCPI > 1: if the project continues to operate at its current cost variance, it will complete over budget

Table no. 5. Summary table of earned value calculations (PMBOK: 2017) [1].

c. Earned value chart analysis

The method is currently used for analysis, integrating project scope, planning and resources into a set of values to determine project performance and progress. Figure no. 18 shows the project's progress analyzed and estimated through the earned value graph:

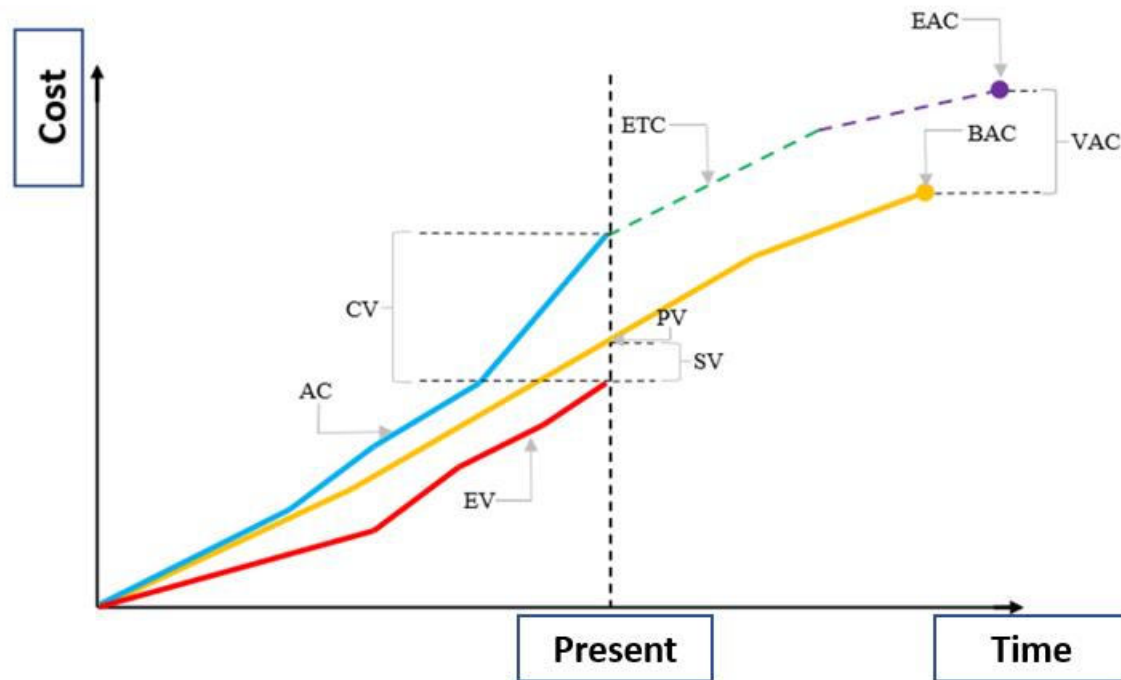


Figure no. 18. Earned Value chart analysis

If financial costs appear to be higher than expected, but there are other factors to be considered, then a cost-benefit analysis can be carried out, identifying a set of options to be addressed in order to minimize the impact. For example, pouring only a layer or two of bitumen on an expressway used by heavy trucks seems to be the cheapest solution, but early deterioration of the road may require the contractor to redo the work on that segment, so a higher initial investment would be the reasonable option to avoid the frequency of future repairs. The next step would be to identify the impact and select the measurement indicators, followed by forecasts of the impact on the proposed measures. The solutions provided should be done in a timely manner.

d. BIM platforms as a tool in cost control

Cost estimation tools can provide relevant information on the cost and time performance of construction projects (Elbeltagi et al.: 2014) [28].

BIM - Building Information Modeling is a complex process, a tool that includes planning, design, construction, collaboration and 3D modeling. It is a collaborative tool that shares relevant data about construction projects in a visual manner. BIM is one of the top technology trends in the construction industry.

BIM technology will increasingly be the catalyst for a fundamental change in the way construction is managed, designed and developed.

Too often BIM is seen only as an innovative digital tool, when its main value is to provide a production-based view and the integrated management of an increasing amount of data that contributes to sharing a management approach.

BIM starts with a three-dimensional model that contains information about dimensions, materials, appearance, technical characteristics, which are not lost in the communication between different computer platforms. Working with BIM offers countless benefits to the designer, starting with the importance of

conceiving the design and execution process in a larger dimension, where the systematization of everything analyzed before the project and internal production processes becomes a fundamental element, because the whole process afterwards will result from it.

Thanks to BIM, the perception of the importance of collaborative and group work increases, strengthening organizational paths and especially improving results through proper organization in relation to customer requests.

Working with BIM methodology actually means using technology to better integrate the skills involved in the process and during execution, allowing a profitable exchange of knowledge, a real-time update of available information, resulting in the radical reduction of errors and obtaining a global improvement.

For this challenge to be successful (that is to promote its dissemination and utility), this technology still needs to be user-friendly and, therefore, accessible to everyone.

Highway and bridge construction is a complex and dynamic process, and as construction progresses, the size and complexity of the project increases, and so does the difficulty of construction management. BIM technology can inform and visualize the entire construction process.

BIM for infrastructures is the methodology that allows work to be organized and classified according to cartography, road construction, railways, structures, bridges, land treatments, pipeline networks. This work methodology facilitates the preparation of changes and revisions due to automation, which allows saving time and performing activities in a more efficient manner.

BIM is an already recognized tool used to improve the planning and implementation of a construction project by obtaining a more plastic, readable and accessible result (Jrade et al.: 2015) [29].

Following corrections to the construction project plan, BMI automatically adjusts the operations schedule, costs and stages involved to ensure high-quality delivery of the construction project.

The results of using BIM are clearly the avoidance of inaccuracy and redundant operations, resulting in cost-effective and time-efficient automatic planning. The correlation between construction phases and operations on one hand and cost and time criteria on the other are sufficient evidence to argue for the usability of BIM in large construction projects, including infrastructure.

There are many advantages when using BIM in infrastructure projects, among the most important are:

- ✚ It helps minimize errors and omissions.
- ✚ Facilitates conflict detection and resolution.
- ✚ Improves collaboration between the work team.
- ✚ It allows for a more realistic and convincing viewing.
- ✚ It is possible to associate physical elements with their virtual counterparts through field surveys to link the physical environment to the virtual model.
- ✚ The digital model results in designs that are much more accurate, faster projects and guaranteed to have fewer problems on site.
- ✚ When designing a project, its components are configured and the technical drawing is prepared in parallel.

✚ After completing the model, if all the materials have been correctly associated, the project presentation can be completed with perspectives created within the program itself, without the need to migrate between platforms.

2.4.3.4 Cost management and profitability analysis

Control measures project performance - as shown in the figure below:

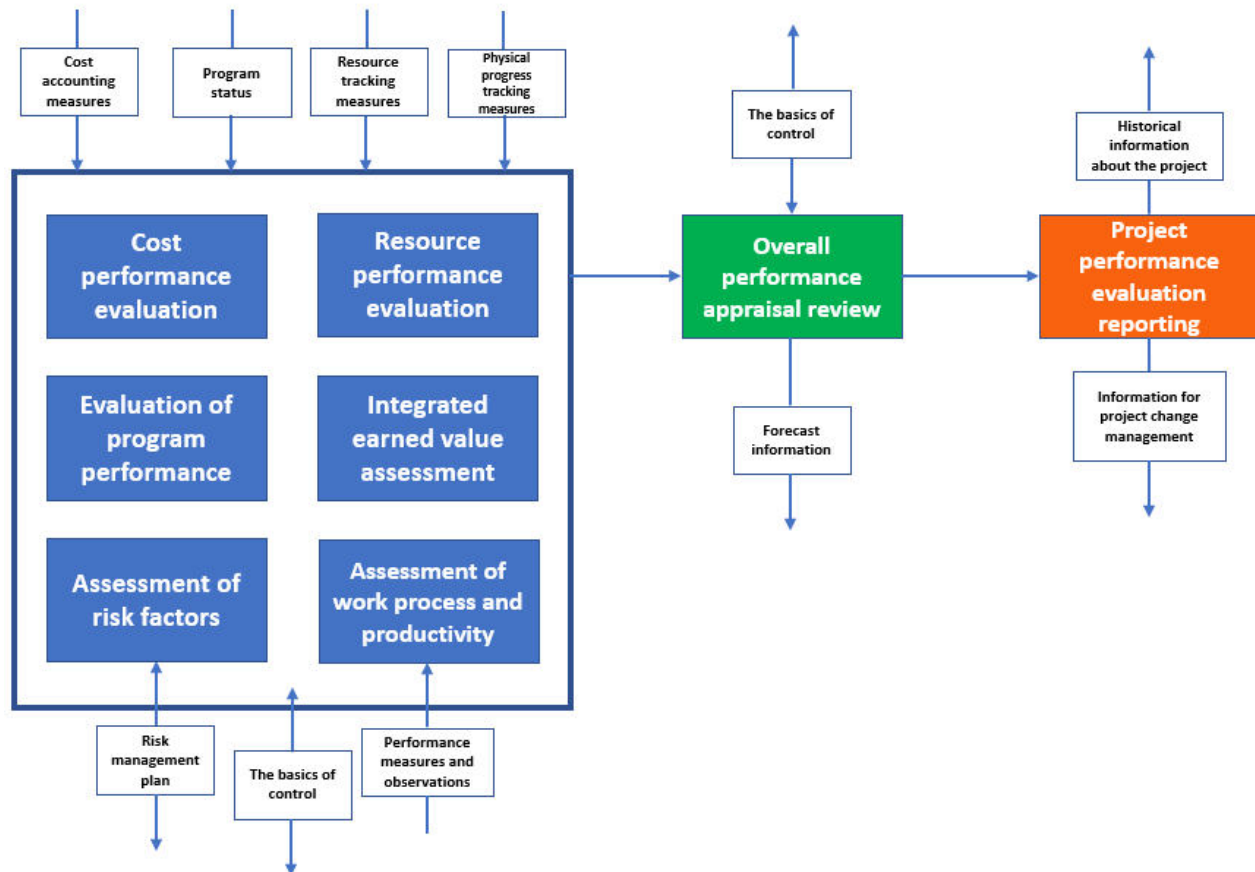


Figure no. 19. Process map for project performance measurement (costmanagement.eu) [27].

Control measures both the project's performance and the operation's performance in accordance to standard criteria, namely the project's completion on time and within budget. This measure can help manage the entire project or its subunits during the implementation/construction of the infrastructure project. Its results, especially when indicating a negative difference, can help in making a timely decision to avoid unwanted outcomes. It can also help the well-managed project have a significant impact, which translates into high-quality infrastructure projects.

Performance measurement is done regularly through the entire project, respecting or connecting all activities to the project's scope.

Performance measurement is important, if not essential, because it produces organizational and project improvements, can help increase performance, identify team weaknesses and strengths, facilitate resource reallocation where needed, and establish benchmarks for high/positive historical data.

Constantly measuring the performance of project operations is an important tool to keep track of project progress, providing vital information about what is happening on site and providing a system for implementing improvement strategies.

III. INFRASTRUCTURE EXPENSES

3.1 Infrastructure projects

Mobility is the basic condition for economic growth, sustainability and social well-being. In this context, sustainable infrastructure projects bring economic, social and environmental benefits.

Infrastructure projects and their success are a major variable in evaluating countries. Major infrastructure projects are among the main criteria for companies investing in a country, which is why they are vital to the economic survival and prosperity of any state. This is why major construction projects play an important role in political discourse, especially during political campaigns. Project costs and delivery are the main variables in this discussion.

The primary form of contracts is essential because it determines behavior at all levels and is the formal framework for exchange and the basis of relationships.

An infrastructure construction project focuses on the development of services, facilities and systems, involving construction and maintenance over time. It can be subsidized by governmental or public institutions, private actors, or financed as a public-private partnership between government entities and private sector companies. Infrastructure construction projects can cover roads, railways, streets, bridges, highways, airports, electricity transmission, telecommunications and waste management (Britannica: 2019) [30]. These are usually defined as critical infrastructure (Nistorescu et al.: 2016) [31].

A contractor is generally the organization or company designated to perform construction works; the contractor directly employs construction workers and supervises the construction work, manages, plans and monitors the work. After a project is submitted, contractors bid on it and the project is usually awarded to the bidder with the best value for money per work.

In construction, the owner or client refers to the party involved in the project who pays for and receives the services/construction. Usually, for major infrastructure projects, the client is the state, and the beneficiary of the project is society as a whole.

Specialist subcontractors are organizations or teams of experts who provide the work and are subcontracted to the contractor. Each specialist subcontractor provides one or more operations/units of a particular service or process.

Finally, the supplier (or economic operator) refers to an organization contracted to provide a service or part of the work.

3.1.1 Typical activities in highway projects

Execution of preliminary works

Preliminary works include activities such as processing authorizations and payments for construction rights, land clearance, drinking water, electricity, wastewater evacuation, first aid, temporary constructions (offices, warehouses, canteens, sanitary services), insurance, safety elements, closures and site signs.

Tracking, lifting and leveling the soil

This activity involves a survey of the existing land, the appearance of the road, of the streets and the drawing of the axes.

Soil movements

- ✚ Land excavations of any kind

Machine excavation and hand excavation are considered based on geometry and level dimensions according to plans and extraction of surpluses

- ✚ Formation and compaction of embankments

It consists of filling the land with inorganic soil and then compacting it to form embankments to conform the road platform.

- ✚ Excavation for drainage works

Ground trenches of any nature are considered for the installation of drainage pipes.

- ✚ Preparation of the subgrade

Land filling and leveling works to form the road platform at the subgrade level are considered.

Placement of granular layers

- ✚ Granular sub-base - consists of placing, compacting and finishing a granular layer, which goes over the subgrades.

- ✚ Granular base - consists of placing, compacting and finishing a granular layer, which goes over the granular sub-base and has a higher strength.

Cladding placement

Considers the work required to carry out the maintenance and covering of damaged flexible or rigid pavements.

Paving with asphalt mixture

Involves surface preparation, mixture production, transportation, placement and compaction of hot or cold asphalt mixture.

Paving with concrete

Involves transportation, placement, spreading, compaction, finishing, curing and concrete protection.

Location of structures and related works

It considers activities including concrete elements, steel, masonry, earth insulation systems, access slabs, bridges, required to realize the highway construction.

Drainage construction and platform protection

Considers the creation of drainages, runoff channels, pipes, siphons and other conduits necessary to divert or channel water flows and ditches.

Execution of subsequent works

Includes site facility disposal activities, cleaning and delivery of the finished project.

3.2 The relationship between the duration of a project and it's cost

The total costs of a project are primarily calculated from direct costs and indirect costs. These costs can vary if the duration of a project increases or decreases, resulting in different costs for different project durations (Laptali et al.: 1997) [32] and for this reason it is possible to generate models that relate duration to project costs.

3.2.1 Relationship between project duration and direct cost

The direct costs of a project are directly associated with the physical work or part of it, that is, with the project outcomes (the final product). These are the costs associated with materials, labor and process equipment used in the required tasks. A simple representation of the relationship between duration and the direct cost of an activity can be a linear function with a negative slope, where an increase in duration implies a decrease in the direct costs of that activity (considering that by increasing the duration of an activity, fewer resources are needed). However, in reality, this relationship is somewhat more complex, which can be observed, for example, in a case where overtime work is used to reduce the duration of activities. These overtime hours cost more than normal hours, implying a greater increase in direct costs as the duration of an activity is reduced (and more overtime hours are used). Therefore, theoretically the relationships between direct costs and duration of construction activities are modeled as a convex function (Figure no. 20) (Sahu and Sahu: 2014) [33]. Other reasons for increased direct costs are reduced productivity due to overtime and increased size of work teams.

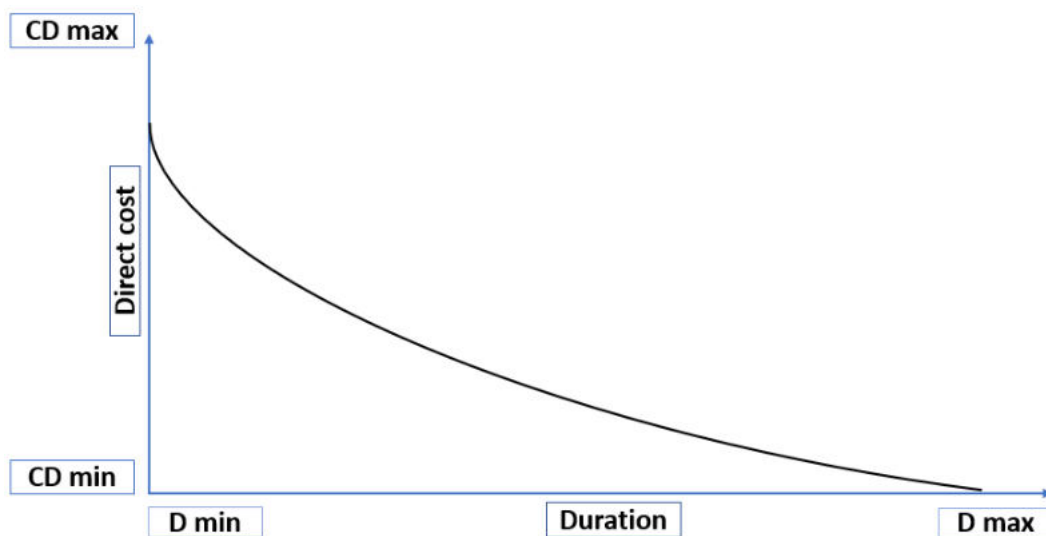


Figure no. 20: Duration - direct cost relationship (Sahu and Sahu: 2014) [33].

An optimal point can be identified on this curve, where variations in the duration of activities involve the lowest possible cost. The solution could be to locate in the lowest area of the curve (coordinates (D max, CD min)), because the direct costs are reduced to a minimum, but in this case the duration of the activities increases a lot, which would not be optimal, because in every project there are restrictions on the maximum total duration. Therefore, generally, the aim is to minimize both the direct costs and the durations of each activity to ensure compliance with cost and duration constraints.

3.2.2 Relationship between project duration and indirect cost

The indirect costs of a project are the costs associated with support activities for project execution (installation, supervision, accommodation, food, mobilization, insurance, testing and supplies), administrative staff costs, management, central office expenses, taxes and utilities.

The indirect costs of a project can be modeled as a linear function, where they increase and decrease directly in proportion to the duration of the project (Figure no. 21) (Sahu and Sahu: 2014) [33]. Indirect costs increase if an activity extends in duration, as there will be higher costs associated with, for example, administrative staff (the increase in costs is caused by the fact that their professional activity is longer in case of an increase in project duration), accommodation, food and other costs associated with indirect costs.

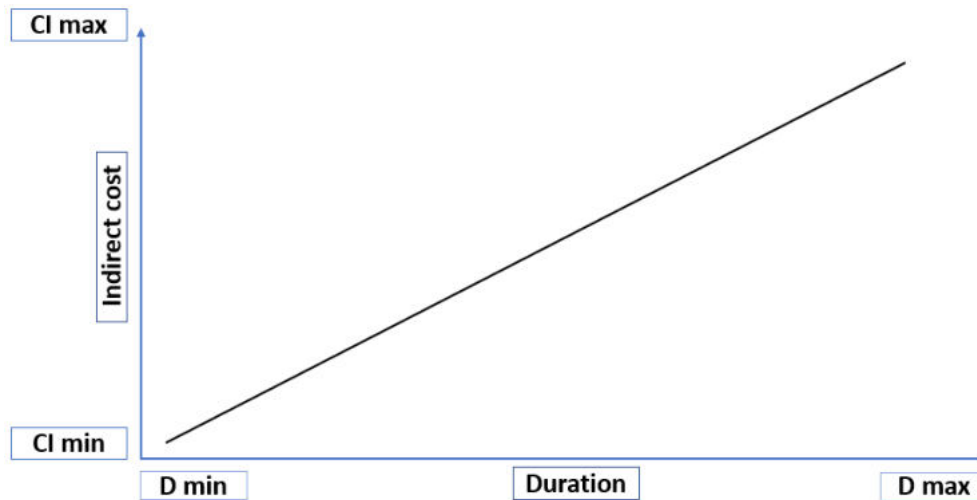


Figure no. 21: Duration - indirect cost relationship (Sahu and Sahu: 2014) [33].

3.2.3 Relationship between project duration and total cost

By summing the direct and indirect costs, a curve is obtained from which it is possible to determine an optimal duration that minimizes the total costs (coordinate (D_{opt}, CT_{min})). And, starting from the sum of the costs of all activities, it is possible to obtain the project's total cost.

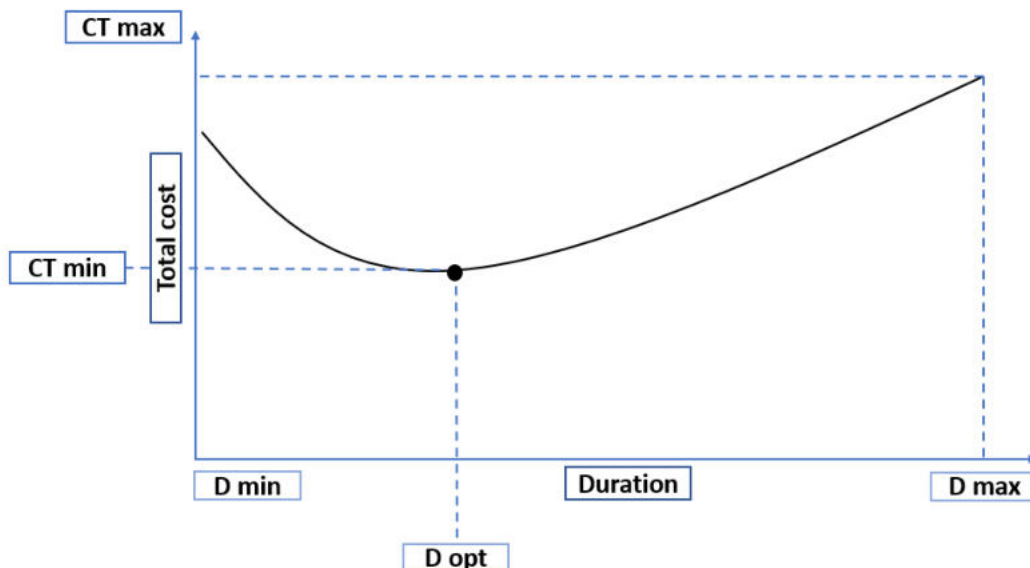


Figure no. 22: Duration - total cost relationship (Sahu and Sahu: 2014) [33].

The overall duration of a project can be shortened by accelerating activities that are on the critical path. Speeding up an activity can be achieved by increasing or changing resources, introducing overtime or shift work, and using different construction methods. While the first two methods result in an increase in direct costs, it is not necessarily the same in the latter case. But, nevertheless, any reduction in project

duration inevitably leads to a decrease in indirect costs regardless of the acceleration method used (Laptali et al.: 1997) [32].

3.3 Types of contracting

No two construction projects are alike, which is why numerous types of construction contracting arise. It is extremely important to properly assess the needs of all parties involved and procure the project that best serves the interests of all - owners, contractors, service providers and materials suppliers - to ensure that the risks involved are managed and conditions are created for payment to be delivered as easily as possible.

The construction work contract is the signed document by which two or more parties agree to respect and fulfill a number of conditions. The contract is intended to create rights and generate obligations. By this, the builder undertakes to carry out the works and the contractor to pay for them. The contract should describe the work to be performed and how payment will be made.

Activities are often complex and involve many different operations, requiring the builder to purchase a multitude of different materials and manufactured items, as well as a wide range of machinery and equipment.

There are several ways to contract construction work. They essentially differ in the method of payment for the construction being carried out. Each of them determines a different strategy in the builder when planning the construction process and especially when setting priorities in the execution of the various work units. The most common types of construction contracts are:

- a. lump sum contracts,
- b. cost-plus contracts,
- c. unit price contracts,
- d. GMP (guaranteed maximum price) contracts,
- e. time and materials contracts.

a. Lump sum contracts

A lump sum contract sets a determined price for all works performed for the project. These construction contracts are also called fixed price or stipulated sum contracts.

These are the basic formula in business, meaning there is a fixed price paid for the entire project, in other words, the contractor agrees to complete the project for a predetermined amount of money. Under a lump sum contract, most commonly known as a predetermined sum of money, the contractor will submit a total contract price instead of a price for each service delivered. Lump sum contracts are very common in construction.

Lump sum contracts have a simple and very clearly defined scope of work. As such, in more complicated projects (eg building a dam), it may not work as easily as building a bridge over a small river. Unexpectedly, in government projects, many operate on lump sum agreements. Due to the fact that the price is set in advance, it is very important that the contractor presents a realistic budget that takes into account all the costs involved.

The advantages of the lump sum contract are: simplicity, profitability, easier financing than other types of contracts, documentation is easier to complete and even simpler (there are fewer requirements) and cash flow is quite easy to manage.

Disadvantages are represented by a higher risk for the contractor, these contracts are potentially more expensive, the course of the project can be quite unpredictable, and contractors may resort to certain subterfuges to hide profits. In simpler terms, lump sum contracts can provide higher profit margins for contractors if they finish under budget, but with higher risks.

When signing a lump sum contract, the builder takes on additional risk because the beneficiary is not obligated to pay more than the original price if the project goes out of scope, if problems arise, or if any other changes occur during the project. Some lump sum contracts account for this by including separate allowances that cover unforeseen costs and changes.

If opting to use a lump sum contract for a project, builders can usually charge a higher fee to account for the additional risk they may face. Otherwise, any unforeseen costs can affect a builder's profit or result in a project that cannot be completed as planned.

b. Cost-plus contracts

These are also known as cost reimbursement contracts. Cost-plus contracts normally require the beneficiary to pay all project expenses, such as the material costs, labor, office rental, space, materials, equipment, consultants, and any other project costs. Additionally, these types of contracts will also include an agreed amount or percentage that covers the builder's overhead and profit.

Depending on the type of cost-plus contract, the beneficiary may end up paying more than anticipated and therefore generally assumes a higher risk than the builder.

The advantages are as follows: the builder is not limited by financial considerations and can feel free to use the best materials, equipment for the delivery of the project; however, the beneficiary may impose a maximum limit that the builder cannot exceed under this type of contract. The profit is predetermined; cost-plus contracts are flexible and allow the contractor and builder to decide how to use the budget.

It is considered that the builder justifies how the budget is used, which may require additional effort to monitor all expenses, and last but not least, some cost justification which may be very difficult.

There are different types of cost-plus contracts that meet different project needs. Each type of contract also reduces the level of risk for the beneficiary.

- ✚ **Fixed percentage cost-plus contracts:** the payment covers both project costs and the builder's profit and overheads. The amount paid for the builder's profit and overhead depends on a fixed percentage of the project cost.

- ✚ **Fixed-fee cost-plus contracts:** The payment includes covering the associated project costs, as well as a fixed fee that covers the builder's profit and overhead expenses.

- ✚ **Cost-plus contracts with guaranteed maximum price:** The payment includes coverage of project related costs and a fixed fee paid up to a maximum cost. If the maximum guaranteed price is not reached, the difference between the total cost and the maximum guaranteed price will not be paid, resulting in savings for the beneficiary. The builder and the beneficiary can also agree to split the difference, giving the builder an incentive to keep costs in line with the guaranteed maximum price.

Cost-plus contracts are normally used when the scope of work, materials, labor and equipment is not clearly defined or difficult to estimate at the start. Projects using this type of contract are more likely

to be completed as scheduled because builders are not completely constrained by cost. However, this type of contract is more complex to manage and requires careful monitoring.

c. Unit price contracts

Unit price contracts typically outline the types of tasks being performed in addition to the materials used for those tasks. This categorical style of pricing makes it easy for beneficiaries to assess each cost and allows builders to charge the precise cost for each category.

This type of contract will divide into subsections, stages or phases of the total work required to complete a project. The contractor provides the owner with the price estimate for each unit of work and not an estimate for the entire project.

This type of contract is valuable for projects where labor is redundant, highly dependent on the price of materials, and where there is no certainty about the amount of labor required to complete the project.

The advantages are simplicity of invoicing and flexibility of planning, without affecting profit margins.

The disadvantages of unit price contracts are represented by the fact that accurate predictions cannot easily be made before project delivery; and re-measurement may delay work and payment.

This type of construction contract is not usually used for major construction projects and is more often used for smaller works such as repairs or maintenance. Unit price contracts make it easier to adjust prices when the business scope changes. Unit price contracts are more commonly used for repetitive work and public works projects. For example, routine maintenance of highways could be more easily charged through a unit price contract because it specifies the values of the various maintenance tasks required.

d. GMP (guaranteed maximum price) contracts

The guaranteed maximum price contract sets a maximum payment amount for the project. The contractor cannot request more than the predetermined amount and any additional cost of the project will be covered by the contractor. Sometimes another type of contract may establish a GMP provision. For example, the cost-plus contract may also include a provision related to a maximum price that will not be exceeded. This type of contract is commonly used in construction projects where there are few variables.

The advantages are: GMP contracts favor project delivery (having a fixed maximum price speeds up bidding and project financing is done faster because lenders know what the maximum point is), and this encourages contractors to reduce costs and complete the project, so it stimulates savings.

However, like lump sum contracts, GMP contracts place the risks on the contractors. Any additional costs above the predetermined limit will be borne by the party providing the work. The contractor's profit is consequently dependent on his knowledge of accurately estimate the project.

e. Time and materials contract

Time and material contracts define an hourly or daily rate for builders. In addition to paying this rate, owners agree to pay any project-related costs, which are mentioned in the contract as direct, indirect, mark-up and overhead costs.

The time and material contract is frequently used in construction; under this type of contract, the client will pay for the materials used during the project and for the time the contractor works on it.

The very simple structure makes things easy and flexible when additional time or resources are required to complete the project.

Time and material contracts are also commonly used when the scope of work is unclear and present a lower risk when used for small projects where beneficiaries can better estimate the scope of the project to anticipate cost final. Price or project duration limits are also common for this contract to mitigate the beneficiary's risk.

Types of contract	Advantages	Disadvantage
Lump sum contracts	- Owners avoid paying unexpected project costs - Builders have a clear scope of expectation - Lump-sum contracts simplify the bidding process. Setting a total price simplifies the selection process - Finishing under budget means high profit margins. Since the project price is set, finishing under budget means economy	- Can result in profit loss if the project exceeds the scope - Budgetary constraints may limit project outcomes - Calculation errors can destroy the profit margin. Every variable must be taken into account. Since there is a fixed price, failures or unexpected changes during a project directly reduce the profit margin - The larger the project, the greater the potential loss
Cost-plus contracts	- The project is more likely to be completed as planned - Reduce risk for builders - Cost-plus contracts are flexible and allow owners to make design changes along the way, with contractors knowing they will be paid for the extra time or materials incurred by these changes. - Calculation errors are not devastating. Since cost-plus contracts are flexible by nature, inaccuracies in the initial offer are not as harmful as in lump-sum contracts.	- The project may exceed the scope if limits are not applied - Difficult to manage and track - Justifying some costs can be difficult. Cost-plus contracts require contractors to justify the costs of a particular project.
Unit price contracts	- Costs of different categories are easy to evaluate - Prices easy to adjust when the scope changes - Unit price contracts simplify invoicing. They allow for increased transparency. Owners can easily understand every cost that goes into the final contract price since the price of each unit is pre-set. This helps avoid disputes - If more work is required, the profit margin remains the same. Any additional work required is simply added as another pre-priced unit, making it easier to manage change orders and other scope changes	- Costs for large projects are difficult to estimate - The final cost is not defined at the beginning - Predicting the final value of the contract can be difficult. Usually, the quantity of units required to complete a project is not immediately known. This means owners may end up paying more than expected.
GMP (guaranteed maximum price) contracts	- Suitable for faster projects - Stimulates savings. Having a fixed cost encourages contractors to reduce costs and finish ahead of schedule	- Pose a risk for contractors, forcing them to absorb cost overruns if the maximum contract price is exceeded - May require more time for review and negotiation. To protect against exceeding the price, contractors may attempt to increase the maximum contract price. When this happens, the negotiation process is lengthened and the project takes longer to start

Time and material contracts	✚ Builders are not completely limited by budget ✚ Easy to use for small projects ✚ Time and material contracts are agile. Since the beneficiary reimburses the contractor for material costs and pays an hourly wage, unexpected delays, roadblocks and other scope changes are covered ✚ Time and materials contracts allow for simple negotiations. Setting the rules for which materials will be covered and what the hourly wage will be is simple with time and materials contracts	✚ The project may exceed the scope if limits are not applied ✚ Difficult to estimate the final cost ✚ Tracking time and materials is time consuming. Recording all material costs to a project is not an easy task, and failure to provide an accurate number at completion means lower profit margins ✚ Efficiency is not rewarded. Since time and materials contracts are paid by the hour or day, there is no real incentive to finish a project earlier. However, it is common practice to stipulate a bonus in case of early completion
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Table no. 6. Summary table of contract types used in construction.

3.3.1 Scheduling

Infrastructure projects involve the coordination of numerous resources and actors. Project planning requires a feasibility study, which is preliminary research and provides the necessary conclusions regarding the feasibility of the project; the outcome should consider all relevant factors such as scheduling, legal framework, technical and economic components. The feasibility study should provide an answer related to the possibility of successfully completing the project.

The schedule also requires an assessment of environmental impact that will conclude whether the project will be harmful to the environment.

In practice, the contractor will specify the order in which the works will be organized and undertaken. As initial steps, the contractor will examine the available and necessary resources and evaluate the work timeline; the contractor shall also ensure that the planning takes into account subcontractors, suppliers and other parties involved in the performance of the contract, taking into account possible delays.

Scheduling will use this assessment and divide the construction work into units or operations; this program will specify the requirements (who does what, using what materials, with the help of which subcontractor, the availability of each resource and any risks potential involved, which will reduce uncertainty and the level of risk). The construction schedule in this format will include the work requirements and requirements associated with each operation.

It is a well-known aspect that time overruns are quite quite common in major construction projects, which is why the contractor develops a construction schedule to complete on time and reduce other potential additional costs.

It is also extremely important to mention that the construction process sometimes makes the schedule unrealistic - as there are certain factors that can stop the process and cannot always be controlled. Such factors are weather conditions, delays in material deliveries, late requirements or changes after the process has started. When such situations arise, the schedule should have a section reflecting potential delays and incorrect behaviors and include a revised action plan (or contingency plan).

Using complex software programs, the contractor coordinates the use of materials, deliveries, subcontractor services and commercial work that can be managed in a visual representation. The software programs provide an accurate representation of real-time operations as well as the correlation between activities. This particular feature is highly relevant because the budget of infrastructure projects must

clearly specify the periods for acquiring or renting materials and services for limited periods of time to reduce costs. However, variables sometimes make planning unrealistic.

3.3.2 Selection process

After careful planning and scheduling of the construction project by the contractor, the beneficiary now faces an extremely important task in the process - which is the selection component.

Efficient, high-quality infrastructure is a key factor and engine for economic growth and state productivity. The client is interested in maintaining the quality of the assets and entering into advantageous agreements with contractors who, not only will provide an efficient infrastructure, but will provide guarantees that they will provide the maintenance of the acquired project (Hansen et al.: 2019) [34].

Decision-making in selecting infrastructure projects is a difficult problem. Therefore, the decision criteria must be well established (Hansen et al.: 2019) [34].

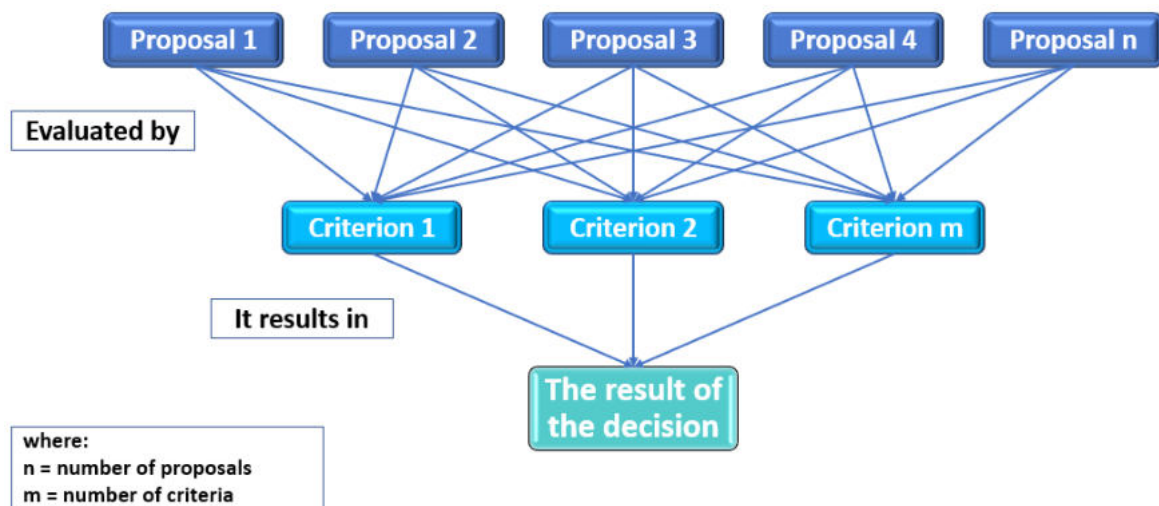


Figure no. 23. Decision hierarchy for project proposal selection.

There are five important steps in developing a model for evaluating and prioritizing project proposals, as follows:

- ✚ establishing evaluation criteria,
- ✚ establishing the scale score for each of the criteria,
- ✚ establishing the scoring method for each of the criteria,
- ✚ determining how to calculate the final score,
- ✚ establishing the list of projects based on the calculated score (Purnus and Bodea: 2014) [35].

The decision criteria for selecting infrastructure projects are as follows (Hansen et al.: 2019) [34]:

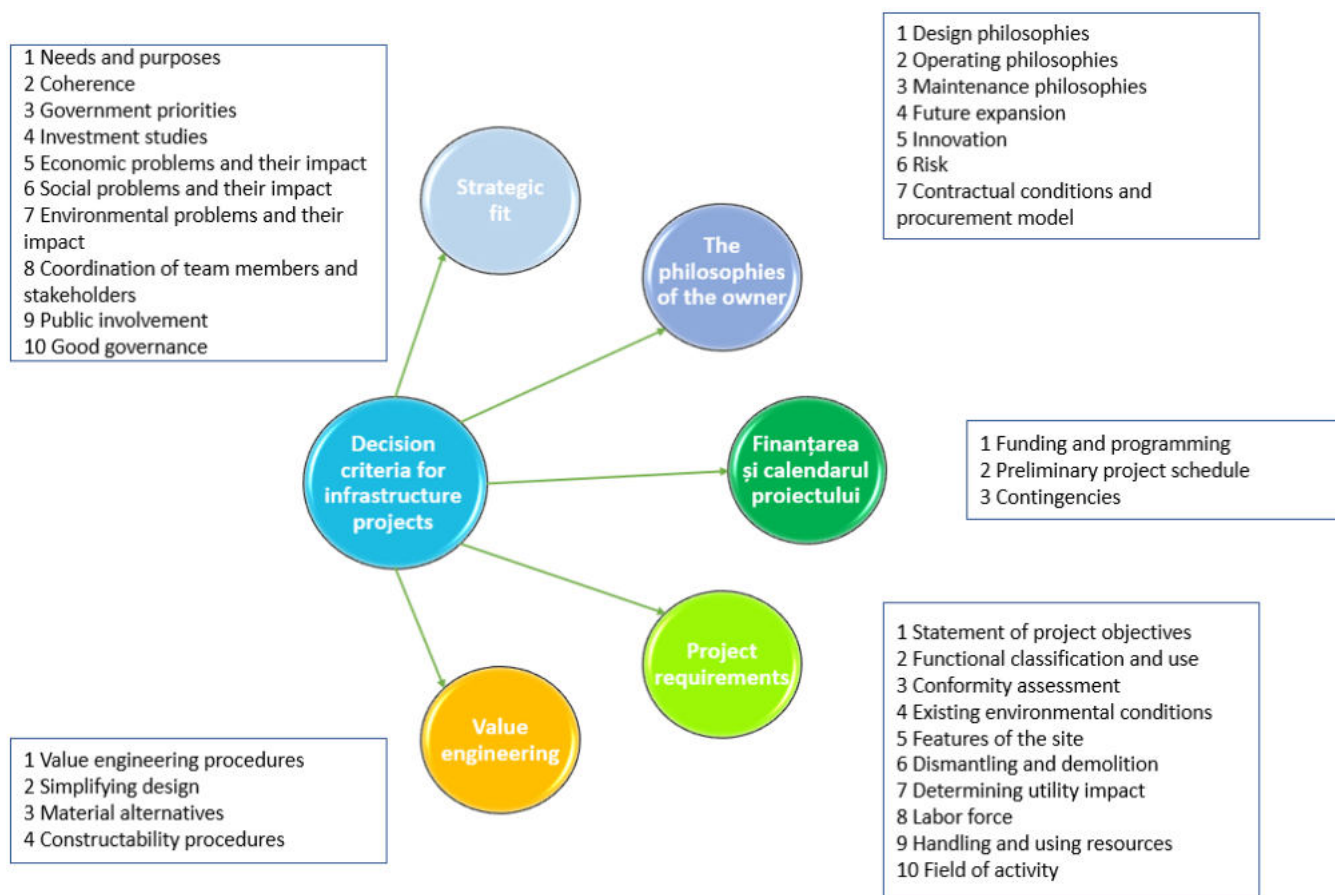


Figure no. 24. Decision criteria relationship diagram.

Project selection also takes into account the reputation of the contractor submitting the proposal, which is as important as the quality of planning and drafting. In this sense, a reliable and reputable contractor with a less attractive proposal should always have priority and prominence over a lesser known contractor with a charming proposal.

3.3.3 Contracting

After planning and selecting a project, the next step in a construction project is contracting. As mentioned at the beginning of the chapter, there are five types of contracts in infrastructure projects: lump sum contracts, cost-plus contracts, unit price contracts, GMP (guaranteed maximum price) contracts and time and material contracts.

The selection of the contract type is based on the uncertainty of the scope, risk assumption and the need for costs that are predictable as much as possible, as well as the relevance of the fulfillment of the predetermined stages in the contract.

The construction agreement will contain general and special conditions, with details regarding designed work, specifications for each unit and operation, milestones, payments and penalties for delays or other inconveniences and will define the rights and obligations of each party. The contract will specify the role of the contractor, subcontractor, suppliers etc. Each project is unique and has its own set of unique characteristics.

3.4 Project budgeting

Infrastructure construction projects have both construction costs and related property acquisition costs - usually lands. The construction budget should anticipate all the costs of a given project. A careful assessment should also be made regarding the costs and benefits of such investments in all areas involved - social, economic and environmental.

The costs should also cover the property on which the infrastructure project is carried out, but this is sometimes difficult to estimate. For example, the law sometimes requires that properties around the land on which the infrastructure project is being built not be used for residential purposes, and in some cases landowners must be persuaded to sell or exchange their land for a property elsewhere, which can prove to be a challenge in practice. Property costs vary widely, given the scope of the project and location.

Taxes and professional services are also a significant chapter of the budget. Various costs are involved in this unit, namely building permits, surveying services, architectural services, general planning and design services, civil engineering services, accounting fees etc.

Important budgeting chapters are material and labor costs, including site preparation and structure-related operations. When evaluating the labor budget, the contractor must take into account legal working hours, compensation and payroll expenses, rest leaves and potential medical leaves, as well as the non-productive time of workers.

The next stage of budgeting concerns equipment and work tools, which have a fixed price, so planning and scheduling should be done accurately and realistically to avoid renting materials, tools and equipment for periods longer than required. This includes delivery charges, equipment rental costs, operating costs and maintenance costs.

The budget also covers project management. This includes salaries and operating expenses. Professional liability is also a mandatory cost in infrastructure projects. Utilities and taxes must also be covered by the budget of an infrastructure construction project.

Contingency expenses are among the most important parts of construction budget planning. Contractors usually leave considerable room for the unexpected. Some matters are beyond the control of the contractors, such as delays in deliveries, weather conditions, health problems, changes to the original scope of the project, improvements in design or materials, failures, power outages, risks or any other unknown costs involved in project etc. In such unexpected situations, the contractor allocates a certain amount for contingency expenses.

All consequences of the infrastructure project must be considered; some undesirable effects on the property or personal integrity of third parties that may also appear on the contractor's cost list. For example, if rented equipment is damaged on site, the contractor will be subject to paying for the repair or replacement of said equipment, as well as paying losses to the supplier for the damages.

This is why contingency expenses usually have an allocated budget of between 3% and 10% of the total project budget.

3.4.1 Evaluation of highway projects

Investments in highway projects need to be justified in a more scientific way so that users can benefit efficiently and resources are directed towards projects that contribute more to the social welfare of the country.

In order to make a purely financial assessment, the social benefits that the projects bring must be taken into account, including the monetary quantification of a particular work's contributions to society in general. Public investments in infrastructure contribute to the economic development of countries, so it is desirable for a country to have the necessary infrastructure that motivates the economy and at the same time increases the standard of living of its citizens.

In order to ensure an efficient and realistic evaluation of a highway construction project, several criteria must be considered over a longer time frame than the construction project's implementation period and regarding a larger geographical area than the project area.

The evaluation should take into account criteria such as: the existing highway network in the region or country, the evaluation of the highway development projects already submitted (taking into account construction projects, operation projects and maintenance projects), the proposal for cost-effective highway development projects presenting economic impact analysis as well as social impact analysis and environmental impact analysis; optimizing budget allocation, evaluating highway network policies in the country/region, and evaluating strategies by discussing "what if" scenarios (Ziari et al.: 2015) [36] .

Various methodologies have been developed for the evaluation of highway projects, among which is the cost-benefit analysis, which consists in taking into account for each project all the costs involved in its realization and confronting them with the benefits that the said project would bring. In this way, cash flows are obtained which, when brought to the net present value (NPV), result in a monetary value of the construction project to be dealt with. There are also other indicators of a work's profitability, such as the internal rate of return (IRR) and the cost-benefit ratio (C/B).

3.4.2 Special considerations for costing in infrastructure projects

Infrastructure projects are highly customized in terms of contracting and budgeting, as well as the conditions and factors that influence cost determination.

These factors vary from the project's complexity (roads, highways are part of critical and strategic infrastructure, and building or maintaining such a site involves strategic considerations, material factors, economic factors, an opportunity assessment, feasibility of the project), the scale and scope application of the infrastructure project, methods used in the construction project, market conditions at the time of the proposal and project evaluation, physical constraints of the site (geographic limitations and meteorological considerations), the financial position of the beneficiary (usually, when the state is the beneficiary, certain additional costs are involved), the feasibility and construction of the project. All these pre-existing conditions cause additional charges in terms of consultancy services, additional construction permits to be issued, additional official viewpoints from the parties involved (Akintoye: 1999) [37].

When including costs, the type of costs whether estimated, current or contractual costs, must be considered. In addition, for projects, the necessary subdivision that characterizes each section and its associated costs must be defined, since the entire project will not necessarily have the same constructive activities. It is important to consider an amount for contingencies that frequently arise in engineering projects.

The amount of costs involved depends on the technical alternatives that are considered for the construction of the project. Thus, for each project it is necessary to establish design alternatives for the analysis period.

A design strategy for highway projects is the combination of initial design and all necessary activities required for maintenance and rehabilitation (Federal Highway Administration: 1998) [38].

Another aspect that must be defined is the period or horizon of the analysis, which in general, for highway projects is 20 to 30 years (Roads and Transportation Association of Canada: 1977) [39].

Every highway project has a life expectancy, requires maintenance treatments and rehabilitation activities. Therefore, for each of these activities it is necessary to identify the scope, time and costs.

In addition, maintenance costs include repair, leveling, cleaning, surface replacement, among others (Porras: 1971) [40]. However, as mentioned, the construction and maintenance cost elements depend on the technical alternative selected for each particular project.

The most important aspect in considering the design strategy is the traffic or the number of vehicles or users benefiting from the project, because depending on the demand of the asset, it is answered with a strategy to guarantee the functionality of the road. In this way, it is important to define some concepts related to the number of vehicles traveling on a highway as attracted traffic corresponding to the part of the existing traffic that will move to the new road from the moment it becomes operational. There is also developed transit, which is the new transit that comes along with the development of the highway.

The value normally used to assess the number of vehicles transiting a road is the Annual Average Daily Traffic (AADT), which is the total annual traffic divided by 365.

The recovery value of road infrastructure projects, which determines their economic value at the end of their useful life, must also be taken into account. Its quantification depends on the volume of the reusable material, its condition, the cost of putting it into operation etc.

3.4.3 Costs associated with road infrastructure construction projects

To evaluate costs within a cost-benefit analysis, one must first define the types of activities that need to be performed in order to assign a monetary value to each of these items. In addition, the unit cost unit in which the evaluation is to be carried out must be defined, which can be lei/km or lei/m².

The classification of the categories of activities is divided into conservation activities and development activities. Then, within each category, different classes of activities are defined, such as periodic, routine activities and rehabilitation works for conservation and improvement or development works, which are further divided into types of activities (partial, total reconstruction) and for each type, there are different specific predominant activities that depend on the number of lanes and the type of material used for the work, which can be bituminous mixture or concrete. These activities are assigned an economic value.

The technical criterion of the activities to be carried out is the one that defines the costs that the respective project will have.

The definition of the different categories of activities, as well as their classes, types and activities, depend on the service objective intended for a road, that is, they depend on the lifetime of the pavement and the desired level of condition to maintain the project, thus defining the strategies that need to be followed in a particular work.

The condition of the road superstructure can be defined based on the levels of the International Roughness Index (IRI) of the road, which is specified as surface irregularity.

For each project, a minimum level of the IRI that is desired to be maintained throughout the road's useful life is defined. Starting from this level there are different activities that can be carried out with different periodicities.

Moreover, each technical alternative has its own deterioration model that determines the IRI to decrease over time. In Figure no. 25, the concept of the International Roughness Index (IRI) is observed in detail.

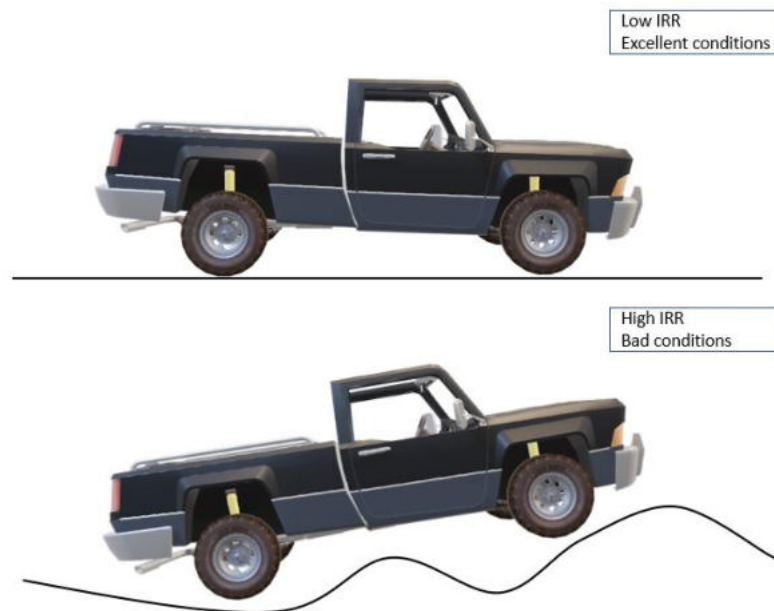


Figure no. 25. Comparison of road superstructure surface condition according to IRI.

IRI is a standardized way of measuring road's roughness intended for use in road projects worldwide. The IRI is determined as the ratio of the accumulated vertical movement of a vehicle over the entire measurement period and the distance traveled by the vehicle during the test.

The IRI value depends on the road condition. A perfectly flat surface without any roughness is represented by the value of 0. As the imperfections in the surface uniformity increase, the value of the index increases.

Surface type	Surface condition	IRI range (mm/m)
Aircraft runways and highways	Flat surface without roughness	0 – 2.0
New pavements	Some surface imperfections	1.5 – 3.5
Old pavements	More surface imperfections	2.5 – 6.0
Maintained unpaved roads	Minor frequent depressions	2.5 – 10.0
Damaged pavements	Shallow depressions, frequent, some deep	4.5 – 11.0
Rough unpaved roads	Large depressions and erosions	8.0 - above

Table no. 7. Typical IRI values in relation to different types of surfaces (Feasibility study "Construction of an uneven overpass over the intersection at km 0 of the municipality of Craiova in order to take over car traffic on the E70, respectively Calea București - bvd. Nicolae Titulescu": 2010) [41].

IV. METHODOLOGIES FOR ANALYZING THE BENEFIT OF COST ESTIMATION OF INFRASTRUCTURE PROJECTS

Major infrastructure construction projects are a significant driver of a society's economic success; these are highly complex projects involving numerous stakeholders and participants, requiring precise planning and cost estimation as accurate as possible - for several reasons that all point to the same rationale - to reduce risk and the incidence of unexpected costs.

Mobility brings economic growth, social well-being, political prosperity and sustainability to any given society, and large highway construction projects determine social, economic, financial and environmental benefits (Brauch: 2017) [42].

The development of infrastructure construction projects produces visible positive outcomes for citizens, enabling important services to function effectively in today's connected world. They immediately stimulate the economy, as investments only go to sustainable countries and economies and generate immediate political success.

But as important as highway construction projects are to our society, they involve significant financial contributions and involve a wide range of contributors: limited partners, major stakeholders, investors, government, local authorities, consultants and experts, contractors and subcontractors from various fields. Highway constructions require the coordination of different actors and resources. It is very important to begin such complex efforts with a thorough cost estimate to reduce the unknown and mitigate risks and unpleasant/unplanned costs.

4.1 Costs involved in highway construction projects

As already mentioned, any infrastructure construction project is long and expensive. Cost planning is a mandatory requirement, as it allows planning the time for equipment rental, the amount of material, the deadlines for hiring staff, as well as choosing those that best suit the project to reduce the possible costs of maintenance operations.

The costs involved in infrastructure projects can be divided into two categories - construction costs and maintenance and operation costs.

4.1.1 Construction costs

Highway construction projects require high investment costs, which are evident by analyzing the quite specific stages of infrastructure development: land acquisition, excavation and clearing of the surface, ground mounting (the soil is mounted, smoothed), sewerage and electrical components are laid, land surface preparation, including manual labor excavation, base aggregate (placing gravel or stone evenly) and asphalt paving (Chester, Hendrickson: 2005) [43].

Investment costs must cover civil works, electrical works, mechanical works, engineering and other services, procurement (purchase or lease) of equipment and vehicles, as well as materials, labor costs (salaries, medical insurance, work permits and taxes etc.), consumables, fuel, office space, consulting, surveying, accounting and everything that revolves around the project (Nistorescu et al.: 2016) [31].

Throughout the life of the project, the level of accuracy provided by the estimated cost in relation to the actual cost varies depending on the stage in which the project is, from idea to execution. In other words, cost uncertainty decreases throughout the project. For this reason, the costs were expressed as

follows, conceptual cost, pre-construction cost, additional work cost and work completion cost (Salinas Seminario: 2002) [44].

Conceptual cost is the cost that the designer provides as a first estimate and is based on the use of known factors or indices. These factors are obtained from engineering parameters, developed from historical data, construction practice and technology used (Peurifoy, Oberlender: 2001) [45]. The parameters can be per unit, square meter, by type of construction, by type of foundation, by finishing material etc. This cost serves as the basis for the work.

The pre-construction cost is that cost based on the conceptual cost and defined for the stage of the work execution which also includes the cost of technical preparation, the construction work cost and the supervision cost.

The additional work cost is that cost incurred, during construction, due to those factors that may affect, at a given moment, the fulfillment of the schedule, such as: type of project, market conditions, site accessibility at all times, material delivery by suppliers etc.

And finally, the work completion cost is the final cost and includes the estimated pre-construction cost plus the variances that occurred. They can be the additional product of an underestimation or work balances in the case of an overestimation.

4.1.2 Maintenance and operation costs

Poorly maintained infrastructure will directly affect mobility, significantly increase vehicle operating costs for citizens, increase accident rates and associated costs to people and properties, and increase isolation and poverty (Burningham and Stankevich: 2005) [46]. The purpose of maintenance is to preserve the conditions/characteristics of the highway sectors.

Highway maintenance refers to activities to maintain the pavement, slopes, drainage facilities and all other road structures and properties as close as possible to their constructed or renewed state (PIARC: 1994) [47].

According to the World Bank's 2005 report "Why road maintenance is important and how to get it done", there are a specific activities included in the highway maintenance sector that can ensure the preservation of infrastructure. These consist of routine maintenance (small scale works to ensure daily passability and safety requirements such as pothole covering, grass clearing and other winter maintenance and repair operations), periodic maintenance operations (which are to preserve the structural integrity of the project), emergency maintenance operations, in case of disasters, accidents etc. (Burningham and Stankevich: 2005) [46].

Highways are the most expensive infrastructure segments due to their width and traffic volume.

4.2 Diagnosis of costs involved in highway construction projects

Among the costs analyzed in this chapter are the following:

- ✚ Construction and rehabilitation costs (initial investment).
- ✚ Road maintenance and conservation costs.
- ✚ Acquisition and operating costs for toll booths and the respective equipment.

These values are projected over the project's analysis horizon, considering the historical behavior of the road and bridge materials index.

Maintenance costs are related to activities that must be carried out within the road infrastructure to maintain acceptable conditions and comfort for users. For road conservation works that need to be carried out, the proposal of a road superstructure damage model corresponds to the design of the possible degree of damage that the road can suffer, based on the technical specifications of its design. Costs are divided for each project section and then added to obtain an annual cash flow.

Cost deviation could, or should, be diagnosed by taking into account the natural deterioration of highways due to traffic. Poor construction will directly result in negative costs for citizens, such as vehicle operating costs, accidents and more. However, since no material can stand the test of time and traffic use, all materials will eventually fail after experiencing heavy traffic such as highway traffic.

In this context, maintenance and operation costs of highway segments are a significant source of expenditure, as the deterioration of the superstructure will require attention, as well as other rehabilitation and conservation costs.

For efficient/optimal maintenance operations - both cost-effective and time-efficient, thorough planning is recommended, namely, the clear determination of responsibilities in case of damage to materials, pavement, surroundings etc., to make the intervention as quick and inexpensive as possible.

4.2.1 Road superstructure deterioration mode

Heavy vehicles crossing the highway every second cause stress on the road superstructure and eventually damage. But floods, high temperature, natural disasters like landslides will also cause these damages.

Tools have been developed under the umbrella of superstructure damage model to predict future deterioration and implement early maintenance to avoid calamities (Taheri et al.: 2012) [48]. Motor vehicles, other than heavy vehicles, are not considered to cause pressure on the pavement, but there is relevant research indicating that the repeatability applied in highway traffic eventually reduces the materials' elasticity and induces pressure which in turn affects the viscoelastic qualities of the pavement. (Taheri et al.: 2012) [48].

The superstructure damage model is used not only to estimate future highway project prioritization and fund allocations, but also to assess highway overload sectors to introduce control measures to reduce the incidence of disasters. But it is important to note that the remarkable distress of the superstructure results in frequent maintenance operations and ultimately, more traffic delays and congestion (Bai et al.: 2010) [49].

A superstructure deterioration model predicts the future behavior of the pavement, in terms of the extent and amount of structural and surface damage that the highway may suffer, based on the current technical characteristics of the road under study. Its importance in evaluating highway projects lies in the fact that starting from the knowledge of the future deterioration of the roads, the periods of the different conservation alternatives can be established, which in turn have an associated cost, a value that allows the mounting future cost flows for project.

There are various deterioration models used to predict pavement behavior. Among the most used are those of increasing progression, decreasing progression and sigmoidal progression. In the first case, damages are estimated to occur incrementally from the moment the project becomes operational, for the second type of model, damages also increase from the moment the project starts, but unlike the first model, the deterioration or damages stabilize after a certain period. The sigmoidal model starts with a progressive

deterioration as the project life progresses, then after a certain period, it increases sharply to stabilize until it reaches a limit value.

Several factors affect the superstructure's behavior and must be considered when establishing a deterioration model:

- ✚ Traffic: analyzed according to average daily traffic.
- ✚ Climate: humidity, temperature, rain.
- ✚ Age: from construction or maintenance.
- ✚ Resistance
- ✚ Drainage: Condition/quality.
- ✚ Construction: type and quality.
- ✚ Maintenance: type and quality.

In addition, the deterioration model can be established based on different parameters such as cracking, aggregate loss, potholes, roughness (IRI).

4.2.2 Initial construction and rehabilitation costs

At first glance, the construction and rehabilitation costs of the works should be proportional, if the construction costs are more generous, the rehabilitation should be less in the future, this being the cost-benefit reason.

For example, comparing paving a road with asphalt versus paving it with concrete, we find that the initial costs for the latter are higher. However, concrete has a longer lifespan before needing rehabilitation, so it can save time, traffic and money in the long run.

This decision should be made by all stakeholders, taking into account the rehabilitation works and their predictability in terms of cost and time. A major rehabilitation in the construction project can and should be included if the cost is predictable before operations. If it cannot be predicted, this can extend the life of the project to an unknown extent. Typically, rehabilitation costs and any future repairs to highway segments as well as routine maintenance are included in the overall project rehabilitation budget.

4.2.3 Maintenance policy

Maintenance policies for the sustenance and maintenance of highways predict the types of operations that need to be performed in order to preserve highway works and their characteristics under overload and to ensure the safety of all citizens (Jamal: 2017) [50].

Road maintenance costs are defined according to the maintenance activities and the frequency of the intervention. Maintenance costs are technical decisions based on available technology that can be applied to maintain an acceptable IRI index for good pavement performance for users.

Maintenance activities carried out can be reactive (as a result of emergencies, complaints or inspections), routine, scheduled (flexible refurbishment of certain structural renewal/rehabilitation activities), regulatory, as well as resilient (eg: maintenance snow removal services).

Various routine maintenance activities may be established, the most commonly used being the repair of surface holes or potholes without affecting the structural or internal bearing capacity of the road.

There are other activities that can be considered road maintenance activities, the cost of which is lower, for example, routine inspections, cleaning of gutters, clearing of roadside vegetation, painting of horizontal signs, maintenance and replacement of vertical signs.

Local and central governments apply highway asset management, organize routine inspection and maintenance programs and have a regular schedule of maintenance activities such as repairing, clearing and cleaning, grass cutting/weed control and landscape maintenance, drainage, electricity, snow removal services etc. All these activities are intended to maximize the investment and quality of the highway and to ensure the preservation of the construction and the safety of citizens while driving.

Routine/Periodic maintenance activities include the following: maintenance the transport path, lateral drainage channels to clean the slot and maintain proper grade; road surface maintenance; maintaining auxiliary works (for example: bridges); periodic improvement of highway geometry, maintenance, replacement or repair of traffic control systems (Jamal: 2017) [50]. According to the National Road Infrastructure Administration Company, expenses in the transport sector dedicated to road maintenance in 2020 amounted to 1.413.991.525 lei (including VAT), as shown in the table below.

2020 MAINTENANCE WORKS ACHIEVEMENTS			in RON, including VAT	
Indicator/Activity	2020 Work and services programs		Estimated achievements from 01.01.2020 to 31.12.2020	
	Physical	Financial	Physical	Financial
1	2	3	4	5
Cap. A Preparatory services, of which:	N/A	155,279,850	N/A	155,279,850
A1. Public roads management	N/A	30,371,108	N/A	30,371,109
A2. Preparation of technical-economic documents	N/A	6,341,943	N/A	6,341,943
A3. Quality assurance	N/A	997,948	N/A	997,948
A4. Studies, research, experiments	N/A	2,044,807	N/A	2,044,807
A5. Coordination of unified development of public roads	N/A	100,658,555	N/A	100,658,554
A6. Monitoring of transport means on public roads	N/A	14,865,489	N/A	14,865,489
101. Current maintenance during summer	N/A	158,591,733	N/A	159,356,536
102. Current maintenance during winter	N/A	256,391,975	N/A	241,937,520
103. Bituminous treatments - equivalent km	0.00	820,759	0.00	820,759
104. Very thin bituminous layers - equivalent km	195.95	30,802,727	214.19	30,802,726
105. Bituminous carpets - equivalent km	955.79	356,397,564	1,016.60	392,951,041
106. In-situ recycling - equivalent km	50.23	27,708,220	50.26	27,708,220
107. Road safety	N/A	100,477,074	N/A	101,459,653
108. Roadside plantations	N/A	1,053,020	N/A	1,053,010
109. Building maintenance	N/A	8,583,746	N/A	6,632,934
110. Paving of dirt roads	N/A	0	N/A	0
111. Road body protection	N/A	840,459	N/A	840,459
112. Periodic maintenance of bridges	N/A	29,640,654	N/A	31,530,077
113. Accidental works	N/A	167,175,619	N/A	175,527,253
114. Light bituminous coating	N/A	0	N/A	0
115. Reinforcements of road systems - equivalent km	33.97	25,974,821	33.97	25,974,821
116. Additional lanes for slow vehicles	N/A	0	N/A	0
117. Removal of dangerous points	N/A	856,344	N/A	856,344
118. Routine bridge repairs	N/A	26,993,237	N/A	26,993,237
119. Routine building repairs	N/A	0	N/A	0

Current maintenance services and works on the A1 Bucharest-Pitesti highway	N/A	4,844,963	N/A	4,844,963
Current maintenance services and works on the A2 Bucharest-Lehliu highway	N/A	12,829,891	N/A	13,787,632
Current maintenance services and works on the A2-A4 highway	N/A	0	N/A	0
Current maintenance services and works on the A3+ A10 highway	N/A	14,185,954	N/A	15,634,490
TOTAL	1,235.94	1,379,448,610	1,315.02	1,413,991,525
Funding sources, from which:		1,379,448,610		1,413,991,525
Transfers from the budget		561,287,000		561,287,000
Own income		812,418,450		852,704,525
Guarantees of good execution		334,160		0
FSUE		5,409,000		0

Table no. 8. Achievements of maintenance works for the year 2020 (CNAIR SA: 2020) [51].

4.2.4 Costs of alternatives for maintenance and conservation

Most of the costs for highway maintenance and preservation work are borne by the state. Maintenance and conservation activities are classified into conservation works and development works. Within each category of work, different types of activities are established.

For conservation work:

1. Routine activities:
 - ✚ Routine maintenance
2. Periodic maintenance
 - ✚ Preventive treatment of bituminous pavement (asphalt)
 - ✚ Unsealed preventive treatment
 - ✚ Preventive surface treatment
 - ✚ Re-covering with asphalt mixture
3. Rehabilitation
 - ✚ Strengthening
 - ✚ Reconstruction.

For development work:

1. Improvement
 - ✚ Partial extension
 - ✚ Partial extension and reconstruction
 - ✚ extension
 - ✚ Expansion and reconstruction
 - ✚ Upgrade
2. New construction
 - ✚ Construction of two-way roads.

A routine maintenance is an activity defined for each year, while a periodic maintenance is defined as activities scheduled at specific time intervals.

Each of these activities involves a unit cost set for each activity, however, they change according to the demand that the project has, that is, these costs are set in the economic offer of each project.

The units of these costs are expressed in lei-km/year, lei/m² or lei/km, depending on the type of activity. Unit costs are annualized, by multiplying this unit cost by either the length in kilometers of the project or sections, or by its area, to produce the maintenance or conservation cost heading that is used to calculate the total cash flows for the year under analyze.

Among the solutions for prioritizing expenditures to improve the quality of life related to transportation conditions is the development of road health analytics, which can provide real-time values on highway conditions and enable informed decisions, ultimately reducing costs related to vehicle repairs (and costly processes and insurance damages).

There are also systems that can be used to seal the pavement and extend the life of the road, as a preventive seal can save up to 50% of the cost of other types of treatment.

However, probably the most cost-effective options for highway maintenance are:

- ✚ not to save in the construction materials by using quality materials;
- ✚ not to rush the construction process and not release pressure on contractors to quickly finish the project;
- ✚ early and routine maintenance that directly reduces emergency maintenance needs.

Timely and effective maintenance can extend the life of highways.

4.3 Diagnosis of the benefits involved in the project

The benefits involved in the project refer to annual cost savings for both the country and the users of the work. In addition, emphasis is placed on the benefit that the project brings to the region.

Poor highway conditions prove to be barriers to transportation, sources of pollution, and sources of accidents and insecurity.

The benefits included in the project evaluation are:

- ✚ Time savings for users.
- ✚ Savings in vehicle maintenance costs.
- ✚ Reducing the accident costs by decreasing their occurrence.
- ✚ Savings in environmental costs.
- ✚ Social benefits for the surrounding region where the new work will pass.

4.3.1 Time savings for users and vehicle operating cost

Time savings for users is a function of travel time, which in turn is a function of speed, which depends on the IRI coefficient. Finally, a function is defined that reports the vehicle operating cost as dependent on the IRI index. VOC (Vehicle Operating Cost) shows the average costs per km for different types of vehicles. The value of vehicle operating costs and travel time costs are closely related to the road's roughness condition, respectively to the IRI coefficient.

Poorly maintained highways affect the quality and value of cars because operating costs include fuel, tires, maintenance and repairs. Poor roads lead to early car deterioration, adding extra expense to the driver's account, and in the long run, will reduce the value of the cars and thus the value that could be extracted from the car's resale.

Vehicle operating costs for users are generated when a person owns or rents a vehicle for the purpose of travel. Operating costs fall into two categories: fuel costs and non-fuel costs. On average, fuel-related costs represent about 42% of the vehicle's total operating cost, while vehicle depreciation holds a share of 34%, with the other components (lubricants, tires, spare parts, labor and depreciation) accounting for a total share of about 24%. The vehicle operating cost depends on the distance traveled, travel speed, road geometry and the road surface condition, an indicator through the average flatness/roughness index, respectively the IRI index.

Good maintenance could avoid a number of major highway repairs, thus avoiding congestion as well as serious accidents, which can ensure the practicability and use of highways, avoiding delays.

Failure to maintain highways to make them practicable will affect the standard of living and cost of living of all citizens using the said highway.

The congestion index calculated by the TomTom Traffic Index refers to the additional time lost by drivers in traffic, compared to the ideal situation (TomTom Traffic Index, www.tomtom.com) [52]. According to the TomTom Traffic Index, one of the most well-known studies in the field of urban mobility worldwide, in 2017 Bucharest was the 3rd most congested city in Europe, respectively the 9th most congested city in the world. In 2018, it was still 3rd in Europe and 11th in the world. In 2019 the 4th in Europe and 14th in the world, and in 2020 the 9th in Europe and 18th in the world (TomTom Traffic Index, www.tomtom.com) [52].

	Rank in Europe	Rank in the world	Level of congestion
2017	3	9	49%
2018	3	11	48%
2019	4	14	52%
2020	9	18	42%

Table no. 9. Urban congestion worldwide (TomTom Traffic Index, www.tomtom.com) [52].

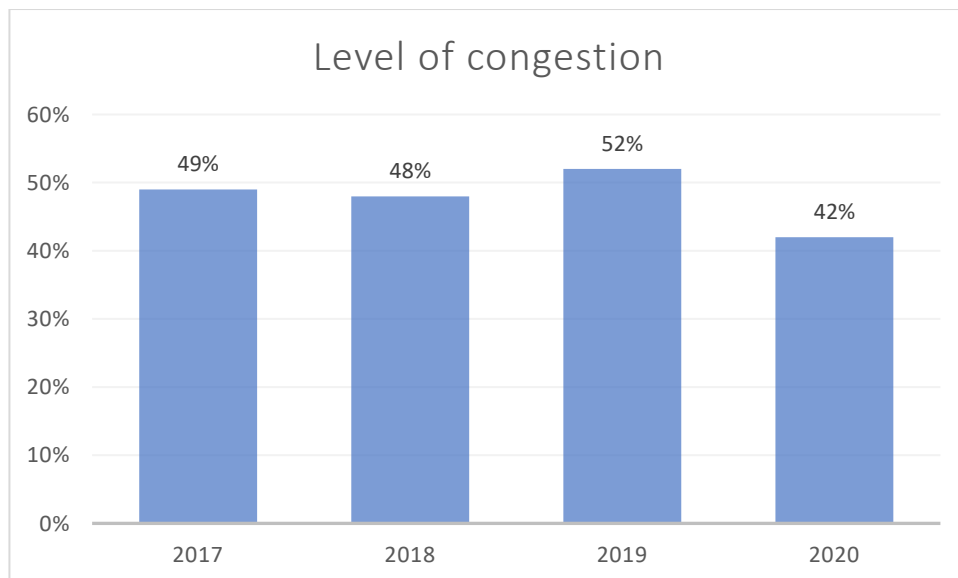


Figure no. 26. Congestion level in Bucharest (TomTom Traffic Index, www.tomtom.com) [52].

Congestion appears to be a problem not only at rush hour. Traffic jams demand not only people's time but also extra money for wasted fuel. Below is how the average hours of time spent in congestion has evolved over the last 4 years.

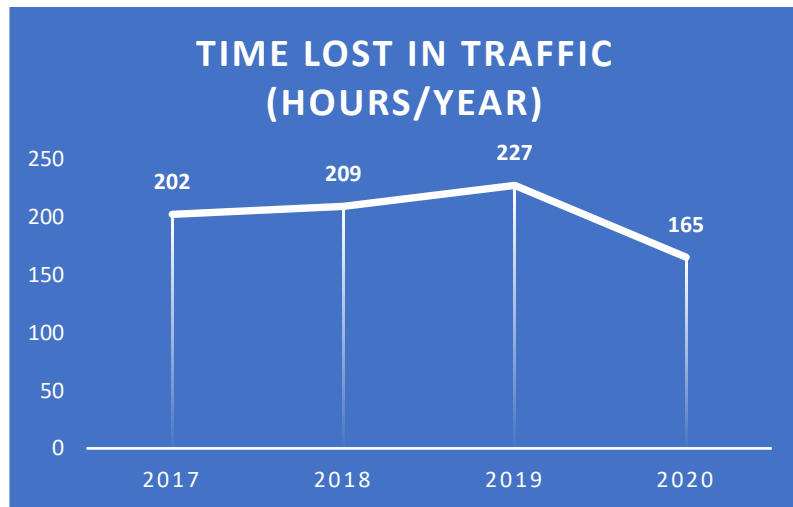


Figure no. 27. Time lost in traffic in Bucharest (TomTom Traffic Index, www.tomtom.com) [52].

Also, in the long run, commuting to a certain city will discourage people from moving there, so lucrative income sources can move to a less populated area to reduce financial and time costs.

Given that major bottlenecks in the highway network cause a severe number of delays, mostly due to the highways' age and improper maintenance, addressing these first seems inevitable. The main solution to this problem would be to add exit lanes and widen the ramps, to reduce the pressure on certain inadequate highway sectors.

And since expanding the highway network in the most populated regions and cities is not always an option due to the general lack of available land and adding extra lanes does not necessarily solve the congestion problem, traffic management and efficient highway maintenance seem to be the only options for such situations.

4.3.2 Cost of accidents

Reducing the number of car accidents is the primary motivation for many road investments or maintenance projects. Approximately one-third of the total benefit comes from avoidance related to the reduction in the number or severity of accidents, which can be converted into annual benefits, measured in money, and included in the socio-economic analysis of the project.

Evaluating accident reduction requires a review of the history of the area. For the purpose of this estimation, types of accidents can be divided into three categories: fatal, serious or with property damage. Fatal accidents result in loss of human life, while serious accidents result in loss of productive life.

Year	Serious accidents	Deceased persons	Serious injuries
2009	10214	2797	9097
2010	9253	2377	8509
2011	9290	2018	8768
2012	9366	2042	8860
2013	8555	1861	8158
2014	8447	1818	8122

2015	9380	1892	9057
2016	8688	1913	8287
2017	8624	1951	8172
2018	8569	1867	8144
2019	8642	1864	8125
2020	6272	1644	5484

Table no. 10. Dynamics of serious road accidents 2009-2020 (www.politiaromana.ro) [53].

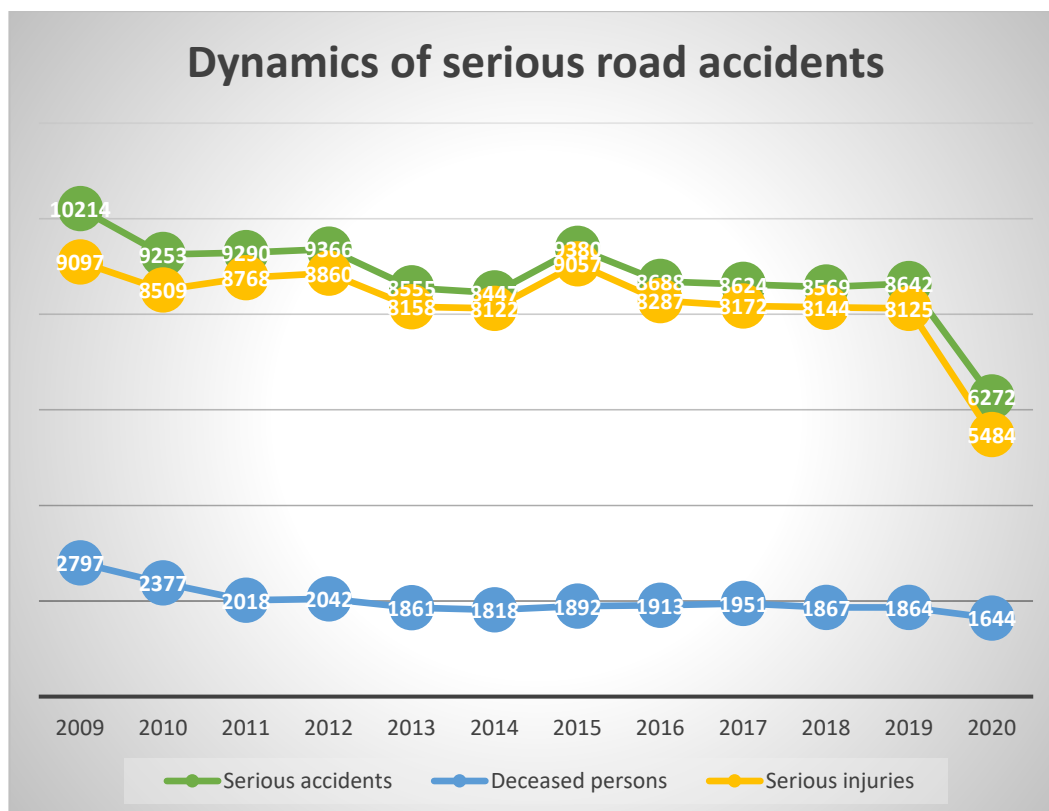


Figure no. 28. Dynamics of serious road accidents 2009-2020 (www.politiaromana.ro) [53] .

The cost of accidents is difficult to estimate; they seriously affect human life, disrupting the destinies of families and children. Personal expenses are involved, as accidents involve major health, legal and logistical changes.

4.3.3 Environmental costs

Highways generate a series of negative effects on the environment, occupying land resources forming unnatural barriers for animals. Highways can also cause a negative impact on natural water sources and discharge areas. However, the three most damaging outcomes of road construction and maintenance are noise, dust and vibration. Traffic pollution can affect small animals by disguising or covering the scent of flowers, fertilizing habitat (with nitrogen) so that it becomes unsuitable for species, and spilling pollution that disrupts animal life cycles. According to Animal People, millions of animals are killed annually on the road, estimating around 40 million squirrels, 20 million cats, 19 million opossums, 15 million raccoons, 6 million dogs (<https://newspaper.animalpeopleforum.org/>) [54].

Highway design and maintenance can have a positive (or less negative) impact by building and maintaining bridges over highway segments that allow animals to cross from one side to the another without exposing themselves at risk.

Among the effects that road construction can have are noise, water and air quality, and effects on the lifestyle of the surrounding community. In terms of noise, there are different sources, such as vehicles that produce a larger amount of noise, drivers' behavior, through the use of horns and radios, noise caused by maintenance and repair work (Tsunokawa, Koban: 1997) [55].

Regarding air quality, vehicles represent one of the main contributors to air pollution in the areas they transit. Different substances, such as nitrogen oxides, hydrocarbons and carbon monoxide, which are the product of engine combustion, have a direct influence on the health decline of residents around the roads. The level of air pollution caused by vehicles depends on fuel consumption and fuel type, engine condition, vehicle size and ultimately speed and congestion. Most vehicles operate with lower fuel consumption and wear at a speed between 80 and 100 km/h, so operating outside this range produces a higher level of contamination. To quantify this factor, vehicle traffic and dispersion, vehicle types, average speed and the main pollutants emitted are taken into account.

The economic evaluation of the environmental impact of a road can be approached in different ways (Tsunokawa, Koban: 1997) [55]:

- ✚ Direct evaluation: this method assumes that an environmental impact can affect current production or production capacity within the study area. In turn, this evaluation can be developed through three different methods, direct changes in productivity, which can be measured as reduced income from the affected land, the opportunity cost, which consists in giving a value to the land where the road passes and which can be used in some productive activities, and the loss of profit, where the impact of pollution can be used.
- ✚ Scope: In this type of evaluation, an estimate is made of the loss or gain in value of certain land, taking into account the impact of air pollution due to the new road.
- ✚ Preventive costs: are considered the costs incurred to mitigate or prevent the impact of a road infrastructure project, although this type of assessment implicitly assumes that the benefits of the project are greater than the costs, so it is worth the to mitigate the environmental impact.
- ✚ Replacement cost: Considers the cost of replacing an asset lost due to environmental impact.
- ✚ Contingency assessment: This method is used to measure the economic impact of intangible values, such as the visual impact of certain projects. The technique consists of conducting various experiments and surveys with affected individuals and based on this information, an economic or monetary value is assigned to each parameter.
- ✚ Cost-effectiveness analysis: When monetary values are rather difficult to assign to the environmental impact produced by a project, a list of objectives (such as the maximum acceptable level of air pollution) and operating and capital costs are then allocated accordingly to achieve these objectives. This method does not put the advantages in monetary terms, it simply calculates the cost of alternative roads to achieve different goals.

4.3.4 Social costs or benefits for the area

Highway construction provides positive outcomes for the area and its residents; building a highway can improve people's lives by providing access to better jobs, better schools, better healthcare for all, and ultimately making the region more attractive and prone to local investment and development.

The social costs resulting from a road project can be very diverse. The economic effect on a certain area is generally positive, as a new road facilitates the diversification of activities in the area, such as an increase in the mobility of people and therefore the increase in trade in goods and services, in addition,

the products of the region can be transported to other areas. The impact on people's lives has been demonstrated over time because the development of societies goes hand in hand with road construction. With a communication path, local residents have the opportunity to access more facilities for medical, recreational and educational services.

But building the highway does not immediately ensure all these positive results; the contractor must also ensure that the highway is also properly maintained, with interventions whenever necessary, so as not to cause negative effects on people's lives, environmental degradation, bringing pollution, dust, dirt and noise to the region, generating a large number of traffic accidents, as well as congestion and other unpleasant surprises.

In order to preserve the safety and security of people, involving health, jobs and the environment, contractors and authorities must ensure that highways are properly maintained so that they keep their condition as close to the initial phase as possible. Otherwise, highways may result in higher costs than revenues for the region.

4.4 Net present value (NPV), internal rate of return (IRR) and cost-benefit ratio (C/B)

Choosing an infrastructure construction project proposal can be tedious and complicated, and an economic evaluation is required to determine the profitability of such a major effort. However, there are indicators to determine which is the most advantageous proposal with the lowest risks. The value of highway construction in a region can be determined using the following indicators to evaluate the financial performance of the project:

Net Present Value (NPV)

NPV indicates the present value at time zero of implementing a project that will generate various future income and expenses based on the discount factor (rate) selected. The benefits of highway construction are considered positive, the costs are considered negative. Their summation gives the NPV. Any highway project with a positive NPV is considered acceptable, so the project with the highest NPV will be accepted by the committee.

Cash flows require an appropriate methodology for forecasting costs and benefits so that real values are obtained, allowing for usable results.

Regarding financial indicators that show the profitability of a project, the most used are the net present value (NPV), which is defined as "the difference between all revenues and expenses expressed in current currency" (Sapag and Sapag: 2000) [56]. This definition shows, in the case of cost-benefit analysis, that when considering all projected costs and benefits of a certain road infrastructure project, they must be translated into today's value or present value, because in this way a real idea of the value or profitability of highway construction for a country or region appears. For a project to be acceptable, an NPV greater than zero must be obtained, that is, it must have more benefits than costs, and these must be reflected in its present value.

$$VAN = \sum_{t=0}^T \frac{CF_t}{(1+r)^t} = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \dots + \frac{CF_T}{(1+r)^T}$$

where:

CF_t = net cash flow value for year t (difference between actual income and expenses)

CF_0 = initial investment

r = discount rate (cost of capital)

t = number of years

T = project lifetime

Internal rate of return (IRR)

In addition to the Net Present Value (NPV) and closely related to it, there is another analysis criterion which is the Internal Rate of Return (IRR) which consists of the rate at which the NPV becomes zero, that is the minimum rate of return of a certain project. Internal rate of return is widely used because it avoids selecting an initial rate of return. The rate resulting from the calculations can be compared with the market interest rate, which is familiar to financial experts. But the big disadvantage is that, the calculations are complex and may involve errors.

$$RIR = \frac{D_1 + NPV_1(D_2 - D_1)}{(NPV_1 - NPV_2)}$$

where:

D_1 = reduction standard, corresponding to NPV_1

D_2 = discount rate corresponding to NPV_2

NPV_1 = positive value of net income

NPV_2 = negative value of net income

For a project to be profitable, the result of the internal rate of return must be greater than the opportunity cost. This indicator has as its main utility the comparison between different alternatives, for when it is imperative to choose between several projects due to limited resources, which is a common situation in the public sector.

Cost/Benefit Ratio (C/B)

The cost-benefit or C/B ratio has some variations, but the simplest procedure is to reduce all benefits and costs to their value, then calculate the ratio between the two. Benefits are positive flows and costs are negative ones. If the ratio is greater than 1, the project is considered advantageous/feasible. The advantage of this method is simplicity.

The cost-benefit ratio (C/B) is defined as the ratio or division between the costs required by a project and the benefits provided by it. A project with C/B ratio values greater than 1 is profitable as it has more benefits than costs.

$$B/C = \frac{\sum_{t=1}^D \frac{V_t}{(1+a)^t}}{\sum_{t=1}^D \frac{(I_t + C_t)}{(1+a)^t}}$$

where:

V_t = the incremental income obtained in year t as a result of the investment (u.m./year)

I_t = investment made in year t (u.m./year)

C_t = the incremental cost in year t obtained as a result of the investment (u.m./year)

a = discount rate (%/year)

D = the analysis period that includes the execution time and the economic life time (years)

The necessary condition for accepting the investment is that $B/C > 1$.

This has been the most widely used parameter in the analysis of highway infrastructure projects worldwide, as it is a simple measure of the value of public assets.

In the case of road projects, this analysis is necessary because it helps to observe the different alternatives that can develop within the project, such as different maintenance periods, the use of one or another technology. From a technical point of view, it produces the same results, but from a financial point of view there can be substantial differences that make the project operator choose a particular alternative.

	Decision rule	Advantages	Disadvantage
Net Present Value (NPV)	For independent projects: NPV > 0: The project is accepted NPV < 0: The project is rejected For mutually exclusive projects (projects where one is chosen over the other): the project with the highest positive NPV is accepted.	✚ Incorporates the value of money over time and considers all cash flows over the project's lifetime: This method takes into account the impact of inflation on the future profitability of the project, thus estimating the monetary benefit of a project. ✚ NPV is a more reliable indicator when evaluating a project. ✚ Ease of decision-making: allows for a simple and accurate application of the project's net value over the planning horizon. It is very easy to select the favorable project through the net present value method. The project with positive NPV or higher NPV is selected, while others are rejected. ✚ Formulates criteria to determine the optimal alternative: facilitates the comparison of future values generated by two or more similar projects to find out the most feasible option. ✚ The NPV approach provides the accept-reject decision for both independent and mutually exclusive projects. ✚ Measures profitability: It is one of the most effective methods to determine the actual profitability of a project over its lifetime.	✚ Accuracy depends on the quality of inputs. ✚ Useless for comparing projects of different sizes, as the larger projects usually generate the higher profits. It is not applicable when comparing projects with different investment amounts. ✚ NPV does not provide an indicator for relative profitability. NPV only provides the total profit earned, not the percentage earned. ✚ Some people find it difficult to understand the meaning of NPV measurement. Therefore, in practice, managers often prefer a percentage profitability.
Internal Rate of Return (IRR)	For independent projects: IRR $\geq$ required rate of return: project is accepted IRR < than the required rate of return: reject the project	✚ It is an indicator that can be calculated using project-specific data, regardless, up to certain points, of the opportunity cost. ✚ It is an appropriate indicator to select projects that are mutually exclusive in terms of funding. ✚ The IRR approach fully takes into account the value of money over time and considers all cash flows over the life of the project.	✚ IRR may have limitations in projects where cash flows are not conventional or to be understood as comparable when there are mutually exclusive projects. ✚ Not a suitable indicator for projects that have multiple IRRs, as these have multiple solutions. Its use for investment criteria faces difficulties when the projects in question are alternatives to other projects.

	For mutually exclusive projects: the project with the highest IRR that is greater than the required rate of return is accepted.	✚ IRR management with information on the safety margin. Thus, the higher the IRR, the higher the safety margin.	✚ IRR assumes that firms can reinvest all cash inflows at the IRR throughout the project's life. This rate may be unrealistic.
Cost/Benefit Ratio (C/B)	Like NPV, the C/B ratio formula generates the following two criteria that guide the acceptance or rejection decisions of projects: $C/B \geq 0$: the project is accepted $C/B < 0$: the project is rejected All accepted projects constitute an investment portfolio in which projects are classified into homogeneous groups according to their activity or line of activity. According to the C/B ratio, projects or investment ideas will have a priority that will be a direct function of the numerical value of the indicator: the higher the C/B ratio, the higher the priority	✚ Provides clarity in unpredictable situations: Performing a cost-benefit analysis provides the opportunity to drill down into the details of what is being spent. The act of defining and listing these costs is a valuable exercise that identifies each future expense. The process can bring benefits, even though it is often impossible to fully anticipate every incurred expense. ✚ Helps in rational decision-making: A cost-benefit analysis is in part a tool aimed at assisting in making rational rather than emotional decisions. By setting the costs to be incurred, it avoids impulse. The act of listing and evaluating costs and benefits forces one to look at these variables as objectively as possible. ✚ It is data-driven: cost-benefit analysis allows one to evaluate a decision or potential project without personal opinions or views. As such, it provides an agnostic and evidence-based evaluation of options that can help the project become more data-driven and logical in the way it operates. ✚ Simplifies decisions: Business decisions are often complex in nature. By reducing a decision to costs versus benefits, cost-benefit analysis can make them less complex. ✚ Can uncover hidden costs and benefits: Cost-benefit analysis forces the description of each potential cost and benefit associated with a project, which can help uncover less obvious factors such as indirect or intangible costs.	✚ This indicator is not entirely reliable as a decision-making tool, because similar to IRR, it can result in providing similar values for projects whose NPV are very different; since both describe unit net benefits but say nothing about the total net benefits produced by the project, it is essential to use NPV as a decision-making tool for selecting between mutually exclusive projects instead of the C/B ratio. ✚ Estimating all costs and benefits may not be practical in all cases. If at least the main costs and benefits can be quantified, a partial C/B report can be completed. ✚ It is only as good as the data used: if the data is incomplete or inaccurate to complete the cost-benefit analysis, the results will be equally inaccurate or incomplete. ✚ It is more suitable for short and medium-term projects: for projects involving longer time periods, cost-benefit analysis has a higher potential to miss the mark, for several reasons. It usually becomes more difficult to make accurate long-term predictions that accurately account for variables such as inflation, which could affect the overall accuracy of the analysis. ✚ Removes the human element: While the desire to make a profit drives most companies, there are other non-monetary reasons why an organization might decide to pursue a project or decision. In these cases, it can be difficult to reconcile moral or "human" perspectives with the business case.

Table no. 11. Comparative analysis of project financial performance evaluation indicators.

Despite the limitations, it is advisable to consider all concepts in mind when making an investment decision. Indicators are essential factors in project evaluation modeling. The objective will be, along with other tools, to identify the solution of financial problems, which will allow the development of structures, formulations and organizations of models in finance.

V. CONCLUSIONS

Major infrastructure construction projects are an important success of the economic society. Mobility brings economic growth, social welfare, political sustainability. Infrastructure projects and their success are a major variable in evaluating countries. It represents extremely complex efforts and involves the coordination of numerous resources and actors.

The importance of the budget in construction projects is undeniable. Managing a company's budget has wide implications for the entire organization, similarly, for road infrastructure, the budget plays an essential role. In terms of planning and control, companies use budgets to forecast the cost/profit analysis of their operations. They usually divide their budgets according to specific needs. Some are regular costs, including production and sales budgets, while others are broader in nature, such as capital expenditures and research and development budgets. This makes it easier for companies to track their expenses and distribute available funds to different departments, making their use more efficient.

Increasingly, companies are focusing on the importance of budgeting techniques. They help in decision-making for overall plans and their execution. Although companies plan with set objectives in mind, the available budget provides companies with specific guidelines and realistic changes to these plans. Failure to do so would result in loss of revenue. As such, budgets must be made with appropriate forecasts in mind to ensure their efficient use. Budgetary control is also important because it protects the firm from unsustainable expenses.

Therefore, companies need to develop a better understanding of the different types of budgets, as well as the central role that budgets play in the planning process.

Moreover, companies must deal with costs and profits in their business relationships. Companies must also be aware of the importance of the ever-changing markets in which they operate. Increasingly, new opportunities are opening up, which require investments. As such, they must be aware of their role to expand or downsize in the face of potential changes.

Decision-making in selecting infrastructure projects is a challenging problem. Therefore, the decision criteria must be well-established.

The selection of the contract type is based on the uncertainty of the scope, risk assumption and the need for costs that are predictable as much as possible, as well as the relevance of the fulfillment of the pre-established stages in the contract. Unforeseen costs should have a considerable proportion of the total budget allocated.

Planning in construction projects, especially road infrastructure development, is fundamental to the cost-effectiveness and time-efficiency of the project, as well as to the provision of high-quality services.

Multi-stage control during the project can help reduce risk, uncertainty and increase construction efficiency, while managing corrections to the initial plan and budget to match the reality on the site.

One of the main functions of the investment process is cost control. The report details cost control methods, specific techniques and tools designed to monitor project development. Thus, the most frequently used method of cost control is represented by earned value management by monitoring the project implementation compared to the initial plan, taking into account certain important indicators. The most effective way to track project development is through graphical representation, which presents the current status and trend of the project in an easy-to-understand form.

Choosing the most suitable highway construction projects should meet all or most of the needs of citizens, businesses and the environment and choose the project with the fewer risks and negative outcomes.

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