Using critical path method for a new project scheduling - the case of a new product launch in production

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Abstract. The assimilation process must take place in the shortest possible time and with the lowest costs. These desires are achievable through the most efficient procedures. The paper proposes a procedure for managing the assimilation process of a new product, based on the critical path method. The procedure is intended for a company producing plastic products. In the first phase there was a critical analysis of the existing procedure for assimilating a new product. In the following the study presents how the activities carried out for the assimilation of a new product were organized into a project. To implement this project it was used the Microsoft Project software. This is a tool that allows project management to use the critical path method. By applying this method, it can identify the critical activities within the project. In order to minimize the execution time of the project, the execution time of the critical activities must be reduced. The duration of an activity can be reduced by allocating additional resources. Using the Microsoft Project software in the analyzed case, provides to decision makers information that allows them to make decisions that will reduce the duration of the assimilation process of a new product.

1. Introduction

Assimilation of a new product is an important issue for any company producing goods and equipment. The importance of this process is given by the competitive dynamics of the market. The assimilation process must be done in the shortest possible time and with the lowest possible costs. It is also important that the result of the process, the product itself to meet the customer's requirements.

In [1] is presented a New Product Introduction (NPI) process template dedicated to business and engineering.

One of the commonly used methods in project management is the critical path method (CPM). In [2] is presented the implementation of CPM in the optimization of the manufacturing procedure of an All-Terrain Vehicle (ATV). The study concentrates on the time constraint. The study [3] presents how the critical path method is applied into the management of job production. The case study referred to a complex installation for packaging detergents. The application of the CPM method in the capital repair activity (retrofitting) is described in the paper [4].

In the papers [3] and [4] the project management was done using the Microsoft Project program. Microsoft Project (MS Project) is a strong tool used in critical path methods applications [5].

The paper [6] develops a qualitative and quantitative approach to selecting a new product launch strategy. In [7] the authors present the results of a study that examines the interplay between these product launch decisions and the new product development (NPD) performance. An overlapping
process model to analyze the impact of process structure on the lead-time of a complex development project is present in [8].

2. The current procedure for assimilating a new product

The procedure used to assimilate a new product in Plastor S.A. is called the Main Procedure (figure 1).

| Providers   | Input data                                      | Actions and decisions | Output data                                      | Customers              | Responsible |
|-------------|------------------------------------------------|-----------------------|-------------------------------------------------|------------------------|-------------|
| Marketing   | Company catalog, Pps presentations             | 1. Company promotion  | Contacts with potential and current clients     | Marketing              | Marketing   |
| Marketing   | Contacts with potential and current clients    | 2. Identifying potential customers | Company rules - potential client, address, representative, contact details | Marketing              | Marketing   |
| Engineering | Mold technical assignment                      |                       | Mold project                                     | Production             | Projectare  |
| Engineering | Production devices technical assignment        |                       | Production devices project                       | Maintenance production | Engineering  |
| Engineering | List of SDV production                         |                       | Control devices project                          | Maintenance quality     | Engineering  |
| Engineering | Flowchart                                      |                       |                                                |                        |             |
| EP          | Optimization proposals: processes, devices, molds |                       | 45. Corrections, optimizations                  | EP                     | MP          |
| Customer    | Question EP, own evaluations, complaints audits|                       | 46. Customer satisfaction analysis              | Division manager       | MP          |

**Figure 1.** Main Procedure [9].
The purpose of the procedure is to specify the responsibilities and how to identify customer requirements for products and services offered by the organization, analysis of requirements and declaration of ability to meet these requirements, monitoring customer satisfaction. The procedure refers to requests for quotations, contracts and orders for the organization's products, as well as to requests for new product development (domestic and export).

For the implementation of the procedure Main Procedure Plastor S.A. use the Excel program. The file called APQP Planning (Advanced Product and Quality Planning) contains all the activities necessary to implement the project. Each activity is associated with the following information: execution time; planned duration and current duration.

An ongoing activity is colored yellow. When the activity ends, the yellow color of the cells turns green. It is also possible to highlight the proportion in which the activity was performed at a given time (in percentages). The color red is used for activities that have exceeded the deadline. To highlight the status of the project (yellow, green or red), an Excel program option called Conditional Formatting is used (figure 2).

When completing the task execution times on the Schedule page in Excel, the cells on the Gantt Chart page are automatically colored based on the use of the Conditional Formatting option, resulting in the Gantt Chart. An illustration of the Gantt Chart can be found in figure 3.
Critically analyzing the procedure of assimilating new products at SC PLASTOR SA, the advantages and disadvantages of its use can be identified. Among the advantages are the following: allows data entry in a simple and easy way, Excel is a program known to employees, this program is part of the Office package and does not involve high costs. Disadvantages of applying this procedure are: it does not provide a tracking of resource costs (employees, equipment, etc.); it does not provide information on those responsible for carrying out the activities, it does not highlight the critical path, respectively the critical activities. Knowing them would allow measures to be taken to reduce the duration of the project to assimilate a new product; does not provide information on the evaluation of project indicators (duration, cost).

3. Implementing the procedure of assimilating a new product using the critical path method

3.1. Product description

The product that will be assimilated using the critical path method is called Connector (figure 4a and figure 4b). Connector 6 has an important role in the cooling circuit of the machine and is composed of: o-ring (1), sperring (2), spring (3) and injected part (5). The injected part will be manufactured in Plastor, the other components will be purchased. The material of the injected part is PA66 + 30% FS (Polyamide 66 + Fiberglass 30%), in the form of granules.

![Connector product](image)

Figure 4. Connector product [9].

3.2. Organizing activities for project implementation in Microsoft Project®

The project of assimilation of the product Connector involves the realization of the activities presented in table 1. The project contains 3 main stages:

- Stage 1 - Planning;
- Stage 2 - Process design and development;
- Stage 3 - Process product validation.

Each stage includes a set of activities necessary for the assimilation of the project. Table 1 associates the following information with each activity: duration, predecessors and resources.

| Nr. Crt. | Activity name                                                                 | Duration (days) | Predecessor | Resource                        |
|---------|--------------------------------------------------------------------------------|-----------------|-------------|---------------------------------|
| 1       | Customer input elements (product design and requirements, materials used, nomination, contract, etc.) | -               | -           | -                               |
| 2 STAGE 1 - Planning                           | Project manager, Sales referent                                                  |
| 3       | Establishing the team and the commitment to team confidentiality                  | 0.1             | 1           | Project manager, Sales referent |
| 4       | Elaboration of *project objectives*                                              | 0.05            | 1, 3        | Project manager, Sales referent |
| 5       | Project planning APQP (Advanced Product and Quality Planning)                    | 0.3             | 4           | Project manager, Sales referent |

Table 1. Activities corresponding to the project of assimilation of a new product.
| Nr. Crt. | Activity name                                          | Duration (days) | Predecessor | Resource                      |
|---------|--------------------------------------------------------|-----------------|-------------|-------------------------------|
| 6       | *New Project Analysis*                                 | 0.3             | 4           | Project manager, Sales referent |
| 7       | Establish *List of critical product / process characteristics* | 1               | 6           | Quality engineer               |
|         |                                                        |                 |             |                               |
| 14      | **STAGE 2 - Process design and development**          |                 |             |                               |
| 15      | Realization of *Flow Chart*                           | 2               | 1, 7        | Technological engineer (I)     |
| 16      | Elaboration of *location plan*                        | 0.5             | 15          | Technological engineer (I)     |
| 17      | Establish *SDV manufacturing devices*                 | 0.2             | 15          | Technological engineer (I)     |
| 18      | Establish *List of materials and parts*               | 0.4             | 1           | Technological engineer (I)     |
| 19      | Elaboration of *PFMEA (Process Failure Mode & Effect Analysis)* | 2               | 7, 15, 13   | Technological engineer (I)     |
| 20      | Control Plan Development (PC)                         | 2               | 19          | Quality engineer               |
| 21      | Establish SDV*_control devices*                       | 1               | 20          | Quality engineer               |
| 22      | Development of a plan for MSA (Measurement System Analysis) | 0.4             | 20, 21      | Quality engineer               |
|         |                                                        |                 |             |                               |
| 51      | Elaboration of *Parameter adjustment sheet*           | 0.5             | 43, 44      | Technological engineer (I)     |
| 52      | Technological tests                                   | 0.1             | 15, 39, 40, 47, 51 | Technological engineer (I)     |
| 53      | Internal validation of the mold                       | 1               | 39, 45, 52  | Technological engineer (I)     |
| 54      | Validation of production devices                      | 1               | 40, 49, 52  | Technological engineer (I)     |
| 55      | Validation of control devices and MSA (Measurement System Analysis) | 5               | 22, 41, 50 | Quality engineer               |
| 56      | Internal process validation                           | 0.5             | 16, 52, 53, 54, 55 | Technological engineer (I)     |
| 57      | **STAGE 3 - Process product validation**              |                 |             |                               |
| 58      | Elaboration of product file                           | 3               | 56          | Technological engineer (I)     |
| 59      | Elaboration of folder PPAP (Production Part Approval Process) | 5               | 14, 48      | Project manager, Sales referent |
| 60      | Training of production operators                      | 0.4             | 49, 58      | Technological engineer (Prod)  |
| 61      | Quality operator training                             | 0.4             | 50, 58      | Quality engineer               |
| 62      | Preparation of PSW                                   | 0.2             | 59          | Quality engineer               |
| 63      | Customer report or internal pre-production audit       | 2               | 58, 59, 60, 61, 62 | Project manager, Quality engineer |

The allocated resources and labor costs, in lei / hour, are presented in table 2. The number available from each resource is also specified.
### Table 2. Allocated resources.

| Nr. | Department         | Resource                | Available | Standard (lei/hour) | Overtime (lei/hour) |
|-----|--------------------|-------------------------|-----------|---------------------|---------------------|
| 1   | Marketing          | Project manager         | 1         | 30                  | 60                  |
| 2   | Sales              | Sales referent          | 1         | 21                  | 42                  |
| 3   | Purchases          | Purchasing referent     | 1         | 21                  | 42                  |
| 4   | Engineering        | Technological engineer(I)| 1         | 25                  | 50                  |
| 5   | Quality            | Quality Engineer        | 1         | 25                  | 50                  |
| 6   | Design             | Design Engineer         | 1         | 26                  | 52                  |
| 7   | Tool workshop      | Mold technician         | 1         | 260                 | 520                 |
| 8   | Production         | Technological engineers | 1         | 25                  | 50                  |
| 9   | Equipment maintenance | Toolmaker              | 1         | 22                  | 44                  |

#### 3.3 Using the Microsoft Project software for project analysis

The program used in this case study is Microsoft Project. With the help of this program it can be follow various aspects related to project management: defining activities, determining the critical path, allocating resources, analyzing costs etc.

For a correct analysis of the activities we will consider the following: working days from Monday to Friday, working hours from 8:00 to 17:00 with a break of one hour between 12:00-13:00.

#### 3.3.1. Version 1

Considering the information in table 1 and table 2, the project was implemented in Microsoft Project obtaining version 1 (figure 4). The program automatically determines the critical path. In order to be able to view more easily, the critical activities are highlighted with red. Figure 5 shows the Gantt chart for version 1. It can be seen in the case of some resources that the available is not at the required level. More precisely, the deficit of resources appears at: project manager, purchasing referent, technological engineer, quality engineer, mold technicians and toolmaker.

![Figure 5. Gantt graph. Version 1.](image-url)
- The project duration: 72.25 days (75 days and 2 hours);
- Work time: 1600.8 h;
- The work costs: 106,069.60 lei.

The shortage of human resources, of a certain category, can be highlighted by the Resource Graph option. Thus, details can be obtained regarding the date when the necessary resources are below the level of those available and what is the difference between necessary and available.

![Figure 6. Technological engineering (I) resource deficit.](image)

![Figure 7. Deficit in Mold technician resource.](image)

In figure 6 it can be seen that the deficit in the Technological engineering resource (I) is on 5/9/19 of 3 units. Also, in figure 7 it is highlighted the fact that the deficit in the Mold technician resource is 1 unit for 5 consecutive days.

The problem of resource scarcity can be solved in two ways.

3.3.2. Version 2. In the case of this version, a first solution to solve the resource deficit is applied. Specifically, it uses a Level All feature of the Microsoft Project® program. This facility allows the scheduling of activities so that the available resources exceed the required resources. Thus, if two activities that initially take place at the same time advertise the same resource, the beginning of one of them will be delayed, after the end of the other.

![Figure 8. Gantt graph. Version 2.](image)
The Gantt chart corresponding to version 2 is presented in figure 8. It is found that the program no longer signals the existence of a deficit of resources. Another shortcoming appears: the duration of execution of the main activities has increased. For example, the duration of the main activity STAGE 2- PROCESS DESIGN DEVELOPMENT increased from 65.05 days (figure 5) to 92.1 days (figure 8). The duration of the assimilation project of the connector product increased from 72.25 days to 99.3 days. In fact, given the available resources (table 2), this is the real duration of the project completion.

3.3.3. Version 3. In version 3 of the implementation of the project of assimilation of the connector product, the second solution for solving the resource deficit was applied; more precisely the number of allocated resources covers the necessary. If this solution were applied, the project could be realized, in a realistic way, in version 1. In order to minimize even more the execution time, another feature of the Microsoft Project program will be used the identification of the critical path.

The critical path defines the minimum duration to complete the project. The critical path is composed of critical activities. In order to minimize the duration of the critical and implicit path of the project, the execution times of the critical activities must be shortened. This is possible by allocating additional resources to critical activities. Two critical activities were identified: Mold design with the duration of 12 days and Mold execution lasting 26 days. For the Mold design resource, the Design Engineer resource was supplemented from one unit to two units and for the Mold execution activity the Mold Technicians resource was supplemented from one unit to three units (figure 9).

Under these conditions, the duration of the project execution decreases significantly, respectively to 59.22 days (figure 10). Compared to version 2, the realistic version in the conditions of the initial resources, the execution duration of the project of assimilation of the connector product in version 3 is approximately 40% shorter.
The Microsoft Project® program provides information on many aspects of project management. Thus, figure 11 shows the share of working time corresponding to each resource in total time. Figure 12 shows the synthesis of the distribution of costs on project resources.

4. Conclusion

The procedure for assimilating a new product, the Main Procedure, used within SC Plastor SA rigorously describes the steps to be followed. It also defines the responsibilities and results of each activity. In the case of this procedure, there is an IT tool for tracking the way in which the activities of the Advanced Product and Quality Planning program are carried out over time. However, this procedure does not offer solutions to improve the assimilation process in terms of duration and costs.

The paper proposes the use of the critical path method in the management of the assimilation project of a new product. Thus, the activities corresponding to the Main Procedure were implemented in the MS Project software considering their durations, the predecessor / successor dependencies between activities, the human resources necessary for the execution of each activity, the costs associated with these resources. The result is a complex picture of how the assimilation process can take place. The estimated duration and costs were highlighted. The program also provides information on how the allocated resources meet the necessary execution of the project activities. A very important advantage is that the program highlights the critical path and, implicitly, the critical activities. If more resources are allocated for the execution of critical activities, their duration decreases, decreasing the duration of the project execution. Several versions can be analyzed, the decision makers (project manager) can choose the best option.

For the analyzed case, the assimilation of the Connector product to SC Plastor SA, by applying the Main Procedure, the duration of the assimilation process was 282 days. The paper showed that by using the critical path method, the assimilation time of the product can be reduced to about 59 days, given that additional resources are allocated for the execution of critical activities.

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