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Ensuring Time-saving and Effective Production Planning by Prioritizing Activities based on Company-specific Validation Success Rates

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Abstract

Through the use of recent technological advances, such as virtual- and augmented-reality validation techniques, many companies were able to reduce the number of physical prototypes used during their production planning process and thus improve their Time-To-Market. However, substituting physical prototypes in production planning comes at a cost, as validation results obtained from virtual- or augmented-reality techniques are not as reliable as those conventionally generated. Considering the fact that up to 85% of a product's life cycle costs are determined during product- and production planning [1,2] raises the question, at which point accelerating the planning process compromises its effectiveness and thus has a negative impact on the Life Cycle Costs. To answer this question, this paper discusses a novel approach to measure the success rate of non-physical prototype validation techniques and, using a Monte-Carlo Simulation, calculate a product's production-readiness. This contemplation allows an algorithm-based identification of part-specific validation activities that need to be carried out in order to ensure a satisfying degree of production-readiness while minimizing the number of physical prototypes needed. Our time-saving and effective approach has been implemented as a software-tool (SIMBAPLAN®) and put to use at a German Commercial Vehicle Manufacturer. Based on this use case, potentials and limitations of the approach are discussed and areas for future research are derived.

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Keywords: Life Cycle Management, Life Cycle Planning and Development, Life Cycle Costing

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1. Introduction

During the New Product Development (NPD) process, up to 85% of a product's life cycle (PLC) costs are determined [1,2]. Therefore, much effort is put into designing products and manufacturing processes in ways that as little costs as possible are incurred during the later phases of the PLC. In this context, the validation[1] of product and production process is a crucial success factor. Through new technological developments, virtual validation has become an alternative to the conventional building of physical prototypes. However, these new technologies cannot live up to the quality obtained through physical validation, thus virtual and physical prototypes are used in combination [3]. This situation raises the question, which parts and processes can be validated through virtual technologies only, and which parts should be validated using a conventional prototype.

While research has been put into feature-based classification of parts and processes in order to recommend a certain type of validation [i.e. 4, 5], none of the reviewed approaches is based on a quantitative assessment of a validation technique's actual capability. Therefore, evidence-based recommendations

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[1] In this context, the term "validation" describes confirmation through objective evidence, that the requirements for a specific application have been fulfilled.

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regarding suitable validation techniques for specific parts are not available.

2. Validation during the production planning process

Goal of all validation activities during the production planning process is to provide evidence, that the previously stated specifications have been fulfilled [6]. Validation activities are usually carried out on module- or parts-level, which, in case of large and complicated products, makes it a time-consuming task [7]. In addition to that, a part is recurrently validated in most cases, as different levels of maturity are provided during the NPD process [8]. Subsequently, different types of validation techniques are briefly introduced.

2.1. Virtual validation techniques

Virtual validation techniques can be applied at an early stage in the design process, before physical prototypes have been built [9]. Necessary changes can thus be identified early and incorporated at comparably low costs [10]. Virtual techniques are applied for evaluations regarding line layout, ergonomics, process planning, tool and fixture design as well as maintenance concepts. Also, virtual techniques are frequently used for operator training [5]. The quality of the achieved validation results crucially depends on the integrity of the utilized data and whether it is up to date [11]. Although sporadic approaches propose an exclusive use of virtual validation techniques [12], most scholars agree it cannot entirely replace physical prototypes in the near future [cf. for example 3, 5, 13]. As neither hypothesis is supported through quantitative evidence in the literature reviewed for this paper, it is not possible to determine if and to what extent physical prototypes should be used during the NPD process.

2.2. Physical validation techiques

In contrast to virtual validation, physical validation requires parts to be built into a prototype. The parts under consideration do not have to resemble all features of the later product, oftentimes different levels of maturity are used in practice [14]. If the physical validation is conducted under conditions close to those of series production and no change-necessities are found, the respective parts can be assumed to have attained series-maturity [15]. As physical validation is expensive compared to virtual validation, not all parts can undergo this process when dealing with large and complex products.

2.3. Other forms of validation and further aspects

The techniques available are not limited to either virtual or physical validation. Some publications promote using augmented reality techniques, which resembles a combination of both worlds [16]. Expert discussions also pose a means for validation, enabled for example through the implementation of simultaneous engineering teams [17]. Aside from the different validation methods discussed so far, validation can also be categorized depending on who is involved (single expert or cross-functional expert team) and what is reviewed (own or third-party work).

3. Prioritization of validation activities

In general, prioritization refers to arranging objects according to their importance [18]. As our goal is to prioritize physical and virtual validation activities for specific parts, existing approaches for prioritizing activities are introduced subsequently.

Scharer [19] proposes to prioritize activities with respect to the dimensions “impact on project” and “experience conducting the activity”. The experience equals the weighted sum of the number of repetitions completed, the degree of complexity (depends on the number of persons involved with the activity) and the degree to with new competencies need to be acquired for conducting the activity. An activity’s impact on the project corresponds to its duration, resource consumption and importance for the project’s success. According to Scharer [19], c*ritical* activities (cf. Fig 1) should then be prioritized.

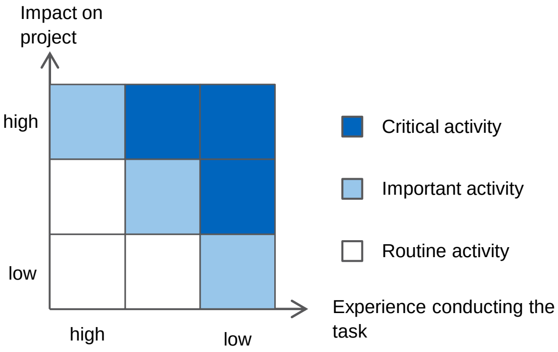

Fig. 1: Prioritization of activities according to [18]

Another approach to prioritize validation activities on parts’ level is proposed by the German Automotive Association (VDA) [20]. Based on a list of 20 product-, production-, supplier- and timeline-related criteria, each part is classified into one of three risk-categories. The categories determine how the part’s validation should be carried out:

- Category A parts: All stakeholders (supplier and original equipment manufacturer (OEM) representatives) must be present for validation.
- Category B parts: validation is conducted solely by the supplier. The validation results and resulting measures need to be actively confirmed by the OEM.
- Category C parts: validation is conducted solely by the supplier. Validation results are documented and do not require active confirmation by the OEM.

Gartzen et al. [18] prioritize according to the ratio between potential benefit and effort. The potential benefit of a given activity corresponds to a reduction of uncertainty in the