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A Case Study on Product Development Performance Measurement

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Abstract—In recent years, an increased competition and lower profit margins have necessitated a focus on improving the performance of the product development process, an area that traditionally have been excluded from detailed steering and evaluation. A systematic improvement requires a good understanding of the current performance, wherefore the interest for product development performance measurement has increased dramatically.

This paper presents a case study that evaluates the performance of the product development performance measurement system used in a Swedish company that is a part of a global corporate group. The study is based on internal documentation and eighteen in-depth interviews with stakeholders involved in the product development process.

The results from the case study includes a description of what metrics that are in use, how these are employed, and its affect on the quality of the performance measurement system. Especially, the importance of having a well-defined process proved to have a major impact on the quality of the performance measurement system in this particular case.

Keywords—Outcome metric, Performance driver, Performance measurement, Product development process.

I. Introduction

Traditionally, product development has often been seen as an isolated part of organizations. Arguing that too much structure and pressure might impede creativity and innovation, the performance evaluation of product development processes was limited to a minimum of backward-looking financial metrics [1]. For many years, the average failure rate of newly developed products remained on a constant level of one-third [2] and only 60 % of newly launched products became successful [3]. The inefficiencies in product development were paid for by long product life times and a market that welcomed new technology. Today however, the conditions for product development are not as forgiving.

Since the mid-nineties tougher competition, increased product complexity and higher customer demands are only some of the trends that set the pre-requisites for product development [4], urging companies to start taking the evaluation of the development process seriously [5].

In many ways, performance measurement has improved during the recent years. However many companies are still primarily using financial metrics, even though they only capture a small part of the dynamics of a company's processes [6], [7]. The one-sided focus on financial metrics that most companies traditionally have used seem to encourage short-termism, encourage sub-optimization and lack strategic focus [8], [9]. Performance measurement in product development is particularly difficult, as there are no or few broadly accepted performance metrics to rely upon [10].

This paper addresses these challenges through a case study that evaluates the current quality of a product development performance measurement system. The study is based on internal documentation and eighteen in-depth interviews with co-workers at a Swedish company that is a part of a global corporate group.

A. Outline

The remainder of the paper is structured as follows. Section II presents some related research in the area of performance measurement systems and process performance evaluation. The outcome of these studies are further described in section IV, presenting characteristics of good product development performance measurement. First however, the research method adapted in this study is detailed in III. The main contribution of the paper can be found in sections V, VI and VII, where results from the case study is presented in section V, discussed in section VI and conclusions are drawn in section VII. in section VIII the implications for future work are discussed and section IX summarizes the paper with conclusions.

II. Related work

This section presents related work in the field of performance measurement systems, process performance, and metrics.

Chiesa et al. have studied performance measurement systems (PMS) in R&D. The extensive study contains a literature review, a survey, and a multiple case study. Their findings have been published in a number of papers [5], [11], [12], [13], and [14], where [5] summarizes the study. In the literature review they found that some sort of specialization in the criteria applied for the design of R&D PMSs is needed. However, the results from their survey suggested the opposite, i.e. there were no differences between the approaches used to measure the performance in R&D units. In the following multiple case study findings show that the studied firms departed from the general model when contextual factors are in place. Other studies with an holistic approach to Performance Measurement Systems are for instance [7], [8], [15], [16] and [17], of which [7] and [16] are R&D specific.

In [18] Syamil et al. conclude that the focus in product development literature has been on the relationship between process and outcome, and not on process performance. In the study they examine this missing link in the product development literature by proposing and validating a model of process performance. In the model seven hypotheses are tested in a survey, e.g. Process Performance has a positive relationship with Product Development Time and Process Performance has a positive relationship with Product Cost (reduction). The findings of Syamil et al. show that behavioral measures of process performance are appropriate for process design in product development. Several other studies examine aspects of process performance relevant for product development, such as knowledge management and it's implications for process performance, see for instance [19] and [20].

Vanek et al. [21] present a literature study focusing on systems engineering metrics in product development. The main goal with the study was to develop a set of metrics for product development using the systems engineering approach. However Vanek et al. did not end up with a key set of metrics, they conclude that in order to develop this set more research is needed. In future research the authors want to put more focus on objective output metrics that are of interest for managers, such as product cost vs budget and overall quality of the product. Frequently used performance metrics in general have been evaluated by [6]. The same author has specified requirements for well-functioning performance metrics in [22].

A. Related work summary

Chiesa et al. [5] found in both their literature study and the multiple case study that the performance measurement system and especially the metrics used need to be customized based on some contextual factors of the firm the system is used in. Similar results were also found by Vanek et al. in [21]. One of their main conclusions were that there is no ultimate key set of metrics for the product development process, but there is probably a set of metrics that are the most appropriate for the product development process at one business unit in a company. The study in this paper looks at the metrics currently used in a development process and how these can be improved and extended in order to provide the best set for this unit. [18] concludes that there is a need for more focus on process performance in research. The present paper studies the product development process with focus on performance measures, just as the findings in [18] ask for.

III. Research method

This section describes the research design and the modus operandi used in this study.

A. Case study design

According to [23], a good case study should be significant, complete, consider alternative perspectives and display sufficient evidence. All these aspects have been considered in the design of this case study. As the product development process affects the entire organization, an embedded single-case design [23] was chosen. A pre-study was carried out in order to determine which analysis approach would be most appropriate for the circumstances at hand. The main study consisted of eighteen in depth semi-structured qualitative interviews with different functions related to the product development process. The interviews were fully transcribed and validated by the respondents before the analysis. Internal documentation from the development process was used to triangulate the interview data. The interview data was used in order to map the current product development process, the goals and measures connected to the process, as well as the effects of the current performance measurement system.

B. Pre-study

The pre-study consisted of an open interactive interview [24] with the Quality Manager at the case study company and served two purposes. Firstly, the interview contributed to aligning the respective expectations on the research project and to establish a good contact with the case study company. Secondly, the interview gave an initial understanding of the circumstances and needs of the studied company, which helped in choosing an appropriate analyze approach. Before the interview, the respondent discussed the research project with the board of directors in order to communicate the opinions of the company at large.

The pre-study showed that the company's major incentive in improving the performance measurement system was to gain an increased reactivity in the product development process, enabling to steer and re-direct ongoing projects. The literature study, see further Sections IV and VI, therefore focused on these aspects.

C. Data collection

The main source of information in this study is qualitative interviews with co-workers at the case study company. The position of the respondents were chosen to both reflect all roles in the product development process and to represent all departments that are directly affected by the product development process. In addition to internal co-workers, external customers of the outcome of the product development process were interviewed. The interviews were carried out in accordance with Steinar Kvale's description of semi-structured interviews [25]. A semi-structured interview means that the interviewer has prepared questions, but let the answers direct the conversation. The prepared questions are used in order to make sure that all relevant areas of the investigation are covered.

The respondents were chosen with assistance from the Quality Manager and Site Manager, as both roles have good insight in all levels of the company. In all, eighteen in depth interviews with nineteen respondents holding eleven different roles were successfully carried out in April and May 2011, see Table I. The interviews took between one and two hours each. When possible, two respondents from the same position were chosen. This way, insights derived from personal interest and temperament could to some extent be separated from insights derived from a certain position in the organization, giving a more objective image of the roles in the product development process.

TABLE I
IN DEPTH INTERVIEW RESPONDENT ALLOCATION

Position	Number of respondents
Sita manager	1
Product manager	2
R&D manager	2
Project manager	3
Salesperson	2
Strategic purchase manager	1
Purchaser	1
Logistician	1
Production personnel	2
Quality leader	2
End customer	2

In order to ensure the correctness of data and minimize recollection biases [26], the interviews were recorded and completely transcribed. All respondents got the opportunity to read the transcribed version of the interview and correct possible misunderstandings, thereby validating the interview data.

In addition to the qualitative interviews, documentation of the product development process was reviewed, including the project manual and the stage gate model used in development projects. This data source was used both to triangulate the interview data [23] and to provide the interviewers with background information.

D. Analysis

The first part of the analysis process overlapped the data collection as recommended by [27]. The interviews were transcribed shortly after each interview had taken place, in most cases by the interviewer. In connection with the transcriptions, questions and possible hypothesis were noted. This lead to intimate knowledge concerning the data at the same time as it enabled adding questions related to the case for the coming interviews. It also enabled immediate improvement of the interview technique from one interview to another, thereby minimizing the interviewer's bias on the interview data [23], [25].

When the data collection was finished, the transcribed interview material was condensed and thematized in regard to the constitution, use and effects of the performance measurement system in the product development process. The material from different interviews was compared, looking for both convergent and divergent statements. Convergent statements are of interest as they indicate objectiveness beyond personal opinions among the respondents; common procedures or a company culture. Sometimes, divergent statements can however be just as rewarding to analyze, if they concern something that the respondents believe to agree on. They could for instance indicate a misunderstanding, a poorly defined process step or a difficulty to communicate something throughout the whole organization. The respondent's answers tended to be either very uniformed or very diversified, which enabled conclusions based on convergence and divergence to be drawn.

E. Validity and reliability

Case studies and all qualitative research have a potential bias due to subjectiveness [23]. In the data collection phase, this bias was minimized by triangulation through multiple sources of information [23], continuous documentation in a case study protocol [23], [27] and continuous evaluation of the interview technique [27]. The respondent bias was minimized by posing the same questions to multiple respondents.

Eisenardt [27] states that qualitative analysis is a process impossible to entirely comprehend for a reader. Indeed, condensing 250 pages of transcribed interview material into a handful conclusions is not a task that is easy to describe, nor to carry through with preserved objectiveness. Therefore, the results from the analysis as they are presented in this article were validated through a discussion with representatives from the case study company. All conclusions were agreed upon as plausible interpretations of their current situation.

IV. PRODUCT DEVELOPMENT PERFORMANCE MEASUREMENT

This section presents requirements for performance measurement systems, performance metrics and goals and objectives, both in general and for product development processes in particular.

A. Characteristics of a good PMS

A good measurement system supports the management of the company by providing decision basis. Innovation is closely related to the long term strategy of a company and the actual product development process includes both portfolio management and execution of specific development projects. This means that a performance measurement system for product development should cover an overall company level, a multi-project level and a single-project level [16]. On these levels, the measurement system serves the purpose of evaluating performance and to motivate the co-workers [28], [29].

A good measurement system also includes objectives that support the strategy work [29]. The metrics that compose the measurement system shall all drive action [21]. This means that every metric shall help to answer relevant managerial questions [29]. This requires an ownership of each metric; someone must request the results of the measurements and use these results. A good performance measurement system should also have a balance between outcome metrics and performance drivers and cover both financial and non-financial aspects [7].

B. Characteristics of a good performance metric

Outcome metrics are backwards-looking measures of facts and evaluate end results. This type of metric provides information such as if a finished process was successful or not [9].

Performance drivers are metrics that evaluate the performance of an ongoing process, enabling pro-active management decisions and improvements that benefit the ongoing project [9]. This type of metric makes the process more reactive.

Many metrics could be used both as outcome metrics and performance drivers, depending on how they are handled. Letting the same metric serve both purposes can be a way of making the measurement system more efficient, as managing metrics require resources. The number of metrics in a measurement system should be limited [15] or approximately 8-12 [30]. In order to make the performance measurement system a system in the true sense of the word, and not just a collection of metrics, the metrics should be connected to each other, creating traceability between the company level, the multi-project level and the single-project level [16]. The cause-and-effect relationship between the outcome metrics and the performance driver also needs to be made clear [9]. The connection could either consist of broken-down metrics, or the same metric used on different levels using broken-down goals. This in turn requires well-functioning goals.

C. Characteristics of a well-functioning goal

Depending on the company level [16], the goals and objectives need to fulfill different requirements in order to be well-functioning. At single-project level, a well-functioning goal is SMART; Specific, Measurable, Achievable, Relevant and Time-bound [21]. This means that it should not be possible to doubt whether a goal has been fulfilled or not. ”Achievable refers not to the performance level, but to the ability to affect the measured outcome. If the measured outcome is influenced by circumstances that the co-workers striving towards the goal cannot influence, the motivating effect of the goal and metric will be seriously diminished [28].

Goals on a company-level are often more distant in time, which makes it more difficult and sometimes even inappropriate to make them too specific. Goals on a company-level therefore don’t have to meet the SMART goals criteria, but they should be derived from the long-term strategy of the company and be well-aligned with goals on other levels.

All goals should be broken-down so as to be directly connected to every-day tasks. Note that if the goal on company level is to achieve a certain profit margin, the desired profit margin divided by the number of employees is not a broken-down goal, as it is not relevant or measurable for a co-worker on an operating level. Instead, a corresponding single-project goal to a turnover number on company level could for instance be to lower the production cost of a product with a certain percentage. If the single-project goal is fulfilled it will directly contribute to the goal on the company level. At the same time, it is relevant for the co-workers within the project and helps them to see how they contribute to the long term goals of the company.

V. Case description

A. The case study company

The case study company is a medium sized company that is part of a global concern operating in approximately 100 countries. They develop and produce components for a multinational high technological industry. This is a mature market, accustomed to a high complexity level. Many development projects at the case study company are therefore improvements of existing products rather than new product development, even more so as the type of business at hand requires that included components and materials in new products are thoroughly tested.

B. Background

The case study company is currently going through a turbulent period, having recently got a new site manager after a period with a vacant leading position. When this project began, a top-to-bottom re-organization had just come into force, wherefore several respondents were new in their positions at the time of the interview. However with one exception, they have worked at the company before and have good insight in the product development process. This situation causes a normal uncertainty about the tasks and delimitation for the newly appointed roles that has nothing to do with the general performance of the company. It can also be difficult to separate recent structural problems from current ditto, as realized improvements might not yet have come into force. The interviewers aimed to minimize this bias by asking for examples possible to place in time and by only using information derived from several respondents. The many recent changes have however had positive effects as well. Most respondents share a belief that things are changing for the better, and have an understanding of the necessity of re-defining roles and processes. Hopefully, this state of mind can facilitate coming structural improvements.

The company climate is nice and open, and everyone knows each other. At the same time as agreeing on this, many respondents talk about communication problems. There can sometimes be difficult to transmit information between functions or to carry ideas through. Most respondents also advertise for better feedback in all directions. Traditionally, the technical R&D department has had a strong influence over the development process. Recently, initiatives have been taken to shift this emphasis, but they has still a lot more influence over the product development process than any other concerned function.

Due to the ongoing re-organization, some ambiguities regarding roles and responsibilities were expected. However, there is also diffuseness on some points where the respondents believed to agree with each other. In particular, this was the case with the stage gate model used in the product development process, which entails vagueness to the definition of the product development projects.

C. The customer perspective

The current state described in Section V-B depict an historical perspective were a misallocation in behalf of the technical parts of the product development process has been trend-setting for many years. The customer's experiences of the case study company begin much earlier than at the time when this misallocation was established. The organization they represent has a twenty-year long customer and partner relationship with the case study company and one of the respondents have personal experiences reaching all the way back to the beginning of the partnership. From their point of view, the misallocations in the product development projects are fairly new. They talk with warmth about the first ten years of their relationship, a time when the sales and market department had great influence over the product development process, when all relevant functions seemed to be properly involved and when the case study company responded quickly to their needs. As they put it: ”they were simply the best”.

To a large extent, it is their positive past time experiences that makes the customer willing to stay and fight for their partnership. Without the already established relationship, they might not have chosen the case study company at the time being, as they see competitors that offer lower prizes and better responsiveness than the case study company. They describe lack of communication as the root cause of the current problems, referring both to internal communication and communication vis-à-vis themselves. They notice lack of internal communication by having to repeat the same information several times to different stakeholders in a project. More severe is however the fact that they don't get notified if a development project is delayed, which has negative consequences for them, both in terms of economic losses and a diminished trust amount towards their own customers. If something happens that affect the requirements or release date of a new product, they wish to be informed immediately. Other intermediates are of less importance for them and do not have to be reported. Apart from better internal and external communication, the customers and partners advertise for increased product quality, chiefly regarding robustness.

D. *Current metrics*

The product development performance metrics that are currently in use according to the respondents are compiled in Table II.

TABLE II
COMPILATION OF CURRENT METRICS

Metric	Description
Project time	Overall actual project time compared to plan.
Time until gate 2	Measured compared to plan, gate refer to the PD Gate Model.
Project cost	Measured compared to budget.
Time spent on funded projects	Time per person (technicians only), reported to external funders.
Product functionality	Measured compared to requirement specification.
Turn-over on newly developed products	Varying definition.

It is worth noticing that the time is measured to every gate in the gate model. Independent of each other, all respondents mentioned however gate 2 as the most important gate, and the time until gate 2 as more important to keep than any other part of the time plan. The metric *Time until gate 2* was therefore singled out. The metrics are described and analyzed in Section VI-B.

VI. EMPIRICAL ANALYSIS OF THE CURRENT STATE

This section problematizes and develops the reasoning about the case presented in Section V in order to map the causal relations between the process, the metrics and the performance of the product development process. The analysis is based on the interview material in the sense that effects of current state and current used metrics are discussed and explained through situations and examples used by the respondents in other parts of the interviews. First, general aspects are analyzed, followed by a separate analysis of each metric.

Many respondents, including the end customer have mentioned what they call severe communication problems within the product development process. However, the same respondents talk about how well they know everyone at Kabeldon and how easy it is to meet anyone at lunch or coffee, wherefore it seems unlikely that bad communication really is the root cause to this problem. This seeming paradox has been investigated in research about organizational structure. Mintzberg [28] states that problems can occur when co-workers are referred only to mutual adjustment for communication with other functions, in other words, when they lack official forums for their cross-functional communication and have to solve too many working issues in an informal context. According to the respondents, co-workers outside the R&D department lack natural meeting points with the rest of the project team, as up to six months can pass between the project meetings for which everyone is invited.

Thus, the communication problems in the product development process could most likely be solved by introducing liaison devices, or formal communication channels between the concerned functions. Another strategy for coping with this problem is to organize the development process in teams with dedicated and equal resources from the relevant functions. Such cross-functional teams decrease the need of official communication channels between departments [31].

The interviews also revealed that ambiguous formulations in the gate model have resulted in different interpretations of the process. One consequence of this is that it gets impossible to compare measurements from different projects with each other. For consequences regarding each metric, see Section VI-B. A clear process definition of the development process would drastically improve the performance level of all metrics currently at use.

A. *Analysis of the customer perspective*

The customer representatives validate several opinions expressed by other respondents, namely that the cross-functional cooperation and communication in the product development process should be increased, that more focus should be on manufacture aspects such as robustness of new products, and that changes to the time plan should be reported immediately.

The customers also contribute with a long time perspective that reaches further back in time than most of the other respondents. As product development per se is strategic and forward-looking, this long time perspective of both the history and the future is important to truly understand the mechanisms of the development process. Certainly, much has happened the last twenty years, with the case study company as well as with the market and the technology, which make changes in the way of work a necessity. Nevertheless, this might be a good opportunity to utilize the co-worker experience in order to return to some of the good practices that made the company an innovative world class component supplier some twenty years ago.

B. Analysis of current metrics

Most metrics (all but one) currently in use are employed solely as outcome metrics, to check whether the project was carried out according to the plan or not. Considering that the company wishes to increase their steering capacity of the development process, they should have more performance driving metrics. This is not only a case of which metrics to have, but also about how they are used. Examples on how the current metrics could be used as performance drivers as well can be found in the following subsections.

Another factor that drastically increases the steering capacity of the performance measurement system is to have a responsible for each metric [17]. This is also an issue that the studied company generally could improve.

Other aspects are discussed separately for every metric in the following sections.

1) Project time: The project time is one of the most obvious and well used metrics in a development process [18], [26]. Measuring the length of a development project from beginning to end is necessary to track the progress of one of the company's long term goals; to shorten the lead time in the development process. Where a product development project begins and finishes is however difficult to decide, but those definitions must be straightened out if the measurements shall provide usable results. The respondents have given many different answers to the question of when a product development project is officially finished, for instance when an acceptable prototype is finished, when the product is launched, when the product is first delivered to the customer and when the project manager says so. At the moment, the measurements from different projects are therefore not comparable with each other. The product development process needs to be well-defined in order to make this metric useful at all.

In order to be motivated to work for a goal, the result of one's efforts must affect the outcome [28]. Applied on this metric, this means that the time plan must be realistic for all functions. Respondents representing support functions of the product development process describe an opposed situation, where their tasks have been allocated far less time than is possibly needed. Thereby, they are delayed already when they start and will receive complaints even if they carry out the task efficiently, wherefore they lack reasons for doing their best. Well-functioning goals connected to this metric therefore require a time plan that is firmly established with all functions. One solution to this would be if the entire project team, with all relevant functions represented, could write and agree on the project plan together. Table III summarizes the current performance level of the metric *Project time*.

TABLE III
CURRENT USE OF THE METRIC *Project time*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Project time	No	Yes	No	No

2) Time until gate 2: Most respondents working within development projects mentioned Time until gate 2 as the most important part of the time plan to keep, apart from the final delivery. At gate 2, the steering committee of the project decides if it is worth proceeding with the project, and a general technical solution is decided on. If delayed through this gate, the project manager receives many complaints. How carefully the preparatory work is done is however not discussed at the gate meeting and many projects participants have recent examples of when the task supposed to be done at gate 2 was only indifferently performed, or left on a to-be-done-later-list after the passing of gate 2. At the time being, this metric seems to encourage negligence in the early project phases, which can be costly for the project at large. Figures 1 and 2 describe the importance of the early development phases. In the beginning of a project, different solutions can be tested at little effort and cost. If the same change is made late in the project, the cost is much higher, if it is possible at all. This is due to the fact that the later the project has been going on, the more the organization has adjusted itself to the new solution, for instance by ordering new production tools or starting the work with the product launch.

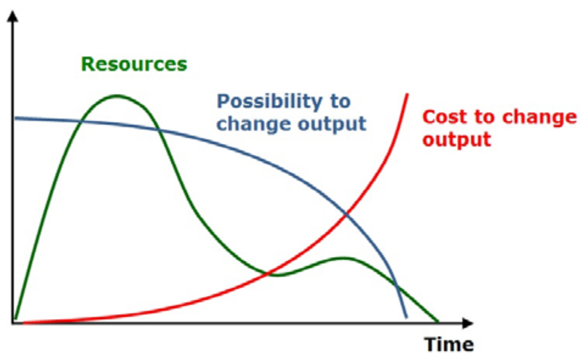

Fig. 1. Effects of a frontloaded development process

A systematic effort to front-load the development process shifts problem-identification and problem-solving to earlier stages of the development project [32]. For the studied company, this indicates that an aggressive attempt to give sufficient resources to the early stages should result in an increased

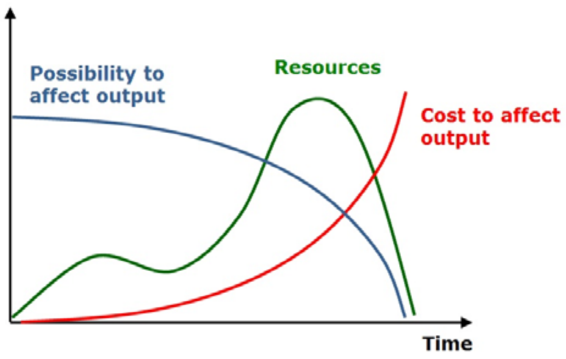

Fig. 2. Effects of a backtailed development process

product quality as well as lowered overall development cost and project time.

It is of course important to decide on a technical solution at some time, and just carry out the remainder of the project. *Time until gate 2* can be a useful and constructive metric, given that the prerequisites for passing gate 2 are quality assured, and that the time plan is realistic for all functions. This in turn requires a well-defined process and a committed steering committee, and a time plan that is established with all functions in the process. Table IV summarizes the current performance level of the metric *Time until gate 2*.

TABLE IV
CURRENT USE OF THE METRIC *Time until gate 2*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Time until gate 2	No	Yes	No	No

3) Time spent on funded projects: This metric is a part of the external funding of development projects. Technicians on the R&D department estimate how much of their time they spend on externally funded projects. This metric is the only one of the current metric that has a precise goal; on a weekly basis, 80 % of each person's time shall be spent on the externally funded projects. All respondents that report time to an external funder say that the goal has made them prioritize differently and dedicate more time to those projects even if they haven't reached the 80 % goal yet. In that sense, the goal is well-functioning, and the metric is performance driving as it changes the behavior of the technicians during the course of the project.

If the goal and the metric increase the performance of the development projects at large is however another question. The respondents agree that the R&D department alone is not the bottleneck of the projects. When they are responsible for delays, it is most often indirectly, due to lack of communication and cooperation with other functions. It is therefore plausible that only increasing the technicians time spent in certain projects wouldn't affect the outcome of the same. At the time being, this goal encourage exactly what it says to do; for technicians to spend 80 % of their time on development projects, but nothing more.

As the only current performance driver, this is already one of the best functioning metrics in the development process. Why not involve other functions in this measurement system? Many respondents, technicians as well as others have advertised for metrics that encourage cross-functional cooperation and a better understanding of each other's work. Making all functions dedicate a certain percentage of their time facilitates such an understanding and contributes to the feeling of belonging to the same team, as it is a step toward a dedicated cross-functional team that many researchers and organizations describe as the most efficient product development organization; see for instance [31], [33], [34]. Reporting time for all involved functions would also give a better overview of the actual cost of a product development project. At the time being, this metric rather reinforces than diminishes the technical emphasis in the product development projects that many respondents want to reduce. Neither one of the other metrics directly supports such a decrease. Table V summarizes the current performance level of the metric *Time spent on funded projects*.

TABLE V
CURRENT USE OF THE METRIC *Time spent on funded projects*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Time spent on funded projects	Yes	Yes	Yes	Yes, one

4) Project cost: Just like the metric Project time, Project cost is extremely dependent of the process definition. The beginning and the end of a project must be well-defined in order to be able to compare measurements from different projects. At the time being, this is not the case. Several respondents claim that the financial situation compared to the budget has a great impact on when a project is officially finished. If a problem occur in the final stages of a project, the project team will tend to it if there are budgeted resources left to cover it. Otherwise, the project is finished anyway. If the problem is too severe to handle in the production, a new development or improvement project with a new budget are started in order to solve the problem. The consequence of the current use of this metric is thus a catch 22; measurements of the metric Project cost will always return the approximate budget numbers, no matter how good the budget is or how well the project performed.

The respondents somehow responsible for a project budget say to strive for keeping costs down, however not so much because of the metric as out of common sense. The metric can therefore not be said to be a performance driver. The resources budgeted for product development currently covers only the R&D department. This entail that the metric does not cover the total project cost, which include resources from several other departments. Therefore the metric cannot be said to be a true outcome measure either. Table VI summarizes the current performance level of the metric *Project cost*.

TABLE VI
CURRENT USE OF THE METRIC *Project cost*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Project cost	No	No	No	No

5) Product functionality: The functionality of a new product is evaluated in relation to the requirement specification at the end of a product development project, which makes this an outcome metric. Exactly when and how the metric is used is unclear; the respondents answers are divergent. As the evaluation only considers the requirement specification, the measurements get highly biased by the quality of that document. Possible market changes that have taken place throughout the project or the actual functionality from the customers point of view will not be visualized by this metric. Several respondents describe this situation as problematic, and say that the requirement specification focus mostly on technical design solutions. They would like it to address other issues as well, such as robustness, cost or ability to rig the new product. This metric would benefit from increased cross-functional cooperation in the pre-study phases in order to extend the requirement specification, or by complementing it with metrics that tend to other aspects of project functionality. Increased team cooperation in the work with the requirement specification would also contribute to front-load the development process, which as discussed earlier, would be beneficial for the process at large [32].

The Product functionality metric could be used as a performance driver if the requirement specification was used as a living document and if the prototype functionality was evaluated iteratively against the requirement specification. This approach would also enable consideration of recent market changes, at least during the early stages of the development process. An iterative evaluation would also increase the understanding of the connection between the process and the outcome, enabling process improvement as well as traceability of the final results. Table VII summarizes the current performance level of the metric *Product functionality*.

TABLE VII
CURRENT USE OF THE METRIC *Product functionality*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Product functionality	No	Yes	No	No

6) Turnover on newly developed products: Only some respondents, and only respondents in managing positions, mentioned this metric and the descriptions of the measure were varying. The interest for this metric seemed chiefly to concern projects that the manager at hand had personally started, arguing that analyzing the fruits of other peoples mistakes would be of little use to them. In all, this metric have the characteristics of personal initiatives that haven't been established in the organization, wherefore it currently contributes with little strategic value. Despite its current weak position, this is a metric with lots of potential. Turn-over of newly developed products is a potentially strategic metric, as it could increase the understanding of customer behavior and market situations [7]. Thereby, it would facilitate future prioritization between products and contribute to a holistic understanding for the product development process.

Due to the long lead times in product development, there will always be a risk that measurements from this metric will be handled by people that weren't involved in the early phases of the evaluated process. It is therefore important to use this metric looking ahead, with the purpose of making good prioritization between future problems, rather than digging into what could have been done differently in the already finished projects, i.e. the metric could be powerful as a performance driver, but never as an outcome metric. If employed this way, and if the definition of the metric is standardized and established within the entire organization, it would be a valuable strategic metric. Table VIII summarizes the current performance level of the metric *Turnover on newly developed products*.

TABLE VIII
CURRENT USE OF THE METRIC *Turnover on newly developed products*.

Metric	Performance driver	Outcome measure	Well-functioning goal	Metric owner
Product functionality	No	Yes	No	No

VII. CASE FINDINGS

The case study company currently use six different metrics in their product development process. This is well in line with recommendations from literature; to have a limited number of metrics [15] or approximately 8-12 metrics [30]. The metrics cover relevant areas of the development process like time, cost and product functionality. The current metric portfolio therefore provides a good base. However, the metrics need to be developed further to support the process in the best possible way.

Most of the current metrics are used as outcome metrics rather than performance drivers, i.e. the measurement is carried out after a project as a way of evaluating the result of the process, at a time when it is no longer possible to change the outcome. This unbalanced measurement situation often results in a difficulty to notice how a process is performing until it is too late to do something about it [18]. This does however not seem to be the main effect at the studied company. All respondents claim to notice how well a project is performing quickly or after only a few weeks. The problem is instead that little is done to change the course of the project, if it is heading the wrong direction. One reason for this can be the lack of metric owners. No one processes the measurement data from the development process or works actively for an increased quality regarding a specific metric. The company is therefore recommended to make someone responsible for each metric, and to start working more actively with the existing metrics, see Table IX.

TABLE IX
CURRENT STATE AND POSSIBLE FUTURE STATE OF THE CURRENT METRICS.

	Current state				*Possible future state*			
Metric	**Performance driver**	**Outcome measure**	**Well-functioning goal**	**Metric owner**	**Performance driver**	**Outcome measure**	**Well-functioning goal**	**Metric owner**
Project time	No	Yes	No	No	Yes	Yes	Yes	Yes, one
Time until gate 2	No	Yes	No	No	No	Yes	Yes	Yes, one
Project cost	No	No	No	No	Yes	Yes	Yes	Yes, one
Time spent on funded projects	Yes	Yes	Yes	Yes, one	Yes	Yes	Yes	Yes, one
Product functionality	No	Yes	No	No	Yes	Yes	Yes	Yes, one
Turn- over on newly developed products	No	No	No	Yes, several	Yes	No	Yes	Yes, one

The difficulty to act on a known problem has also been acknowledged in research about organizational structure mechanisms, and can be caused by too abstract goals, or goals too far away in time [28]. Both these causes were mentioned by several respondents. It is difficult to motivate anyone to work over-time to avoid a delay that won't have any effect until two years later. Equally difficult is it to cooperate efficiently without a common understanding of a goal [34], [18].

The solution to these difficulties are to make the final goal as concrete as possible, preferably a goal that cannot be postponed and to use interim targets well connected to the final goal. This strategy was successfully tested in a recent project at the studied company. The overall time goal of the development project was to launch the product at an exhibition 2011. Several interim targets, including an early first prototype were used. Thereby, everyone understood the severeness of delays early in the process and worked hard to reach the sub targets. It was also possible for the project team to visualize the result of their work in form of customer reactions at the exhibition.

One general aspect that was found to have a distinct effect on all current metrics used was an unclear definition of the product development process. As the stage gate model was interpreted differently in different projects, the measurements of the metrics varied from project to project, even though the metrics themselves are well-defined. The case study company could probably increase the performance level on all their current metrics, and the performance measurement system at large, by ensuring that the stage gate model is consistently used in all product development projects and that the handing over between functions are well-defined.

A. Summary of case findings

The case study company was found to have a reasonable amount of metrics covering relevant aspects of the product development process. They should focus their future improvements of their product development performance measurement system in the following areas:

- Define the measured process
- Relate the used metrics to well-functioning goals
- Strengthen the ownership of each metric
- Balance the PMS with more performance drivers

VIII. FUTURE WORK

This study has focused on evaluating the current set of metrics used in the product development process of the case study company. A natural continuation of this work would be to determine whether the company could benefit from complementing their present set of metrics with other metrics, e.g. metrics suggested in previous research for other companies. That study would include a more extensive literature review on measurement systems for product development as well as an analysis of metric requirements derived from the interview material of this case study.

It would also be rewarding to return to the case study company some years from now and evaluate the performance measurement system when improvements derived from this study have been implemented and used.

IX. CONCLUSIONS

Vanek et al. [21] found that there is no ultimate key set of metrics for the product development process, but that there probably exists a set of metrics that are the most appropriate for the product development process at one business unit in a company. This is in line with research that has focused on performance measurement systems in general, such as [6].

The results from this study indicate that not only the set of metrics, but also how they are used have a crucial effect on the quality of the performance measurement system. The case study company was found to have an appropriate set of metrics connected to the product development process. Nevertheless the performance measurement system at large have great improvement potential mainly concerning four aspects, namely:

- A well-defined process
- Well-functioning goals connected to the metrics
- Ownership of the metrics
- A balance between outcome metrics and performance drivers

Of these four aspects, most problems in the existing measurement system originate from inconsistencies in the process description and ambiguous handing of routines. Without a common process definition, measuring time and cost of different projects are of little use as the results from the measurements are not comparable with each other. Goals and metric owners would increase the effect of using the metrics. A better balance between outcome metric and performance drivers would increase the steering capacity of the performance measurement system, as outcome measures without performance drivers don't help to achieve the desired outcome [9].

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