FMEA-AHP Multi-criteria method for NPD project launch analysis

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Garcia, Pedro A.*

IIT; Universidad Autónoma de Ciudad Juárez. Ciudad Juárez, México. peagarci@gmail.com

Perez-Dominguez, Luis

IIT; Universidad Autónoma de Ciudad Juárez. Ciudad Juárez, México. luis.dominguez @uacj.mx

Luviano-Cruz, David

IIT; Universidad Autónoma de Ciudad Juárez. Ciudad Juárez, México. david.luviano@ uacj.mx

Solano Noriega, Jaime

Universidad Autónoma de Occidente, Culiacán, Sinaloa, México. Jaime.solano@ udo.mx

Cordero-Díaz, Marling Carolina

Universidad Francisco de Paula Santander. San José de Cúcuta, Colombia. marlingcarolinacd@ufps.edu.co

Abstract:

Nowadays, the New Product Development (NPD) process demands shortest development cycle-time to introduce the products into the global markets as well as offer better products for the consumers, different tools and methods are used to assure product launched on time without failures. In this document will be introduced a novel Failure Mode and Effect Analysis (FMEA) used in combination, Analytic Hierarchical Process (AHP) and Dimensional Analysis (DA), changing the way to get the RPN over the FMEA ranking process, getting an accurate FMEA-RPN-DA, to help Engineers and project manager to handle their project resources available in a wisely manner. This paper contains an experimental case to validate the proposed new method.

Keywords: NPD, FMEA, DA

1 Introduction

New Product Development (NPD) is an essential activity for the industry nowadays (Fang & Chyu, 2014) and it is required to keep the global economy healthy, most of the companies have important investments in new product research and development area, because this helps to launch products for different markets with the main objective to launch the products in the fastest way as possible (Chen, Wang, & Lin, 2015), and within the customer desired quality, moreover the companies struggle getting right tools to simplify the NPD process and assure the expected results on the

final products, even dedicated companies created manuals to manage the product development (Kahan, 2012).

There are multiple NPD methodologies, and all companies are trying to get the most effective process, due to our current rapid global markets. One of the NPD most used process is the stage gate process by copper (Cooper, 2008), and from this, several other NPD methodologies was deployed as a variant of it, modifying the stages and trying to reduce the process time, even with this modifications, one of the noted inconvenient with this methodology is that usually takes too long to launch a product into the field.

2 THEORETICAL AND CONCEPTUAL FRAMEWORK

FMEA with Fuzzy Sets was combined by Pillay and Wang in (Pillay & Wang, 2003). FMEA is a systematic tool used to analyze the inputs and outputs contained on each stage of product development (AIAG, n.d.). FMEA tool had been evolve over the time, and since 1996 to the date the Risk Priority Number (Pillay & Wang, 2003), which is obtained from the product of Severity (S), Occurrence (O), and Detection (D) values ranked by the Subject Matter Expert Team. The RPN helps to identify the relevant factors that affects the process under analysis.

Analytic Hierarchical Process (AHP) was introduced first time by Saaty (R.W. Saaty, 1987), Saaty uses the AHP to compare different scales like the continuous and discontinues.

Dimensional Analysis (DA) was first introduced by Professor Bridgman in the early 20's (Bridgman, 1922). According Perez-Dominguez et al, DA has advantages to solve problems within multiple criteria applied (Pérez-Domínguez, Alvarado-Iniesta, García-Alcaraz, & Valles-Rosales, 2018). DA is useful to rank S, O and D over the FMEA. Villa et al. (Silva, Dominguez, Gómez, Alvarado-Iniesta, & Olguín, 2019) used Dimensional Analysis to solve Multi-Criteria problems.

3 METHOD

Method used on this document is divided in three stages, starts with the three NPD Subject Matter Experts (SME) and complete the FMEA identifying nine main risks that affect directly to the NPD project results. See figure 1.

Second stage of the method is to rank same FMEA using AHP scale, same SME Team should assess the same FMEA using AHP, and the average of the three SME rank is obtained for S, O and D.

In the third stage, Dimensional Analysis is apply using S, O and D values obtain from the previous stage, in the AHP-FMEA.

As a result, the AHP-FMEA-DA is obtained, and the validation of this methodologies integration is performed using Cronbach's alpha.

Five steps follow during the methodology are listed as per below:

Three Subject Matter Experts (SME) select nine risks for NPD Project.

Make the three SMEs rank the risks at the FMEA for Severity (S), Occurrence (O) and Detection (D) fields using Analytic Hierarchy Process (AHP).

Get the average of the three SMEs for the FMEA S, O and D.

Make the calculations applying DA to get the AHP-FMEA-DA rank.

Get, analyze, and validate the project results using Cronbach's alpha.

FIGURE 1. METHODOLOGY BY STAGE.

4 RESULTS

DA is introduced after rearranging the AHP scores by the SME Team, DA Matrix is feed it with the weights averaged.

Computing applying DA to get the AHP-FMEA-DA rank. Where C1 is FMEA severity, C2 is FMEA Occurrence and C3 is Detection.

DA Criteria Matrix is analyzed to get the *IS* of each Criteria.

Three weights assigned from SME, then applying weights to the normalized DA. See table 1.

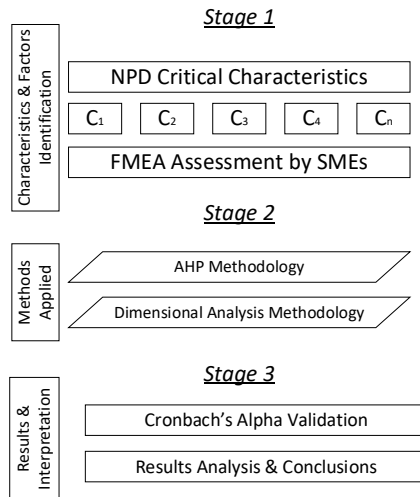TABLE 1. AHP-FMEA-DA MATRIX WITHIN FINAL CALCULATIONS.

Criteria	C1	SDA Rank	C2	ODA Rank	C3	DDA Rank	Conventional FMEA RPN
A1 = Z1	1.549	1	1.26	1	1.419	3	280
A2 = Z2	1.442	2	1.186	3	1.289	6	245
A3 = Z3	1.126	8	1.123	5	1.37	4	105
A4 = Z4	1.289	6	1.101	6	1.529	1	128
A5 = Z5	1.197	7	1.000	9	1.229	7	84
A6 = Z6	1.000	9	1.077	7	1.000	9	42
A7 = Z7	1.419	3	1.053	8	1.508	2	216
A8 = Z8	1.317	5	1.205	2	1.317	5	140
A9 = Z9	1.395	4	1.145	4	1.087	8	96

Get, analyze, and validate the project results using Cronbach's alpha (Cronbach, 1951). In this mode, the result is 0.63, range of good correlation.

5 CONCLUSIONS

Currently FMEA tool has some drawbacks regarding to the consensus under group decision environment. In addition, there is a concern to capture the opinions of the cross functional team. In this manner, we carry out a MCDM problems using AHP and DA methods. This study shows the integration of Failure Mode and Effect Analysis, Analytic Hierarchic Process and Dimensional Analysis to rank importance over New Product Development criteria, is proved that this integration of methodologies is effective to rank the NPD criteria. This work will help on future investigations applying this novel integration of methodologies to get better

projections for New Product Development projects getting more accurate ranks helping to improve any process.

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