Case Study: Making and Monitoring of Critical Path in Shoe Production Planning

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Abstract
India is one of the leading exporters of various qualities of shoes to the international market especially to European and American Nations. Receiving international orders seems to be a smaller challenge in comparison to the challenge of delivering on time. The small sector players of this industry in India usually face this problem and are levied with heavy fine owing to not able to meet the promised delivery time while receiving orders. This paper is an attempt to provide the solution of this problem to these small sector players by implying Critical Path Method in the planning department of shoe manufacturing. In later stages the same method may also be applied in various departments like manufacturing and sampling of the shoe industry to cater the problem of on time delivery. The Critical Path on the network is identified and is monitored continuously to observe any shift in the critical path. Thus solution to the problem lies in: Identifying the critical path, monitoring the critical path, Resource leveling using crashing.

Keywords: PERT, CPM, Fulkerson’s rule, crashing, Shoe Production Planning, Monitoring Critical Path etc.

Critical Path Method
Main differences between a PERT and a CPM network is that former is event based and later is activity based. Further to this in CPM network no allowances for uncertainties in duration of time is involved and in CPM time is related to the cost directly.

Once a network is created following the precedence rule, it is numbered using Fulkerson’s rule, subsequently following times are estimated for a PERT network:

1. Earliest Event Time: (TE)
The earliest commencing time of an event, is the time on which if event is not started, will cause delay in the project. For calculating it forward pass is used and to the earliest time of each event that immediately precedes it, the duration of the job which connects it is added and the highest of the obtained values is chosen.

2. Latest Allowable Occurrence Time: (TL)
It is the latest time by which the event must be completed to keep the project on schedule.

For calculating it backward pass is used and from the latest time of each event that immediately succeeds it, the duration of the job which connects it is subtracted, and the lowest of the values obtained is chosen.

3. Slack Time and Critical Path:
Slack is the difference between the latest and earliest event time. However it is usually associated with event controlled network.

The Critical Path connects those events for which the earliest and latest time is same, i.e. have zero slack time.

4. Float: For a given activity i-j, following time elements can be calculated:
   a. Earliest Start Time: is the earliest occurrence time for the event from which the activity arrow originates, i.e., TE.
   b. Earliest Finish Time: This is the earliest occurrence time for the event from which the activity arrow originates plus the duration for the activity, i.e. = (TE + tij).
   c. Latest Start Time: This is the latest occurrence time for the node at which the activity arrow terminates minus the duration for the activity, i.e. = (TL – tij).
   d. Latest Finish Time: This is the latest occurrence time for the node at which the activity arrow terminates, i.e. = TL

After the calculation of aforesaid times, a network following precedence rule and Fulkerson’s rule is created, which is finally solved to determine the critical path in the network.

This critical path made up of critical activities once identified need to be monitored continuously to observe and avoid shift of this path in practical situations

Planing in Shoe Industry using PERT Technique
1. Problem Formulation:
To make, solve and monitor a PERT network for a project of making 1500 pair of shoes for a European buyer with given specification sheet. The critical path during the project based on the stipulated time is to be calculated and all the activities lying on the path are to be closely monitored so as to avoid delay in the completion of the project.

The consignment should reach the buyer within 120 days of the receipt of the order. The order has been booked on 24/11/12 and should reach the buyer by 24/3/13.

Europe experiences holiday of 10 days around the Christmas in which no comment on any sample sent should be expected.

Planning manager has spoken with various departments and obtained optimistic (to), most likely (tl) and pessimistic (tp) time element for every activity involved.

<table>
<thead>
<tr>
<th>Activity</th>
<th>to (days)</th>
<th>tm (days)</th>
<th>tp (days)</th>
<th>( t=(to+4tm+tp)/6 ) (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>10</td>
<td>18</td>
<td>11</td>
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<tr>
<td>B</td>
<td>5</td>
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<td>C</td>
<td>14</td>
<td>18</td>
<td>22</td>
<td>18</td>
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<tr>
<td>D</td>
<td>2</td>
<td>3</td>
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<td>M</td>
<td>20</td>
<td>28</td>
<td>36</td>
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<td>N</td>
<td>8</td>
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<td>O</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>8</td>
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<tr>
<td>P</td>
<td>15</td>
<td>19</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Q</td>
<td>16</td>
<td>20</td>
<td>36</td>
<td>22</td>
</tr>
</tbody>
</table>

The details of every event and activity involved are as follows:

i. Order Received 24/11/12
A. Confirmation sample making
   ii. Confirmation sample sent
   iii. Confirmation sample approved
B. Leather procuring
   iv. Leather procured
D. Pattern for last making
   v. Pattern for last made
E. PU procuring
   vi. PU procured
F. Stud procuring
   vii. Studs procured
G. Lace procuring
   viii. Lace procured
H. Insole material procuring
   ix. Insole material procured
I. Patterns for dies of upper, sole, insole, wedge, and heel making
   x. Patterns for dies of upper, sole, insole, wedge, and heel made
   xi. Dies procured
J. Dies of upper, sole, insole, wedge, and heel procuring
   xii. Production sample making
   xiii. Production sample made
L. Production sample approval
   xiv. Production sample approved and production started
M. Upper Making
   xv. Upper made
N. Sole, heel, wedge making
   xvi. Sole, heel, wedge made
O. Insole and socks making
   xvii. Insole made
P. Lasting and packaging
   xviii. Lasting and packaging done
Q. Material shipping
   xix. Material received by the buyer
Step 1: PERT network is made based on the precedence rule

Step 2: Numbering is done on the basis of Fulkerson’s Rule
Step 3: Representing the activities

Step 4: Calculating \( t_e = (t_o + 4t_m + t_l)/6 \) based on Beta distribution and forward pass is calculated.
Step 5: Calculating the backward pass:

Step 6: Calculating the difference between forward and backward pass. The Longest Critical path with the activities having minimum difference is calculated.
Result
The critical path is as follows: 1-2-3-10-11-12-13-14-15-17-18

Conclusion
1. The path is closely monitored continuously for:
   a. Non compliance of activities on time.
   b. Any shift in the critical path pertaining to 1.
   c. Crashing of the activities lying on the critical path by adding resources so as to minimize their duration and thus minimizing overall duration of the project.

2. If any of the aforesaid two possibilities are encountered, it is expected to raise alarm by the planning department and search for the rescue measures to be adapted to stick to the completion of the project.

3. For any shift in the critical path observed, the network is resolved and stress on timely completion of the activities is levied.

4. If anyhow the critical path tends to increase the duration of the project, crashing techniques are used to reduce the length of the critical path by adding resources to complete the project within stipulated time.

5. This technique has been successfully used by the construction industry for timely completion of the projects.

The same technique can also be put to use in shoe industry and the miracles created by the technique in deciphering and soothing the activities responsible for the delay of the project can be observed.

Initially this method can be applied for small projects and gradually can be adapted on a large scale.

Also this technique can be used by every department as a tool for meeting the commitment of the delivery to other related department and thereby reducing the problem of internal delays which in turn causes the delay in delivery of the final product of the company.

References
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