Abstract

The technique for the representation of the information based on the time chainage diagrams (usually denoted as T.C.D.) is the most common approach, compared to more traditional systems such as networks (P.E.R.T., C.P.M., precedences, etc.) or the Gantt charts, for the development of linear work planning. . Although the use of time chainage diagrams can control small variations in construction works, these diagrams are widely used for the development of linear works.

The development of a software tool that allows planning engineer installations by the use of this technique is a problem that has not been solved yet for general cases. Although there are several commercial software applications that work with time chainage diagrams, all of them show limitations that make their use unfeasible in a general practice setting. Visual 4D Civil Works is a software framework that solves great part of these problems, allowing the user to plan building work designs with the interactive time chainage diagrams and to visualize them by means of 4D techniques.

Keywords: Programming, planning, linear work, civil engineering, time chainage, 4D, virtual reality.

1 Introduction

This paper is one of the contributions of the Strategic Singular Project "Multidimensional City", financed by the Ministry of Education and Science and by the European Regional Development Fund (FEDER).

This research project, with 35 M€ of budget, includes a series of sub-projects, in one of which it takes place the exposition of new tools of planning and linear work programming.

The technique of the time chainage diagrams [1] has been used to world-wide level for the representation of civil engineering plan, generally linear, although also it has application in construction. Nowadays, this technique is considered as an alternative to others practices such as the network representations (P.E.R.T, C.P.M., dependences, etc...) or the bar charts. In addition, this technique fits correctly with

representations originally used to handle earthmoving problems, such as the mass diagrams [2].

The development of a software tool that allows planning engineer installations with the use of this technique is a problem that has not been solved for general cases. In this sense, despite several commercial programs work with time chainage diagrams, all of them show some limitations, which make their use unfeasible in most of building work designs [3].

For this reason, the challenge is the creation of a software application, denoted as Visual 4D Civil Works, that is able to solve, at least partially, those existing limitations presented in other commercial programs, which currently limit the generalized use of these tools for the accomplishment of work planning by means of the technique of time chainage diagrams.

Besides building work design, Visual 4D Civil Works allows performing representations of the Civil Work programs in 4D, offering three-dimensional visualization in real time. This feature allows maintaining different building work plans for the same construction site offering different alternatives from the planning to the execution, based on the advantages included into the techniques based on 4D representations and the Virtual Reality [4, 5].

In the field of the 4D representation, several approaches have been presented to assign the 3D models included in a virtual representation of a building to the task incorporated in the design of the building work project. However, the construction presented in the field of Civil Engineering included not only static work units, but also dynamic units, which geometry varies with the plan of the work. An embankment or a clearing unit could be considered as an example for this type of behavior. In this case, the 4D visualization is much more complex and it is not totally solved either by other commercial programs. Visual 4D Civil Works approaches this problem with the implementation of a model editor oriented to dynamic units.

As a conclusion, we have developed a software tool that plans, programs and performs visualizations based on 4D strategies in real-time, all related to civil engineering.

2 Objectives of the research.

The research pursues a global objective related to the creation of a software application (denoted as Visual 4D Civil Works), that in particular, it is translated in two concrete objectives:

I. On the one hand, the creation of a planning module and work programming in the scope of civil engineering by means of the use of the technique of the interactive time chainage diagrams.
II. On the other hand, a module of representation in 4D of the building work plans performed with the previous module.

Nowadays, most of companies use computer programs such as Microsoft Project, or Primavera Project Planner, where the Gantt charts are included as the main method for representing organized tasks in the composition of building work designs.

Within the present research project, in a first instance it has been used as a reference and therefore, as a starting point, the export of data from MS Project software for the representation of the chainage time diagrams in the Visual 4D Civil Works and from this one, in an interactive way, to redesign different alternatives from work programs that are considered opportune.

Concerning the second objective (the three-dimensional visualization in real time (4D), this module must allow to handle different plans from the same construction site. This strategy offers a more visual approach for the development of building work designs, as well as a more intuitive mechanism to represent different alternatives from planning to execution, that are when 4D methodologies and Virtual Reality technologies are combined.

In conclusion, the final mission is to obtaini a tool that plans, programs and performs visualizations in 4D, all this applied to civil engineering.

3 Operational methodology

3.1 A general approach to obtain T.C.D.

Starting from the base of an initial work program generated by project management tools such as Microsoft Project or Primavera Project Planner, using the traditional Gantt chart, the systematic operation that sets out for the obtaining of a T.C.D.is the shown in Figure 1.

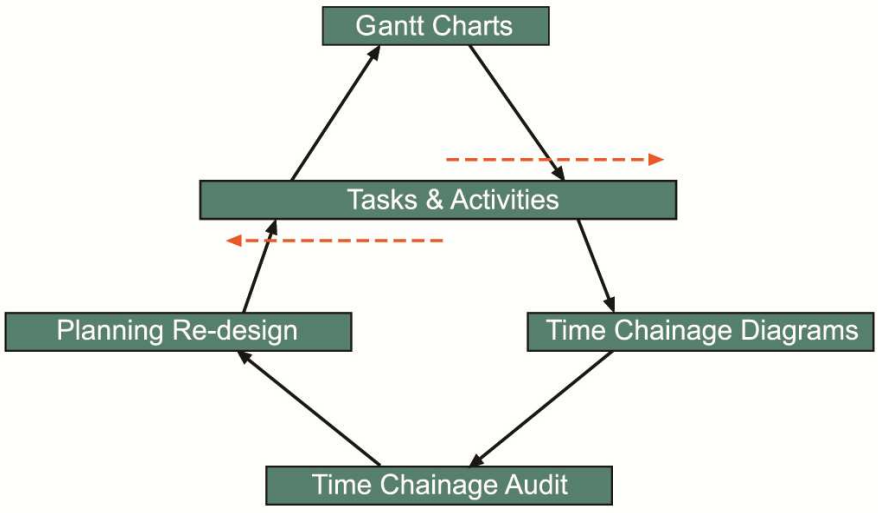

Figure 1: Operational systematic in the work programming by means of T.C.D.

This it is the conceptual scheme on which the tool Visual 4D Civil Works is based with the planning module/programming by means of the technique of the time chainage diagrams.

3.2 Problematic in T.C.D. - MS Project.

From all the steps shown in Figure 1, the one that deserves to be analyzed with greater depth due to its complexity is the passage of tasks to activities and vice versa.

Generally, the tasks are each one of the detached work units in the MS Project. When moderately complex engineer installations treat, the great amount of tasks makes its immediate representation nonviable on a T.C.D., reason why a previous work of grouping several similar tasks in a few activities is necessary, of coherent form with the aim of obtaining possible intuitive the most versatile T.C.D. and, without losing the global representativeness of the work.When the inverse step is realized, that is to say, the transformation of activities to tasks once has been performed a reprogramming by means of the technique of the T.C.D.exist two problems, basically:

- Affection to other activities.
- Affection to other tasks within the own activity.

When the manipulation of an interactive T.C.D.with the aim of varying the initial work programming is realized carried from MS Project, to the salary represented in the T.C.D.activities and nontasks, evidently, due to the existing relations of precedence, it is incurred of direct form an affection to the preceding and consequent activities. Figures 2 and 3 are shown.The Figure 2.a has an example of T.C.D.of a work in which three located activities in three sections different from the plan exist (A.1., A.2 and A.3., respectively). Also are the precedence relations that obey, the times of beginning and conclusion of each activity, the kilometric points initial and final of the same as well as waited for time of execution of a.2 activity that is the used one of reference for the explanation.

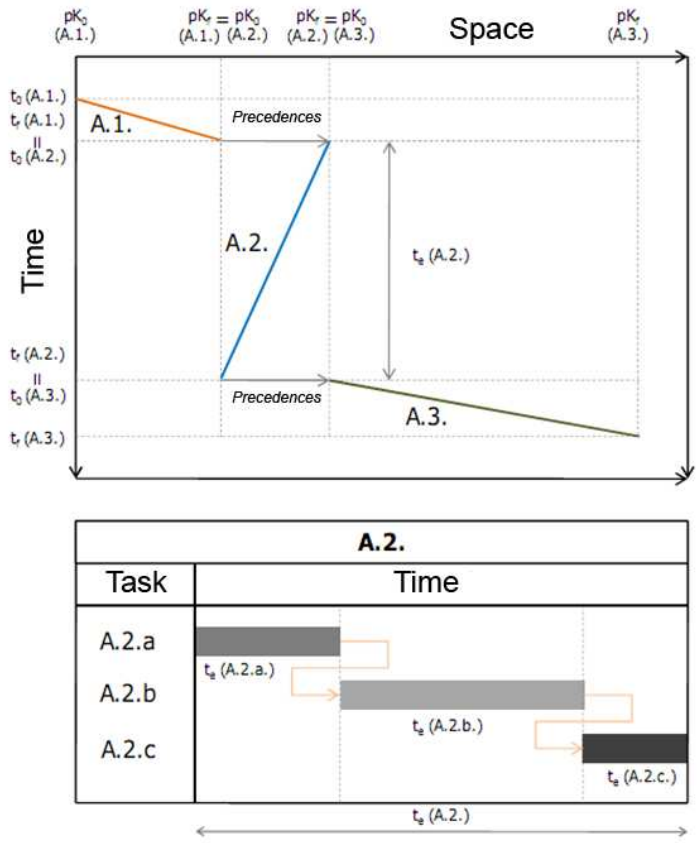

Figure 2.a: Illustrative example of the departure situation of a work program in T.C.D.

Figure 2.b: Representation in bar chart of the tasks that conform a.2 activity.

As Figure 3.a shows if the time waited for the execution of the activity is varied (it goes of A.2 to A.2'.), it is clear that the consequent activity, in this case, undergoes an alteration. A possible solution is the indicated one in this figure and consists of moving a.3 activity until the position of A.3'., without varying the duration of the same. Perhaps in some case this solution is not feasible, but what it is clear it is the affection that occurs by the mere fact to modify A.2 activity.

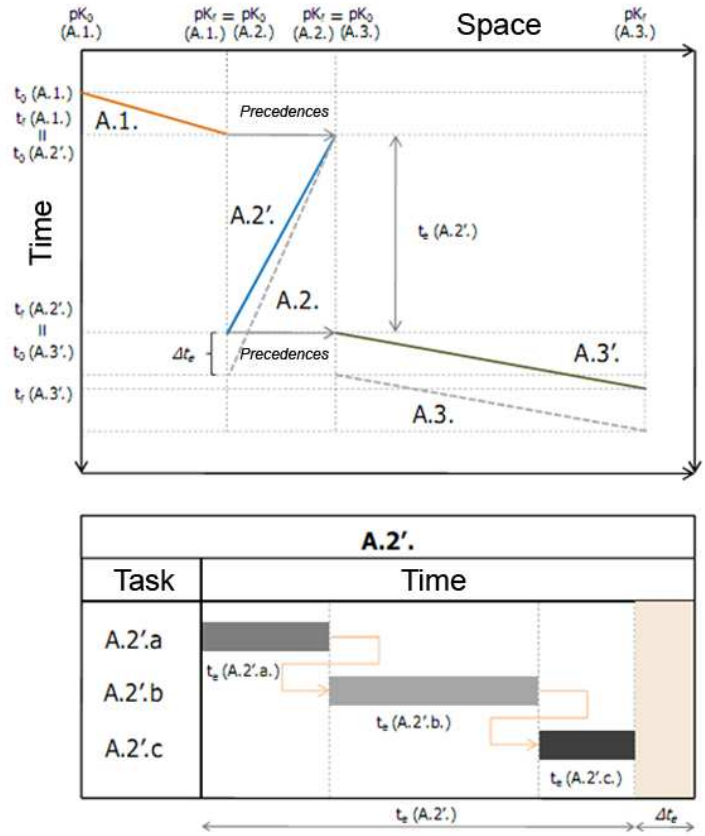

Figure 3.a: Affection of the modifications of a T.C.D.to other located activities in another section.

Figure 3.b: Affection of the modifications to the tasks grouped in an activity.

In the same way, as each activity can have associate several tasks (of that the grouping consists), the modification of any activity located in a determined section of the plan of a linear work, implies an affection of internal character to the own tasks that conform that activity in particular. This circumstance is show in the figures 2.b and 3.b.

In the Figure 2.b imagines of sample form in bar chart, the three tasks (A.2.a, A.2.b and A.2.c) grouped within a.2 activity. Here the departure situation is had, where each task is characterized by its duration, that altogether they give rise awaited at the same time of a.2 activity, shown previously in the figure 2.a.

When realizing the modification of a.2 task, that since it has been indicated, gives rise to a.2', also an internal affection to the own tasks exists that group in the activity object of study. In the figure 3.b is the solution adopted in the example, consisting of a diminution of the waited for times of the tasks, giving rise to new ones (A.2' .a, A.2' .b and A.2' .c), of such form that the sum of the times hoped of execution of each of them, computes the same hope time that is reflected in the figure 3.a., called te (2.A'.).

In principle, no commercial program solves this situation, being the most common omission of the grouping process. The objective is that Visual 4D Civil Works solves these two affections.

3.3 Problematic of 4D.

For the generation of the simulations 4D, which becomes is to assign to models 3D of certain constructive elements to the selected work activities [6].

When one is construction is a more or less trivial problem that in any case is solved by several commercial programs [7]. This is because it is static models, that is to say, they do not have to adapt to any drawing up that it can imply a curvilinear route. This is indeed the problematic existing when it is linear works, like a highway, railroad, etc., always exists drawing up curvilinear, as much in plant as in cash settlement. The simulated 3D models throughout this plan cannot be static because we would have interferences in the connections between models, existing overlap and emptiness's. For this reason, and in order to give solution to this problem, Visual 4D Civil Works introduce the concept of dynamic model. Dynamic models are objects that are generated from a cross-sectional section, which geometry adapts to drawn up a tax, rectilinear and curvilinear.

For the generation of dynamic models, an auxiliary module is due to program call Extruder that is an editor of sections, which in turns allows defining the cash settlement and plants of the linear work.

3.4 Description of the program.

The application Visual 4D Civil Works is a program designed in surroundings Windows, conceived for the work programming by means of the use of the technique of the T.C.D., previous feeding of bar charts created from MS Project.
Of complementary, form Visual 4D Civil Works allows to previously design work simulations in 4D of the different established alternatives of programming.
No one of the commercial programs solves directly and/or satisfactory some of the following phases:

- Export the data of planning from MS Project. Some program allows this export, although, at the time of the truth turns out more laborious to adapt the MS Project to the exigencies of the software, that to make a bar chart from zero in the application of space-time. This circumstance that the planning engineer is obstinate to use these tools, to the detriment of the MS Project or for Primavera has been taking using all the life.
- Redesign of the programming within the time chainage diagrams. Most of the programs do not allow to vary the activities represented in the diagram of interactive form, that is to say, being dragged on the own time chainage diagrams. The majority of the re-planning processes happen to modify the bar chart and to return to concern the data to generate the time chainage diagrams again. In the best one of the cases, the direct variation of the activities gives rise to consequent adjustments in the Gantt, although no program solves the conflict when activities are had that include several tasks.

One of the advantages that present/display all these programs, is the options of representation and print of the diagrams. This circumstance supposes an advance with respect to the systems manuals of generation of plannings with space-time. However,

nowadays, the lack of total interconnectivity between classic tools of planning (MS Project, Primavera, etc.) and the software of space-time, cause the use of these programs are far from been generalized.

For this reason, Visual 4D Civil Works is outlined like an alternative that tries to provide a solution to:

- Facility of import of data from MS Project.
- Representation of time chainage diagrams.
- Planning on the time chainage diagrams.
- Redesign and interactivity of the time chainage diagrams.
- Adjustment of the bar chart according to the modifications of the time chainage diagrams.
- Design and model-making of impression formats.
  Standardized formats, based on labelling language type XML, for the representation of the information 4D.

The program Visual 4D Civil Works is constituted by a series of basic modules represented in Figure 4:

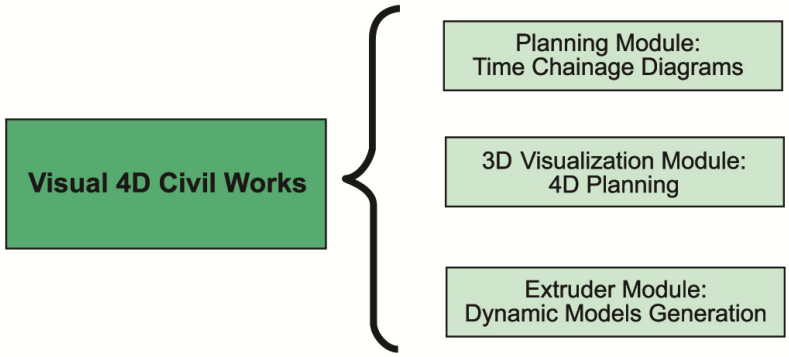

Figure 4: Line of Visual 4D Civil Works. Modules of the program

4 Conclusions

In the present paper the basic concepts for the development of a planning software, specifically oriented to linear work programming in civil engineering, have been defined work programming in civil engineering, describing of brief form the potential of the method of the T.C.D., the goal pursued in the research project, as well as the operational methodology that is to follow themselves for the final attainment of these objectives.

Within this last point is where there are detailed of deeper form the problematic mysteries and at the moment not solved in the technical scope of programming of software, doing special emphasis in the passage of activities of the T.C.D.to tasks of the bar chart of MS Project, as well as the necessity of dynamic objects for the simulations 4D. All these specifications of technical character are those that are used for the development of Visual 4D Civil Works.

5 Acknowledgements

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