

Proposing a Proceeding for Evaluating the Reliability of Innovator Product

*Prof. Dr. João Chang Junior (chang.joao@gmail.com) and Marcelo Leonildo Teruel
(mteruel@ig.com.br)
Centro Universitário da FEI*

Abstract

The paper's objective is to propose a methodology that evaluates and improves the innovative product reliability in its development phase, using accelerated life testing data in prototypes, ratifying product warranty period and assessing company costs in warranty period. The methodology was applied to an electronic product launched in Brazilian market.

Keywords: Reliability, Development of Innovative Products, Warranty.

Objectives

The main objective of this paper is the reliability evaluation of an innovative product in its development phase, using data from accelerated life testing of prototypes. The secondary objectives are: ratify the warranty period of an innovative product set in the early stages of NPDP- New Product Development Phase; estimating the costs that the company will have during the warranty period; dimensioning the structure for warranty service (materials, labor etc.).

Methodology

The development methodology of this paper can be classified as a quantitative applied research, since it aims to solve a specific problem of assessing the reliability of new products with the need to survey data from tests with prototypes in the stages preceding the launch, where there is little or no data availability. To this end, an experimental field research, conducted in the laboratory issued as the main method of investigation.

Literature review

A new product is defined by the client or the company's perspective, which leads to different concepts. From the viewpoint of the company, a new product can be any increase in the existing product portfolio. From the viewpoint of the customer, however, the novelty of a product is determined by the realization that the potential users (market) has of this new product, when considering its adoption (Nunes, 2004).

Combining the degree of novelty in which products are identified by companies and the market, Booz, Allen and Hamilton (1982) cited in Nunes (2004) distinguished six categories of new products: 1. New products to market; 2. New lines of products; 3. Introduction of products in current lines of the company; 4. Improvements or revisions of existing products; 5. Repositioning; 6. Cost reductions (as shown in Figure 1).

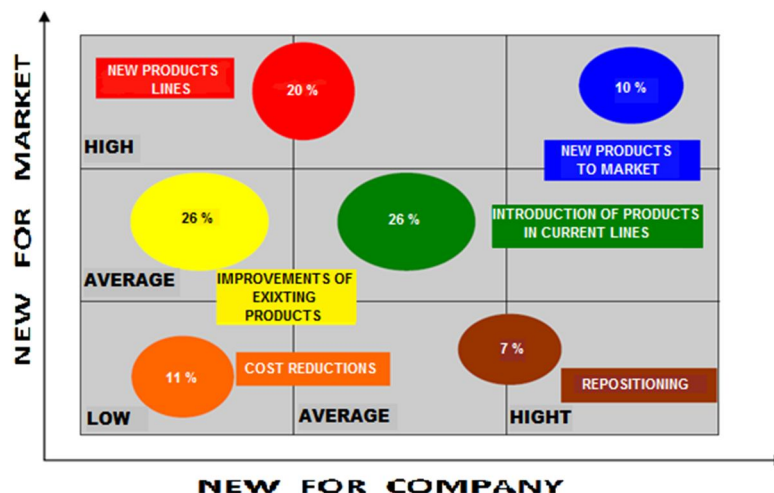


Figure 1: Categories of New Products

Companies typically look for a suitable combination of products of the six categories listed in figure 1, allowing them to take the full potential of the technologies they use to meet the different preferences of their customers and, anticipate obsolescence of the portfolio of products starting to explore new technological possibilities (Nunes, 2004).

This paper considers a new product that will demand high level of company involvement, great loss of resources in case of failure and high expectations of profit in case of success. Consequently, the understanding of new products is: the product technologically advanced or which presents a technological and innovative breakthrough comparing with other.

New products reliability evaluation model

To assess the reliability of new products, an operational procedure (a model) was developed and was inserted into the new product development process (NPDP), consisting of: 6 basic assumptions (BA) + 5 steps suggested in NPDP (SS) + 10 steps (S).

The procedure will be described and detailed below.

Basic Assumptions (BA):

BA-01: Product type - The product should be innovative, new to market.

BA-02: Product complexity - Product with two or more blocks operating in parallels or in series.

BA-03: Sample size - Due to economic, temporal, or physical limitations, there are not many available prototypes.

BA-04: Product maintainability - The product must be repairable.

BA-05: Prototyping phases - The NPDP must contain at least two phases of prototyping embedded in its context (APHA and BETA).

BA-06: Product performance - Determine, in the early stages of NPDP, the minimum expected performance.

Figure 2 shows the 5 suggested steps in NPDP (SS).

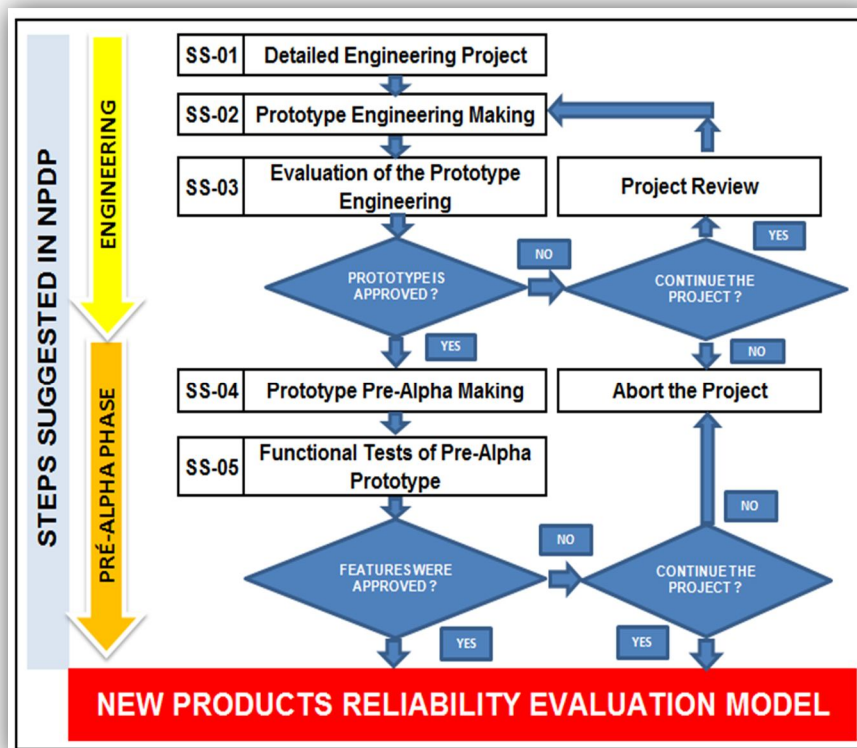


Figure 2: Suggested Steps in NPDP for New Products Reliability Evaluation

SS-01: Detailed Engineering Project - Fabrication drawings of parts, assemblies and subassemblies; exploded view of all parts of the product, bill of materials (BOM).

SS-02: Prototype Engineering Manufacturing - In NPDP, after the end of the conceptual and detailed design starts the prototyping phase, which is necessary for the check (in practice) of the product basic functionalities.

SS-03: Evaluation of the Prototype - Operational tests are carried out without the concern and commitment to deeper analysis and detailed performance and reliability. We analyzed the functional aspects and the basic visual aspects, (finishing style modeling of subassemblies and components, handling, size, weight, shape, appearance, texture of materials).

SS-04: Prototype Pre-Alpha Manufacturing - New prototypes must be made using their respective final fabrication processes. A larger number of units can be provided, so that such units are used in subsequent experimental tests.

SS-05: Prototype Pre-Alpha tests - The first phase of construction of units using the actual manufacturing processes. The units are put into operation in order to simulate the field use by accelerated operation tests. The prototypes are evaluated relative to the functionality of their components and subassemblies. Dimensional aspects and their tolerances should be analyzed in order to verify if the tolerances are appropriately projected.

10 steps(S) for Reliability Evaluation of the New Products (as shown in figure 3):

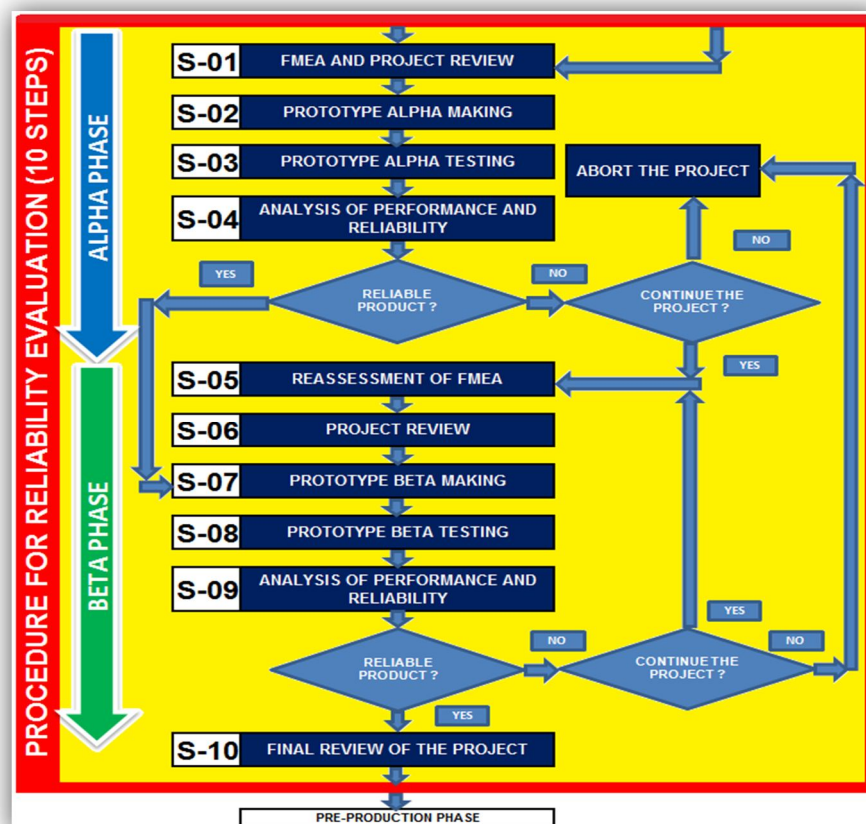


Figure3: New Products Reliability Evaluation Model

S-01: FMEA – Failure Mode Effect Analysis (ASQC, 1995) and Project Review - with the information of minimum expected performance of the product, and the results of tests with prototypes of engineering and Pre-Alpha phases, a preliminary study of the qualitative behavior of faults must be done before the manufacturing of the Alpha units, aiming to identify critical points of the product, and minimize risk of occurrence of failures. This analysis will suggest corrective actions that will be incorporated in the project (design review). The FMEA is the tool of choice for this purpose.

S-02: Prototype ALPHA Manufacturing - Taking into account the results of FMEA, ALPHA prototypes are made with the objective of laboratory testing and field, aiming at improvement of the project in order to establish and consolidate the product features (performance and reliability of the product). The prototypes are made using their final manufacturing processes: plastic injection processes, machining, rolling, forming and casting, among others.

S-03: Prototype ALPHA tests - units are subjected to accelerated life tests, simulating the field use in a continuous and uninterrupted mode. The MTTF (Mean Time to Failure - experimental) and the MTBF (Mean Time Between Failure - experimental) are determined. The Test Monitoring Report will be the basis for the registering of the fault occurrences and assessments.

S-04: Performance and Reliability Analysis (ALPHA Phase) - The results of the Monitoring Report will be inserted into the table called Evaluation Report Test and Fault Occurrence containing the scatter chart that shows the average range of occurrence of failures (MTBF).

The possible results are: 1. Satisfactory performance (GOOD): $MTBF (exp.) \geq MTBF (expected)$
→ No corrective action; 2. Unsatisfactory performance (BAD): $MTBF (exp.) < MTBF (expected)$
→ Apply corrective actions.

The analysis of the product reliability will be carried out using the failure data collected during the test with the prototype to obtain the function $R(t)$. The Weibull distribution is used to model the failure rate.

Following the steps of Dorner (1999), a Microsoft Excel spreadsheet will be used to determine the Weibull distribution parameters α and β (alpha and beta) in order to obtain an evaluation of the product reliability (reliability curve).

If performance and reliability are satisfactory, proceed to Step 7, otherwise a failure analysis would be done to determine whether the project will proceed. If the decision is to continue the project, proceed to Step 5 (reevaluation FMEA).

S-05: Reassessment of FMEA - The purpose of this review, similar to Step 1, is to identify and define new components, parts or assemblies that are more critical in product, causing higher risk of error occurrences, defects and faults. It should suggest some corrective actions that will be incorporated in the project (design review) in order to minimize their risks.

S-06: Project Review - The suggested corrective or preventive actions, obtained after the analysis of the test results with the ALPHA experimental prototype(s) and the reevaluation of FMEA, should be documented and should generate a design review.

S-07: Prototype BETA Manufacturing - After changes and revisions in the project on ALPHA phase, BETA prototypes must be made using also their final fabrications processes. Some units will be gathered for life test in the laboratory.

S-08: Prototype BETA Testing - Similar to Step 3, accelerated life testing in laboratory with BETA prototypes should be conducted.

S-09: Analysis of Performance and Reliability (BETA Phase) - Similar to Step 4, the results of accelerated tests are entered in a table generating scatter plots of faults and failures in sets. It performed the analysis of performance and reliability with the following results: 1. Satisfactory

result → S-10 (Final Review Draft); 2. Unsatisfactory result (with continuing the project) → S-05 (Revaluation FMEA); 3. Unsatisfactory performance (without continuing the project) → abort the project.

S-10: Project Final Review - With satisfactory results, the product can be manufactured at production scale. A general and final review should be performed in the project, where all the details are reviewed and revised. So, the later stages (pre-production and production) will be implemented without major problems or interventions.

Field research (experimental)

Microservice is a major national manufacturer of optical discs (CDs, DVDs and BD's), PVC laminated films for use in plastic packaging type "vacuum forming" and motorcycles.

Seeking to diversify its portfolio, Microservice initiated development activities of technology products, having as main objectives: 1. Develop and launch products at lowest possible TTM – Time To Market; 2. The products launched must be highly reliable in the market; 3. The warranty service must be fast and efficient.

To meet the above objectives, Microservice is structuring a NPDP model, which necessarily must include a preliminary evaluation of the reliability of the products to be launched in the market. As a result, the company will scale and reshape your customer service department.

The product object of this work is an electromechanical system, not "stand-alone" for automatic handling of optical discs, called DiscLoader (figure 4).



Figure 4: DiscLoader Product

The basic functions of DiscLoader are: 1. Copying optical discs (CD's, DVD's, CD-R's, DVD-R's, BD's); 2. Ripping songs from an audio CD, transferring them to the computer hard drive or other data storage device; 3. Perform backup or making copies of computer files or folders to CD-R media, DVD-R, computer hard drive or to an external hard drive that is connected to the machine; 4. Restore backup, recovering to the computer hard drive, and a full backup of it, just a file or set of files.

All the functions above described are performed automatically, without human intervention by means of a set called handler.

The DiscLoader is a new, an innovative product, which will soon be released in the Brazilian market. The company will provide all customer support during the warranty period, which was set at one year from the equipment purchase date.

Since there is no preliminary studies that shows how reliable is this product in the market, and there is no scaling of the structure necessary for technical assistance, the New Products Reliability Evaluation Model (the object of this work) was applied with the following results:

The 6 basic assumptions (BA): DiscLoader contains all 6 basic premises for application of operational procedure.

The 5 suggested steps in PDNP (SS): The DiscLoader PDNP contains all the steps suggested in the operating procedure.

The 10 steps for assessment of reliability (S):

S-01: FMEA and Project Review - done.

S-02: Prototype ALPHA Manufacturing - 10 units are made.

S-03: Prototype ALPHA Tests - Endurance Tests are made.

S-04: Performance and Reliability Analysis (ALPHA Phase) - Performance was satisfactory MTBF (exp.) > MTBF (expected), but the reliability R (13,780) = 0.5628 (figure 5).

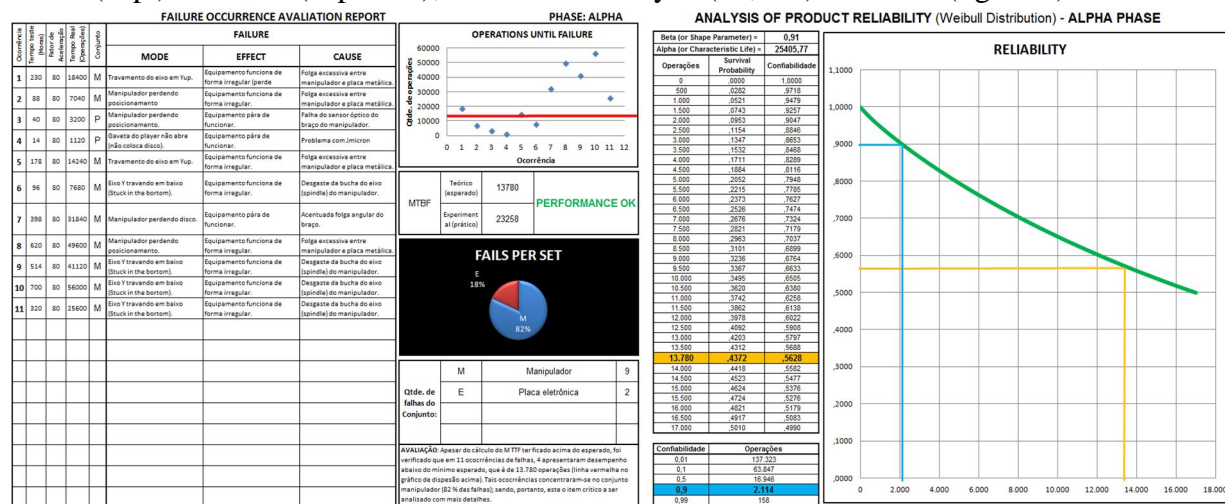


Figure 5: Performance and Reliability Analysis (ALPHA Phase)

S-05: Reassessment of FMEA - done.

S-06: Project Review - held, containing 5 corrections.

S-07: Prototype BETA Manufacturing - 10 units made.

S-08: BETA Prototype Tests - Endurance Tests are made.

S-09: Performance and Reliability Analysis (BETA Phase) - good performance: MTBF (exp.) ≥ MTBF (expected). Reliability: R (13,780) = 0.9530 (figure 6).

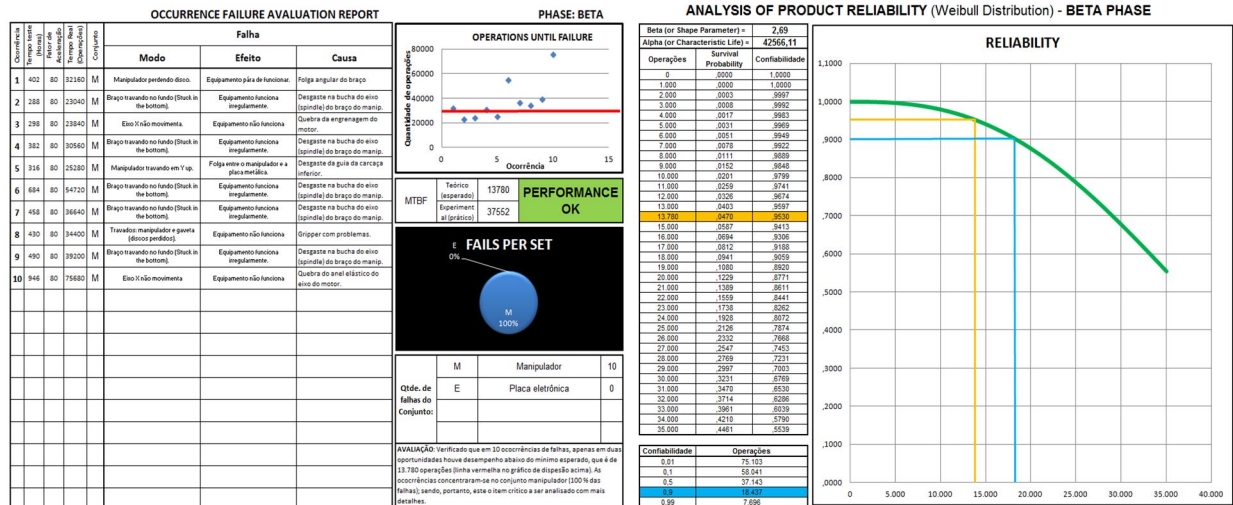


Figure 6: Performance and Reliability Analysis (BETA Phase)

S-10: Final Review Project: revised drawings, procedures, processes, manuals and BOM's.

Analysis of results

During phase ALPHA product performance was slightly weaker than expected – $R(13,780) = 0.5628$ (only 56.28% of the units ALPHA bear more than one year of field operation).

It was found that the prototypes of BETA phase showed much higher performance of the ALPHA phase prototype, showing a reliability of 0.9530 (95.30% of units BETA endure over one year of operation in the field).

If there was a need to get even better values for product reliability (continuous improvement), it would be necessary to repeat steps 5-9 of the procedure developed. This next step could be called BETA phase 2.

Dimensioning of technical infrastructure for warranty service

Based on information from the departments of Sales and Marketing of the company, it is estimated that the product will display the following sales performance: 1. First month after launch: 300 units per month; 2. Second month after launch: 600 units per month; 3. Third to sixth month after launch: 900 units per month; 4. Seventh to twelfth month after launch: 1,200 units per month; 5. The twelfth month onwards: 1,500 units per month.

As evaluated, the reliability of 95.30% is expected for one year of operation in the field (4.7% of the units sold will return to service during the warranty period).

Considering that the return units for repair is evenly distributed during the warranty period and in the first two months, after the sales, there are no monthly return units for repair (the return of the units starts from the third month onwards), it is estimated that the calls or service orders will occur as shown in table 1 and figure 7.

Table 1: Return forecast of units for repair under warranty

MONTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
FORECAST FOR SALE		300	600	900	900	900	900	1200	1200	1200	1200	1200	1200	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500											
RELIABILITY:																																					
95%																																					
RETURN UNDER WARRANTY:																																					
5%																																					
MONTH (After Launch)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Forecast Return (Orders)		0	0	1	4	8	13	17	21	27	32	38	44	48	51	54	56	59	62	63	65	66	68	69	71	71	71	71	71	71	71	71	71	71	71	71	71
		FIRST YEAR = 205,9												SECOND YEAR = 731,8										THIRD YEAR ONWARDS= 846													

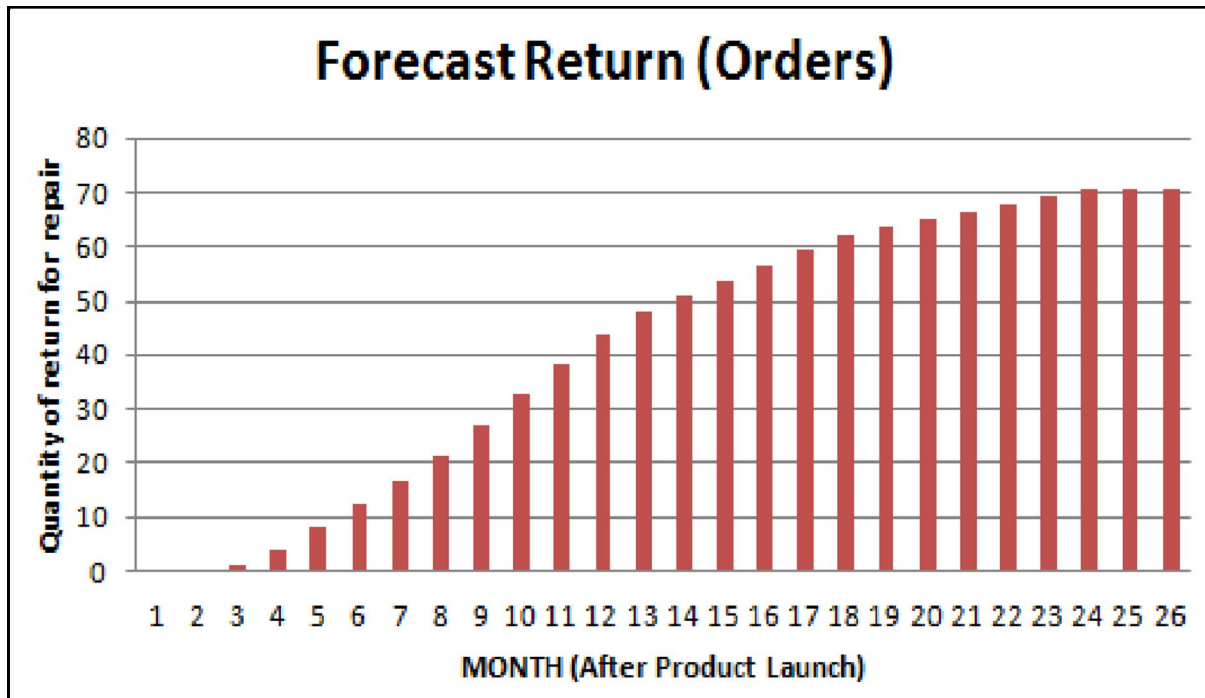


Figure 7: Chart of forecast return for repair under warranty

Knowing the number of units that will return for repair under warranty, one can scale the minimum structure necessary and sufficient to the company service department. The table 2 includes the mean and maximum amounts necessary to Labor, Parts and Materials and Machinery and Tools.

Table 2: Dimensioning of technical infrastructure for warranty service

Dimensioning of technical infrastructure for warranty service		First year		Second Year		Third year	
		Average	Max.	Average	Max.	Average	max.
LABOR	Qty. units for repair monthly (units):	20,586	43,71	60,9825	70,5	70,5	70,5
	Qty. units for repair daily (20 days) (units):	1,0293	2,1855	3,049125	3,525	3,525	3,525
	Time for repair and testing for 01 unit (h):	1	2	1	2	1	2
	Time for delivery of parts and materials per unit (h):	0,25	0,5	0,25	0,5	0,25	0,5
	Daily time to repair the units (h)	1,286625	5,46375	3,811406	8,8125	4,40625	8,8125
	Available time per technician per day (h):	7					
	Qty. technicians needed to perform the repairs (un).	0,183804	0,780536	0,544487	1,258929	0,629464	1,258929
		1	1	1	2	1	2
	Salary and monthly charge of 01 technical (R\$):	4.000,00					
	Monthly cost of labor (R\$):	4.000,00	4.000,00	4.000,00	8.000,00	4.000,00	8.000,00
PARTS AND MATERIALS	Qty. critical parts or assemblies for monthly stock (un):	20,586	43,71	60,9825	70,5	70,5	70,5
	Cost of the part or critical set (R\$):	200,00	300,00	200,00	300,00	200,00	300,00
	Monthly cost of parts inventory or critical assemblies (R\$):	4.117,20	13.113,00	12.196,50	21.150,00	14.100,00	21.150,00
MACHINES AND TOOLS	Set of Tools / Machinery 01 (R\$ / month):	200,00	500,00	300,00	600,00	400,00	800,00
	Set of Tools / Machinery 02 (R\$ / month):						
	Set of Tools / Machinery 03 (R\$ / month):						
	Set of Tools / Machinery 04 (R\$ / month):						
	Monthly Cost for Tool and Machine (R\$):	200,00	500,00	300,00	600,00	400,00	800,00
	TOTAL MONTHLY COST OF TECHNICAL STRUCTURE (R\$):	8.317,20	17.613,00	16.496,50	29.750,00	18.500,00	29.950,00

Final considerations

The operating procedure developed for assessing the reliability of new products in a very simple and objective, consisting of 10 steps (S), based on 6 basic assumptions (BA) and in 5 steps suggested in NPDP (SS), and the aid of FMEA, when applied to the product studied achieved the following goals: 1. Assessment of the reliability of innovative product prior to its launch on the market during the NPDP; 2. Ratification of the warranty period of an innovative product set in the early stages of NPDP; 3. Scaling of the structure for warranty service and cost estimate that the company will have during this period; 4. Improving the reliability of the product.

The study was directed to a specific product. If the reliability assessment model used in this dissertation is applied to products that have no similar characteristics to the product studied, some adjustments may be necessary to the procedure may prove adequate and efficient.

The product reliability evaluation was obtained through the data collection failures resulting from laboratory tests with prototypes of life (accelerated tests in bench operating). It is suggested that after the launch of the product in the market, where begins the phase of production and marketing scale, the data are collected from field failures, warranty phase and even post-warranty.

During phases of product development, in parallel to the studies of reliability assessment, was also studied their respective manufacturing process. As a suggestion to future work, one can integrate to the product reliability study with the reliability of the manufacturing process, with the application of the DOE- Design of Experiments - methodology.

References

- ASQC (American Society For Quality Control); AIAG (Automotive Industry Action Group). Análise do Modo e Efeitos de Falha Potencial (FMEA) – Manual de Referência, 1995.
- Dorner, W.W. 1999. Using Microsoft Excel for Weibull analysis. Quality Digest.
- Nunes, M.J.L. 2004. Metodologias de desenvolvimento de novos produtos industriais. Dissertação de Doutorado – Escola de Engenharia da Universidade do Minho, Departamento de Produção e Sistemas, Campus de Azurém, Guimarães, Portugal.