# The Establishment of a Tourism Information System by Theory of Constraint (TOC)

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**Keywords:** Geographic Information System (GIS), Tourism Information System (TIS), Gantt Diagrams, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT), Theory of Constraint (TOC).

## SUMMARY

Tourism Information System (TIS) is one of the fields of the Geographic Information System (GIS) useful for the tourism organization. This system is used for the management of tourism activities and decision-making for the future.

This study we are insisted sample prototype based on Internet and supporting GIS-Multimedia database infrastructure progressing tourism regions planning procedure to municipality's structure to knowledge tourists less than 100 000 people in Turkey. We are aimed to establish TIS in municipality's structure. We compare Gantt, CPM, PERT and TOC procedure to aim establishing TIS and we point out advantages and disadvantages to planning procedure.

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## 1 INTRODUCTION

TIS are, as its name implies, one of the application fields of GIS. Generally, tourist regions are facing more management service problems in high season because of increasing populations. Sometimes it doubles or, occasionally, increases tenfold. In this situation, the first aim of TIS is constitution of effective management services.

The first duty of the TIS is serving knowledge to tourists on time and impressively. So, if tourists went to anywhere, they could get required data about the environment quickly and correct (Erdogan & Tiryakioglu, 2006).

Studies on the development of project planning and programming techniques have been around since 1950. In this area, the main methods are GANTT diagrams, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT) and Theory of Constraint (TOC). In these methods, critical path and critical duration can be found by total activity durations. Project planning techniques help managers to anticipate planned and unexpected period deviation and effects in the future. In this study we have taken the TOC method and compared it with other methods.

## 2 PLANNING METHODS

### 2.1 Gantt Diagrams

In this method, the possible shortest duration is chosen by diagrams which show more than one activity and process by definite elements. Because of the first usage of this method by Henry Laurence Gantt, this method's name is GANTT diagrams (Biyik & Tudes, 2001).

### 2.2 CPM

The CPM, worked out at the beginning of the 1960s (see Goldratt, 1997), has become one of the tools that are most useful in practice and are applied in the planning and control of the realization of complex projects (Chanas & Zielinski, 2001). CPM was the results of a joint effort to develop a procedure for scheduling maintenance shutdowns in chemical processing plants (Kutlu, 2001). First of all it consists in the identification of the so-called critical paths, critical activities and critical events in the network, which is the Project model, assuming the earliest possible completion time of the whole project. By chance certain values useful for the decision maker such as: events and activities slacks, the earliest and the latest moments of the start and finish of the particular activities, etc., are calculated (Chanas & Zielinski, 2001). CPM allows for the traditional critical path analysis in deterministic activity-on-the-arc project networks, and also allows for the formal analysis of the linear time/cost trade-offs assuming a linear direct activity cost function and unlimited availability of resources. Neither of these is a 'scheduling' procedure (Elmaghraby et al., 2003).

## 2.3 PERT Method

In its historical process, Gantt usage is foundation of PERT. So, it can be said that PERT is more developed form of Gantt (Kafarov & Cabuk, 2000). PERT makes no claim to cope with resource usage or activity scheduling. Activity durations are modelled as stochastic variables with an appropriate beta distribution, and a simple approximate method is used to calculate the expectation and the variance of the network event times (Elmaghraby et al., 2003). Generally the duration is taken to be one week but it can be changed from project to project. Estimation of duration will be fourfold: the shortest optimistic estimate (a), the longest pessimistic estimate (b), the most probable duration, which is between (a) and (b) is (m). Time estimation for all activities must be between a and b, and m may not be equal (a+b)/2. It may get a value left or right of m value. Because of this feature beta distribution is used in estimation of duration. After this three-duration estimation, weight average is used as formula 1; t is an expected duration.

$$t = (a+4*m+b) / 6 \qquad (1)$$

## 2.4 Theory of Constraint

The theory of constraint (TOC) proposed by Dr. Goldratt emphasizes on the systematic management of project by discovering the uncertain factors hindering the project implementation, and suggests the global deployment of resources (see Kelley, 1961; Goldratt, 1986). The concept of thinking globally and acting locally recommends the use of the global safety time and the reduction of the activity duration. However, a practical method to reduce the activity time and exert the management control remains nonexistent. The critical chain (see Lee, 1997) coupled with the Project buffer and the activity buffer incurs several problems that need to be clarified (Steyn, 2000).

TOC uses the global safety time to schedule the project, and stresses that a system must have a constraint. Otherwise, its output would increase without the upper bound. Thus, TOC project management focuses on the constraint that blocks the achievement of goal of the project. Five steps used to apply the TOC skill to the project scheduling is given below (see Gardiner & Blackstone, 1998; Steyn, 2000; Esen et al., 2007).

1. Identify the project constraint.
2. Exploit the project constraint.
3. Subordinate everything else to the project constraint.
4. Elevate the project constraint, and
5. If, in the previous step, a new constraint has been uncovered, repeat the process. Do not let inertia become the project constraint (Steyn, 2000; Mahdi, 2004).

The TOC approach applies the principle for aggregation to project schedule risks: contingency reserves for individual activities are reduced so that activity durations are realistic but challenging. The provision for contingencies that are removed from the individual (lower-level) activity durations are replaced by a contingency reserve or "buffer" at project level. As a result of the effect of aggregation this buffer is smaller than the sum of the individual reserves that have been removed from low-level activities. Thus project duration is reduced. The higher the number of activities on the critical path of a project, the more project duration can be reduced. The TOC approach changes the way we think about project scheduling. A major problem when implementing the TOC project management approach is that it implies a paradigm that is radically different from the prevailing one. It would, however, be unrealistic to expect improvement without change and change invariably leads to resistance (Ozdamar & Ulusoy, 1994). The critical chain approach, provides a powerful basis for raising the criticality and performance of procurement (Steyn, 2002). The TOC time management technique (critical chain scheduling) has been extended to allocate resources to multiple projects that share common resources (Rand, 2000).

### 2.4.1 Implementation Procedures

Step 1. Determine the critical path and project length ($T_1$) without considering the resource constraint, and obtain the critical chain and project length ($T_2$) using heuristics when the resources are limited.
Step 2. Compute the duration cut ratio (C.R.= $T_1/T_2$), where $T_1/T_2 \leq 1$ and modify the critical chain when no other resource utilization alternatives are feasible.
Step 3. Use the strategic project flexible coefficient ($k_p$) and the practical activity flexible coefficient ($k_A^m$) to modify the revised critical chain (R.C.C.). The project flexible coefficient allows the management to rectify the project length by considering the strategic factors, such as market pressure, delay penalty, etc., while the activity flexible coefficient enables the project leader to control the activity by means of its unique feature by using strict, moderate and loss means.
(a) If resource constraint results from strategic factors, for example, equipment is too expensive to be purchased, the management may decide not to procure this machinery, etc. The project flexibility coefficient can now be applied to revise the critical chain.

$$\mathbf{R.C.C_{(p)} = TFIN + k_p} \qquad \mathbf{(2)}$$

where TFIN is the original project length, and $k_p$ is the adjusted time, $k_p>0$ denotes that the management decides to lengthen the project after considering all strategic factors. The following inequality must, however, be maintained.

$$\textbf{If } k_p > 0,\ T_1 < TFIN + k_p \leq T_2 \qquad \mathbf{(3)}$$

If $k_p<0$, meaning that the management decides to shorten the project length using means, such as the purchasing of additional equipment and recruitment of workers. In this case, the following inequality shall hold,

$$\textbf{If } k_p<0,\ 0< TFIN + k_p \leq T_1 \qquad \mathbf{(4)}$$

(b) The activity duration can also be adjusted by the project leader based on project features, but the project length of the modified critical chain should not be exceeded. The activity flexibility coefficient can only be applied to the activities associated with resource constraint on the critical chain. Given the activity flexibility coefficient, the project length ($R.C.C_{(A)}$) can be expressed as given below in Eq. (4) (Wei et al., 2002).

## 3. EVALUATION OF PROJECT PLANNING METHODS

### 3. 1 Description of Project Area

In this study, as mentioned above, a tourist area with fewer than 100 000 population is studied for establishing TIS by TOC, Gantt, CPM-PERT. 55 weeks are accepted as a total duration for the TIS.

### 3. 2 Main Activities and Estimation of Durations

TIS project activities are similar to City Information Systems (CIS) at the point of process. Durations in these projects are determined approximately (Table 1).

**Table 1** Activity Durations and relations between them

| Activity number | Duration | Name of activity | Symbols | Proceeding activity | Gathered | Following activity |
|---|---|---|---|---|---|---|
| 1 | 3 | Taking decision | A | | | B |
| 2 | 3 | Technical Research | B | A | | C |
| 3 | 3 | Form of studying unit | C | B | | D |
| 4 | 3 | Software research | D | C | | E |
| 5 | 3 | Buying software | E | D | F | F |
| 6 | 4 | Education | F | E | E, G | G |
| 7 | 8 | Collecting of data | G | F | F, H | H |
| 8 | 4 | Establish Photographs and image bank | H | G | G, I | I |
| 9 | 8 | Preparing of related data for query | I | H | H, J | J |
| 10 | 4 | Preparing intelligent maps | J | K | I, K | K |
| 11 | 4 | Design of query kiosks | K | J | J, L | L |
| 12 | 4 | Establishment os system | L | K | K, M | M |
| 13 | 4 | Submit of system and update. | M | L | L, M | |
| | 55 Weeks | | | | | |

### 3. 3 Application

After designation the durations and relationship between them are seen (Table 1). Critical path has been found of 45 weeks by CPM and Gantt.
Table 2 shows trio durations and expected durations for each activity.

**Table 2** Estimation of trio duration, expected durations (duration=week)

| Activities | The most optimistic durations (a) | The most probable durations (m) | The most pessimistic durations (b) | Expected durations (t) |
|---|---|---|---|---|
| A | 1,43 | 2,00 | 3,00 | 2,08 |
| B | 1,43 | 2,00 | 3,00 | 2,08 |
| C | 1,43 | 2,00 | 3,00 | 2,08 |
| D | 1,43 | 2,00 | 3,00 | 2,08 |
| E | 1,43 | 2,00 | 3,00 | 2,08 |
| F | 2,86 | 3,43 | 4,00 | 3,43 |
| G | 5,71 | 6.42 | 8,00 | 6,57 |
| H | 2,86 | 3,43 | 4,00 | 3,43 |
| I | 5,71 | 6,42 | 8,00 | 6,57 |
| J | 2,86 | 3,43 | 4,00 | 3,43 |
| K | 2,86 | 3,43 | 4,00 | 3,43 |
| L | 2,86 | 3,43 | 4,00 | 3,43 |
| M | 2,86 | 3,43 | 4,00 | 3,43 |
| | | | | 44,07 |

In Pert method, by (1) equation Critical path is calculated 44,07 weeks.
By TOC method;
Step 1.From activity table and flow diagram derived from activities $T_1 = 33$ and $T_2 = 55$ (TFIN = 55)

Step 2. Computation of the duration cut ratio, C.R. = $T_1/T_2$ = 33/55 = 60 % is used.

Activity table is formed by using $k_A^m$ values from Table 3 for each point $k_A^m$ at critical path (Table 4).

**Table 3**
$k_A^m$ Values

| Importance | $k_A^m$ | Easiness | $k_A^m$ |
|---|---|---|---|
| Very high | 0 | Very high | 0 |
| High | 1/4 | High | 1/4 |
| Moderate | 1/2 | Moderate | 1/2 |
| Low | 3/4 | Low | 3/4 |
| Very low | 1.0 | Very low | 1.0 |

Definitive control method has been used which is derived as minimal $k_A^m$

$k_A^m$ = **Min (importance** $k_A^m$**, easiness** $k_A^m$**)** **(6)**

**Tablo 4** Activity table

| Activity | A | C | E | G | I | J | M |
|---|---|---|---|---|---|---|---|
| Importance | 0 | 1/4 | 1/4 | 0 | 1/4 | 1/4 | 1/4 |
| Easiness | 1/2 | 3/4 | 3/4 | 1.0 | 3/4 | 1/2 | 3/4 |

By ecceptance of $k_p$ = 0, formula (6) has been replaced in formula (5)
R.C.C(A) = 33+[0+(9–6)*1/4+(14–10)*1/4+0+(32–22)*1/4+(35–26)*1/4+(45–30)*1/4] = 43,25 week values have been calculated.
The using of TOC completely duration has been calculated as 43,25 weeks.

## 5 RESULTS

Tourist regions have very fast interchanges. Hence touristics regions have a lot of problems for managing. In this study, a prototype has been planned to city information system infrastructure.
GIS applications aim to use integrated layers which determine topological models besides querying analysis at main coordination. So we can say that the applications are complex. In the TIS's applications, Gantt and CPM methods are not suitable for calculating duration and critical path at the point, of certain duration, certain time designation and long duration. In this phase, any problem in any stage will affect other stages. So, target duration will swerve and coordination will corrupt.
It is observed that although the results of PERT are more suitable than those of Gantt and CPM because the planning duration is calculated by trio duration time, if time estimations are not accurate, the project will be delayed. The shortest duration has been obtained by TOC. TOC's advantage over other methods is a shorter number of activities, so it will be more rapid. At this point, research, education and control operations are eliminated, and these steps are evaluated in other steps. So, base steps are decomposed. As a result, TOC has not disagreement with GIS: on the contrary, it is more suitable for GIS application. Table 5 compares advantages of all methods.

**Table 5** Comparison of Gantt, CPM, PERT and TOC

| Methods | Advantage | Disadvantages |
|---|---|---|
| Gantt | • Easy preparation<br>• All steps can be seen with execution data and all elements. | • Does not show the interdependencies of the activities.<br>• Cannot show the result of either an early or a late start in activity.<br>• Does not show the uncertainty involved in performing the activity and, therefore, does not submit itself to sensitivity analysis. |
| CPM | • The activities on the critical path have no float time, therefore limited resources must be first assigned to those activities to avoid project delay.<br>• Here the user is required to think through a project logically and with sufficient detail to establish firm, clear, project objectives, activities and specifications. This minimizes the chance of overlooking necessary activities and goals of a project. | • Considers only logical constraints during planning, which is not the real world of a construction process.<br>• Duration is estimated once only. |
| PERT | • It serves as a necessary tool when the condition is changed to administration. It researches diverse effects. It lists all effects before executing other steps, so precautions can be taken.<br>• Helps how sources can be transferred critical activities, which affects result duration. All helps are served to administration from non critical to important critical activities. Makes multi-estimation a possibility so indefiniteness can be accommodated. | • Probability distribution which assumed in beta curved is not based on theoretical foundation or investigation.<br>• Calculates duration variance between the beginning and end of the projects and deals with independence of activities.<br>• Estimation of the most optimistic and pessimistic and probable duration is not easy and all activities are dependent on subjective ideas. |
| TOC | • Uses systematic approach to find critical chain and establish related buffers.<br>• Emphasizes both strategic (global $k_p$) and practical (local $k_A^m$) aspects to control the project schedule.<br>• Proposes guidelines to establish various buffers and activity duration cut to shorten the project length rationally.<br>• Focuses very much on how senior management deal with human behavior. | • Lack of guidelines to establish project, feeding and resource buffers.<br>• All dynamic factors, the activity duration and project length should be included for correct management of the Project Schedule. |

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