GDPro: a concurrent product development assessment tool

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Abstract: New product development (NPD) has a very close relationship with economic competitiveness in global businesses and, therefore, sustainability. The present work proposes an assessment tool to evaluate how companies address concurrent product development (CPD) internally as well as collaboratively with their clients, partners and suppliers. GDPro is a desktop java-implemented user-friendly tool that allows NPD metrics to be compiled and presented in such a way that trends may be revealed and eventual problems may be diagnosed in all five dimensions of CPD: people, process, tools, technology and strategy. As semi-structured questionnaires are submitted and figures extracted from previous product development efforts, GDPro builds tables, charts and diagrams that depict current NPD practices within a company and provides a CPD implementation roadmap based on best practices and metrics identified by industry sector.
Keywords: new product development, concurrent product development, metrics, diagnosis.

1. Introduction

Sustainability, regarding its economical, social and environment approaches, has a strong correlation with a companies' ability to develop successful products. One can notice that, in several countries that have survived for many years on natural resources, there has been a shift on the actions performed by their societies as a whole towards focusing on economical activities that add commercial value, such as new product development (NPD) and related services. This paradigm change is revealed by a greater consideration of innovation and knowledge protection, as well as the improvement of management techniques related to effective new product development.

Before the necessary changes happen within a company, such that NPD takes place in a foreseeable and systematic manner, it is important that one can determine the current status regarding best practices and apply proper metrics. As a consequence of this work, one can establish correction measures, which will be necessary to ultimately provide the right products, the right way.

Diagnosis tools meant to evaluate and compare NPD practices are rare. The present work deals with this need, as it provides a user-friendly tool that allows one to diagnose and apply metrics to new product development.

2. NPD Diagnosis and metrics

2.1. NDP reality

NPD failure rates are alarming. According to COOPER (2001), in average performance US companies 40% of NPD projects fail. This rate varies from 25 to 45%, but can be as high as 90%, depending on their industrial sector. It is estimated that 46% of the total resources spent in R&D are wasted on failed products.

In Brazil, the situation is not different. According to DE NEGRI et al. (2005), 77.1% of the companies do not differentiate their products and have low productivity indexes. This fact yields negative impacts on companies' revenues and unemployment rates. It is necessary to create and offer added-value innovative products. In that case, the customer will be willing to pay a premium price.

It is not necessary to create new theories and methods to improve those figures. However, companies have to understand NPD as a business process that generates wealth and, therefore, deserves special care so that best management practices are identified and applied, according the companies' reality. Improving those figures can be carried out by systematically applying concurrent product development (CPD) concepts and fundamentals and using an appropriate NPD metrics system.

2.2. CPD fundamentals

Concurrent Engineering, a term coined in the 80s, emerged as a collection of methods and techniques that compose a set of fundamentals which new product development is based upon (SMITH, 1997). As people realized that this term could restrain its application to traditional areas such as engineering, it has been modified to Concurrent Product Development (CPD) (GOLDENSE, 1997) or Integrated Product Development (BORSATO, 2003).

It is possible to identify fundamentals grouped in categories by similarity. According to SCPD (2005), CPD's body of knowledge can be organized into five different dimensions: people, process, methods, technology (tools) and strategy. On the other hand, CARTER & BAKER (1991) suggest that CPD dimensions are: organization, communication, infrastructure, requirements and product development.

No matter how such grouping is made, implementing CPD correctly in companies will necessarily be done by diagnosing them according to the concepts under each dimension, for later planning of correcting measures that aim at continuous improvement. This vision is also aligned with other management-related implementation efforts, such as CMMI and Six Sigma that, at some point of their basics involve acquiring knowledge of a company's reality, analysis and improvement actions (VASQUES, 2006).

Besides diagnosing CPD practices, it is also necessary to set up instruments that make it possible to evaluate NPD activities quantitatively. This allows that decision making is done based upon figures and tendencies. The purpose of a set of metrics is to acquire insight on the real performance of a given business process.

A suggested analogy is that of an airplane with no instrumentation. One cannot decide based on guessing or subjective estimates. If an altimeter indicates low altitude, the pilot has to be able to read that gauge and decide whether he will take actions to reach higher altitudes. In a similar manner, NPD metrics must be used to orient project teams' decisions (KAYDOS, 1999). This set of figures is commonly referred as a "**metrics system**".

According to PATTERSON (1993) there are some key attributes to be worked on, so that a metrics system does not yield unexpected results:

- Relevance – metrics should provide clear information that focus on important aspects of a given task;
- Amplitude – a set of metrics should make all important factors visible, with a balanced emphasis;
- Response in time – it is a function of how fast a given business can change; and
- Elegance – metrics should not mean extra burden to a given organization, generating significant additional work, as they demand effort to be collected, reported, compiled, monitored and filed.

As to NPD, there has been a shift on metrics systems that used to focus exclusively on results. Now they refer to previous phases of a product development process (front-end), such as planning and definition. According to GOLDENSE (1997), there are five categories of metrics in CPD environments: enterprise-wide, project planning and initialization, team contract, projects in-process and accelerated metrics. When companies are base lined, what counts is «**best-in-class**» figures and by industry sector. Comparing to averages has value, but new development process designs should be based on best-in-class. Also, specific competitive advantages or disadvantages that a company has must be incorporated into the thinking process of collecting metrics.

3. Objective e methodology

3.1. Objective

The main objective of the present work has been to create a user-friendly desktop application that allows one to: a) diagnose CPD environments using pre-established criteria in its several dimensions and regarding best practices recognized in various industrial segments; and b) collect NPD-relevant metrics aiming to shape correcting actions for continuous improvement.

3.2. Methodology

The application has been developed in two independent parts: one for diagnosis and another for NPD metrics. The diagnosis part has been based upon CARTER and BAKER's studies (1991), which suggest four CPD dimensions.

The **organization** dimension deals with matters related to CPD teams as well as management and leadership. Managers should be creative, practice empowerment and support CPD teams whose number and qualification of members, as well as involved disciplines are based upon the complexity of a product. Product development teams must take authority and responsibility for project decisions and individuals must agree unconditionally with what the team, as a whole, decides.

The **communication** dimension deals with the necessary infrastructure to connect people and allow a seamless flow of ideas, specifications, process information and feedback. The key to effective communication is its timeliness attribute. In other words, the right teams must receive the information they need at the proper time.

The **requirements** dimension assumes different shapes in time, since it regards the limitations imposed by the costumer, company, industry and environment.

The focus in this dimension is on the costumers' needs, which are translated into product requirements and must be, in turn, aligned with costumer satisfaction. A company must determine what its costumers want, assure he gets it and make sure the product follows corporate specific and industry standards.

The **product development** dimension brings and integrated vision of a NPD process as a whole, from idea generation throughout its manufacturing, servicing and retirement. Therefore, it involves the whole product life-cycle, with emphasis on continuous improvement and process optimization.

On the other hand, the metrics system adopted in the current work derives from GOLDENSE's (1997) studies. Specific mechanisms for metrics capturing, analysis and graphical representation have been created, for the metrics in all four categories employed.

In the organization-wide category, the metrics **staffing ratio** and **project size target** have been implemented in the desktop application. In order to assure that a given company has minimized the chance of new product bottlenecks, the different resource requirements for the functions involved in new product development must be initially estimated and then actively managed in the future. The **staffing ratio** metric is calculated by measuring the ratio of engineers to the "number of full-time equivalent or dedicated product development staff" in each of the other functions to the number of full-time engineering staff. It is important because it provides for scalability as an organization grows or shrinks over time.

The **project size** metric target permits the evaluation of product portfolios according to their sizes and nature. Each and every company has unique capabilities and limitations in its ability to manage and execute projects to a plan. When a project is too large, the risk increases greatly and delays are certain. When a project is too small, the payback may not be worth the effort. It is highly useful to understand the project sizes and attributes that make projects in a company successful. A so called "bubble chart" has been implemented for the purpose of visualizing projects by size in relation to pre-defined targets.

In the project planning and initialization category, the metrics **concurrency matrix** and **project staffing speed** have been employed. iA concurrency matrix is used to determine the degree of early cross-functional involvement in new product development projects. It allows one to determine the proportion of specific disciplines involved in each phase of product development and its progress throughout a product's life-cycle, as functional knowledge is needed.

Project staffing speed helps evaluate how projects are accelerated by allocating proper resources as needed. The purpose of this metric is to focus attention on the rate at which projects are ramped-up. Traditional engineering practitioners usually obtain an S-shaped profile, since a cross-functional approach does not take place. In that case, functional departments get involved in an emergency effort to compensate for "over-the-wall" project handling.

In the category team contract, metrics **time-to-market**, **product cost**, **development cost** and **market size** have been delivered. This set of the metrics is the heart of CPD processes and are base lined during the feasibility phase, when planning and analysis efforts are conducted. These metrics result from the team's own estimates of the resource and time requirements necessary to complete the project. These are the measures that the team is willing to live by during the development process, and be measured by upon conclusion of the project.

In the category of projects in-process, the metrics static **time-to-market**, **dynamic time-to-market** and **engineering change orders** have been implemented. Static time-to-market presents charts used to perform comparisons between figures of ongoing projects with historical ones obtained in successful projects. It refers to differences between planned and executed activities. It is possible to calculate overall schedule forecast accuracy, examine the variation in predicted and actual phase times across projects, and identify the places where the development processes typically break down all with the same set of data.

On the other hand, The metric **dynamic time-to-market** allows projects to be evaluated in order to visualize how planned and as-done schedules differ in real time. Every time a schedule prediction is made by the team during the course of a project, the date is plotted on the graph against the date that the prediction was made. As time passes, and several predictions are plotted, it is possible to extrapolate the data to estimate a prediction date. This approach inherently incorporates the ongoing forecast error, whether it is positive or negative, into the extrapolation.

The metric **engineering change orders** reveals the evolution of the number of modifications that occur during a given product development effort. Similarly to the **project staffing speed** metric, traditional engineering practitioners usually obtain an S-shaped profile as opposed to "sugar-loaf-shaped" profiles of cross-functional practitioners.

In the category of accelerated metrics no metrics have currently been implemented. Future work will be carried out to implement such measures.

4. Results

4.1. GDPro

This application has been developed using Java technology, with the purpose to allow its utilization on personal desktops, no matter what operating system is used. The Java programming language has become extremely popular essentially due to its portability, consistency and affinity with the web. It is possible to conceive applications that operate well under various platforms, such as palmtops and cellular phones, once their interfaces are adapted to each kind of device targeted. Developed logic can be easily reused.

GDPro has two independent main functions. The user is prompted to choose between CPD diagnosis or NPD metrics. The first one will provide a straightforward analysis of all dimensions necessary in a CPD environment, while the latter will offer proper mechanisms to evaluate a given company's NPD processes and practices.

4.2. CPD diagnosis

The diagnosis function takes place in three steps: data gathering, analysis of results and target setting for the construction of an appropriate CPD environment. In the data gathering step, the user responds a questionnaire with 83 items, regarding all CPD dimensions. Questions are grouped in four sections, one for each dimension and, in turn, each section is organized by specific topics in that dimension. Figure 1 brings a screenshot of the GDPro application during a questionnaire session.

The next step, following data gathering, is to fill out an **approach matrix**, by key-factor. It is a tool that allows one to plan for CPD implementation in a balanced way (CARTER & BAKER, 1991). In order to fill out the approach matrix, it is necessary to have a product in mind, which may be an ongoing project, or a future project. On the lines of the matrix there are key factors for the construction of a appropriate CPD environment within a given company. On the columns of the matrix there are lists of desired features, organized by their scope of implementation: tasks, projects, programs and enterprise.

The user picks up the actions that are demanded in his case by key-factor, according to his own judgement on which scope to implement next. This selection is made by marking a box under each set of features. Similarly to the questionnaire, the matrix is also organized in four distinct dimensions. At the end of this operation, it is possible to determine a set of targets in order to build an environment well adjusted for CPD. Figure 2 shows a screenshot of GDPro while an approach matrix is being filled out.

After data is gathered, a situation map can be drawn and a roadmap with implementation priorities is made available by the application, in all four dimensions. Analysis of the graphical output is straightforward. One has only to compare the current CPD situation (shadowed area) with the desired CPD environment for a given product (coloured area). Concentric circles represent each implementation scope, from task to enterprise. The larger a gap between these two areas is, the farther a company is from a proper CPD environment. It is also possible to find certain aspects of CPD which present better performance than expected. This situation can be perceived when the shadowed area advances beyond the coloured area. In this case, it might be a good idea to reallocate resources where mostly needed. Figure 3 presents a screenshot of a situation map in GDPro.

The roadmap is a tool to help use a situation map. It allows one to build an action path to reach an appropriate CPD environment. More specifically, it shows where current flaws are and suggest how to best solve them. The user receives a list of questions that must be answered affirmatively.

Each question is accompanied by text boxes for annotations on what measures should be taken, an option to indicate a priority number and a checkbox to be used in case the problem has already been solved. When a problem

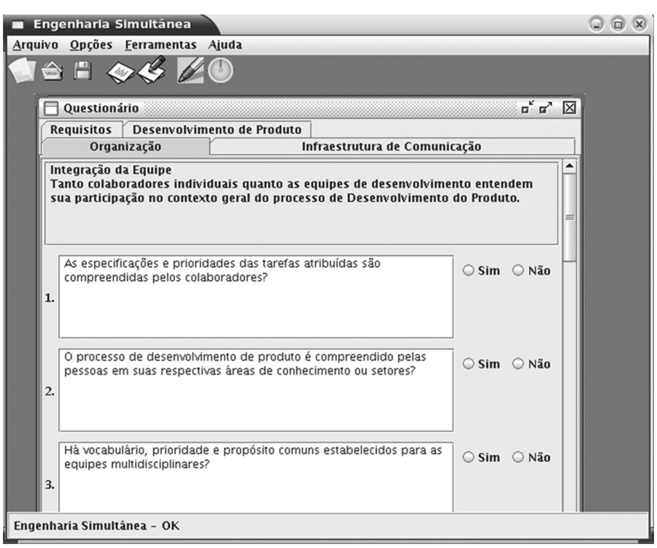


Figure 1. Filling out a questionnaire in GDPro.

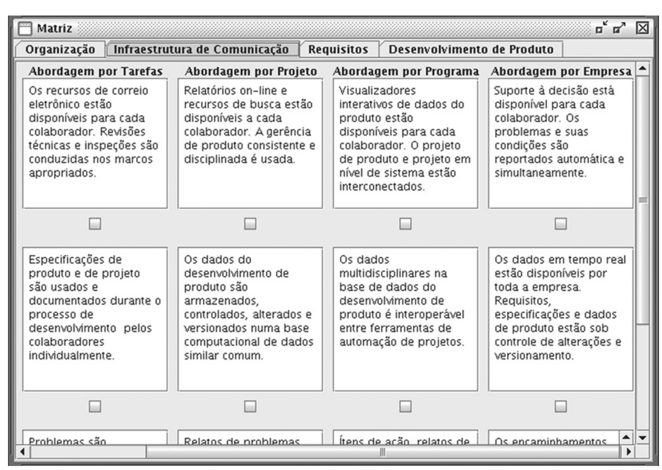


Figure 2. Approach matrix in GDPro.

is marked as solved, it is transferred to a “concluded task” in the roadmap. The GDPro application has been developed so that a file keeps all saved data. Also, graphics can be exported to image files. Figure 4 brings a screen shot of a roadmap in GDPro.

4.3. NPD metrics and tools

The metrics function of GDPro is a lot different from the diagnosis function. It is divided into eight independent modules that correspond to eight metrics and their own features, data structure and graphical output. Nevertheless, data gathering and output generation are quite similar.

In order to work with the **staffing ratio** metric, the user informs company type, product type and the number of representatives of each area of knowledge involved in all phases of product development. A graphical output is generated as numbers are entered. It is possible to observe the ratios amongst significant functions throughout the entire life-cycle and compare them with reference indexes. Figure 5 presents a screenshot of GDPro with a staffing ratio graphical output.

Also in the enterprise-wide metrics arena, target project size prompts the user for data regarding finished projects, in order to evaluate them according to their nature, development time and size. Graphics put into perspective the relationship between workforce involved and time to product launching, in order to compare real projects with strategic targets. Figure 6 brings a screenshot of the graphical output for this metric.

Next, the concurrency matrix is a tool built out of information regarding cross-functional involvement in NPD efforts during all phases of product development. It allows one to evaluate how and when functional resources are used. Figure 7 depicts a concurrency matrix.

The **project staffing speed** metric requires the user to enter data regarding the number of people engaged

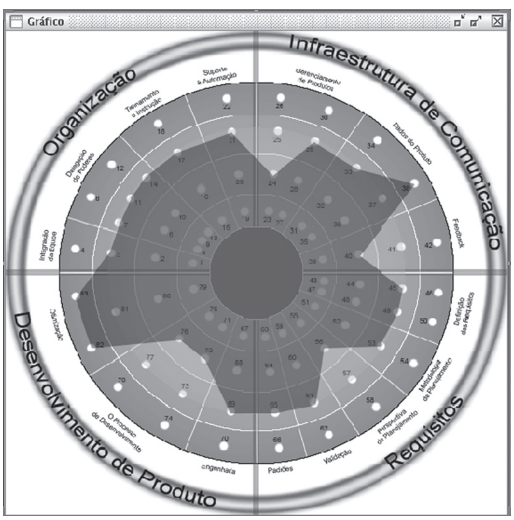


Figure 3. Situation map in GDPro.

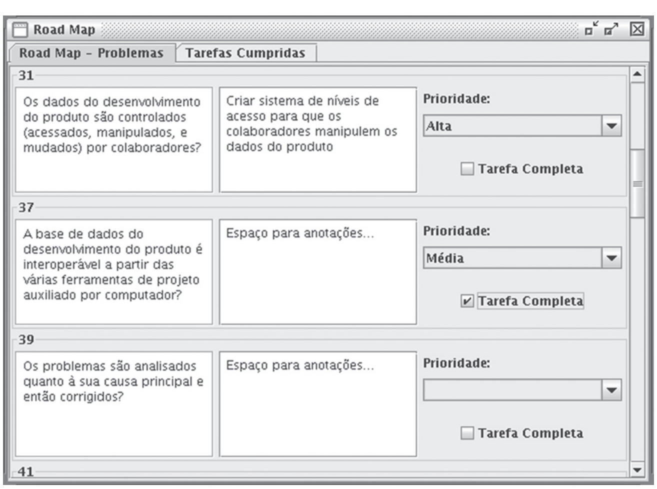


Figure 4. A roadmap in GDPro.

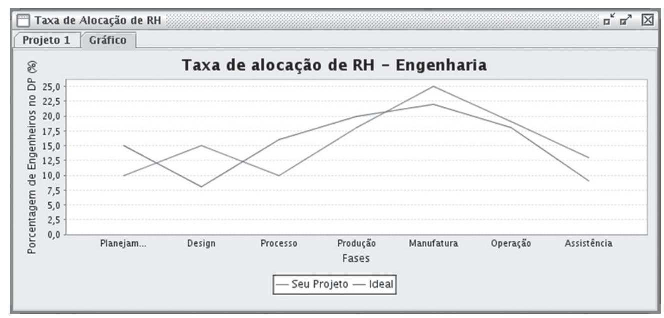


Figure 5. Staffing ratios in GDPro.

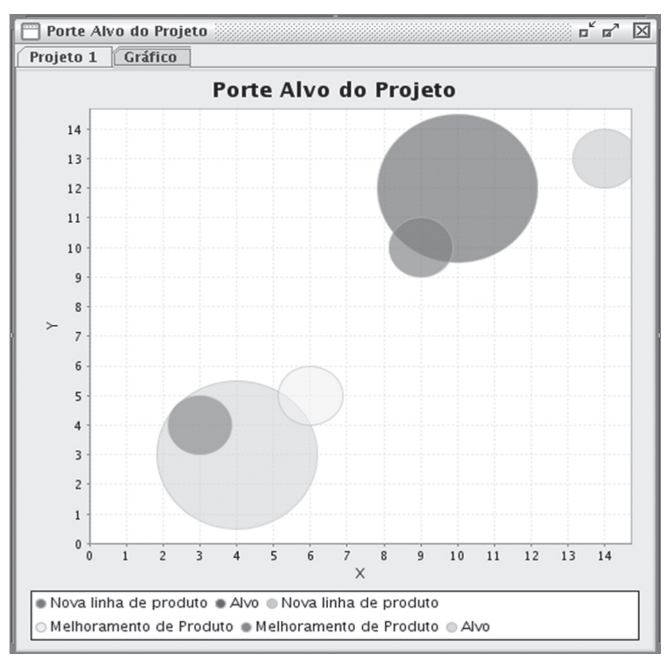


Figure 6. Target project size in GDPro.

throughout a product development process. Differently the **staffing ratio** metric, which yields an index for specific knowledge areas, such as engineering, project staffing speed produces a graphical output with a strong emphasis on absolute numbers and its variation rate during each stage of product development. Figure 8 presents a screenshot of this metric for a given project.

All team contract metrics were gathered in the same interface: time-to-market, product cost per subsystem, development cost and market size. Figure 9 brings a screenshot of GDPro's yielded results for these metrics.

Regarding the last category of metrics, the so called projects in-process metrics, **static time-to-market** compares as-planned to as-executed schedules as projects are finished. Figure 10 presents some sample results for this metric in GDPro.

On the other hand, dynamic **time-to-market** is shown in real time, as planned and executed schedules get apart in time. It evidences project stages when schedules slip, but at the same time, allows room for countermeasures, when necessary. Figure 11 brings a sample graphical output for this metric.

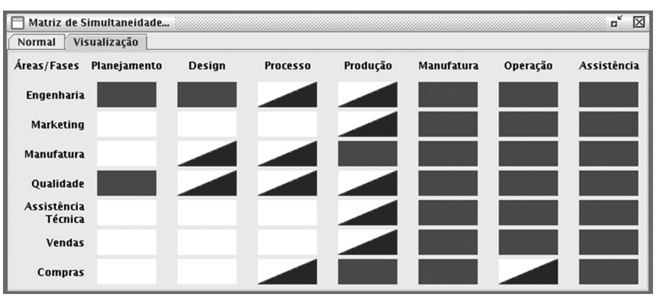
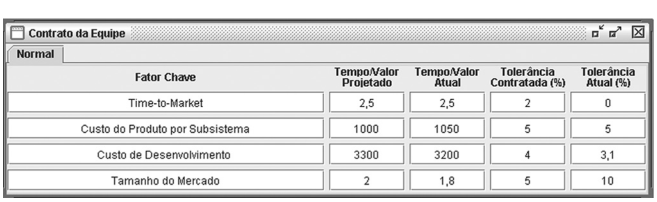


Figure 7. Concurrency matrix in GDPro.

Figure 8. Project staffing speed in GDPro.

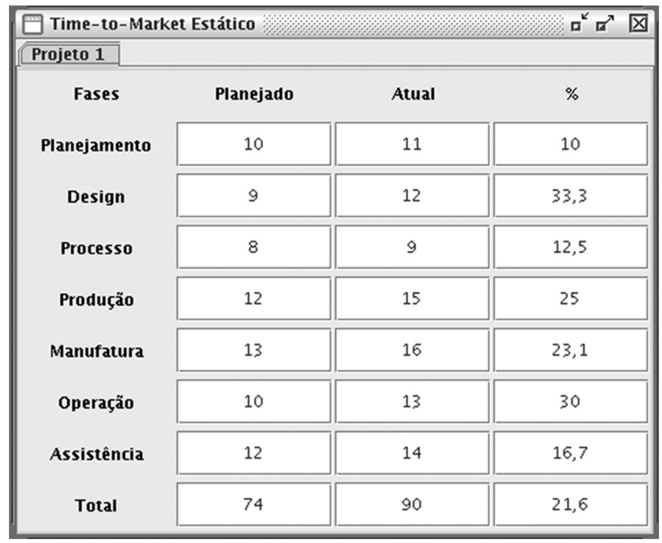

Contrato da Equipe

Normal

Fator Chave	Tempo/Valor Projetado	Tempo/Valor Atual	Tolerância Contratada (%)	Tolerância Atual (%)
Time-to-Market	2,5	2,5	2	0
Custo do Produto por Subsistema	1000	1050	5	5
Custo de Desenvolvimento	3300	3200	4	3,1
Tamanho do Mercado	2	1,8	5	10

Figure 9. Team contract in GDPro.

Last of projects in-process metrics, **engineering change orders** prompts the user to enter the amount of modifications requested through all phases of product development. Its characteristic curve resembles that of project staffing speed, as allocation of resources during NPD has a strong correlation with problems that arise at the ramp-up stage. Figure 12 depicts a graphical output for this metric in GDPro.


Time-to-Market Estático

Projeto 1

Fases	Planejado	Atual	%
Planejamento	10	11	10
Design	9	12	33,3
Processo	8	9	12,5
Produção	12	15	25
Manufatura	13	16	23,1
Operação	10	13	30
Assistência	12	14	16,7
Total	74	90	21,6

Figure 10. Static time-to-market in GDPro.

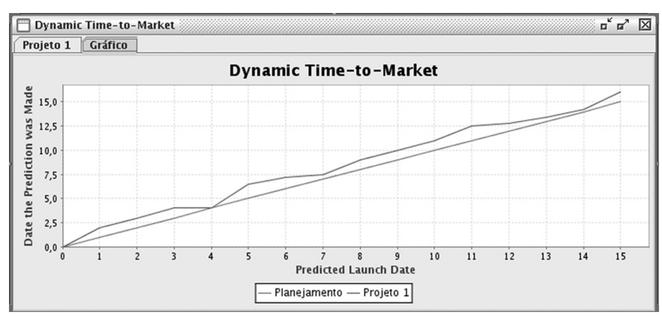


Figure 11. Dynamic time-to-market in GDPro.

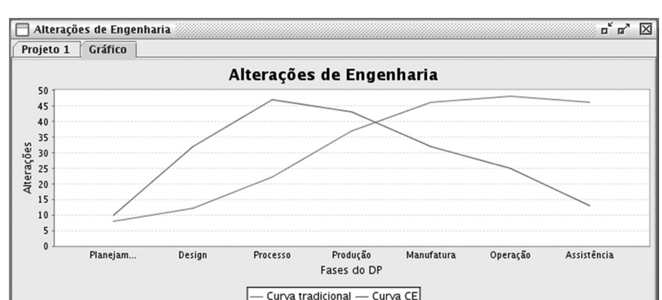


Figure 12. Engineering change orders in GDPro.

5. Discussion

GDPro is an application tool developed to help companies evaluate their NPD practices and determine correcting actions to get closer to best-in-class CPD environments. Nevertheless, it is necessary that such reference indexes are carefully identified as they serve for internal benchmarking.

The present work did not have such intent, but in order to be effectively used and fulfil its objectives, the tool must be accompanied by additional work to baseline performance before current status is to be evaluated. Possibly, those reference indexes must be gathered at companies to be mirrored as for their NPD practices. The authors understand that additional work is needed on statistical tools that will certainly make GDPro's results more reliable.

Another possibility to improve the present tool is to create versions for portable devices and for the web. Chances are the application will be extensively used when user-friendly ways to input data are added. Moreover, extra effort must be made in order to clarify how the application is to be used, by providing help functions at a click. These would provide theoretical background to the user as needed.

More importantly, GDPro is yet to be tested in the field. As users get the chance to use it, valuable feedback will certainly be provided for further enhancements and bug clearance.

6. Summary

There is a strong correlation between sustainability and new product development. As companies face the challenges that have risen from market globalization and fierce competition, effective and continuous development of new products has gained importance as an alternative that grants competitiveness to companies, employment stability and economic growth.

The present work has been carried out with the aim to conceive a desktop application that would help companies who wish to diagnose their NPD environments, as well as to gather metrics that demonstrate how such project efforts take place.

GDPro has been developed with two functionalities: one to promote a straightforward diagnosis of CPD environments, and another to help gather data and show relevant NPD metrics graphically. The outcome is a tool that is useful to support change decisions, so that current NPD practices get closer to those of best-in-class practitioners.

7. Acknowledgments

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