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Cooperation of functional areas in agricultural machinery development process

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Abstract: With the growth of the agricultural machinery market, due to the need to increase the production of food, it is necessary for companies from this sector to stand out due to their business strategies, but also due to the products and services offered to their clients. Thus, the sector has been searching for best practices to organize and manage its product development processes. This study discusses the Product Development Process taking into consideration its multidisciplinarity, that is, the participation of the several functional areas that intervene on this process. Therefore, the objective of this article is to identify the participation of these functional areas established on a reference model for the Agricultural Machinery Development Process. For such, a structure was created in an attempt to quantify this participation throughout the model. It was possible to identify and determine on a chart the percentage of participation of the functional areas in each phase of the machinery development process. It was observed that, in order to develop the concept of an agricultural machinery and to get to the final product efficiently, the participation of 12 functional areas is necessary throughout the process, acting individually or cooperating together on the prescriptive activities.

Keywords: product development process, multidisciplinarity, integration, reference model.

1. Introduction

Similarly to the other industrial sectors, the agricultural machinery sector needs an organized and well-managed Product Development Process (PDP), where the effects from this organization may increase the productivity and reduce the production costs, maintaining the competitiveness among the companies from this industry (TOLEDO; SIMÕES, 2010). According Marini and Romano (2009), to structure and to systematize the process is critical to supporting the development of innovative and effective products.

However, on the Brazilian agricultural machinery companies, there is still a strong resistance in relation to the organization of PDP by the managers, due to several factors, among them, the complexity of the development process of an agricultural machinery (ROMANO, 2013).

According to Romeiro Filho et al. (2010), in order to reach an organized PDP, it is necessary to use a formal process to guide the project, which would also be helpful for an adequate management. There are several authors that suggest models that work as a basis for this formalization, and these models may contribute for the maturation of the companies, since each one of them shows a specific approach for PDP (BACK, 1983; BACK et al., 2008; BAXTER, 2005; PAHL and BEITZ, 1988; ROZENFELD et al., 2006; ROMANO, 2013).

One of the characteristics of the product development process is the multidisciplinarity of the involved knowledge, since it requires the participation of several functional areas and their respective specialized knowledge. Therefore, Romano (2003) points out the importance of a management model that integrates the knowledge from these functional areas to the PDP activities, in order to obtain better results on the projects. Thus, it may be stated that a product development project requires the coordinated effort from the work of different functional areas throughout time. Now, which are the functional areas that work on PDP? In which phases do they work on? In which activities? Do they work together during the entire time of the project? In order to answer these questions, the aim of this article is to identify the participation of the different functional areas/knowledge domains established on a reference model for the Agricultural Machinery Development Process (AMDP).

2. The agricultural machinery sector

A long technical evolution process sets the initial bases for the localization and the current structure of the agricultural machinery industry in Brazil; however, over the last years, companies are being installed in regions with a major potential for the sector, with perspectives of also supplying for the neighboring countries (VIAN et al., 2013). According to the referred author, most of the global production of agricultural machinery comes from Western Europe (43%), followed by North America (28%), Asia and Pacific (14%) and Latin America (8%).

Currently, the global industry of agricultural machinery may be described as a mixed oligopoly, where factors such as innovation, product differentiation and scale economies are fundamentally important in the competitive market (VIAN et al., 2013). Also, according to the author, this sector has become an oligopoly due to the fact that it has three companies as the most important ones worldwide: CASE-New Holland, AGCO and John Deere. These companies are present in all continents through their own factories and partnerships with local companies.

In a research conducted by Fero (2014), the market of agricultural products is seasonal, showing instability, where the main determining factors for the demand are expectations created by the government for the agricultural policy, the funds granted by BNDES, incentives for exports, and the foreign market commodities, which affect the producer on the capitalization level.

Another important characteristic of the sector is that the manufacturing companies have a significantly segmented market, where the produced machinery meets specific demands throughout the agricultural production process, divided among tractors, harvesters, sowing, soil-preparation, transportation, and storage machineries (BERGAMO, 2014). These machineries, according to Fero (2014), in addition to optimizing the agricultural activities, have become fundamental, since, according to data from the Brazilian Institute of Geography and Statistics (INSTITUTO..., 2010), the number of workers on rural properties in Brazil dropped 16% between 2005 and 2011; going from 64% of the total population of the country in 1950 to 16% in the last 2010 census. These numbers indicate that there is less workforce in the rural area producing food for a growing urban population, thus, justifying the increase on the agricultural mechanization over the last decades.

Considering that the increase of productivity is the main benefit of mechanization, Vian et al. (2013) indicate that it is no longer an option and it becomes a standard for the countries that intend to compete on the global sphere, since it allows a greater approximation between the dynamics of offer and demand by agricultural machinery.

3. Reference models for PDP

The reference models are structures that allow us to understand the information on the life cycle of the projects, and the use of tools and methods to assist the product development process. Despite the complexity of the process, the reference models offer a detailed and integrated perspective of what must be made, regarding the work of the team and the support systems for the development of products (ROMANO, 2013; ROZENFELD et al., 2006).

The literature shows generic reference models, which may be used with adaptations in several types of projects, without compromising them. Therefore, the model described in Rozenfeld et al. (2006) is highlighted, emphasizing the perspective of development as a broad business process, following the entire life cycle of the product, comprehending integration and the strategic planning of the company, going through all phases up to the removal of the product from the market or its recycling.

Reference models are also found for the development of a specific type of product. In that sense, the reference model for the Agricultural Machinery Development Process (AMDP) suggested by Romano (2003) is highlighted, mentioned in Back et al. (2008) as the generic model PRODIP, also described in Romano (2013). The author introduces the development process in three macrophases, called Project Planning, Designing and Production, the corresponding phases, the knowledge domains connected to the process activities, as well as the results from each phase.

Both the project planning of a product and its execution do not depend only on the knowledge of a single specialist or of a functional area of the company. One of the main characteristics of PDP is multidisciplinarity, involving specialized technical knowledge from several areas, referred to by Romano (2013) as knowledge domains, whose purpose is to assist in the identification of the people and the necessary skills to conduct each activity of the project. Typically, each area or functional department of a company is responsible for a certain set of activities throughout the different phases of the project. Therefore, in order to get satisfactory results at the end of the development, it is necessary to know how much the expertise from each functional area may contribute to each phase, and, thus, manage these contributions in an integrated manner (CARVALHO, 2006).

According to Onoyama (2006), by working together, the areas of Marketing, Research and Development, Production, Finances, among others, favor the maximization of the product project, since a varied expertise is accumulated. Also, according to the author, the integration of all of these knowledge domains is fundamental for the adequate development of PDP, creating speed to meet deadlines, efficiency for the process, and quality for the final product (ONOYAMA, 2006).

4. Case study

The technical procedure used on this study was characterized as a case study applied on the industrial sector of agricultural machinery, above all, on the methodologies used for the product development process, with the purpose of identifying the participation of the functional areas on the referred process. In this context, the reference model was chosen for the agricultural machinery development process – AMDP, suggested by Romano (2003, 2013) as the object matter of the study. This model was elaborated with the purpose of explaining the knowledge on the process, helping in its understanding and the formalization of its practice.

AMDP is structured from three macrophases: the first one is the "planning" phase, which comprehends the planning phase for the product and the project itself. The second one is the "designing" phase, and it includes the elaboration phases for the product design and the manufacturing plan (informational, conceptual, preliminary and detailed plan). The third macrophase is the "production", involving the production preparation, product launch on the market, validation of the agricultural machinery and project closure.

The described phases are constituted by sets of activities, and they are subdivided into tasks. Each phase has a different number of activities; the first phase, Project Planning, counts on 29 activities; Informational Design has 25 activities; Conceptual Design, 20 activities; Preliminary Design, with 24 activities; Detailed Design, with 34; Production Preparation, also with 34 activities; Launch, 21 activities; and Validation, with 18.

Romano (2003, 2013) defines that the AMDP tasks belong to twelve knowledge domains, seen here as functional areas, on which the data used on this paper are found.

The knowledge domains/functional areas comprehended on AMDP are:

- Business Management (BM): area responsible for the decision-making phase approval;
- Project Management (PM): area that involves the initiation, planning, execution, monitoring and control processes, as well as the project closure;
- Marketing (MK): area responsible for the market research, marketing planning, advertising and product sales;
- Product Design (PD): area responsible for the development of the product conception, detailing and prototype;
- Manufacturing Plan (MP): area responsible for the development and implementation of the manufacturing plan;
- Supply (SU): area responsible for the planning and control of supply acquisitions, as well as for the involvement of suppliers in the development of the product design and the manufacturing plan;
- Quality (QU): area responsible for assuring that the quality targets are met;
- Safety (SA): area responsible for the aspects connected to the safety standards;
- Dependability (DP): area responsible for verifying that the product meets the reliability and maintainability goals, including the conduction of experiments with the prototype and the preparation of the technical assistance logistics;
- Administration-Finances (AF): area responsible for the administrative, legal and financial procedures related to the product under development;
- Production (PR): area responsible for the implementation of the manufacturing plan, production preparation and production;
- Post-Sales (PS): area responsible for the corrective and technical assistance actions in cases of failure or defects of the product on the market.

4.1. Data collection and treatment

The data analyzed on this research were collected from the AMDP reference model (ROMANO, 2003; 2013), and they were stored on an electronic spreadsheet. The data collected comprehend the phases and respective activities, as well as the knowledge domains defined on the market considered as agents whose participation is necessary for the agricultural machinery development process. As previously described, these knowledge domains generically represent the functional areas of a company, and their names may vary from one company to another. Therefore, the data collection involved the verification of the 8 phases of the process, 205 activities and 12 functional areas.

In order to identify the participation of the functional areas throughout the phases and activities of the studied model, a structure was elaborated according to Table 1. The phases and activities of the model constitute the rows of the first column on the spreadsheet. The functional areas are identified on the adjacent columns. The procedure used consisted in verifying on the studied model the participation of the functional areas on the activities of each phase. The evaluation occurred in such a way that, when the participation of a certain functional area was identified on the activity, the cell from this intersection was filled with the number one (1), and when there was no participation, the cell was left blank. Thus, it was possible to quantify the

Table 1. Structure to identify the participation of the domains/functional areas.

Functional Areas / X. Phase	BM	PM	MK	PD	MP	SU	QU	SA	DP	AF	PR	PS	Number of functional areas per activity
X.1 - Activity 1		1											1
X.2 - Activity 2		1								1			2
X.3 - Activity 3	1	1	1	1	1	1	1	1	1	1	1	1	12
...		1		1		1							3
X.n - Activity n		1		1		1	1	1	1	1		1	8
Number of activities of the phase in which the area participates:	1	5	1	3	1	3	2	2	2	3	1	2	
% of activities of the phase in which the area participates:	**20%**	**100%**	**20%**	**60%**	**20%**	**60%**	**40%**	**40%**	**40%**	**60%**	**20%**	**40%**	

percentage of participation of the functional areas in each phase of the process.

Each phase of AMDP contains a different number of activities, therefore, the percentage of participation from each functional area was calculated by simple cross multiplication. Those areas that participated in all activities of a phase were taken into consideration as 100%.

4.2. Results

Through the suggested identification structure, it was possible to identify and determine on a chart the percentage of participation of the functional areas on each activity and on each phase of the machinery development process of the reference model by Romano (2003, 2013).

The Planning macrophase comprehends the Project Planning phase, whose aim is to organize the work to be performed throughout the product development. This phase counts on 29 activities. From them, it was observed that only two activities count on the participation of all functional areas for their execution, representing approximately 7% of the activities of the phase. The other activities (93%) are conducted with the varied participation from the functional areas, as expressed in Figure 1, with the prevalence from the Project Management area, which participates in 90% of the activities of this phase, since this is the initial phase of AMDP, and it is responsible for the planning and organization of the activities. Therefore, the management of tasks, the definition of the work team, initial costs, necessary material, project documentation, which are typical management activities, are strongly present and visible on this initial phase of definition for the development process.

Starting the Designing macrophase, the second phase of the reference model aims at defining the design specification of the agricultural machinery. It is the so-called Informational Design phase, where the Project Management phase stands out, with 100% of participation, present in all

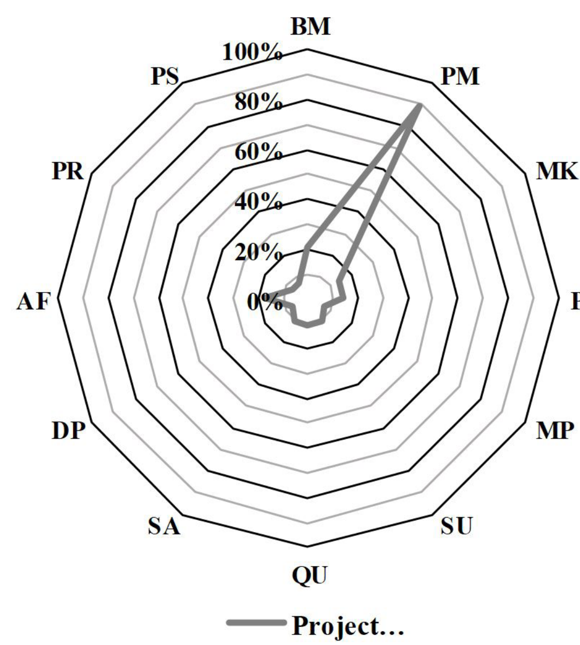

Figure 1. Planning Macrophase: Project Planning phase.

25 activities of this phase. The Quality and Administration-Finances phase are both present in 40% of the activities of the phase, as shown in Figure 2. Among all activities, 24% of them count on the participation of all areas for their execution.

The third phase of the model and the second phase of the Designing macrophase is the Conceptual Design, where the concept for the agricultural machinery is developed. This phase counts on 20 activities, where 35% of them are developed only by one area, which, in this case, is the Project Management area, participating in 100% of the activities of this phase (Figure 2). In general, this phase requires less participation from the areas than the other ones.

On the Preliminary Design phase, the third one from the Designing macrophase, the activities aim at establishing the final layout of the machinery and at determining the economic feasibility. This phase involves 24 activities, and a greater participation from the following areas was observed: Administration-Finances (54%); Product Design (50%); and Quality (50%), in addition to the Project Management area, which appears in all activities of the phase (100%), as it may be seen on Figure 2.

The fourth and last phase of Designing involves the approval of the prototype, finalizing the specifications of the components, detailing the manufacturing plan and the investment request to begin the preparation of the production. This phase is referred to by the author as Detailed Design, and it shows 34 activities. This phase counts on a greater participation from different functional areas, although these participations vary from activity to activity. The areas with greater presence are Project Management (97%), Product Design (59%) and Quality (53%) (Figure 2).

The first phase of the Production macrophase involves the Production Preparation of the pilot batch of the agricultural machinery and the implementation of the marketing planning. It counts on 34 activities, and it is, together with the Detailed Design phase, the most extensive of the model. It requires the involvement of several areas in order to meet the activities, with 97% of participation from the Project Management, 56% from the Product Design, and 50% from the Quality areas, regarding the activities, which may be observed in Figure 3.

The following phase involves the launch of the agricultural machinery on the market, and it is where the initial batch of machineries is produced. It shows low involvement from the areas throughout the activities, as observed on Figure 3, despite showing 86% of participation from the Project Management area. On this phase, there are 21 activities, and only 2 involve all areas for their development.

The last phase involves the Validation of the agricultural machinery with the clients, and the audit and validation of the project regarding the client that hired the project. Since this is the last phase of the production and of the agricultural machinery development process, this is where the project is finalized. It counts on 18 activities, where 4 of them involve all areas for their execution.

Among the eight phases of the AMDP model by Romano (2003, 2013) studied on this paper, none of them needs the cooperation of all areas in all activities, which may be justified by the demand of only one or more specific areas to fulfill a certain activity. However, as it may be observed throughout the study, through the different phases, there are activities where the participation from all functional areas are necessary (Table 2).

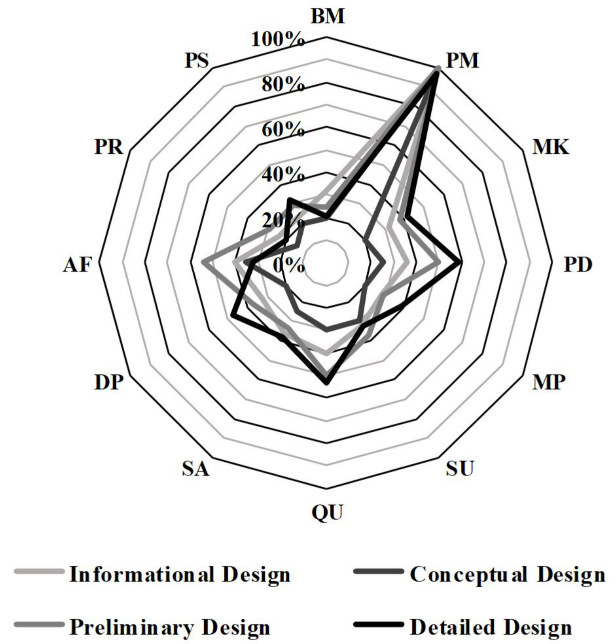

Figure 2. Designing Macrophase: Informational Design, Conceptual Design, Preliminary Design and Detailed Design phases.

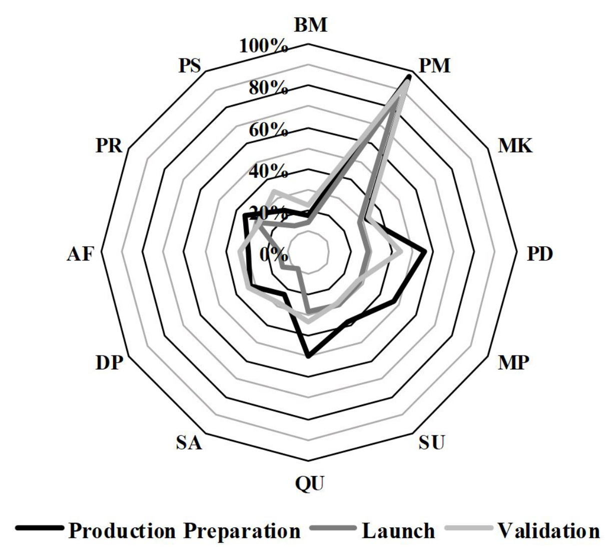

Figure 3. Production Macrophase: Production Preparation, Launch and Validation phases.

5. Final considerations

With a deeper study of the phases and activities of the AMDP model by Romano (2003, 2013), it was observed that, in order to develop the conception of an agricultural machinery and to get to the final product efficiently, the participation from 12 functional areas is necessary throughout the process: Business Management; Project Management; Marketing; Product Design; Manufacturing Plan; Supply;

Table 2. Table of activities per phase with 100% of cooperation from the areas.

Phases	Activities
1. Project Planning	• To evaluate the risk of the project for the involved areas of the company; • To record the lessons learned.
2. Informational Design	• To identify the needs of the clients/users; • To establish the requirements from the clients/users; • To establish the project requirements; • To establish the project specifications; • To record the lessons learned; • To update the project plan.
3. Conceptual Design	• To guide the team and show the updated project plan; • To select the conception for the agricultural machinery; • To record the lessons learned.
4. Preliminary Design	• To guide the team and show the updated project plan; • To develop alternative layouts; • To develop the dimensional layout of the agricultural machinery; • To evaluate the economic feasibility of the agricultural machinery; • To record the lessons learned.
5. Detailed Design	• To guide the team and show the updated project plan; • To build the prototype of the agricultural machinery; • To show prototype; • To submit the prototype of the agricultural machinery for approval; • To evaluate the investment request; • To record the lessons learned.
6. Production Preparation	• To guide the team and show the updated project plan; • To start the production of the pilot batch; • To evaluate the pilot batch; • To approve the pilot batch and the assembly test; • To record the lessons learned.
7. Launch	• To guide the team and show the updated project plan; • To record the lessons learned.
8. Validation	• To guide the team and show the updated project plan; • To discuss the failures occurred on the project and record the lessons learned; • To submit the result of the project to audit and validate the agricultural machinery project with the direct client or sponsor; • To complete the documentation system of the project.

Quality; Safety; Dependability; Administration-Finances; Production; and Post-Sales. These areas may act both individually on the activities or with the combination of 2 or more areas. From the 205 activities of the model, 33 (16.1%) count on the cooperation of all areas.

In most cases, the activities demand the participation from 1 or 2 areas, usually, from the Project Management area alone, or combined to another area. This area holds a mean participation in 95.5% throughout the phases; this occurs because during the execution of the activities throughout the phases, the Project Management team must keep an ongoing monitoring regarding the progress of the project, maintain the involved people updated in relation to scope, cost and schedule deviations.

The participation from several areas during PDP is justified by Romano (2013) due to the fact that the tasks may have several origins, and they are more easily conducted by personnel with expertise on domains from specific areas. There are some cases, such as during the Project Planning phase, where the activity to elaborate the opening term for the Project belongs to Business Management, since it is the responsibility of an executive of the company to describe the project and the product to be develop, as well as to identify and assign the project manager.

Within this context, it is said that, for an agricultural machinery development process, specific knowledge from certain areas is necessary for the activities to be performed in such a way that the delivery deadlines are met, the manufacturing costs observe the project estimations, and the quality of the final product becomes according to expected. In addition, identifying the participation from the functional areas/knowledge domains on the AMDP model will work as a parameter to evaluate the participation from the functional areas of specific agricultural machinery development models, that is, models from companies.

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