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Deploying Strategies with Integrated Events in a Home Appliance Manufacturer: Application of FMEA Through Toyota Kata

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Abstract. Manufacturing companies have been undergoing problems related to the deployment of strategies in the development of product design, with few applications of methods to facilitate the alignment of activities in this process. In order to solve this lack of alignment, this paper proposes to implement a method of strategic alignment in product design development with the use of integrating events with the participation of a multifunctional team. The method uses Failure Mode and Effects Analysis (FMEA), having the Toyota Kata continuous improvement approach as basis, as well as the Project Management Body Of Knowledge (PMBoK) guide. The proposed method was applied in a company that manufactures appliances, in the electric grill product. The use of FMEA has led to the generation of innovative and appropriate ideas, as well as the implementation of significant improvements. With the unfolding of activities by the Toyota Kata approach, a change in the way of thinking was perceived by the participants of the multifunctional team, who proposed more focused improvement actions and reflect on the result of each action in each cycle of iterations, always with the focus on the strategic goal.

Keywords: FMEA, Toyota Kata, Strategic Alignment, Product Design, PMBoK.

1 Introduction

Companies have been striving to supply the market more quickly, safely, with quality and at a lower cost, in a context where projects have grown in size, quantity, complexity and uncertainty. Companies are challenged to apply new management tools to achieve their strategic objectives [1]. Organizations that successfully execute projects employ effective project management (PM) practices as a change-generating tool. In view of the strategic impact that projects have on business, organizations must maintain effective PM processes that: capitalize on innovation; monitor progress, value and risks; and confirm that projects can cooperate with the organizational strategy [2].

In order for projects to meet the organizational strategy, companies must carry out the deployment of strategies in order to strengthen: (a) the external alignment, which refers to the competitive environment of the organization, which seeks to align the strategy with external variables; (b) the internal alignment, which is related to the mobilization of resources aiming to align the strategy with the internal variables (e.g. the structure, the management system and the organizational culture) [3]. According to data from a large benchmark survey in project management in Brazil, 56% of organizations execute their projects without prior alignment with their strategy [4].

In addition to the difficulty of aligning strategies, projects are often late, over budget, or have some of their requirements and specifications excluded to meet their original deadlines. In this environment with uncertainties, strong pressure for deadlines and limited resources, conventional project management practices seem to be no longer appropriate [5].

To achieve the expected financial result, a well-structured and managed product

development process (PDP) is necessary to reduce development time, manage the risks involved and create better products that meet quality requirements [6].

The processes involved in product design are also subject to uncertainty [7]. To minimize these uncertainties, Failure Mode and Effects Analysis (FMEA) can be used, which consists of a method used to identify in advance the modes, effects and possible causes of failures that may occur in systems, products and processes, as well as establish preventive actions. FMEA tries to improve quality and reliability in designs, systems, processes and services [8].

A set of systematic and organized processes provides order and efficiency in project management. Therefore, the existence of well-defined processes, usually grouped in a project management methodology, differentiates consistently companies that are capable of delivering better results from those that do not have this capacity [2]. In this context, to implement this alignment method, the PMBoK guide project management tool was used as the basis for unfolding product development activities.

In order to facilitate team alignment and engagement in product development activities, the Toyota Kata approach promotes the active participation of employees in the implementation process through analysis, construction of improvements, generation of ideas aligned with the strategic objective of the organization and reflections on each planned action [9]. To implement the alignment, improvement challenges towards a target vision condition are presented, and actions are taken as step-by-step experiments in the same direction [10]. In the Toyota Kata approach, the definition of the challenge for each team is carried out from the unfolding of a greater objective of the organization. This will guide the improvement processes at all levels [9].

This article presents a strategic alignment method with a combination of FMEA and Toyota Kata methods in the initial stages of the product development process in a company that operates in the home appliances sector, based on the knowledge present in the PMBoK guide, seeking to deliver a project that provides greater probability of success in changing or launching new products.

The article is organized as follows: section 2 provides context and objectives for the application of FMEA, Toyota Kata and PMBoK. Section 3 describes the method applied in this work, which is tested in a real case in an appliance company, which is described in section 4. Finally, obtained results and recommendations for future work are presented.

2 FMEA, Toyota Kata and PMBoK guide

A crucial factor for an FMEA project to be successful is the commitment of top management. It is essential that it has a long-term vision, and appreciates the time and resources spent on the activities, encouraging employees to commit themselves to the project [11].

Toyota Kata is a structured routine that is practiced to form new skills and supportive habits. Current research in neuroscience supports the idea that, through repeated practice of a routine (Kata), we can reconnect our brains to new ways of thinking and habits due to the capacity that brain has to change throughout life [12]. Toyota Kata can be considered as a four-part system: Vision; Challenge; Improvement Kata; Coaching kata. Two of these parts are related to understanding the direction of improvement activities (vision and challenge), and two are behavioral routines (Kata's) to improve and teach/train/manage improvement [13].

In order for barriers to be overcome by strategic alignment, such as unclear strategies and poor vertical communication, the project management tool (PMBoK guide) was used as the basis for unfolding the product development activities. The PMBoK guide identifies a subset of project management knowledge and is widely recognized as "good practice", which means the presence of a general consensus that

the application of knowledge, skills, tools and techniques can increase the chance of success for many projects [14].

Regarding the product development process, there is a need to strengthen the strategic alignment to increase the chances of project success. There are barriers that hinder the process of strategic alignment, among which are: unclear strategies or conflicting priorities; an inefficient management team; the leadership style, when excessively hierarchical or too permissive; poor coordination; preponderance of vertical miscommunication [15]. In view of these barriers, some tools used in companies such as FMEA and Toyota Kata contribute to solving the issues highlighted in this article, such as team engagement.

This work proposes a strategic alignment method for the product development area, with practical applications of the FMEA and Toyota Kata tools, with organization of actions throughout the project according to the knowledge base present in the PMBoK guide, contributing to the fulfillment of the gaps in the search for strategic alignment, with the application of project management tools, quality and improvement. These factors are organized in a flowchart that considers the integration of the elements with the specific application of those tools, leading to the improvement of the organizational performance.

3 Proposed Method

A flowchart with the proposed method for strategic alignment is shown in Figure 1, which was applied in the PDP of a company in the home appliances sector located in Southern Brazil, which has approximately 800 employees. That company was chosen for the application of this work due to the following: its technological innovation; the complexity of the processes of product development; the lack of strategic specifics regarding the product development process.

The method foresees project development through small incremental cycles, with constant involvement of all departments influenced by the strategic goals. Each cycle must be planned, managed and evaluated through the analysis of the project development status, information always updated at the end of each iteration.

3.1 Phase 1 - Definition of the Project Charter

In this first phase of the alignment method, senior management defines the project's objective. Based on this, it is sought that projects in the company are authorized by senior management as a result of market demand and strategic need. Then, the initiation phase of the project takes place. In the Project Charter (PC), key performance indicators (KPI) of the project are defined, which are represented by a metric related to a goal. The following indicators were defined: Quantitative and Qualitative Goal (Deadline for project completion and Product Assignments); Lessons Learned (With Action Plan); Stakeholder Satisfaction Level (Totally Accepted, Partially Accepted or Not Accepted).

In addition to making the project official, PC also seeks to align expectations regarding the product, both technically and commercially. Therefore, the document addresses the technical requirements of the product in a descriptive way, so that the intentions referring to the desired attributes, such as quality and functionality, are mentioned. This information directly assists in defining design requirements that are based on customer requirements. The PC is filled out by the product development manager and senior management, since these areas define the scope of the project with the strategic guidelines.

3.2 Phase 2 – Assemble the Project Team

The project team needs to be mobilized, that is, it is necessary to confirm the allocation of each member to work on the project, establishing how their participation should be. When choosing team members, it was decided to choose employees linked with different departments and related to the strategic objective described in the PC, to improve the performance of the PDP and provide flexibility when changes are made during project development. This cross-functional integration provides a shared vision of the project as a whole and not just in parts.

The project coordinator must develop the project team (e.g., with skills enhancement), and increase team interaction to improve its performance. He/she must also be responsible, together with the team, for meeting commitments in terms of deadlines, costs and quality. In addition, the project coordinator mainly controls the project (monitoring activities, updating schedules, disclosing information, among others). The project coordinator reports directly to senior management.

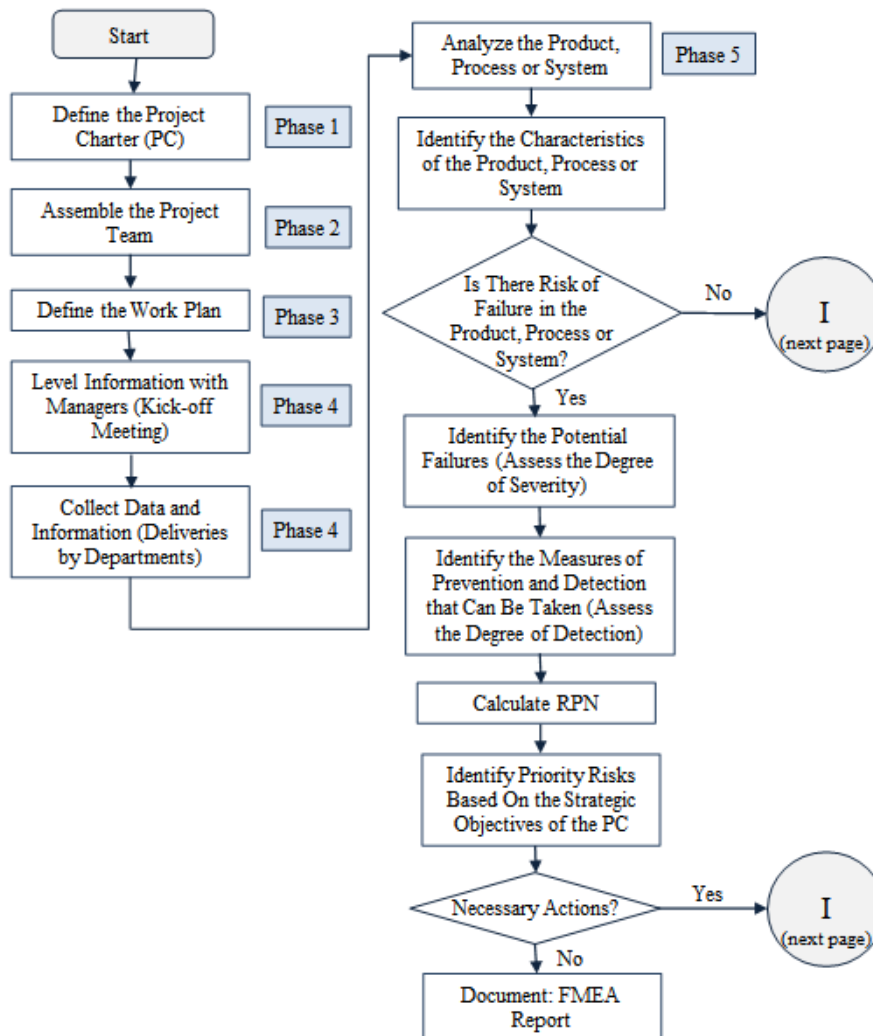


Fig. 1. Flowchart of the strategic alignment method

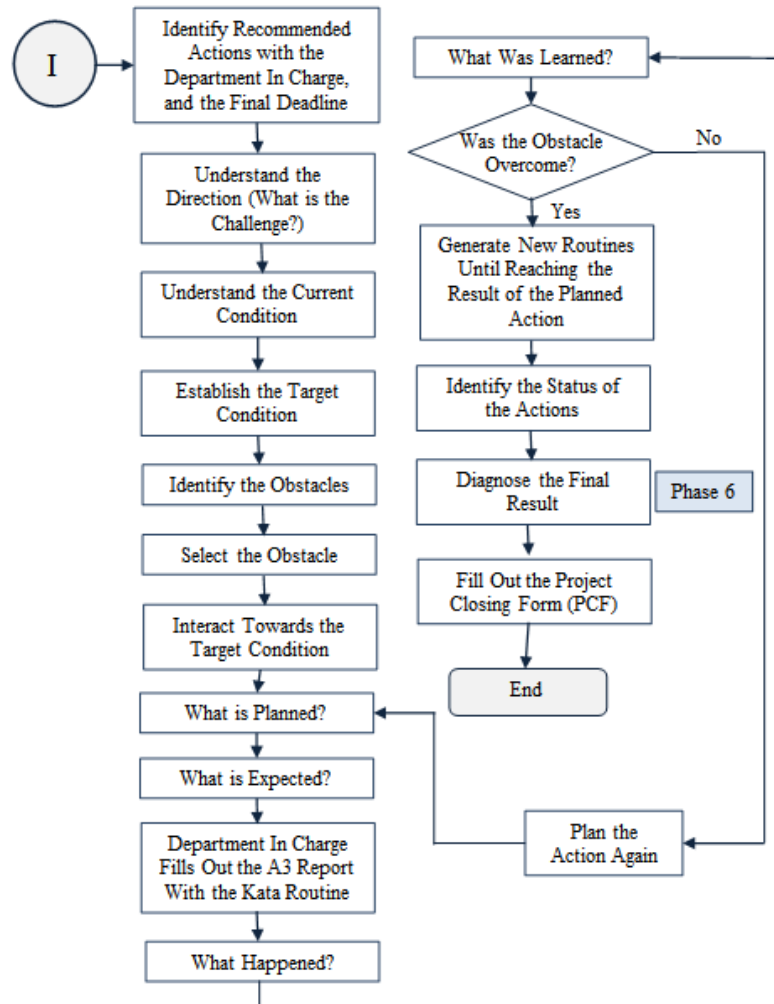


Fig. 1. Flowchart of the strategic alignment method (continued)

It is also observed that all functional areas involved have at least one representative. This configuration allows the area representative to integrate the team with the respective areas of activity, guaranteeing the synergy of product development with the other areas of the organization.

3.3 Phase 3 – Define the Work Plan

After defining the members of the project team, the work plan is developed, which is the responsibility of the product development manager and the project coordinator, with a schedule based on the information presented in the PC. The main objective of this phase is to provide a view of the time required for executing the project, with the definition of the steps to reach the deadline and the scope determined in the PC document. Approval milestones are defined at strategic points throughout the work plan, allowing the project to proceed to the next stages with proper planning, control and direction towards the strategic objectives. These milestones were defined as deliverables, and delimited at three points during the development of the project:

- Deliverable 1: PC + Formation of the Teams: Consists of the approval of the project scope and authorization for executing the project by senior management. Also in this

deliverable there is an indication of the departments that will compose the project team, by the project coordinator and product development manager, whose authorization is from senior management;

- Deliverable 2: Activity Breakdown Chart: Involves the completion of all actions performed during project development, with results described by completing the breakdown charts of FMEA and storyboard. The project coordinator is responsible for this deliverable, and presented to the product development manager;
- Deliverable 3: PCF (Project Closing Form): Consists of presenting the achieved results by completing the PCF document to senior management, with approval criteria for the proposed improvements, in order to follow the execution of the changes to the product identified by the predefined strategy.

3.4 Phase 4 - Leveling Information with Managers

The purpose of the kick-off meeting is that everyone involved had a more accurate notion of the impact of their responsibilities and work to achieve strategic objectives, in addition to the fact that each part of the structure, under an integrated perspective, contributes so that all units are aligned and connected to each other, creating productive and collaborative convergence among them. This involvement is essential for the effective execution of the organizational strategy. In this phase, the project's stakeholders are identified. With the list of stakeholders and the project charter, an opening meeting should be held, calling in advance all stakeholders to participate. The following stakeholders have been defined:

- Project Coordinator: First author of this article;
- Client: Senior Management and Product Development Manager
- Team members: Employees from Production, Costs, Processes, Product Development, R&D, Purchasing, Automation and Quality departments;
- Sponsor: Senior Management.

To increase the efficiency of the project and to force the engagement of the participants, initial deliveries are defined by departments that are part of the team, with the specification of the initial responsibilities of the parties involved. The deliverables by departments are data and analysis of quantitative and qualitative information about the product focused on the strategic objectives defined in the PC, to enable a holistic view of the whole product development process, contributing to the convergence of the members' ideas seeking to meet predefined goals. The Kick-off meeting is the responsibility of the project coordinator.

3.5 Phase 5 - Breakdown of Activities

After defining the competitive strategy presented in the PC document, the unfolding of the production strategy should be assessed, seeking to maintain the vertical strategic alignment. The tools to be implemented in this phase are FMEA and Toyota Kata. To record the information along the deployment of the actions in the iteration cycles, two charts called "FMEA - FAILURE PREVENTION ANALYSIS" and "STORYBOARD" were used, in which different colors assist in visual management. In addition, information and other significant data are synthesized, written on sheets of adhesive paper (post-its), and highlighted to have more focused attention by the team.

After presenting the PC to the project team, with emphasis on the strategic goal to be achieved, the first step is taken to complete the FMEA. Then, the project coordinator is responsible for initiating the discussion to identify the failure modes and stimulate the other participants to question technologies, functionalities, characteristics, standards, company capabilities, costs etc., motivating the team to build new ideas, concepts, proposals and analyzes of what the product will look like and how those perceptions affect companies' ability to complete the task.

In order to facilitate the organization of ideas and thoughts about the application of FMEA, consequently gaining speed and focus in the analysis process, a logical sequence of questions was created, whose answers fill the FMEA chart, presented on the FMEA card, with dimensions of 10 x 15 cm.

The sequence of questions on the card are: What functions or characteristics should be achieved?; What could go wrong?; What effects does this type of failure have?; How bad will it be if it happens? (Severity); Why does the failure happen?; How often does this happen? (Occurrence); How to detect this? How to avoid this?; How easy is it to realize that it occurred? (Detection); What are the priority risks? (Severity x Occurrence x Detection - SOD); Action plan.

With the responses filled out from the FMEA card in the chart, the potential types of failure and their causes are analyzed in order to calculate the risk priority number (RPN), in which each failure mode are assigned numeric values that quantify likelihood of occurrence, likelihood of detection, and severity of impact. After this stage, the priority of the risks discussed is analyzed, with the prioritization of actions focusing on the scope of the project defined by senior management, providing engagement of the team in order to achieve the strategic goals.

If it is necessary to take action on the risk based on the team's decision, the application of the Kata routine begins. If there is no need to deploy the action, the survey carried out on the failures and their causes is recorded in the FMEA report of the project. The application of the Coaching Kata begins, in which the project coordinator plays the role of Coach, with the responsibility of aligning the direction of the improvement actions to the recommended action described in the FMEA framework. The Kata card was created, based on the work of Rother [9], containing questions on both sides, which are discussed repeatedly with the person responsible for the recommended action, in order to help stay focused on learning the path to the next target condition through the Plan, Do, Check, Act (PDCA) fast cycle. PDCA is a method for control and continuous improvement of processes and products [16].

The sequence of questions on the card is: What is the target condition? What is the current condition? What obstacles do we need to jump? How can we evolve? What do you expect with this new experience? What was the last step taken? What did you expect? What actually happened? What did you learn?

One of the tools applied to unfold the action of each one of those responsible for the "Recommended Action" is the A3 report. After defining the information of the current condition, target condition, obstacles and the first two stages of the PDCA, with guidance from the Coach, using the Storyboard chart, the Apprentice or person responsible for the action fills out his A3 report to organize the action data for the next integrating event. The person in charge becomes the leader of the action to be carried out, having the autonomy to deploy it, including with the insertion and assistance of other departments. In the A3 report, the project name, challenge, department, date and review or integrating event, current condition, target condition, obstacles and the PDCA cycle are described.

If the obstacles are overcome in each integrating event, the requirements of the target condition are reached and new Kata routines are initiated to achieve the expected result in the "Recommended Action" described in the FMEA chart. On the other hand, if the obstacles are not overcome, it is necessary to redesign the action with a new PDCA cycle until reaching the target condition. Thus, each cycle of iterations is finalized, some of which are necessary to achieve the strategic objectives described in the PC.

To provide weekly information on the progress of activities to all project stakeholders, with the management and control of stakeholder engagement, a spreadsheet called "Project Status" was created with information relevant to the development of activities, such as: deadline for project delivery; baseline reviews

(changes to the deadline for delivery defined in the PC); number of iteration cycles; number of activities performed by department; description of ongoing activities; number of completed, delayed or ongoing activities; percentage indicator of the value reached of the strategic goal present in PC; indicator of the quantitative participation of the departments in the iteration cycles.

3.6 Phase 6 - Definition of the Project Closing Form

With the use of Toyota Kata and FMEA in the previous phase, the documentation of the analysis process throughout the development of the project is prepared, containing the knowledge generated in each action. In this context, it was decided to register the lessons learned to generate the knowledge base only at the end of the project, recorded in the PCF document. The following information is recorded:

- Results Achieved: Validation of responsibility of the project coordinator;
- Acceptation: Totally; Partially or Not Accepted. Validation of Senior Management's responsibility based on the results achieved;
- Status: To file; Deploy or Standby. Validation of senior management responsibility;
- Approval of stakeholders by the project;
- Records of Lessons Learned: based on the knowledge, skill and attitude generated throughout the development of the project, with both positive and negative impacts;
- Action Plan: This information is intended to improve and spread the knowledge acquired throughout the development of the project.

In this last phase, the results achieved are recorded in order to verify if the justifications were validated and if the benefits were obtained, in addition to formalizing the delivery of the final product of the project.

4 Case Study

This work was carried out in a company in the home appliances sector, located in the southern region of Brazil. In view of the competitive market of home appliances, the company periodically considers the need for project updates, be it adaptation or the launch of new products. Such changes generally occur in order to meet new market demands, such as design evolution or suitability of the product in relation to sale price.

In order to apply the method, the product "Electric Grill" was chosen as a pilot project, since senior management considers the need for commercial leverage of the product, with losses of market share over the last years, and also the relatively low complexity both of assembly and parts/items that compose it. The electric grill has an average monthly demand of 9,500 units (data from 2019), with an average annual turnover of US\$ 1,979,000.00 only with this product.

The application of the alignment method according to the flow chart in figure 1 begins with phase 1 (definition of PC), with the approval by senior management for conducting the research, with the awareness of the responsibility of defining the strategic objectives by the document PC to start developing the project. It was defined that the first author of this article would be the project coordinator and would develop the alignment method and, as interventions were necessary, they were authorized to be conducted together with the team participating in the action research in order to meet the predefined objectives.

This stage was characterized by the definition of the challenge to be achieved by the company at the organizational level. Based on information from the market research carried out by the Marketing department, senior management determined the strategic objective to be achieved by the team, which would be to reduce the cost by 15% of the product electric grill, to increase competitiveness compared with the main competitors. Thus, the PC document was filled with the following data:

- Document number: project identification, used as a title in all communications made between members of the project team and interested parties: number 2167;

- Requestor: responsible for defining strategic objectives, corresponding to the senior management representative;
- Date required for implementation: deadline for delivering project results according to defined strategic goals: date;
- Item description: product defined by senior management with strategic objective – Electric Grill;
- Description of the request: scope of the project with a description of the sought product attributes, and market research performed by the Marketing department;
- Justification and Evaluation of the benefit of the request: definition of strategic goals by senior management, which can be quantitative or qualitative: quantitative Goal: 15% reduction in the cost of the product.

Still referring to filling in the PC, it is worth mentioning the specification by senior management of the project metrics, such as project execution deadline and product cost reduction, essential objectives. In phase 2 (Assembling the project team), seven departments were chosen, with the participation of senior management and the product development manager. The departments were: Product Development, R&D (Automation), Purchases, Production, Manufacturing Processes, Quality, and Costs

In each of the departments in the company studied, it was sought to include managers or leaders/analysts to contribute to this development process.

In phase 3, the work plan (table 1) was defined by the product development manager and project coordinator, with a schedule based on the information defined in the PC. Deliverable dates were also determined at strategic points throughout the project development.

Table 1. Work plan

Phase	Date
Deliverable 1 - PC (Phase 1) + Formation of Teams (Phase 2)	May 9 th , 2019
Kick-off meeting (Phase 4)	May 16 th , 2019
Data and Information collection (Phase 4)	May 30 th , 2019
Application of tools (integrated events) (Phase 5)	May 30 th , 2019
Deliverable 2 - Activity Breakdown Chart (Phase 5)	June 28 th , 2019
Define the Project Closing Form (Phase 6)	June 28 th , 2019
Deliverable 3 - PCF (Phase 6)	July 12 th , 2019

In phase 4 (Leveling information with managers), the leveling of information about the strategic objectives proposed in PC and the need for data deliveries by departments is carried out in a meeting called Kick-off, with the presence of the chosen project team. The project coordinator explained the stages of the work plan (table 1), emphasizing the dates of deliverables throughout the project, such as deliverables 2 and 3, respectively, “Activity Breakdown Chart” and “PCF - Project Closure Form”. The project coordinator communicated the dates of the meetings, which would initially be weekly, depending on each integrated event, at a predefined time, in the place called the Obeya Room or Project Room. During the meeting, the initial planning of the iteration cycles was explained, with emphasis on the duration of each meeting (60 minutes) and the format (stand-up meeting).

After the kick-off meeting, the project team begins phase 5 (Breakdown of activities), with deliverables displayed on the flipchart board, such as:

- ABC curve of product costs:
 - 82% of raw material costs (items: set/plastic support, aluminum blank, resistance, cable, grate, base);

- 18% of process costs (8.87% third parties, 9.13% internal processes). Third party costs include enameling the base;
- Total cost of the electric grill: US\$ 10,56 (127 V) and US\$ 10,09 (220 V)
- Benchmarking:
 - Comparative analysis of product attributes with 4 main competitors, such as: activation; temperature regulation; grate design; operating light; product dimensions; weight; power; voltage; consumption; base material and price
- List of main suppliers.
- Market share:
 - The company currently has 27% of the national electric grill sales market. This indicator is decreasing 10% on average in the last 3 years, based on the absolute value.
- Preliminary tests and trials:
 - The R&D department presented information relevant to product performance standards and adjustments that must be complied with.
- Quality indicators.
- Flowchart of the manufacturing process:
 - The whole production chain was encompassed, with its sequential steps of operations from the raw material to the assembly of the product.

After all deliverables, the project team initiated brainstorming on the first actions that should be taken towards the strategic objective. It was decided to direct efforts to analyze possible improvements and potential flaws in the materials used in the manufacture of product parts (this corresponds to 82% in the ABC curve). With data from benchmarking, it is possible to visualize alternatives of materials and functions that may impact the cost of the product.

After this initial meeting, the project team met 10 times in a period of two months, in cycles of iterations in order to unfold the product design development activities, focusing on the strategic goals defined in PC. At this time, the FMEA and Kata routine tools were applied, based on the flowchart in figure 1. The period between each cycle of iterations alternated from 2 to 12 days, with the definition of dates by the project coordinator based on the possibility of delivering results by the target condition determined in the storyboard, minimizing the risks of deviations from the strategic objective.

In the first iteration cycle, the project coordinator started the meeting with FMEA, analyzing and identifying product characteristics focused on raw materials, according to the flowchart of the alignment method (figure 1), phase 5. The initial questioning on the FMEA card was made, which was as follows: “What functions or characteristics must be met?”. The group answered for the characteristic or item “Electric Grill Base”, due to the impact of this raw material on the total cost of the product. Following the flowchart, there is a risk of failure of the item. Thus, the project team began to implement FMEA and complete the chart. Since the meetings should last a maximum of 60 minutes, the project coordinator directed the group’s actions and discussions so that, at the end of the estimated time, at least one recommended action should be deployed by the Toyota Kata tool. In this context, three potential causes of failures were analyzed in this first iteration cycle, until reaching the RPN number.

With the multiplication of SOD indexes, the highest RPN value (288) was reached for the potential type of failure “oxidation”. At this moment, the recommended actions must be aligned to achieve the strategic objective predefined in PC. To proceed with the alignment, the project team decided which action had greater alignment with the scope of the project, regardless of the RPN value. Since the objective of the project is to reduce costs, actions were taken in this direction to achieve the level of efficiency expected in the development of the project.

Four actions were recommended regarding the item “grill base”, and their respective departments. Action 1 is intended to analyze the type of failure “cleaning”, while action 2 proposed the raw material “Alusi”, which is a steel covered by an aluminum (90%) and silicon (10%) coating, an alternative brought by comparing with other bases used by competitors. Action 3 is intended to test the base with “Teflon”, while action 4 analyzes thermal variables such as conduction, radiation and convection, in the use of different materials in the base to meet the expected quality.

Another item analyzed by the team was the painting process. However, in this case, there was no need for FMEA analysis FMEA, due to the decision of the project team based on the lack of risk of failure or uncertainty that impact the product through the painting process, after checking the production indicators presented by the quality department. After defining the deadlines to deliver the recommended actions, the development status is filled out with the following classification options: in progress, overdue or completed. All actions were deployed simultaneously, with no need for additional prioritization criteria.

With the identification of the recommended action as well as the department in charge and the deadline, the application of the Toyota Kata tool begins, having the project coordinator as Coach, and the person representing the department in the recommended action as the Apprentice. As the first step of the Kata routine is to understand the challenge, the storyboard chart is filled with the strategic objective present in PC: to reduce costs and establish market positioning.

Action 1 is provided by the R&D department (Apprentice), for which the questions described on the Kata card are performed by the Coach: What is the target condition? What is the current condition? The answers were filled out on the storyboard by means of post-its stickers, by the Apprentice and, later, in the A3 report to record the information related to the action that will be deployed. By filling out the information on the current condition, target condition and obstacles, the PDCA cycle begins, with definitions of what is planned to be done, expectations, what happened and what was learned. In action 1, the R&D department plans to select 2 bases with the Alusi plate, define a test plan and buy the food to run the test, with the expectation of collecting results from the use of the Alusi plate. The account of what happened in action 1 was written in the next iteration cycle, at the beginning of each meeting, enabling the project team to communicate the necessary results, which stimulates new ideas and actions to be taken.

In order to provide flexibility and robustness in the application of the Toyota Kata, adaptations were made in the analysis of the obstacles, diverging from the traditional Kata, being composed of adversities or difficulties, not just problems, to reach the requirements of the target condition. The actions were focused on reaching the target condition when overcoming the identified adversities or difficulties, evolving in the search for the solution of the action defined in FMEA, different from that described in the works of Rother [9] [12] in the traditional Toyota Kata.

Another adaptation of the Toyota Kata application in this work corresponded to address all the obstacles described, instead of individually, since the situations brought up could be deployed simultaneously seeking to achieve the target condition. In addition, the target conditions were defined differently from the traditional Kata, with adaptations to requirements such as product attributes and activities to be delivered. Figures 2 and 3 present the records in the FMEA and storyboard charts for the iteration cycle (revision 0), with the filled out information related to the PDCA cycle.

FMEA								
PROJECT	2167	GROUP MEMBERS	R&D; Quality; Costs; Processes; Product; Production; Purchases; Automation					
DATE	June 6th/2019	REVISION:	00					
ITEM/FUNCTION	FAILURE			CAUSE				RPN
	POTENTIAL TYPE OF FAILURE	POTENTIAL EFFECTS OF FAILURE	SEVERITY (1-10)	POTENTIAL CAUSES	OCORRENCE (1-10)	PROJECT/PROCESS CONTROL (DETECTION)	DETECTION (1-10)	
grill base	cleaning	aesthetic	5	material (finishing)	3	test	3	45
	oxidation	useful life	8	material	9	test	4	288
	peeling	useful life (aesthetic)	8	material (coating)	3	test	5	120
	stamping	waste	3	material				
		machine adjustment	3	processes				
	cooking (time)	efficiency	6	current project				
	IEC adequation	recall	8	project alteration				
painting process								
resistence	cooking (time)	efficiency	6					
		consumption	2					
	deterioration	useful life	8					
		safety	10					

RECOMMENDED ACTIONS					
ACTION		DEPARTMENT RESPONSIBLE	DEADLINE	TOTAL	STATUS
Execute test with food + chemical product	1	R&D	June 13th / 2019		ongoing
Analyze viability of supplier for the Alusi	2	Purchases	June 13th / 2019		ongoing
Test the plate with Teflon material	3	Product	June 19th / 2019		ongoing
Analyze thermal variables of the base's	4	Automation	June 13th / 2019		ongoing
Analyze manufacturing costs with painted	5	Costs	June 13th / 2019		

Fig. 2. FMEA - iteration cycle 0

With the application of the Kata routine linked with the recommended actions of FMEA, it became evident the importance of working the PDCA in an established direction, since, without a specific target, it frequently changes direction, especially when problems are encountered, resulting in the loss of focus of the project, in this case, the strategic objectives.

To unfold the actions indicated in the storyboard, each of the members representing the department uses the Kata routine on A3 sheet to write down the information related to their action. This unfolding with the A3 sheet led to a good result, in which the systematic construction of the report forces the participants to reflect on the objective, actions already taken, restrictions and actions for the next

cycle of iterations. Another important factor is that there is an effort to simplify the presentation of information (in the post-its), since the need to report, in just one sheet, led to a more focused reflection and construction.

STORYBOARD - KATA ROUTINE				
PROJECT	2167	CHALLENGE	reduce costs and establish range of prices	
Action	CURRENT CONDITION	TARGET CONDITION		OBSTACLES
1	alusi plate in stock; no food	cleaning test	June 13th / 2019	request food purchases; request product purchases
2	no available data	feasibility of purchase	June 13th / 2019	minimum batch; deadline; price; Alusi plate specification
3	teflon base requested	cleaning and temperature test	June 19th / 2019	deadline; supplier
4	no literature about thermal variables	information on thermal variables of materials	June 13th / 2019	supplier survey; availability for analysis
5	current enamel plate	analysis of painted plate	June 13th / 2019	paint budget

PDCA CYCLE			
WHAT IS PLANNED?	WHAT IS EXPECTED?	WHAT HAPPENED?	WHAT WAS LEARNED?
select two bases; define test plan; buy supplies for tests	collect results	tests conducted in november/2018; there were no non-conformities in the tests	check history of tests
contact supplier	collect data and information	only one Brazilian supplier; low volume (predefined date); minimum batch 26 tons; value of ton = US\$ 940.90	size of market of the Alusi plate
contact supplier to assess his/her proposals	analyze alternative material	color (black) teflon; unfeasible cost (US\$ 10.42 per unit)	high value of teflon material
request information from experts (processes)	feasibility and comparison of materials	analyze thermal variables	white color meets radiation better (emissivity)
contact supplier	obtain information about alternative material	cost of painted base (-2.56%)	always analyze new alternatives

Fig. 3. Storyboard - iteration cycle 0

There were nine more cycles of iterations until reaching the expected results, each cycle complying with the steps described in the flowchart of the alignment method (figure 1). The results achieved were:

- Alteration in the grate design, with greater spacing between the bars;
- Application of the Alusi plate in the base and deflector plate of the grill;
- New electrical cable project;
- 23.97% reduction in product cost.

In the last iteration cycle, the project team updated the information in the FMEA and storyboard charts, and began phase 6 (Definition of the project closure form) by completing the PCF document referring to the lessons learned throughout the project development, with focus on both positive and negative results in three areas:

knowledge, skill and attitude.

With the PCF document completed by the project coordinator, the achieved results were presented to both senior management and the product development department manager. Senior management decided to accept “Partial” results due to the commercial impact raised by the marketing department regarding the raw material Alusi replaced the current enamel plate in the item “Base”, which would mischaracterize the product image in terms of value such as durability and ease of cleaning in the eyes of the customer. Therefore, the enamel plate was kept in the “Base”. On the other hand, the use of the Alusi plate in the item “Deflector Plate” was approved, resulting in cost reduction. With the “Partial” acceptance, the reduction amount achieved with the proposed changes in the project was 12.47%, instead of 23.97% if the acceptance were “Total”.

Also at PCF, in this meeting with senior management, the Action Plan on the opportunities raised in the Lessons Learned was completed, to promote an evolution of knowledge in future projects.

5 Conclusion and Future Works

With the results achieved, the proposed method provides greater efficiency and effectiveness in planning and control of the company’s project activities, and improves the alignment among employees. Some results obtained include the strategic alignment involving senior management and the management of the area in the project, recording and monitoring suggestions and applying specific tools to solve problems.

Another advantage of applying the alignment method is the high speed to obtain results, which results from the short time between integrated events. This enabled foreseeing deviations between the planned and the real situation and, based on this information, actions can be taken promptly to correct the deviations.

The adaptations made in the traditional Toyota Kata in relation to the analysis of obstacles, descriptions of the target conditions and the deployment of actions in order to achieve the target condition, provided flexibility in the use of Kata, facilitating the alignment of the members of the project team and conducting training of solution developers at all levels, who started to solve problems themselves instead of asking for the presence of specialists.

The application of FMEA provided robustness as well as minimized the engineering risks present in the development of product projects, consolidating the quality in the final decision made by the team during the iteration cycles. In addition, with the use of FMEA, the satisfaction of those involved in preventing, reducing and eliminating problems was observed, in addition to allowing knowledge sharing. In this way, through the proposed alignment method, all participating areas worked to facilitate the decisions and solution of the flaws found in the PDP.

With the integration of FMEA and Toyota Kata techniques, and PMBoK, the method helped to reduce uncertainties, reduce project costs and, consequently, product costs. The language was standardized between the personnel involved and the storage of lessons learned, resulting in customer satisfaction when using the developed product or service. This adaptability characteristic and the consequent reduction in response time are very important factors in the development of product projects, as they provide greater speed in launching products to the market, meeting the strategic guidelines defined by senior management.

Future research could apply the proposed method in developing projects for other products of the considered company, as well as in other companies.

It is also suggested in a future work to assess the proposed method for a longer period of time, at least two years. Thus, greater maturity would be achieved in project

management and in the application of FMEA and Toyota Kata tools, with likely greater impacts on the results obtained in the companies. In order to reduce the impact of subjectivity that exists in FMEA, research is suggested to define FMEA SOD criteria with greater objectivity and simplicity.

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