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Frontloading in Aircraft Development Process by Integration of a new Validation Method

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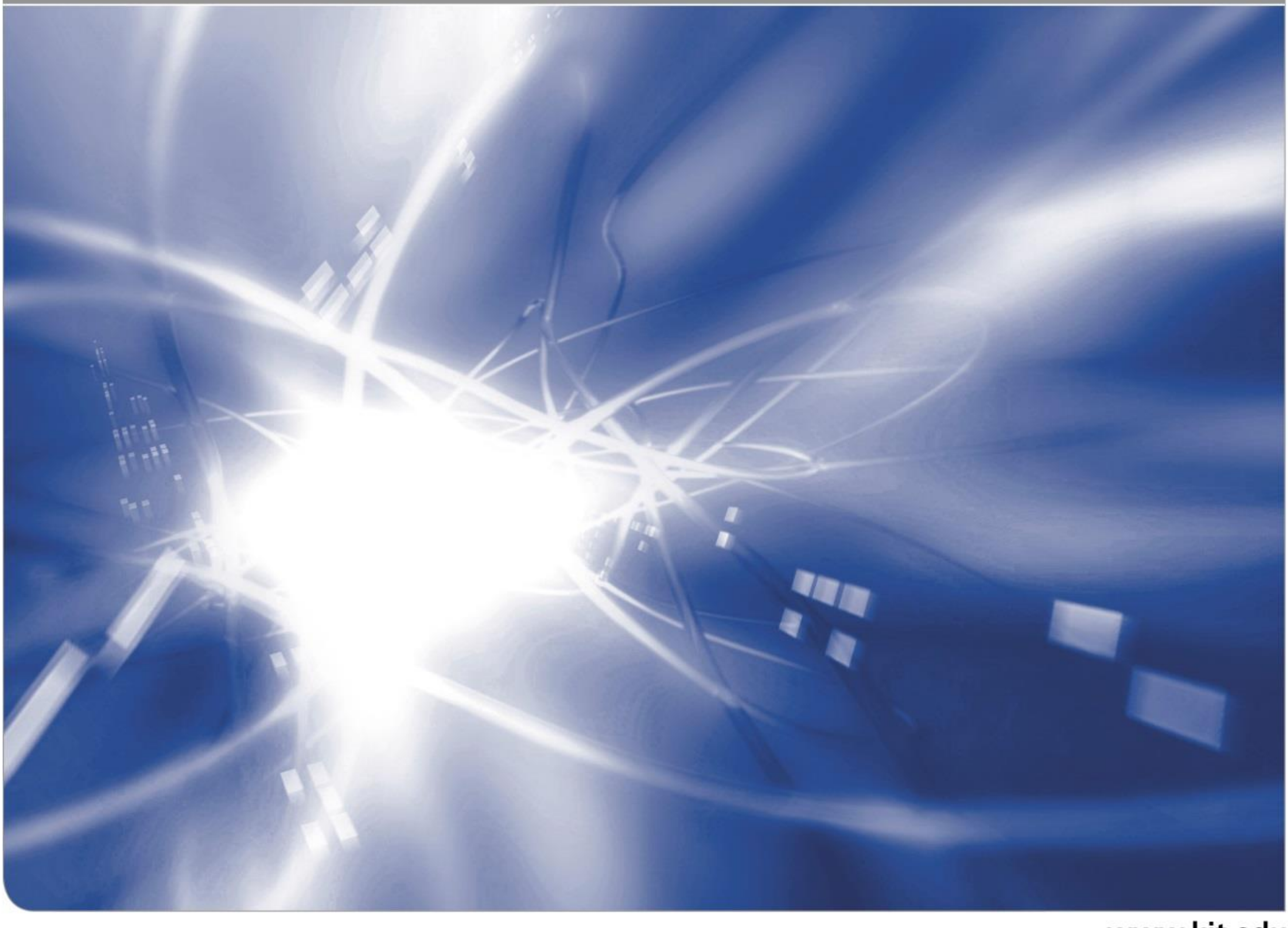

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Abstract

In product engineering Frontloading can be supported by the implementation of new methods in a product development process. In this contribution the integration of a new validation method called *Scaled-Components-in-the-Loop* in an aircraft development process is presented. The requirements for the application of the validation method are discussed.

Keywords: Frontloading; Product Engineering; Product Development Process; Aircraft Development Process; Aerospace; Preliminary Design; Validation Method; Test Method

1 Introduction

Frontloading and Concurrent Engineering are strategies to improve the performance and reduce the time of a development process [1, 2]. The reduction of time leads to a reduction of the Time to Market, what is a major cost factor in the product development process. Figure 1 shows a common and an ideal product development process in Commercial Aircraft Projects. We can see that in an ideal product development process the design and production phase can be shorten significantly through a longer planning phase. The reduction of Time to Market can be achieved by using methods that support the design activities, e.g. by shifting design problems to earlier phases of the product development process [2].

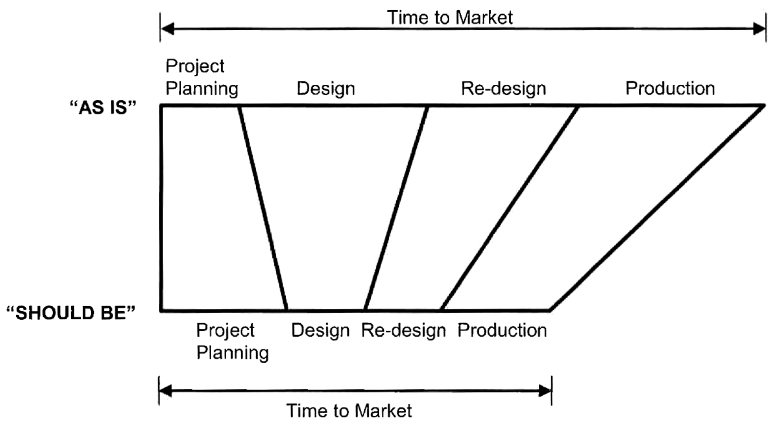

Figure 1: Reducing Time to Market in Commercial Aircraft Projects [1].

Looking at the main steps of an aircraft development process in Figure 2, it can be seen that the *Preliminary Studies* and the *Preliminary Design* are the first two phases with many possibilities for design changes with little effort. Therefore, it is useful to validate concepts already in the *Preliminary Design* phase. It is reasonable that a method that enables early validation by pulling the validation activities forward is particularly effective in the early phases of product development.

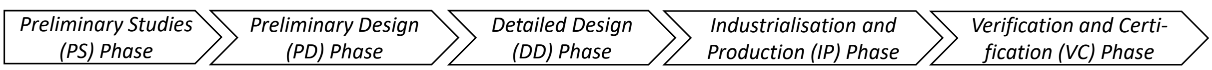

Figure 2: Main Steps in an Aircraft Development Process based on [3, 4].

There is a need for methods that validate these concepts for the system in development. The aim of this contribution is the integration of a method for early development stages in an aircraft development process. In the following, the validation method *Scaled-Components-in-the-Loop* is briefly introduced and its integration into an aircraft development process is explained.

2 Validation Method *Scaled-Components-in-the-Loop*

The validation method *Scaled-Components-in-the-Loop* enables the analysis of scaled prototypes in a hardware test bench during early development stages. The method has the objective of obtaining system knowledge as well as the verification of the system components regarding functional aspects. The method has already been presented in detail in [5]. Figure 3 shows the main steps of the validation method.

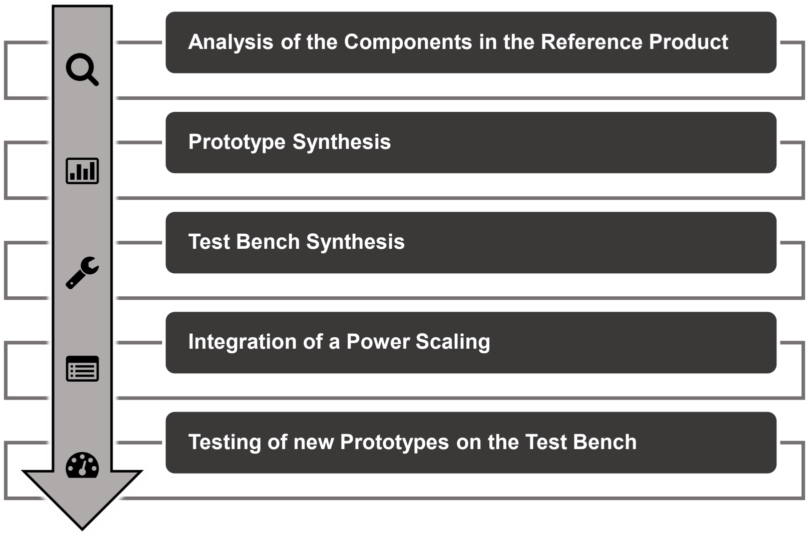

Figure 3: Main Steps of the Validation Method *Scaled-Components-in-the-Loop* according to [5].

The first step contains the analysis of the components in the reference product. The reference product can be the predecessor product of the last product generation with regard to the critical function. Based on this, a prototype is synthesized, which represent the system to develop of the next generation. Then the prototype embedded in a system is functionally tested on the test bench. The integration of power scaling allows the adjustment of the load on the test bench. The power scaling enables the testing of new prototypes in the early development phases without changing the physical setup of the test bench. [5]

3 Integration in the Product Development Process of Aircraft Components

The validation method is particularly suitable for the *Preliminary Design* phases in which no fully functional system is yet available. But at the same time an early functional validation with hardware components (prototypes) is desired. The early functional validation should reduce the amount of further development activities to reduce Time to Market.

The validation method is located in an aircraft product development process parallel to the *Preliminary Design* phase (see Figure 4). This means that the functional validation of selected components can already be taken into account in the review of the *Preliminary Design* phase. In the D*etailed Design* phase, a validated concept at component level is thus available, which accelerates further design activities.

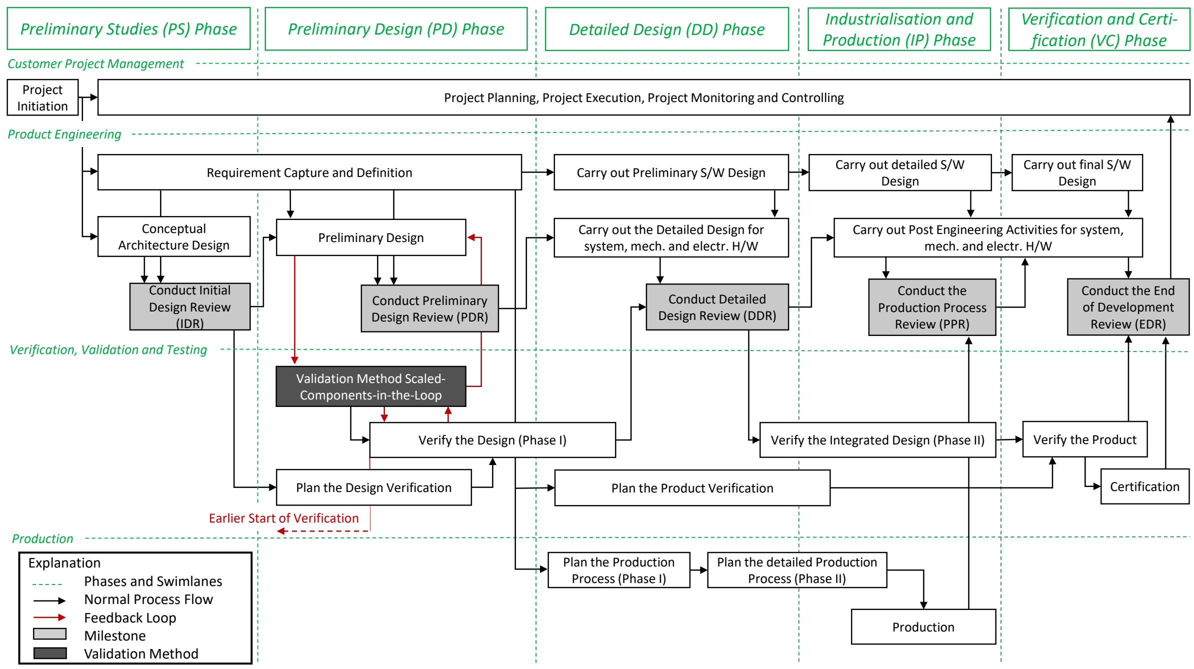

Figure 4: Product Development Process of Aircraft Components with integrated *Scaled-Components-in-the-Loop* Validation Method based on [4].

As requirements for the use of the validation method, the following points were identified:

- There is a prototype of the system in development with regard to functional aspects available. For example, the component from an existing series can be used, even if the size does not fit into the design space.
- The prototype should only differ from the system under development in performance or size, but not in its functional principle.
- A flexible test bench should already exist or develop in an upstream process.

The first requirement is often fulfilled in aircraft product development, since developments are based on existing products, thus simplifying the provision of physical prototypes. Since the prototype is not bound to the design space of the system to be developed, existing components from previous developments can also be used.

The second requirement is an indispensable condition since a prerequisite for the use of the validation method is that the functional principle in the prototype is the same as that of the system in development, in order to ensure transferability of the test results. However, this requirement is often present in aircraft development processes, since known and proven designs are reused and adapted to the development-specific boundary conditions by a design variation. This requirement is particularly fulfilled in the context of series production.

The third requirement is not a necessary condition, but is an important aspect from the point of view of costs and development time. The validation method aims at reducing the development time by increasing the product maturity level in early development phases and promoting functional validation. Additional resources are required to provide the test bench, so flexible test bench that can be used over several product generations should be aimed for.

4 Discussion

The integration of the presented validation method *Scaled-Components-in-the-Loop* enables Frontloading in the aircraft development process. The integration of validation activities in the *Preliminary Design* phase enables the reduction of further development activities through early decisions. The benefits of the early validation must be weighed against the costs of the additional testing activities. The use of the validation method *Scaled-Components-in-the-Loop* is particularly effective when there are uncertainties in the design of functional components, where a late discovery leads to high costs and an extended time to market. Beside the proposed method for early validation in the *Preliminary Design* phase there is need for cross domain development methods and especially reduction of test time for the *Integrated Design* phase.

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