Resource Allocation Strategy in the Design of BIM Dimensions in Detailed Engineering

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Theme: Project engineering, BIM technologies, experiences and applications

Estrategia de asignación de recursos en el diseño de dimensiones del BIM en Ingeniería de Detalle

Resource allocation strategy in the design of BIM dimensions in Detailed Engineering

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Abstract
The Building Information Modeling technology, (henceforth BIM), in its life cycle from beginning to end, develops the Detailed Engineering process, where it is necessary to apply a correct resource allocation strategy, in the dimensions of the 4D time and 5D cost, as a way of materializing scheduling, cost control and integration, in a process of preparing project documentation, before construction. The objective of the topic, is the development of the resource allocation strategy, based on the applications of the critical path and the cost / time slope, in the 4D and 5D dimensions of BIM, as a way of guaranteeing compliance with the directive figures of Basic Engineering, and the obtaining of the results, in the term of time, within the framework of the budget and with the required quality, by the client and the interested parties. In the process, the contents of the 3D design are developed, the allocation of resources, the times, the computer support and the information is prepared for the development of the next construction process, within the framework of the integrated management system provided by the BIM.

Keywords: strategy, resource allocation, BIM, detailed engineering.

Introduction

Detailed Engineering in the Integrated Project Management is characterized by the elaboration of the project documentation by the designer and its delivery to the constructor for its execution, the interpretation of the documentation by the constructor in many cases has brought problems that imply over cost in the execution of the project. In BIM making use of its dimensions in detailed engineering, the investor directs the process, starting from achieving the integration of the design and construction preparation, with the builder's resources, in an integration process that guarantees the Identification of design problems, before execution, thus avoiding the increase in the cost of the project.

The development of BIM technology is a necessity of social development, in order to guarantee its ever-growing needs, in the field of constructions. It is the integrated, strategic, unique, collaborative and multidimensional information system for the management of construction projects, in a 3D virtual model, during the investment life cycle, where the project is prepared before its execution, in a collaborative process of continuous integration and constructability, which allows raising the quality of the preparation, to guarantee effective and sustainable constructions, from pre-investment to demolition. It is the methodology that allows the representation of graphic and written documents, with physical and functional characteristics, developed for comprehensive projects, by mature organizations, with significant computer support and a protocol that regulates its operation. The present work aims to show a strategy to guarantee the correct execution of what is planned in basic engineering.

Materials and Method.

The investment system methodology is developed in three main processes, before, during and after, with their well-defined contents as established in Decree 327 and in correspondence with the pre-investment, execution and closing phases of the project. The PMBOK of the Project Management Institute, [1] defines the process in five phases, initiation, planning, execution, control and closure. The ISO 9001 and 21500 standards show content aimed at providing information on the subject, in order to facilitate the work of builders, in the development of the investment life cycle.

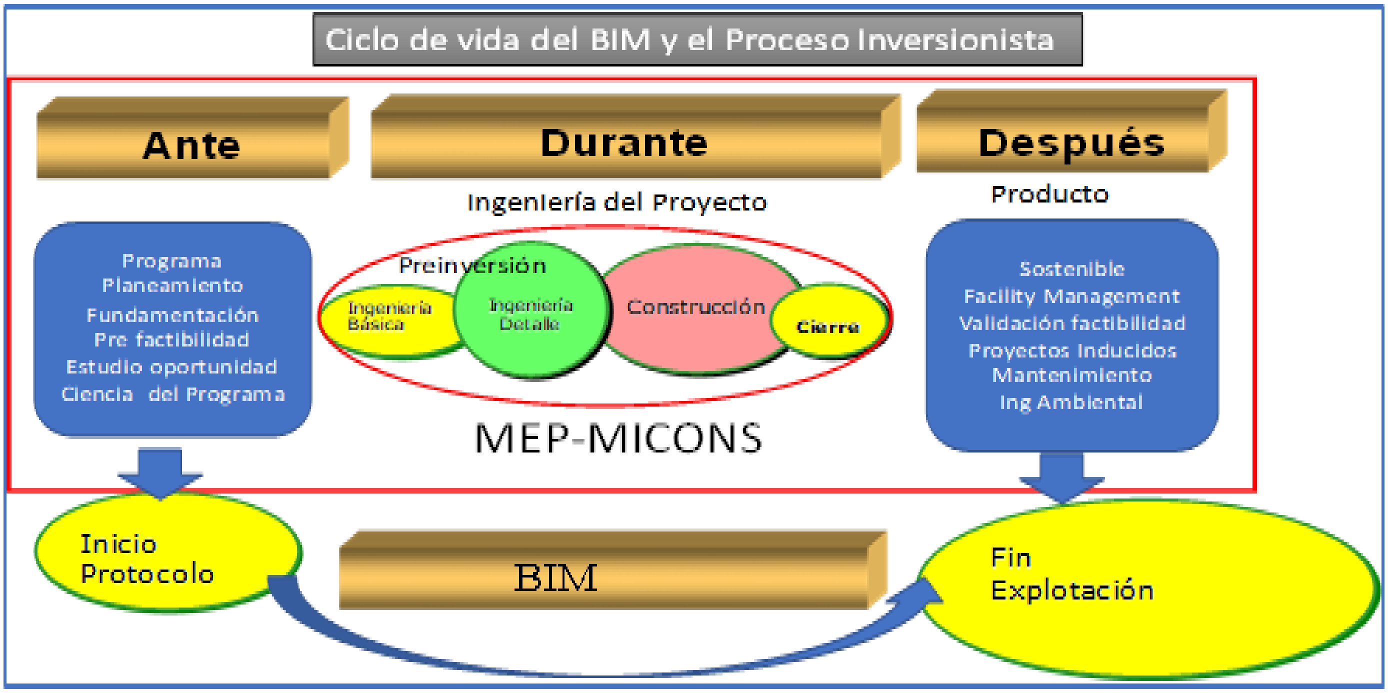

Figure No 1. Project life cycle in BIM

Taking the theoretical framework as a reference, the content is proposed as the life cycle of the investment project, the one shown in figure No 1, taking into account the provisions of the methodologies that govern project management, the value chain and its system. Of costs, the life cycle in project management in BIM is proposed, in four key processes, since these are the ones that generate values, have a schedule, budget and financing, where it generates financial economic management and its indicators.

The four key processes are basic engineering, detail engineering, construction and closure, since it is in these processes where values, partial and total results are generated, as deliverables measurable in time, cost and quality, which respond to a contract, in an integrated management process. The project team develops the basic engineering and the closing with the investor, the detailed engineering by the designer's team, and the construction by the executor, with differentiated schedules and contracts. The planning and control processes are transversal to the life cycle of the project.

Figure No 2. Detailed engineering dimensions

Results and Discussion

Detailed Engineering is presented in four stages or dimensions defined in BIM, with the development of business intelligence and the maturity of the organization. The 3D model design, scheduling, resource allocation and 4D time, 5D cost and 6D preparation of the construction process, as shown in figure No.2.

The construction industrialization process goes with new materials, the development of new technologies, the optimization of resources and the application of management techniques, with the support of information technology and communications. BIM is a novel technology, which allows obtaining higher quality in the design and construction of the project, through 3D design, navigation, visualization or simulation, in order to achieve a good preparation of the construction before its execution, with the objective of achieving higher quality in the construction of the project, with significant cost reductions.

The objective of the detailed engineering is the development of the project documentation through the 3D design of the approved preliminary project in basic engineering, within the framework of the approved directive figures. It has a budget for the design, which is planned and executed at this stage and another budget for the construction that is planned in the detailed engineering and is executed in the next life cycle of the construction. The plans and 3D representations are defined, with the use of computer support such as Revit, Civil 3D, Presto, Preswin or Siecons, Project, Open Project, Gespro, Primavera, Naviswork and Syncho pro, with their specialized complements, elaborated by the designer and his team. It has the technical means and the necessary knowledge for the development of the 4D time and 5D cost dimensions. It develops the 6D construction preparation with the resources of the builder and the active participation of the investor.

3D design stage

The design is the initial action of the detailed engineering process, which aims to create the 3D representation of the virtual model and the project documentation, based on the directive information approved in basic engineering, in a virtual environment. , with the multidisciplinary participation of the group of specialties that participate in real time, developing the object-oriented model, modules, elements and parts with their attributes.

The BIM environment generates a multidisciplinary process, where developments of specialties in different formats are found, carried out by different specialists, with their own technical standards, such as architecture, structures, hydraulics, climate, lighting and energy among others, that when are integrated initially, they generate interferences, incompatibility, interoperability or inconsistencies, which have to be resolved in this preparation process with adjustment facilities, in order to guarantee the continuous integration of the system. Sometimes they find different files of the same or different format, which when they are integrated, if they are not compatible, corrupt the system. The formats used guarantee interoperability. The system itself generates a level of discipline, dependency and organization in real time, which guarantees the quality of the process, in an integrated management system.

In the development of the 3D design, use is made of the most important parameters to highlight in the families, such as the parameterizable geometric information and its possible adaptation to the design, compatibility with the IFC format, dimensions and other details of the element.

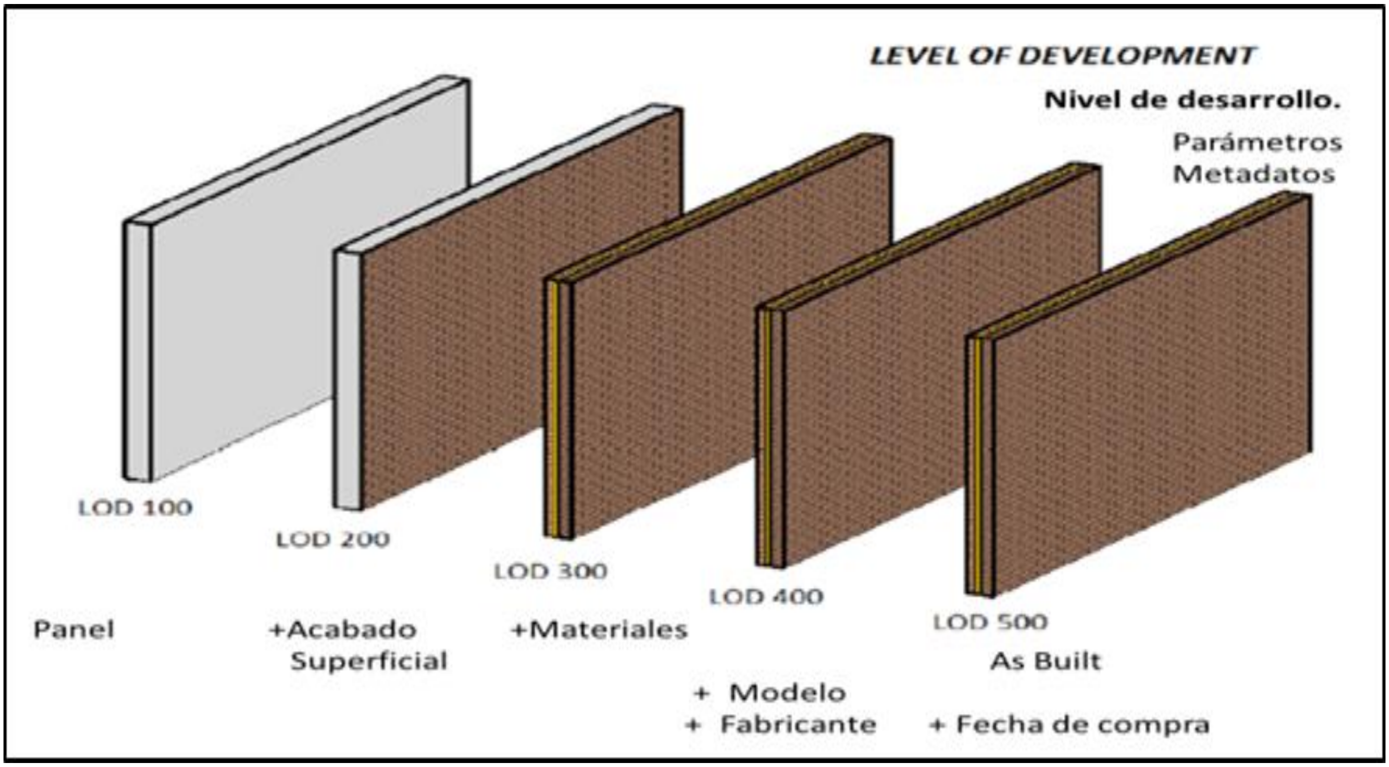

Figure No 3. Sample of the different levels of development

Once the design elements are defined, it is necessary to determine the level of aggregation of the same and its level of detail in the completion and finish. The designer at this stage determines the material resources of the objects, elements, components and parts, depending on the dimensions and volumes of work, following the normative indications of the development levels, LOD, with the support of the supplier and its base. Supplier data. Figure No 3 shows the different levels of development of the elements and components, which make up the model according to the degree of completion and the information available by the specialist.

The elaboration of the common data environments, CDE, integrating the information provided by the LODs, allows the creation of the work premises, Work set, with the aim of achieving the integration and studies of the elaborated designs, in a space where a good use of computer equipment, with a correct distribution of the weight of the files, in the process of integrating the information and the design of the work objects.

The Figure No 4 shows a form of distribution, in which Basic Engineering and Closure can be common to a certain number of works objects, which make use of families, LODs in the detail of the information, the CDE for the organization by common parts and the Work set as a way to develop the integration of the designs.

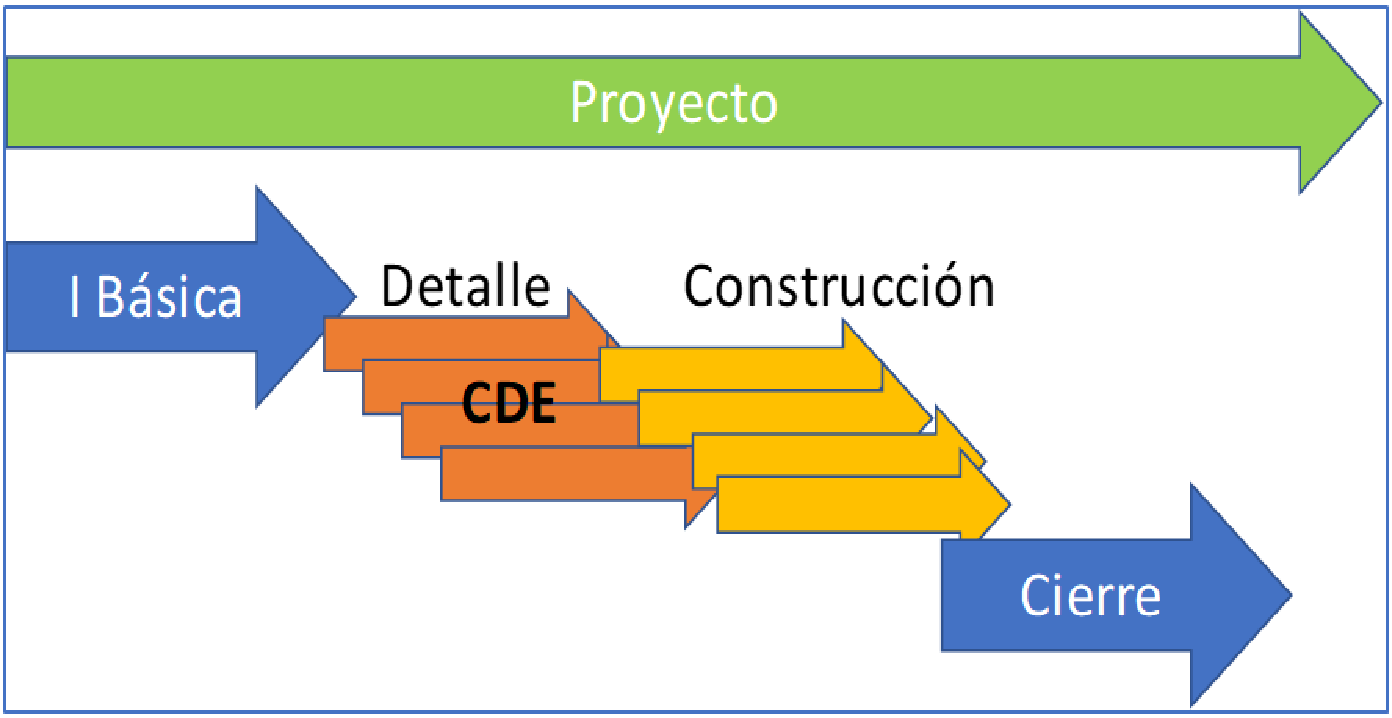

Figure No 4. Distribution of common data environments

To avoid an excessive slowdown in the work making use of a structure of the computing equipment based on an I7, the operational size of a Revit file can be in an environment of 200 MB, for an average area of 5,000 m², which contains all its facilities and these are not of great complexity and it is expected to reach a degree of detail and complexity acceptable in all disciplines. The scale can be 1/50 and the granularity 10 cm.

Once the design elements with their materials and attributes have been defined, it is necessary to develop the resource allocation strategy for the execution of the project, in the next stage of the 4D time dimension. The content of the 4D time stage, organized with the input of the process, its processing and the output is shown below.

Entry: 3D design of the model and documentation of the project by objects, elements, components, parts, properties and attributes according to its level of development. LOD and the information system.

Prosecution.Team: Designer. Budgetary. Supplier. Specialists. Supplier. Nominal Resource Allocation Strategy: Elements, Variant Lines. Minimum resource allocation. Dimensions. T = Volume / Yield. Labor, equipment and materials. Technological schemes, Logistics. Internal and external workshop. Chains, Time by variant lines.

IT Tools: Siecons, Preswin, and Presto.

Departure: Determination of times by variant elements and lines. Information system for the executive project 5D.

Information processing: This process begins at the entrance of the design, directed by the designer and the specialists, to continue the 4D process, with the estimator, the supplier and the specialists, applying a strategy of allocation of minimum unit resources by elements, components and variant lines, to calculate the time using computer tools.

Nominal resource allocation strategy: The allocation of resources is the stage of the detailed engineering process, in the project life cycle, which aims to estimate the 4D execution time, of the modules, elements, parts, and components designed by specialists, in consults with the supplier and the budgeter, to add the labor, equipment and materials, with the aggregates defined in the LODs and from the dimensions of the parts, the calculation of the volumes of work, the minimum resources and their yields, estimate the duration times, according to the technological schemes, the basic organizational units of work and the crews, in the environmental conditions of the execution of the project, making use of computer tools such as Siecons, Preswin or Presto. The allocation of nominal minimum resources to the elements of the 3D model design, in order to obtain the 4D durations and the cost, is developed using computer systems such as the one shown in figure No. 5. [11].

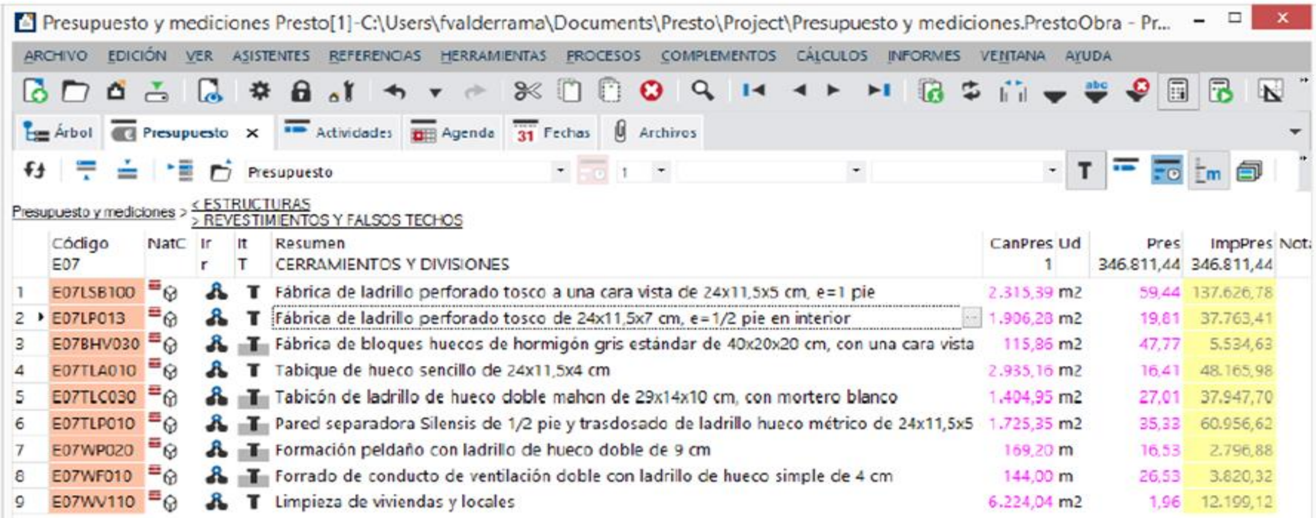

Figure No. 5. Resource allocation. Source: Presto

The budgeter, the information system takes the design documentation, reviews and incorporates information, with the quantities and allocation of material resources of the elements and attributes by families and LOD, created in Revit, using Presto or similar, determines the allocation of human resources and equipment by objects, components, elements and parts in a nominal way, for later in the 5D in the integration process, make use of the real resources of the builder.

From Revit, each type of element is assigned an “assembly code”, which will be associated with a code of the corresponding Presto. For example, from Revit select in the model through the filters all our 30 cm thick retaining walls and in the type properties assign in the "assembly code" field the corresponding code in Presto to "HA retaining wall -25, 30 cm thick ”. Once all the necessary assembly codes have been assigned, the Presto plugin for Revit must be started and a Presto file generated with all the units previously assigned to codes. This file is the basis for starting the budget. [7].

The main measurement and budget programs are adapted to Presto, Archimedes from CYPE or Gest from Artek with plug-ins that connect them with the main BIM software, with the aim of guaranteeing their commercialization, especially with Revit and ArchiCAD, in a way bidirectional and interoperable, where a change made in the model is updated in real time in the measurements; or a change in the price base, it is immediately updated in the corresponding parameter of the model element. [11].

The calculation of time is expressed by the relationship between the volume of work and the performance of resources. The volume of work is obtained from the dimensions of the elements and the performance of human resources and equipment, by technical standards and necessary estimates. The strategy for assigning resources by tasks, basic organizational units and crews, in this process is of minimal resources, since the budgeter does not have information to define another variant.

At this stage it is not possible to define the optimal allocation of resources that should be used in the tasks and generally at least one module is taken, which is why the allocation of resources is considered as the minimum for each task, which, as a whole, as a system Through the critical path, it determines the maximum duration for the project, which is generally higher than that defined in the directive figures of Basic Engineering and requires the adjustment of the term.

Once the adjustment of the deadline for compliance with the directive figures has been defined, one of the most efficient ways to manage the deadline is by assigning resources to the tasks to reduce execution times, without cost increases.

The first question would be, in which tasks is the possible increase in resources being studied to recover the deadline? Clearly, the allocation of resources is in the tasks of the critical path, since they are the ones that define the duration of the project. An increase of resources in a task with ease, far from solving the problem, may be creating other problems of unnecessary resource movement. The next question is what task to start with? The critical path has several tasks, for the longest. If the objective function is to reduce duration, this may be an acceptable variant, although there may be other better ones.

This is possible if the resource is not very expensive, is prohibitive in the economic order and is available. The most practical thing is to include in the analysis the slope m = cost / Time of the tasks in the algorithm of the resource allocation strategy, evaluating together these two important variables in the management of the term, ordering the slopes from lowest to highest.

The process begins with the critical task with the least pending, where the process is most effective, with the objective of achieving a greater reduction in the duration of the task with a less expensive resource allocation. The analysis must take into account the different aspects, among which the following stand out: the availability of the resource by the executing entity, the quality, the feasibility of execution and the priorities established in the project.

If the assignment in the first task of minimum pending is not possible or despite performing it, the established requirements are still not met, can the process be terminated? No. The procedure provides a logical sequence of ordered critical tasks that allows you to go on to analyze the next task in the consecutive ascending order of the slope and repeat the process looking for solutions, until you reach the last task. The procedure in figure No. 6 provides a solution strategy based on the value of the slopes, optimizing cost and time.

The allocation of resources in critical tasks decreases their duration and can modify the critical path, so if once the critical task with the greatest pending has been analyzed, the requirements have not been met, the critical path must be recalculated and the process continued analysis in a new iteration until the requirements for the reduction of the term in the established time are met, whenever possible.

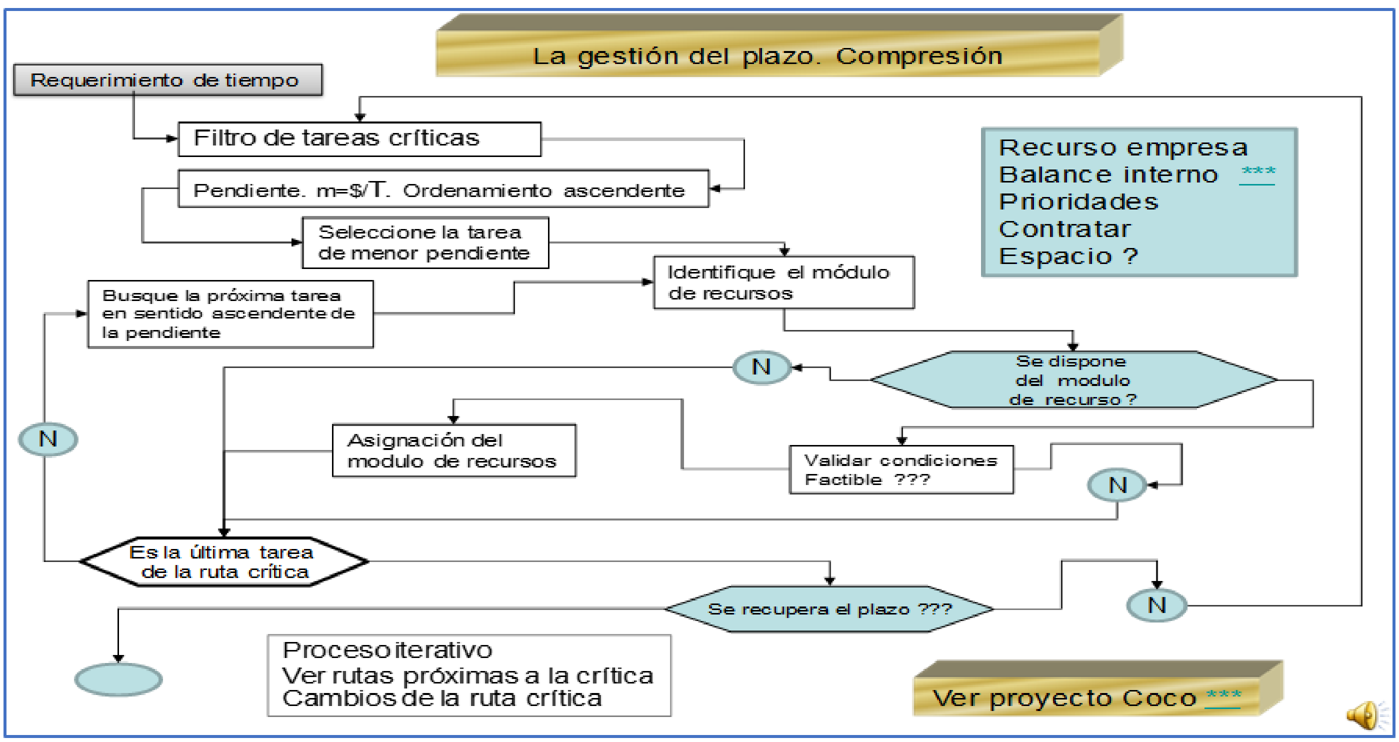

Figure No. 6. Algorithm of the term for the optimization of resources

If, even so, compliance with the established requirements is not achieved, the project manager must manage the knowledge stored in the database of completed projects in search of other solution variants, among which are to analyze the roads very close to the critical where good results can be achieved, assess project priority, identify resources that are allocated to lower priority projects under the Resource Sharing Fund, overlap tasks with resource analysis, hire new resources, or re-evaluate budget allocation approved in Basic Engineering.

The following order allows the development of the term management.

1. Specify in Basic Engineering the management term contracted with the client.

2. Determine the fit in time from the critical path.

3. Apply a filter for critical tasks

4. Calculate the slopes (cost / time) of critical tasks.

5. Order the slopes from least to greatest

6. Select the task with the least pending

7. Identify the resources assigned to the selected task

8. It is possible to double the allocated resources to cut time in half without cost increases?

9. Does the company have the necessary resources?

10. It is `possible given the working conditions to double the resources

11. Is it feasible? It can.?

12. Yes! Allocate resources and verify deadline reduction without cost increases.

13. No. The analysis with the first task selected does not allow the reduction of the deadline. Does the process end here? Not

14. Select the next task according to the established order and repeat the process until you finish with the last critical task.

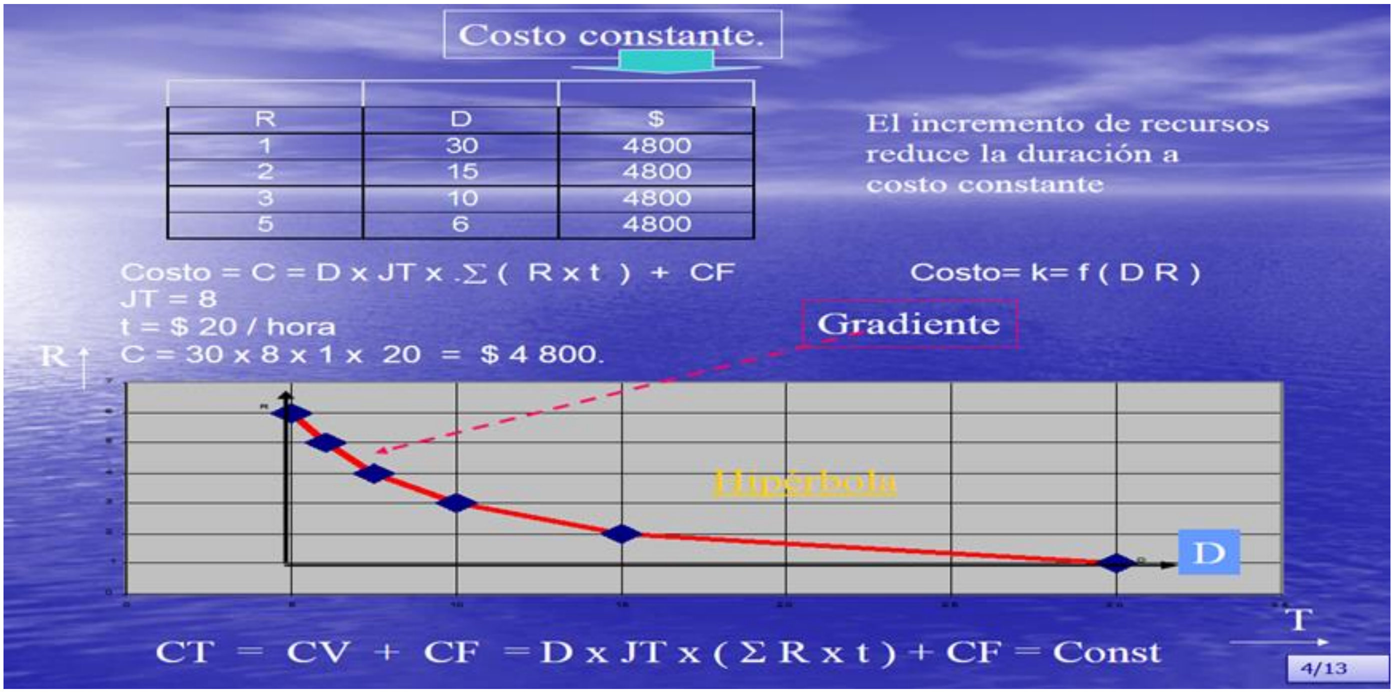

Figure No 7. Allocation of resources keeping the cost constant

The procedure provides a resource allocation strategy, in order to guarantee the planned term, managing Time through a process of optimization of resources, making use of the Slope = Cost / Time, where with the allocation of a resource Low cost, the greatest reduction in time is achieved, applying the analysis of the system and the critical path, without cost increases in the project, taking into account the availability of the company, the working conditions and contracting possibilities, maintaining the cost constant, as shown in figure No. 7. [10].

The slope (m = cost / time) is ordered from lowest to highest. The critical task with the smallest slope m is the one that satisfies the resource allocation requirement with less cost and with greater effectiveness to achieve the reduction of time. However, it happens that in the first selected task where the cost and time requirements are met, the necessary resources are not available.

It is then necessary to continue the iterative process according to the order defined by the slopes until finding the feasible application solutions whenever this is possible. The process provides a strategy in which cost, time and resources are combined on the critical path. In the process, it is possible to carry out searches by incorporating the resources available by the entity into the filters or queries.

Pendiente ordenada de menor a mayor.

Nombre de tarea	Duración	Costo	Pendiente
Tareas críticas: Si	**46 días**	**$86,332.84**	**1876.8**
125131 DE CHAPAS GALVANIZADAS DE 1	1 día	$20.83	20.83
316331 ARME Y DESARME DE ANDAMIOS	12 días	$265.64	22.14
062111 SIN FORRAR (5600 X 940 MM)	1 día	$53.12	53.12
062111 SIN FORRAR (5600 X 940 MM)	1 día	$53.12	53.12
061311 TIPICO (45 X 95 X 1700 MM)	1 día	$255.18	255.18
061311 TIPICO (45 X 95 X 1700 MM)	1 día	$255.18	255.18
063139 DE ENTABLADO (TABLAZON) PAR	5 días	$2,265.12	453.02
063139 DE ENTABLADO (TABLAZON) PAR	2 días	$1,157.73	578.86
063139 DE ENTABLADO (TABLAZON) PAR	4 días	$3,090.04	772.51
063139 DE ENTABLADO (TABLAZON) PAR	4 días	$3,090.04	772.51
061411 Izaje de vigas TIPICAS	2 días	$1,607.64	803.82
052402 HASTA 0,5 TON,LONG HASTA 10 I	1 día	$1,263.18	1263.18
052402 HASTA 0,5 TON,LONG HASTA 10 I	1 día	$1,263.18	1263.18
061411 TIPICAS (45 X 95 MM)	4 días	$6,408.70	1602.17

Figure No. 8. Filter with critical tasks and ordered pending

The Figure No. 8 shows a view with the critical tasks, the duration, the cost and the Slope = Cost / Time ordered ascendingly in the Maintenance / Aerocaribbean project. Master's Thesis. [10]. It is also necessary to analyze the paths very close to the critical where good results can also be obtained.

The theory of restrictions or constraints, buffers, the system of restrictions and customer requirements, provide the necessary elements, for an intelligent resource allocation strategy, making use of the current budgeting system, define a schedule that guarantees obtaining of the project results, with the support of ICT to guarantee an effective management system. The procedure has been applied in the content of master's degrees and maintenance projects prepared by specialists, who participate in the development and attention of the aviation resources at Aerocaribbean

Conclusions

1. In the work, the resource allocation strategy was developed, based on the applications of the critical path and the use of the cost / time slope, in the 4D and 5D dimensions of BIM, in order to guarantee compliance with the directive figures of Basic Engineering and 6D construction preparation, in order to achieve the results, within the time frame, within the budget and with the required quality, by the client and the interested parties, making use of computer tools such as Presto, Preswin or Siecons.

2. The condition of minimum resources originates maximum time for the tasks and in the calculation of the duration of the process, maximum duration is obtained, which generally exceeds the directive duration for construction and therefore it is necessary to incorporate new resources to reduce the duration, following the strategy developed, in order to optimize resources.

3. From the analysis of the aforementioned, it can be deduced that the management of the term is based on a resource allocation strategy in which the critical path, the slope and the analysis of the system, provide practical solutions without cost increases.

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