Development of a decision support model for planning and production control selection tools

Francisco José Rodrigues Mendes da Silva

francisco.mendes.silva@tecnico.ulisboa.pt

Instituto Superior Técnico, Universidade de Lisboa, Portugal

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Abstract: Nowadays, after a long period of globalization, competitiveness driven by technological developments and liberalization of the world economy has increased in the business sector. Regarding this companies are required to develop their performance standards to keep up with product innovations and customer needs. The small and medium organizations face challenges in optimizing the use of resources through planning and production control. With this in mind the companies have been adopting software tools for planning and production control.

The aim of this study is to support the company's case study in selecting a planning and control software suitable with their needs and based on the same approach to develop a generic support selection model. The study focused on the characterization of the planning and control procedure, the planning analysis of a group of parts, on the identification of the requirements and needs. Following the characterization were listed a set of criteria to compare available *softwares* on the market and based on the benchmarking were assigned ratings for each criteria. With the literature in mind and the methodology applied on the company a support model for planning and control software selection were developed to be use in small and medium companies.

Keywords: Planning and production control, SME, Enterprise Resource Planning, Software Selection, Pair-wised comparison

1 Introduction

The competitiveness level is increasing globally and to achieve competitive results and customer satisfaction is critical to promote an organizational culture with standardized and optimized processes. To accomplish this, fully integrated software tools for planning and production control are used. However, the selection of a software tool is extremely challenging due to the risks and consequences of an unsuccessful selection. Related with this concern, the case study´s company hereby described, launched the challenge to select a planning and control production tool best suited to their needs.

To carry out the selection process, an analysis of the production process of the plant was made, with special detail to the planning and production control phase in order to identify procedure and improvement needs and determine the comparison criteria for software tools. Moreover, it was possible, through a market research, to classify each one of the criteria. As a result, to this approach, it was possible to identify the appropriate tool to the company needs. Therefore, a model was developed to support the selection of software tools for small and medium companies, with planning and production control needs.

2. Bibliographic Research

Production management is defined as the way a company manages the use of the resources needed to produce a product [2]. Chase and Aquilano [2] claim that management production covers different companies´ departments and proposes a model. This model shows that planning and production control systems are a component of management production and are conditioned by the production strategy, the company's strategy and the market. Additionally, Jimmie Browne et al[3] claim that planning and production control are defined as the systematic preparation activities based on projections resulting from acquired data. Thus, the main objective of planning and production control systems is to specify the optimum combination of the production rate, the level of hand labour and stocks available to subsequently monitor the process and evaluate performance indicators.[3]

2.1. Characterization of production planning and control systems

Planning and production control systems are considered crucial tools in production management, as they are known for increasing process efficiency, reducing costs and meeting the customer´s expectations. Over the years, these systems have been developed, adapted and integrated, resulting in different types that are presented in this chapter.[4]

The MRP system (Material Resource Planning) is a method whose purpose is limited to inventory management, in order to meet the needs of production and customers. As MRP´s successor, the system MRP II (Manufacturing Resources Planning) appeared. The MRP II, in turn, is mainly focused on the planning of all production operations, while focusing on customer needs [5]. MRP II system is able to manage the production of short and long term, keeping in view the demand for the product, compliance with deadlines, planning of purchases and the respective production [1]. Additionally, this system is characterized by its dynamic nature and flexibility, which places it in a favourable position to be implemented in situations where structures products are complex, requiring different materials and production processes and a robust planning. [6]

Subsequently, the Manufacturing Execution System (MES) was developed in order to provide a software application to facilitate the various functions and helping decision makers daily on the shop floor. This system is able to fill the information flow gap between the strategic planning of the company and the control of production [1]. According to AC Deuel [7], the MES system monitors and controls the materials, operators, procedures, documentation and infrastructure.

Over the past few years, a new category of software called Enterprise Resources Planning (ERP) has been developed. This software category pretends to manage and integrate a full range of processes and functions of a company, in order to present an overview of the business from a single information tool [10]. An ERP is a preconfigured tool usually composed by several modules. This system enables the transaction of data between the various company departments [11]. An ERP is a system that includes everything from the material requirements planning functionality (MRP), manufacturing resources planning (MRP II) and manufacturing execution system (MES), including in its system features of planning and production control. [1]

2.2. Software Selection

The selection of a tool proves to be a challenging process that consumes a high amount of resources and includes greater risks if a company underestimates the selection phase, causing high costs later when the tool doesn't fit the company needs. [10] [11].

According to Edward Bernroider and Stefan Koch [12], small and medium sized companies select these systems differently from the way large organizations usually do. In a study of 138 companies, of which 56.6% belong to the industrial sector, were identified the selection criteria that the two previous mentioned groups value. Small and medium-sized enterprises granted a higher importance to criteria such as software adaptability and flexibility, short implementation period and low cost. In turn, large organizations gave greater importance to criteria such as use of software to multinational level, customer satisfaction and integration with suppliers. Moreover, small and medium-sized enterprises collect information throw methods like presentations assistance and software demonstrations, along with an analysis of solutions catalogues. In contrast, large organizations acquire prototypes and analysis technical reviews. In addition, it is consensual that the selection team should be compound by elements of various departments, in order to make decisions with a higher degree of accuracy and to have a solution that will most likely be accepted by everyone when implemented [13].

In regards to the selection methodology, there is no consensus on the existence of a procedure for such an important task. [14] [12]J. Constantinos Stefanou [11] proposes the following framework for the selection of a software tool:

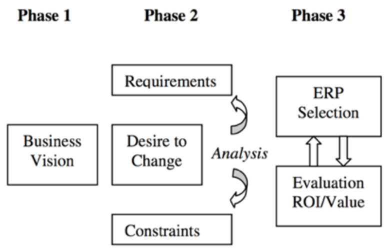

Figure 1 Selection framework model [11]

The first phase requires that the company's vision and strategy are clearly defined, in order to be align with the tool implementation. In the second phase, the organization´s elements are expected to be aware of the need to implement a tool. The elements involved must identify the constraints on current procedures and the requirements that the tool should include. Finally, the third phase is the selection of the system to be implemented. The proposed methodology for the selection takes a generalist approach, identifying four areas to be examined: the main modules of the tool, tool integrations, implementation and the consultants responsible for the implementation.[11]

On the other hand, Oyku Alanbay [14] suggests a selection methodology through an analytical hierarchy process. This methodology assumes that the organization is large and only compares two software since the remaining were a priori eliminated. This methodology includes three distinct groups, each with a comprehensive set of criteria, that are listed in the figure 2.

Based on the above criteria, this methodology

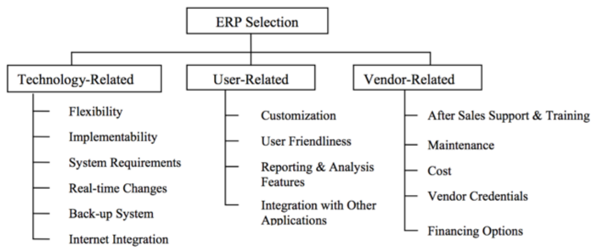

Figure 2 Criteria proposal [14]

proposes going through three steps using pair wise comparison: compare the two software by each criterion; compare each criterion relatively to its group; compare each group to others groups. At the end of this procedure, is obtained a direct comparison between the tools and the relative importance of each criteria in comparison with others. By using simple arithmetic calculations and the variables previously mentioned, is obtained a tool with higher score.

2.3. Software Implementation

According to Prasad Bingi, Maneesh Sharma and Jayanth K. K. Godla [15], the implementation of a tool is a matter of repositioning the company in the market, transforming the current procedures. Thus, Edward Koch and Stefan Bernoider[12] refer that top management take an active role in changing and monitoring the whole process, by directing all departments throughout the implementation [15]. The selected employees must understand the business as a whole and show willingness to prioritize the tool implementation[16]. When the implementation phase arrives, it is necessary for companies to choose for one of these three situations: redesigning processes and adjust to the tool; customize the software to the current processes; or a combination of the previous two [15]. For Esteves J. and J. Shepherd[17], no tool has the ability to meet all the needs of a company, especially when it comes to the ability to integrate with technical work of software. Thus, the same author suggests that the selection of expert consultants with technical, functional and interpersonal characteristics is a key factor in decision making. According to Reuther D and Chattopadhyay [18], implementation time is a decisive factor and on average the typical implementation period is 14 months. This implementation process can occur in three ways: using a step-by-step logic, where features are installed gradually and continuously; in a big bang logic, where all features are implemented at once; or in a roll out logic, where the functionalities can be implemented in a step-by-step or in a big bang logic in one department and if it well-performs the implementation is rolled out to other company's areas [19]. Marsh [16] adds that the process of training employees is a major challenge when implementing a software. Employees who use the system will be accounted for decisions and is essential that they understand what the direct impact on other departments is.

3 Case Study

A part of the work for this thesis was carried out in a metalworking company. During this period, it was intended to have direct contact with the procedures carried out by the collaborators. The work developed at the company aimed to help them in the selection of a software tool for planning and production control. With this goal in mind, it was developed an approach, using the requirements found in the literature, together with the needs identified in the company.

The case study's company produces metal structures, made of steel or aluminium, whose main destination is the aviation, aerospace and railway industry. The company production process is characterized by project type where the products are tailored to customer's specifications. Therefore, the process begins with the customer's contact, make-to-order- MTO. Once assigned the order by the commercial department, the time required for manufacturing is estimated. These estimations are used for planning purposes. Then, the work is forwarded to the preparation department, where the raw materials required for the order are identified and the 2D drawings are prepared in order to create a workbook. Consequently, the department responsible for acquisitions orders the raw materials and monitors its reception. Once these materials are ready, the customer's order starts to be produced. The collaborator responsible for manufacturing oversees managing the beginning of the components manufacturing, production scheduling and control of deadlines. After the manufacture of all components and the respective assembly, the entire structure undergoes a quality control process. If not identified any irregularities, the shipment to the client is made.

3.1. Approach

The first stage consisted in characterizing the production process and the flow of information in the production planning and control process. In the first contact with the company, a brief summary was presented about the macro flux and information management systems normally used. Afterwards, it was given a visual analysis of the entire production system and of the planning and production control process. This analysis was performed in an unobtrusive way, without altering the normal functioning of the usual procedures. Additionally, in this first phase of the approach, informal interviews were held to the collaborators involved in the processes identified in the previous phase.

The second phase of the approach consisted in identifying the needs for improvement of the planning and production control process and identifying the criteria that the software tool should contemplate. Once all stages of planning and production control process were characterized, a thorough analysis was made to identify improvement needs. Based on these identified needs and with the criteria found in the literature, was then defined a list of criteria to compare tools on the market.

The third phase of the approach included the research of market solutions and their comparative analysis. Using the characterization of the above-mentioned process and the identified needs, a specification document was developed, which was then submitted to various software houses that provide tools with a high potential applicability to this case study. The tools provided by the software houses were classified according to the list of criteria previously established. This classification resulted from meetings and demonstrations assisted for each tool.

In the fourth and final phase of the approach, it was recognized that the established criteria have different weights, depending on the organization's strategy. Thus, it was necessary to calculate the relative importance of each criteria, in order to build different scenarios. Therefore, to differentiate the relative importance of each of the criteria, a pair-wised comparison methodology was applied. This methodology consists in the direct comparison of one criterion with each of the remaining criteria individually, indicating which of the two criteria is more important or if it is the same. Hence, the percentage amounts are calculated for each of the criteria in order to build the scenario. Different scenarios were constructed in order to obtain results for different strategies.

3.2. Planning and Production Control Process Description

The process of planning and production control is developed in accordance with a sequence of activities: Customer Relationship Management; Commercial; award; Preparation and Purchasing; Manufacturing and shipping.

The planning process in the company starts with the contact by the customer in order to schedule a meeting, where the customer presents the product intended to be made and a set of specifications. After that the commercial department proceeds with budgeting, consisting of two phases: project budgeting and manufacturing budgeting.

After budget agreement, the client presents the date when pretend the project to be done and on that moment the commercial department query an Excel document where factories capacities are presented. In this document are works in progress and expected allocated to the respective factories. At this time, the commercial department estimates the time required to perform the work in question, using two indicators: the mass of the work components and the productivity of each plant. The first is obtained from the CAD software, the second is calculated in kg per hour per man, which is obtained based on the collaborators experience.

The resulting estimate values are entered the spreadsheet developed in Excel associated with the components of the respective work. So, with this indicator the company takes planning decisions and identifies the need to subcontract work to fulfil the deadline.

At the time of awarding, the work is identified by an internal code and starts the process in the Agir software. The Agir is a software used internally that provides a workflow which identifies the tasks to be done and notifies the responsible for those tasks. After the award of the project, the scheduling phase is performed when requested by the customer. The aim of this step is to develop a time-bound plan tasks, to present to the customer and will be updated weekly.

Once done the planning, the work is sent to the subcontractor company that analyses the 3D models so check that all necessary information has been provided by the client and converts 3D models into 2D drawings. The designs, in 2D, are sent via email to the preparation department. Once assigned to a work, the preparation responsible is notified through the Agir. Initially, he begins by quantifying the drawings and make an analysis of the quantities and types of materials that are need to implement. The necessary materials are categorized into two groups: trade parts and row materials. The preparator walks physically throw the warehouse to check the availability of the necessary parts, if the parts exist, when return to the office he proceeds to the internal request, through the Agir. If the pieces do not exist, is necessary to request externally. The external request process is performed by the responsible for acquisitions that access to Agir to check the necessary raw materials. After analysing what is missing for the production the orders are made. Simultaneous to the acquisition process the preparators works the 2D drawings. At this stage, the preparators identified prospects and details of the components to be manufactured and that the manufacturing processes associated with each component. When the drawings are in accordance, The operator submits them in Brimaq, internally developed software production control functionality, in order to define the quantities of components to be manufactured and the manufacturing processes already identified. Next, the responsible for drawings preparation prints the drawings, and the manufacturing specifications and associated with each drawing a bar code which is generated by Brimaq glued in each drawing. From this moment the manufacturing notebook is delivered in the factories. If the work is performed managed by the head of production the steps are register on Brimaq using the code bar printed on the drawings.

3.3. Planning and Budgeting Analysis

This study aimed to identify and formalize the budgeting and planning logic followed by the company's employees in order to compare the resulting estimates with actual data collected by Brimaq.

The budget is realized based on the categorization of articles ordered in four different types: slight framework (type A), heavy framework (type B), industrial guards (type C) and plating (type D). A responsible budgeted and classified classified drawings and obtained the following results:

Table 1 Budgeting Analysis

Number	Type	Mass (kg)	Area (m2)	M / A
0619-01-B109	A	198.4	7.85	25.27
0619-01-B118	B	293.32	7.94	36.94
0619-01-B119	B	244.82	7.02	34.87
0619-01-B140	A	465.44	18.43	25.25
0619-01-B147	C	47.99	3.05	15.73
0619-01-B149	C	34.2	2.19	15.62
0619-01-B110	B	431.58	12.96	33,30
0619-01-B108	D	1731.49	142	12.19
0619-01-B145	D	237.9	17.48	13.61
0619-01-B122	A	2128.42	111.17	19,15
0619-01-B124	B	46.85	1.33	35.23
0619-01-B166	A	1650.2	55.68	29.64
0619-01-B169	A	1326.89	46.42	28.58

As can be seen in the drawings table assigned the type A has a ratio of 19.15 to 29.64; type B has a ratio of 33.30 to 36.94; type C has a ratio of 15.62 to 15.63 and D has a ratio of 12.19 to 13.61. It should be noticed that the classification according to four types was done tacitly and ratios were obtained later. Thus, we may say that the categorization of the types and the respective association with the drawings correspond to intervals of the ratio M / A defined. At the time is not possible to quantify through records which is the productivity of the factories, so it is used the vast experience gained by the company's element to estimate the average value of productivity that is associated. In this respect, it has been carefully selected a piece composed of several subassemblies and proceeded to the comparison between the estimated values and the brimaq collected data. The values obtained for the deviation percentages between the value expected and real value are of 27%, 118%, 30%, 26%, 19%, 1815% and 1558%.

3.3. Needs Identified

After analysing the procedure and information flows were identified the needs for improvement in the process, and listed below:

- **Streamline the flow of information.** The company analysis uses three different software to manage information that are not integrated.
- **Standardization processes.** The process of the companies are made in different ways in detail the planning and production control process, the budgeting and the acquisition processes
- **Discrete production planning.** The type of production the company is characterized by being the discrete type where works are ordered in production numbers between 1 and 15 units.
- **Computer record of raw materials.** Raw materials and trade parts not listed in a computer record that can be consulted by any company member.
- **Robust planning for unforeseen situations.** Currently, in scenarios where it is necessary to change the priorities of the works can not readjust the planning by allocating resources to the new situation in order to optimize the production process or simulate depending on customer needs.
- **Short-term planning of the optimizer.** The scheduling functionality enables the resource allocation capacity, from raw materials to hand labour and sets the tasks for a short time horizon.
- **Integrated planning with subcontracting.** The company has percentage of its production which is subcontracted. So the process should include the subcontracting capacity to obtain a rigorous planning.
- **Reduce information redundancies identified in the purchasing process.** The acquisition process has redundant steps due to the need of one software to find the material need and other software for accounting effects.
- **Control of the current state of the works.**
- **Calculation of the production capacity of the factories.**

3.4. Identified criteria

In line with the information gathered and following the identified needs it was identified a set of criteria for tool comparison. The criteria are presented in the figure 3.

General

- Symbiosis between departments
- Integration with current software
- Discrete Production Planning Capability
- User-friendly
- Cost

Implementation

- Portfolio
- Implementation Period
- Support and Maintenance

Functionalities

- Integration with technical software
- Needs Calculation (Resources Required)
- Scheduling
- Gantt maps for planning
- Scenario simulation according to priorities
- Creation of new product specifications and operative range
- Attach documents to manufacturing orders
- Integrated programming with subcontracting
- Purchasing Management
- Warehouse management and material arrival
- Data acquisition
- Analysis of construction reports
- Creation of sub-works
- Quality control
- Back-up

Figure 3 Criteria identified

3.5. Score System

Based on the descriptions provided in the previous subchapter ratings assigned to each of the criteria identified in Chapter 3.5. for each tool. The distribution of ratings followed the following logic:

- General requirements: for these requirements have been assigned ratings from 1 to 5, where 5 is the highest capacity to meet the criteria and 1 is the least capacity to meet the criteria.
- Implementation requirements: for these requirements have been assigned ratings from 1 to 5, where 5 is the highest capacity to meet the criteria and 1 is the least capacity to meet the criteria. Exception for the implementation period criterion monthly intervals corresponding to where different scores were established. For every 1 to 4 months assignment 5; 5-8 months assignment score 4; 9 to 12 months assignment score 3; 13 to 16 months assignment score 2; 17 months or more assignment score 1;
- Functionality requirements: for these requirements were 0 or ratings assigned 1. Where 1 was assigned to the software where the criterion is contemplated and 0 was assigned to the software where the criterion is not contemplated.

4 Software Analysis

In order to proceed with the software analysis was developed a market research with the aim to identify the software houses that develop specific tools for planning and production control. After the period of research were identified 8 software houses with high potential product offers and a relevant portfolio. Then was carried out a selective analysis, along with elements of the company's case study, using the information gathered, which resulted in a group of five software houses, with high expertise and successful cases in the implementation of production planning and control solutions. The tools will be referred as tool 1 (FR1), tool 2 (FR2), tool 3 (FR3), Tool 4 (FR4) and Tool 5 (FR5). As mentioned before the approach consisted in carrying out a set of specifications of process where were characterized and identified the needs arising from chapter 3.3. Accordingly, the specification was presented to each selected software house, which was used as a support for the meetings and demonstrations about the tool. Based on the information collected and demonstrations assisted and tested each tool was scored for each of the criteria's referred in the 3.4. section. The scores obtained are presented in the table 2:

Table 2 Tools classification

N.º	Critérios	FR1	FR2	FR3	FR4	FR5
1	Symbiosis between departments	5	4	5	4	4
2	Integration with current software	4	4	2	1	3
3	Discrete Production Planning Capability	3	4	4	4	3
4	*User-friendly*	4	4	4	1	5
6	Portfólio	1	4	4	3	2
7	Implementation Period	5	5	5	3	5
8	Support and Maintenance	4	4	4	4	4
9	Integration with technical software	0	1	1	0	0
10	Needs calculation	1	1	1	1	1
11	Scheduling	1	1	1	1	1
12	Gantt maps for planning	1	1	1	1	1
13	Scenario simulation according to priorities	1	1	1	0	1
14	Creation of new product specifications and operative range	1	1	1	1	1
15	Attach documents to manufacturing orders	1	1	1	1	1
16	Integrating programming with subcontracting	0	1	1	0	1
17	Purchasing Management	1	1	1	1	1
18	Warehouse management and material arrival	1	1	1	1	1
19	Data aquisition	1	1	1	1	1
20	Analysis of construction reports	1	1	1	1	1
21	Criation of sub-works	1	1	1	1	1
22	Quality control	1	1	1	1	1
23	*Back-up*	1	1	1	1	1
	SUM	**40**	**44**	**43**	**33**	**41**

4.1. Scenario Building

It was considered that the comparison of the tools through the criteria it was a multi-criteria analysis. This type of analysis requires that relevant data is provided to determine the importance of each criterion compared to the others, so it is necessary to filter information that does not add value to the decision process[20]. Thus, it was decided to carry out a selection of the criteria already presented in Table 2. The criteria that obtained the same rating for all the tools were deleted, since their analysis did not reveal distinctive but redundant

Once analysed the value propositions of each of the 5 tools, it was recognized that the comparison between them depends on the priorities set by the company, by which were built three different scenarios that depict different priorities. To calculate the relative importance of each criteria, framed in different scenarios it was used the methodology of pair-wised comparison.

Scenario 1: This scenario pretends to promote a transition phase where the implemented tool is integrated with current software. Predicts an easy implementation that meets the need for improvement identified.

Scenario 2: This scenario intends to promote consolidated shift, centralizing all information in one software. It is expected a long-term implementation which will be redesigned processes.

Scenario 3: This scenario pretends to promote the companies' collaborators and manager's motivations and expectations by their daily working day.

Table 3 Scenarios characterization

	Criteria Weight		
	Scenario 1	Scenario 2	Scenario 3
Symbiosis between departments	4%	15%	11%
Integration with current software	19%	4%	19%
Discrete Production Planning Capability	19%	15%	21%
User-friendly	6%	15%	3%
Portfolio	11%	15%	3%
Implementation Period	19%	7%	4%
Integration with technical software	11%	15%	18%
Scenario simulation according to priorities	7%	9%	11%
Integrated programming with subcontracting	3%	5%	11%

4.2. Results

In order to reach the final results, the weighted scores were calculated for each criteria group. The results are shown in the table below:

Table 4 Tools results

	Criteria	Scenario 1	Scenario 2	Scenario 3
FR 1	General	1,79	1,96	2,04
	Implementation	1,08	0,21	0,23
	Functionalities	0,07	0,09	0,11
	Total	**2,94**	**2,26**	**2,39**
FR 2	General	1,94	1,96	2,14
	Implementation	1,31	0,75	0,29
	Functionalities	0,21	0,30	0,40
	Total	**3,46**	**3,01**	**2,83**
FR 3	General	1,79	2,07	2,06
	Implementation	1,42	0,90	0,32
	Functionalities	0,21	0,30	0,40
	Total	**3,22**	**3,27**	**2,59**
FR 4	General	1,19	1,39	1,48
	Implementation	0,92	0,63	0,21
	Functionalities	0,00	0,00	0,00
	Total	**2,11**	**2,02**	**1,69**
FR 5	General	1,61	1,92	1,99
	Implementation	1,19	0,6	0,26
	Functionalities	0,10	0,15	0,22
	Total	**3,90**	**2,67**	**2,47**

4.3. Results Analysis

When it comes to the use of different scenarios it was observed that it was obtained different results for each of them, thus confirming the importance of building a scenario aligned with the company's strategy for a proper selection. In this sense, in line with the strategy of the case study of the company it was considered the scenario 3 for the selection in question. That scenario assigns greater importance to criteria such as the ability to integrate with the software currently used, the discrete production planning capabilities and integration with 2D CAD software / 3D. This scenario, considering the classification of other criteria, proved to be a scenario with balanced characteristics between Scenario 1 and Scenario 2. This scenario is identified with scenario 1 in the ability to integrate with the software currently used, the discrete production planning capacity and the importance of finding a user-friendly tool. In turn, is identified with the stage 2 in which refer to criteria such as symbiosis between the plant, preparation, sales and purchases, the period of implementation and integration with 2D / 3D CAD software.

Regarding the results in table 2, it was observed that the tool FR2 has the highest rank in the third stage which is the selected tool to meet the needs identified in Chapter 3.2. The result is since the FR2 tool provides a solution that has 8 specialized sub-modules in various functions and centralized in a single module that clearly promotes the symbiosis between the various departments. In contrast, the FR4 tool for example, features a solution with a single module. Additionally, the FR2 tool enables the integration with the existing software with the software that acquire of shop floor data. In turn, the FR4 tool, displays only a single module does not allow integration with any other software. The FR2 tool presents an application with high level of friendliness that offers the possibility to navigate between the various features in an environment and careful design. However, it turns out that some of the features presented are available on menus that appear in cascade, which is considered it difficult to use. On the other hand, FR5 tool presents an application that stands out positively, in the design displays and whose features appear logically step by step making it easier to use. Regarding the phase of implementation, this software house has a portfolio with a two metalworking companies with discrete production planning requirements, in contrast to the FR1 tool in its portfolio does not included industrial customers. Also, it provides a set of features that comply with all the comparison criteria. Is to highlight the ability to integrate with 2D/3D CAD software needs calculation, scheduling, integrated management with subcontracting and analysis of the works reports. This set of features makes the FR2 tool a robust and versatile solution that meets the identified needs.

In addition, and taking into account the results obtained, the FR3 tool achieved a competitive score in relation to the FR2 tool, with a specialized solution in the symbiosis of the different departments of the company promoting the centralization of information flow, but has no flexibility to integrate their solution with current systems used. The implementation of the requirements FR3 tool features a complete portfolio with production requirements identical to the case study company. Furthermore, the criteria for comparison of features and like the FR2 tool, this has all the desired features in comparison criteria revealing why an extremely complete solution and according to the needs identified in section 3.4. Thus, a hypothesis to consider, so the company chooses for FR3 tool instead of FR2, would be in its strategy, abdicate to integrate with existing software, opting for a standard implementation using the data migration of existing software, so chooses the implementation of the FR3 tool that resembles largely to the strategy depicted in the scene 2. Finally, it is believed that the more thorough the analysis is to each of the tools will be greater the number of identified criteria, with different classifications, so the number of differentiating criteria increases in order to obtain more diversified results.

4.4. Implementation Plan

The proposed implementation plan is aimed at the challenges found in the literature review including top management commitment throughout the process, the identification of employees directly involved in the implementation, process redesign, integration with technical software and users training [18]. Apart from these factors were added actions that resulted from the identification of certain company specific characteristics and its compatibility with the selected tool. During the implementation plan is recommended maximum involvement of the company's top management. It is intended that managers make available the necessary resources to make faster and informed decisions, support each department individually and promote the need for sustained implementation [19]. However, and before starting the implementation schedule is proposed to hire a team of external consultants. Due to the complexity and the challenges that arise during implementation it is fundamental the selection of consultants with extensive knowledge in the implementation of computer tools and the ability to analyse objectively the company's procedures. Consultants assume the meetings control, and make sure the actions are being taken as well as being present for a consistent implementation. The implementation plan proposed in Figure 4, takes place over 12 months, divided into four stages.

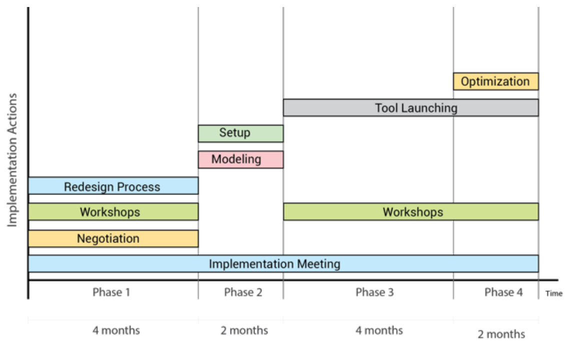

Figure 4 Implementation Plan

The first step is the organization's preparation for the tool implementation. At this stage it is recommended that external consultants organize an implementation team which naturally includes the top managers. This should incorporate elements of each department based on their capabilities, reputation, providing flexibility in previous projects and business vision[26]. It is hoped that this team meets weekly in order to formalize the challenges encountered in the week and to establish resolution plans. During this phase, it must be communicated to customers that the company will proceed to change the system so it can arise delays in production, therefore delivery times must be renegotiated. Since the implementation requires a vast knowledge of the way to allow problems to be solved tool that arise, the implementation team should be trained by the software house in order to understand its operation. Simultaneously with the training period, it is proposed to redesign business processes and the team determine how the software will work to ensure the necessary tasks implementation.

The second phase of the implementation process includes the tool configuration. At this stage, all the details and system modulation decisions must be made throughout the implementation team. In the case study, the company currently uses software that will be replaced, in this case it will be necessary to the data migration. Finally, in the second phase should occur at test session.

The third phase of implementation is the initial use of the tool, this activity should be gradually and simultaneously allowing the use of existing systems, to cause minimal interference with the business operation and consequently production. In parallel, it is intended that occur training sessions. The initial use of the tool should be viewed as a start-up period in which adjustments are made constant and the same processes redesigned.

The fourth and final implementation phase deals with the optimization tool and the respective evaluation, it is a process of monitoring the effects seen with the use of the tool. This monitoring is relevant for decision support to the need for acquisition of upgrade tool or adoption of new features to improve. The training action should be extended to the period in which this stage is preparing the players for maintaining the tool and the respective upgrades.With this implementation, it is planned to centralize the flow of information, allowing the symbiosis between the various departments and standardization of the company's procedures. In turn, the increase is expected the monitoring capacity of the company's resources to the execution of works which, together with the scheduling functionality and integration with subcontractors, ensures robustness to the planning process. As a result, it is planned to decrease the discrepancies between the expected period in the planning and reality. Regarding the company culture, it is expected that this implementation is the start of the motivation for the installation of principles of continuous improvement and further deployment of new modules according to the evolution of the business.

5 The model

Based on the work developed in the company's case study described above a model to support the selection of software for production planning and control tools is proposed. The proposed model was developed based on the methodologies identified from Constantinos J. Stefanou [11], Moutaz Haddara [10] and Oyku Alanbay [14]. However, and as noted, from the work in the company it was necessary to complement the approaches proposed with: a set of criteria upon which specific functionality for production planning and control are contemplated; information gathering mechanisms of appropriate tools for SMEs; an approach for analysing a wide range of tools; analysis according to different deployment scenarios. The framework of the proposed model for support in selecting a software tool for production planning and control consists of four: characterization, selection of criteria, market research and decision support. In the following sub-chapters are detailed each step.

Characterization This phase proceeds to the characterization of the product, ie, it is intended to identify the raw materials used, the degree of complexity, its technical characteristics and the type of typical requirements by the customers. Then it is proposed to characterize a macro production flow and motorize a set of order, to define the typical flow of an order. Furthermore, special attention is recommended for specific analysis techniques and equipment subcontracting needs in respect to manufacturing processes.Next, a detailed analysis to the planning and production control systems is recommended as well as tasks related to it. With the characterization above and the respective analysis is necessary to identify the process needs for its operation and the need for improvements.

Comparison Criteria Based on the needs recognized it aims to identify the criteria for evaluating tools. It should be taken into consideration that the selection criteria should account the global organization and integrated manner in order to avoid restrictions the planning phase and production control, as these tools work as a mean of value chain connecting everyone involved in the organization[14]. This model proposes that the criteria are selected according to three types: global, implementation and functionality. This model suggests the criteria identified in figure 3, and used on the case study. Finally, once identified the criteria is proposed the document development to identify the needs and the criteria to be evaluated in the computer tool.

Market Search Once developed the document with the specifications proposed to carry out a market research and select a set of *software houses* candidates for future implementation. For each selected tool is suggested to start the collection of information through catalogues analysis, software presentations and demonstrations tailored to business needs[12]. Next, the model proposes to assign scores to each of the selected comparison criteria. For general and implementation criteria is proposed rating from 1 to 5. With respect to the functionality criteria is suggested that the score ranges from 0 if it does not cover the functionality or 1 if it covers the functionality.

Decision Assister In order to assist a software tool selection process it was developed a program that is included in the proposed model. The program was developed using Microsoft Office Excel programmatically with Visual Basic for Applications language. The purpose of the program is using the user inputs, ie, the criteria defined in the previous step and the resulting score of the respective market research, proceeds to the exclusion criteria, of the same rating for all tools. With the selected criteria, the program presents the user with a double-entry table, allowing to compare each of the criteria with the other and thus build the scenario analysis. With the scenario values and the scores, the program presents the results.

Results Analysis the purpose is to determine the impact of the *inputs* on the *outputs*. That is, it is considered important to analyse the impact on the result of small variations in the proportions specified above. For this, it is suggested the interpretation of the relative percentages that gave results and the simulation of variations that result in new relative percentages. If the variations in the relative percentages, always respecting the company's strategy, not significantly change the results, it means that the choice can be considered valid.

6 Conclusions

The aim of the present dissertation is, after the analysis of the procedures performed in the company, to identify a set of needs for improvement in the planning process and production control and rank a set of necessary criteria for the selection of computer planning tool and controlling the proper production company. In addition, based on the approach taken in the selection of the case study of the company proposed a decision support model in selecting tools. While in the company was gathered necessary information for the realization of this work. Based on the analysis procedures and the data collected was identified the improvement needs. Later, was listed comparison criteria for the selection of the software tool. Criteria listed resemble the criteria identified by Oyku Alanbay[14] and Moutaz Haddara [10]. However, it was considered that they are generalists and not fully directed to planning and production control needs. Thus, it became necessary to identify specific requirements for the functionality of planning and control.

In this case, a market study was conducted to identify solutions that meet the criteria listed. The methods used in information gathering followed the methodology proposed by Edward Bernroider and Stefan Koch[12] suitable for small and medium enterprises such as attend presentation meetings, attending software demonstrations tailored to company catalogues and study. Of the study resulted in the characterization of different tools and subsequence classification according to the comparison criteria. To select the tool, with a higher level of assurance. It was built three scenarios that meet different implementation strategies as the most appropriate tool depends on the company's motivations, that is, the criteria to which the company attributed greater importance. Thus, the final results were obtained, and the tool selected. It is concluded that the tool selected for the scenario developed with the company's case study is the FR2 tool that presents a solution composed of sub-modules promotes the symbiosis of the various departments. Additionally, this tool is flexible and allows integration with this software currently used by the company. This solution has all the features listed for the planning and production control is to emphasize integration with 2D CAD software / 3D needs calculation, scheduling, integrated management with subcontracting and analysis of the works reports. This set of features makes the second tool in a robust and versatile solution to meet the identified needs. Based on this work the proposed selection model consists of five sequential steps, sensitive to the analyst firm for what is prepared and to be use by other companies. This model promotes the involvement in the selection of various elements of the company, ensuring a framed selection. The proposed model presents a selection methodology with specific criteria for the need for planning and production control by setting different scenario analysis. In addition, the model is suitable for small and medium enterprises indicating adequate mechanisms for market information collection. It is still possible to conclude that the work done in this thesis used a case study with obvious needs for improvement in the processes of planning and production control that allowed work with procedures with potential for improvement.

As future work for the company in the case study and following the selection of the software tool is proposed to analyse the implementation plan proposed in this dissertation and adopt the different sequential steps for carrying out the implementation. The model developed and proposed in this thesis is could be applied in other SME. Thus, it is intended that the characterization steps, selection criteria, market research and decision support is optimized in order to refine the model.

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