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Procedia CIRP 48 (2016) 265 – 270

www.elsevier.com/locate/procedia

23rd CIRP Conference on Life Cycle Engineering

A holistic approach to risk oriented lifecycle engineering: Assessing lifecycle risks in early phases

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Abstract

Innovative companies nowadays face demanding challenges as more complex product architectures and shorter product lifecycles endanger the success of innovative products. Rising product recalls and critical software patches are the observable consequences, threatening not only revenue but reputation and customer satisfaction. Therefore, it is evident that companies need to frontload their development processes while managing complexity through effective and in-depth product lifecycle monitoring. This becomes even more crucial in the context of multi-project management, employee turnover and low in-house production depth.
In this paper, an approach to systematically assess project specific technical risks and uncertainties in early phases is presented. Based on qualitative ratings of risk and control factors and a staged aggregation and transformation of the assessment data into continuously updated maturity indicators, an effective method for product lifecycle monitoring is accomplished. It is shown how this will help companies to drastically reduce lifecycle costs. The approach is flanked by embedment into a real-time online information system satisfying several critical requirements. The application is validated by an industrial use case of an innovative manufacturer with a strong focus on critical uncertainties in subsequent product lifecycle phases.

Peer-review under responsibility of the scientific committee of the 23rd CIRP Conference on Life Cycle Engineering

Keywords: "Product Life Cycle Development; Product Maturity Assessment; Technical Risk Management; Product Development; Requirements Management"

1 Introduction

Within the field of product development, enterprises nowadays have to face increasingly demanding customer requirements and a competitive environment. While the customers may evaluate the maturity of a product by checking the degree of fulfillment of their requests on the delivered product and its documentation, the developers' situation within the development process is much more complex. From the developers' point of view, various experts and disciplines have their own specific ideas about feasibility and risks of implementation of requests at different stages of the development process. Their knowledge is often not formally represented in the database of previous products, but still existing. Moreover, this knowledge is underlying a certain but unspecified uncertainty [1]. Due to these facts, the question arises how the maturity of a product can be assessed during the development process, especially in early phases.

In manufacturing industries, maturity occurs in different ways, e.g. maturity in projects, processes, products or technology. Technology Readiness Level (TRL) supports the assessment of proven technology's maturity in comparison with recent technologies. TRL is nowadays widely used in several industries worldwide. However, the assessment of technology readiness remains the enabler for product

Peer-review under responsibility of the scientific committee of the 23rd CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.03.152

development and hence is not eligible for measuring the maturity of a product in the development process. [2]

The need for a more complete understanding of product maturity during the development process is shown by detailed analysis of development project success factors by Cooper and Kleinschmidt. Among the key factors are having a well-defined product prior to development activities and excellent conduction of technological activities. [3] Nevertheless, many companies nowadays face changing and fuzzy customer needs, and technological activities often undergo efficiency measures and cost-effectiveness analyses, both jeopardizing these targets.

So how can management and development assure that technological activities in the product development process are really conducted flawless? And what are the real technical risks and uncertainties within this process at each point of the development? The answer can be given through a consistent and technologically profound maturity assessment of the product itself, starting in early phases of development projects.

2 Measuring maturity in development processes

At this point, maturity must be defined clearly in the context of this work. In deviation from common definitions of process maturity and on the basis of the definition of Müller, Bär and Weber, maturity may here be defined as the degree of achievement of a set of product requirements compared to a specified maturity at an end stage [4]. With this definition, maturity models that assess the organizational maturity in product development like CMMI-DEV are outside the scope of this work [5]. Furthermore, in this paper knowledge is defined as information and skills acquired through experiences or education. This includes all knowledge of enterprise's employees, not only knowledge of proven expert. [6]

Following the production process step by step is not sufficient for an effective development project management because of its complexity nowadays. Therefore, the development process must be systematically structured and designed to enable consistent verification and validation. Quality Gates (QG) provide an appropriate framework to achieve this goal for developing physical products. They have proofed their benefit in several commercial deployments in branches like automotive, aerospace industry and machinery industry. [7]

Each QG includes a request of necessary deliverables, e.g. documents, resources or operations, which have to be assessed with a maturity rating before passing the gate to the next phase (fig. 1). Additional, these gates may be supplemented by economic key figures, thus giving a comprehensive management summary at each checkpoint. [8]

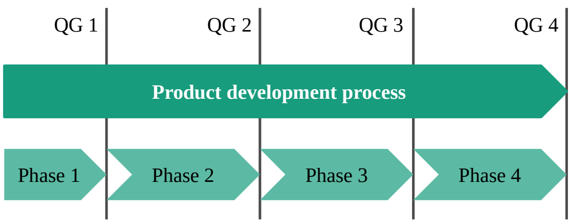

Fig. 1: Example of Quality Gates approach

But this method of checking essential parameters at defined gates has its weakness in early phases, when there is only insufficient data for a valid assessment of maturity levels. At this point, technical parameters cannot be checked by tests, simulations or customer's specifications yet. Instead, often the only data source is knowledge of experienced employees about specific requirements, functions or challenges. While the strength of the QG approach lies in the high flexibility regarding requested deliverables and maturity levels, its weaknesses lie in a lack of guidance on which deliverables are to be assessed, and on how best to assess the described uncertain data.

A maturity assessment methodology widely used in the automotive industry is the 'Verband der Automobilindustrie' (VDA) maturity level assurance for new parts. In this model, the fulfillment of requirements and the acquisition of key figures concerning the project goals are requested in pre-defined checklists at a predefined set of milestones (ML), ML0 to ML6. All items in the checklists have to be answered with either 'yes' or 'no'. The maturity level at each ML is classified into three stages as follows:

- Green: all requests are answered with 'yes'
- Yellow: at least one request is answered with 'no'
- Red: at least one request is answered with 'no' and at least one project goal will not be achieved

At each ML all requirements from all previous ML are reviewed carefully and are assessed again. The maturity level of the worst assessed ML checklist determines the overall maturity level (fig. 2). [9]

While the predefined checklists give a strong guidance to users, it also remains a weakness since individual items can hardly be integrated. Technological deepness of the assessment is fixed through these checklists, while large-scale projects may need a deeper assessment and small projects may profit from a more thinned out assessment. Furthermore, the coarse range of assessment leaves a wide room for interpretation. Based on discussions of the authors with users from German automotive companies, another negative aspect of this assessment is the fact that users tend to build consensus when having different opinions, leading to an over-representation of the stage 'yellow'. That is why the advantage of having only a few stages may lead to distorted assessments in real situations. Our concluding finding is that through a lack of individualization and a missing real-time assessment of technical risks in depth a real assessment of product maturity is not possible with this model.

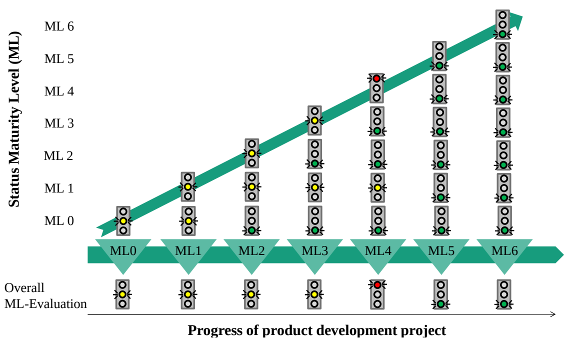

Fig. 2: Seven-staged maturity levels with a three-staged traffic lights assessment according to VDA