APPLICATION OF EVALUATION LINES IN THE ANALYSIS OF TIME-TYPE DATA OF PROJECT PLANS

Orsolya Bokor[1], Gabriella Szenik and Tamás Kocsis

Department of Construction Management, Szent István University, Ybl Miklós Faculty of Architecture and Civil Engineering, Budapest, Hungary.

The Gantt chart is the most commonly used way of displaying a project plan. Its original purpose is to show how the tasks are placed in time and the logical relationships between them. When making the project plan, one problem often arises, that the plan could be hard to comprehend. In case of megaprojects consisting of thousands of activities and even more logical dependencies, it is almost impossible to detect the planning mistakes. The development of the project management software allows the handling of not only the basic parameters of the project but much more data concerning the planning and the tracking as well. In case of hundreds or thousands of activities, the evaluation and presentation of these data is a very time-consuming task.In this paper, a new method is introduced that has been developed based on the generalization of the progress lines. It is called the system of evaluation lines. With the help of this system, quick and effective evaluation of the project plan is possible. Hundreds of evaluation lines can be defined, which are suitable for the visual display of data concerning activities and costs. These can then be grouped, so that the information related to planning and tracking can be managed separately. In addition, the differences between the plan versions can be pointed out as well. The paper presents that set of evaluation lines that could be used for the analysis of time-type data.

Keywords: construction planning, evaluation lines, network analysis, project management.

HISTORICAL OVERVIEW

The history of project planning dates back to probably centuries or millennia even. Despite the fact that Vitruvius complained about the problems that arose due to improper cost planning (Vitruvius, 24 BC?), standardized techniques only appeared in the beginning of the last century, mainly due to the work of Gantt and Adamiecki (Gantt, 1903).

Adamiecki invented the harmonogram in 1896. Every activity was represented by a paper strip with a vertical timescale. The most important task data – e.g. ID, duration, predecessors – could be found in the header. Owing to the fact that this technique preserved the logical dependencies between the activities, it could be considered the forerunner of today's modern network planning techniques. In addition, from a displaying point of view, it could be seen as the ancestor of the "logic Gantt" used today. Due to the fact that Adamiecki applied this method before Henry Gantt (1903) (1919) first created the Gantt chart, the harmonogram could be regarded as the forerunner of today's Gantt chart as well.

[1] bokor.orsolya@ybl.szie.hu

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The harmonogram was also a graphic method of calculation. The tasks had to be ordered from left to right in the following way: the predecessors of the given activity had to be to its left. The clips representing the progression of the activity had to be placed after the bottom most of the predecessors. This is basically the forward pass of the time analysis of a CPM network.

Adamiecki also elaborated a sophisticated method for the tracking of the tasks, which allowed the recording of the progression data and a simple evaluation.

The modern history of the project planning approaches dates back to the late fifties of the previous century, when the techniques that are currently used were developed. Among these the most important ones are the CPM (Critical Path Method) that was a cost optimization method originally (Kelley and Walker, 1959) (Kelley and Walker, 1961) (Kelley and Walker, 1989), the stochastic PERT (Program Evaluation and Review Technique) (Malcolm *et al.*, 1958) and the MPM technique (Roy, 1959; Roy, 1962) that was developed as the forerunner of today's PDM (Precedence Diagraming Method). In case of the latter, all kinds of logical dependencies, even maximal-type precedence relationships, are allowed. John Fondahl's (1961) name should also be mentioned, who suggested that activity-on-node networks should substitute the activity-on-edge display of CPM networks. The common feature of the techniques used today is that the applied models are capable of storing the logical dependencies between the activities, thus making the updating and rescheduling quick.

The fast development of the mathematical models has not been followed by the development of the graphic displaying methods. The Gantt chart and its variations (showing the precedence relationships, floats) are the most widespread visualization tools of project plans even today. In case of huge plans, where the whole plan should be overviewed and all relations should be detected quickly, display of only the bars representing the tasks is insufficient. Progress lines are – for example – great tools for following the progression of the project. This gave the idea for extending and applying the method of progress lines to show the connection between the time and cost of the planning and realization. The developed method in general is called evaluation lines, which has been introduced by Hajdu (2010). The progress line, which can be found in project management applications, is just one member of the large family of evaluation lines.

SYSTEM OF EVALUATION LINES

Owing to the development of the project planning software, more and more data related to the activities can be managed. Reviewing and comprehending these is a very time-consuming task that requires close attention. When creating the system of evaluation lines, the Gantt chart and the method of progress lines served as a basis to work out a system that is fitted for the display of project data. In the course of our work, projects with several hundred, occasionally a thousand activities and budget items were used to create the system of the aspects that should be considered during the evaluation. Our goal is to establish a method that can be applied by any user with average project management knowledge in order to draw the right conclusions from the evaluation of their project plans.

Evaluation lines are applied to show the connection between the time and cost data of activities. An evaluation line is basically a polyline that should be read from top to bottom and is broken at each task. (Hajdu, 2010)

The system of evaluation lines can be used for the analysis of the time and cost data of our projects both in the planning and in the realization phases.

Our research can be divided into three different stages. Currently, we are at the first phase, which consists of determining of the system of evaluation lines and grouping these. Evaluation lines are defined and interpreted; their possible practical significance is analyzed. In the second phase real-life projects are going to be fully evaluated based on this system, while in the third one conclusions are going to be drawn. Evaluation lines can be divided into two main groups. They are suitable for analyzing time-type and cost-type data. These can be further broken down into subgroups.

Time-type data:

- Analysis of the feasibility of activities
- Showing the shortcomings of planning
- Revealing other shortcomings
- Showing the delay of the actual starts
- Reports based on survey data
- Showing the differences between plan versions

Cost-type data:

- Showing the connection between the budgeted costs of activities
- Cost analysis based on survey data
- Showing the differences in cost between plan versions

Due to the fact that the constraints of this paper do not allow the description of the entire family of evaluation lines, the introduction is restricted to the ones that are used for evaluating time-type data. An example for each type is shown as well.

MANAGEMENT OF TIME-TYPE DATA

Many conclusions can be drawn about the project from the time data calculated during scheduling. In the course of our work, the following time-type pieces of information were used:

- Start and finish: the date of the scheduled start and finish of the activities.
- Early start and early finish: the date of the earliest possible start and finish of activities, if the project duration cannot change.
- Late start and late finish: the date of the latest possible start and finish of the activities, if the project duration cannot change.
- Updated start and finish: the date of the actual start and finish of the tasks that have been finished or are in progress.
- Date of update: the date of the survey of the activities.
- Date of percent of completion: the date of the state according to the current percent of completion based on the activity’s percent of completion and the date of update.
- Date data of baseline plan: date data valid at an earlier plan version.

Regarding the fact that current project planning programs have certain functions that can be used for the analysis of the time-type data, the examples below are such that can be demonstrated in network view by the already existing applications. Obviously, in order for the system to work properly, the programs should be developed. However,

the functions necessary for examining cost-type data cannot be found in the project planning applications that we know of. Consequently, certain improvements are required in this field as well.

All of the following figures were made with the same project management software called ProJack the Manager 2010, which is a 100 % Hungarian developed program.

APPLICATION OF EVALUATION LINES

When analyzing time-type data, different conclusions can be drawn in each phase of the project.

Analysis of the Feasibility of Activities

During the course of this analysis, the start and finish – within the time provided - of the given activity is determined. The relations of early, scheduled and late start and finish dates are investigated. Three evaluation lines are displayed on Figure 1:

- the early starts of the activities are connected by a blue,
- the scheduled starts by a red,
- and the late starts by a green line.

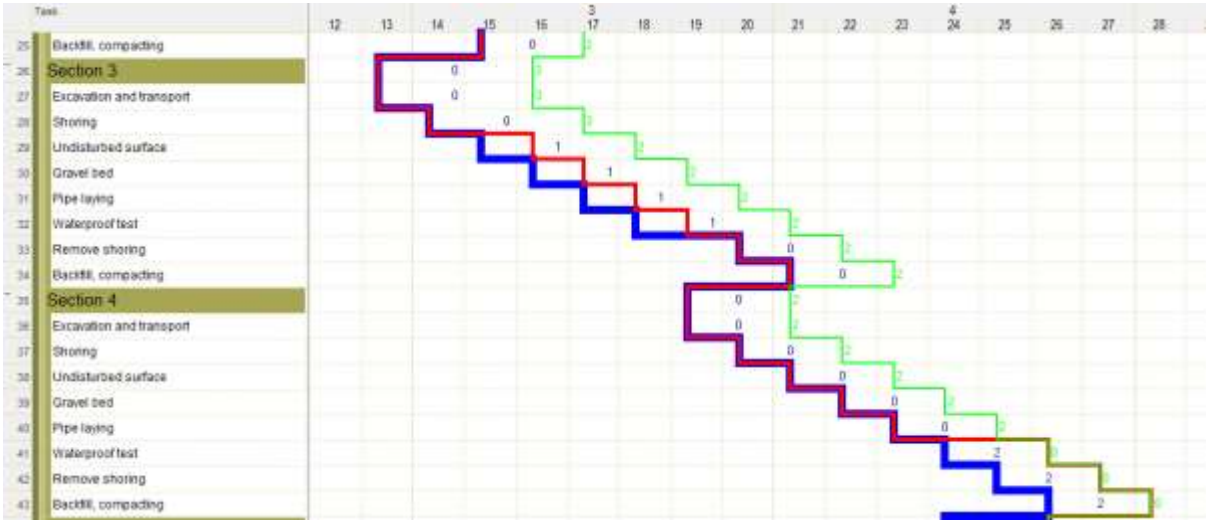

Figure 1. Early, scheduled and late starts

There are two numbers next to each activity: the blue one is the difference between the scheduled and the early start, the green one is the difference between the late and the scheduled start. Those activities where the blue and red lines concur are critical; the floats are zero. The other tasks are non-critical, meaning that they could start earlier or later by some days keeping the project duration intact; the exact number of days is shown on the figure.

Showing the Shortcomings of Planning

The shortcomings of planning are usually due to the fact that an insufficient number of or inadequate types of logical dependencies have been defined. Conclusions can be drawn based on the investigation of the scheduled, early and late dates. Two evaluation lines have been defined on Figure 2:

- the red, continuous line marks the early finishes of the activities,
- the green, dashed line connects the late finishes of the activities.

With the help of these lines, we can see when the individual tasks can be performed within the given project duration.

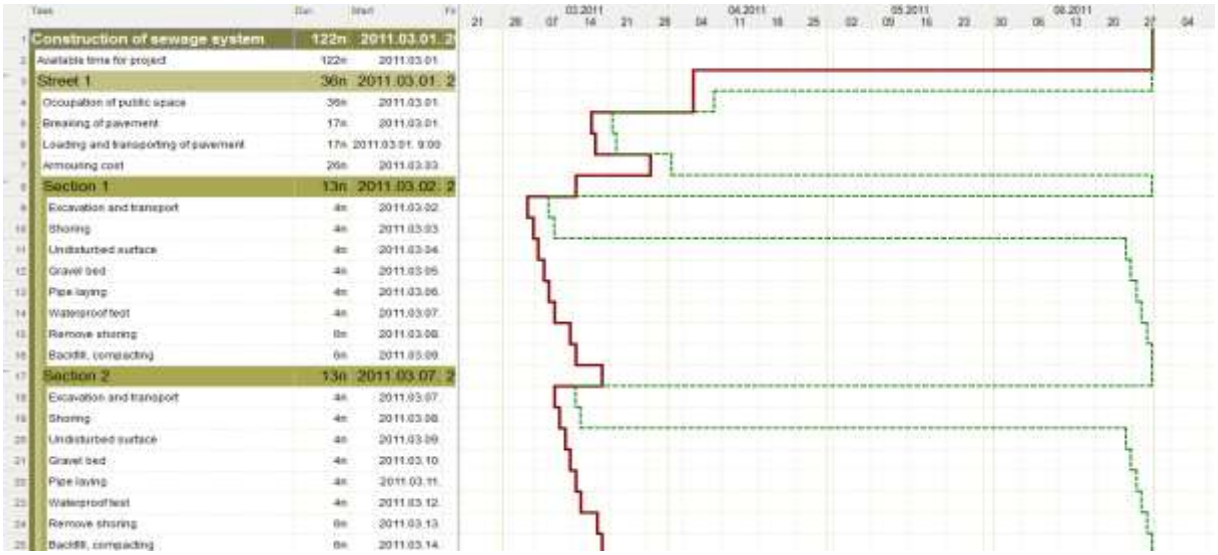

Figure 2. Early and Late Finishes

Too great difference between the early and late finishes can indicate inadequate planning. Figure 2 shows that most of the tasks can be performed almost anytime within the project duration. In cases like this, it is worth investigating the logical dependencies between those activities and their successors. In this instance, only the activities of each section have been linked to one another and the 'excavations' and the 'shoring' and 'remove shoring' of different sections. However, this is not enough. Further relationships should be defined. Those tasks that can only be realized after each other but are in different section should also be linked. For example, there ought to be a Finish-to-Start task dependency defined between the pipe laying of section 1 and 2. Figure 3 shows the result of the corrections. This way the late finishes of the activities have got closer to the early finishes. It can be concluded now based on the evaluation lines that there are not any shortcomings of planning resulting from an insufficient number of task dependencies.

Figure 3. Early and Late Finishes after Modifications

Revealing Other Shortcomings

Deficiencies or mistakes can not only appear in the planning phase of the project, but later, during the updating process as well. A usual fault is that when the logical relationships of the given activity are not taken into account, are not modified accordingly, thus they become insatiable. In these cases, the free float of the given task takes up a negative value because the early finish is set to a later date than the late finish. It can be seen that the pair of evaluation lines defined for the early and late finishes is not only suitable for showing the shortcomings in planning. On Figure 4 two evaluation lines can be seen:

- continuous blue marks the early finishes,
- while the late finishes are connected by the dashed, green line.

The mistakes of updating can be easily filtered by looking at the early and late finishes, if the latter precedes the former, some amendments are due.

Figure 4. Early and Late Finishes

On Figure 4, it is clear that a problem occurred during the updating of the task indicated by the red ellipse.

Showing the Delay of the Actual Starts

Tracking provides a real picture of the project compared to the original schedule. By using these data, it can be determined which activities are delayed and which ones started earlier than scheduled. The evaluation lines displayed on Figure 5 show the starts according to the baseline plan saved before updating and the actual starts given during tracking:

- continuous blue line depicts the starts according to the baseline plan,
- while dashed green line connects the actual starts of the activities.

The figure reveals that the first two sections were constructed as scheduled, but from the beginning of the third section, for some reason, the activities started later than planned.

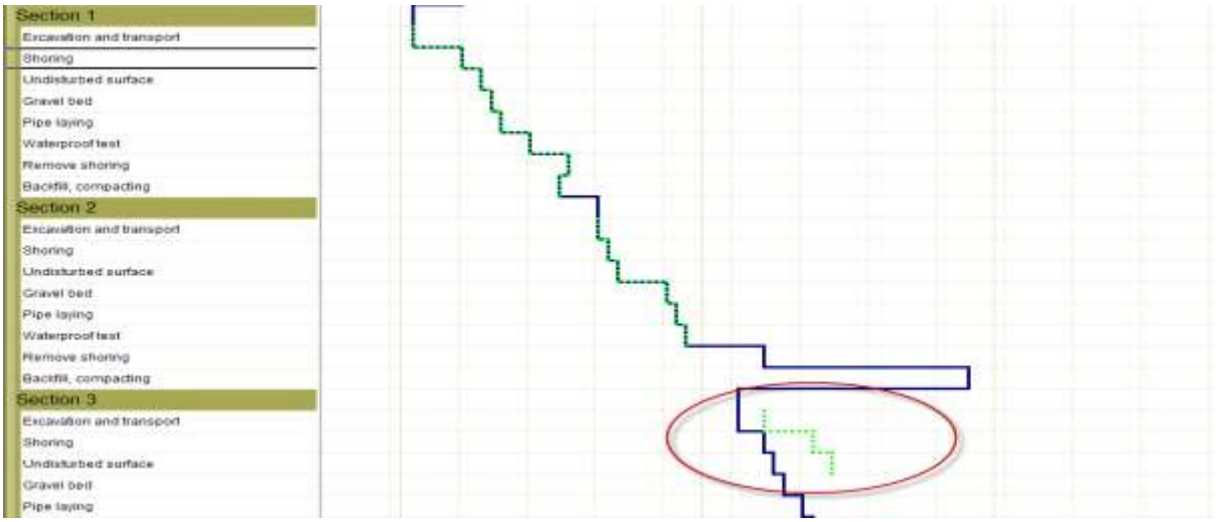

Figure 5. Baseline and Actual Starts

Reports Based on Survey Data

When making a survey, an actual picture of the project can be obtained contrasting to the schedule. It is expedient to examine how each task is progressing in comparison with what was scheduled before. Two evaluation lines have been defined on Figure 6:

- the green, dashed line marks the date of updating,
- the red, continuous one connects the date of percent of completion.

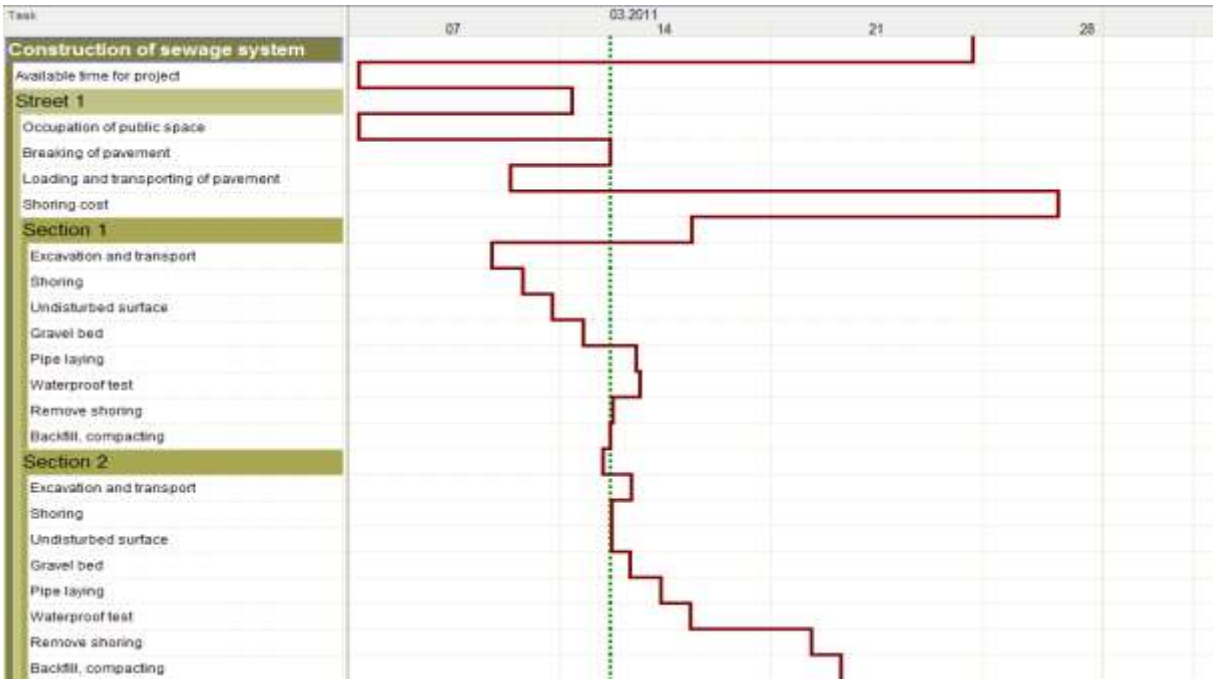

Figure 6. Date of Update and Percent of Completion

With the help of these two data, we are able to determine which activities are ahead of schedule and which one are lagging behind:

- if the date of the percent of completion is to the right of the date of update, the percent of completion is greater than scheduled; the task is ahead of schedule,

- if it is to the left, the percent of completion is less than scheduled; the task is lagging.

It has to be noted, in order for the figure to be understood, that the date of percent of completion can only be defined in case of tasks that have already started at the date of update. However, in order for the whole project to be analyzable, it should be assumed that the update of the project has occurred. Based on this, it can be premised that there are not any tasks with zero percent of completion whose scheduled start is before the date of update. In case of activities whose percent of completion is zero percent at the date of update are displayed with their scheduled starts.

Showing the Differences between Plan Versions

In the lifetime of the project, many plan versions are produced. After the project plan is approved, it is worth saving the initial state as a so-called baseline plan. Moreover, it is wise to create another baseline plan, which will store the data of the actual state, after every update or before every plan modification. Therefore the difference between the plan versions can be shown in every phase of the project. The two evaluation lines defined on Figure 7 show these differences:

- the original starts (according to the baseline plan) are marked by the continuous green line, the finishes by the dashed green one,
- the starts that have been modified after the update are connected by a continuous, the finishes by a dashed red line.

By displaying the data of the baseline and the actual plan, we can demonstrate how the actual plan is doing in contrast with the original version. In case of those activities where the actual finish is after the baseline finish, we can state that there is a delay compared to the baseline plan.

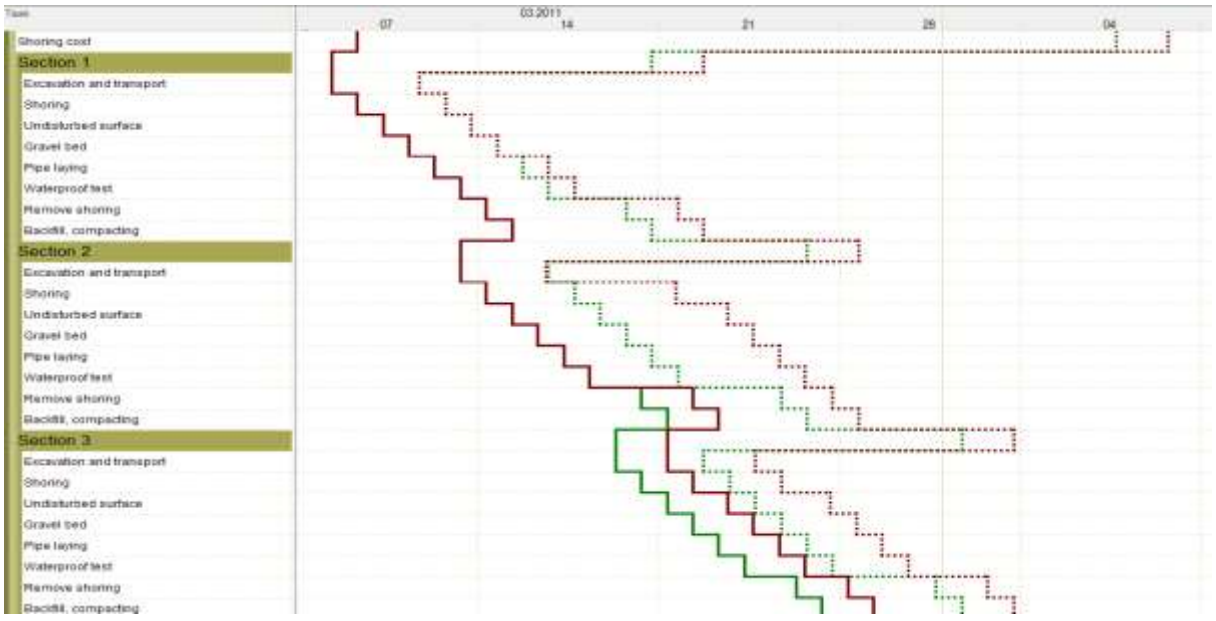

Figure 7. Baseline and Updated Data

CONCLUSIONS

When creating the system of evaluation lines, the main goal was to develop a visualization tool that helps to detect the shortcomings of the project plan at just one glance in both the planning and tracking phases. Earlier the analysis of these data could only be done by comparing huge and complex tables. In all cases, the applied

project planning software was able to make these analyses. With the help of the evaluation lines, the project can be analyzed according to many different aspects in the project planning application.

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