Technische Universität Dresden

# TOWARDS AN INTEGRATED USE OF SIMULATION WITHIN THE LIFE-CYCLE OF A PROCESS PLANT

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TECHNISCHE UNIVERSITÄT DRESDEN

**Fakultät ET/IT,** Institut für Automatisierungstechnik, Lehrstuhl für Prozessleittechnik

DISSERTATION

# TOWARDS AN INTEGRATED USE OF SIMULATION WITHIN THE LIFE-CYCLE OF A PROCESS PLANT

MATHIAS OPPELT

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# PREFACE

The idea for this thesis was born in spring 2012 during a dinner discussion with Dr. Stefan Bamberger. I just joined his team of global product management for process automation within the Siemens AG and took over the responsibility to extend the existing product portfolio with simulation products. Based on some experience with simulations in automotive, aviation, production machine and machine tool industries, I liked the idea to integrate simulation more into the process automation workflows. Some discussions with customers quickly revealed a gap between the current use of simulation and the potential attributed to it. Also in academia very little work could be found on an integrated use of simulation within the life-cycle of a process plant. Thus, in autumn 2012 we discussed with Prof. Dr. Leon Urbas the idea of a scientific collaboration and dissertation in this area and I accepted the challenge to work on this in parallel to my product management duties.

Hence, I want to thank especially Dr. Stefan Bamberger for providing me with this unique opportunity and the necessary freedom and trust in arranging my work. Special thanks also to Georg Kluge as my direct manager for enabling a self-determined working environment.

Further, I am deeply grateful to Prof. Dr. Leon Urbas for all the great and fruitful discussions, the scientific guidance over the last years and for providing me with the opportunity to write this thesis. I also want to thank Prof. Dr. Georg Frey for accepting the co-supervisory for this thesis.

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I also want to thank my colleagues working with me to realize the vision of a more integrated use of simulation, for all the great support, discussions and trust. Special thanks to Günter Schmidt, Jürgen Raab, Thomas Stör, Chris Leingang, Werner Ammon, Alexandre Bouriant, Bernhard Iffländer, Horst Jäckisch, Roland Rosen and all the others who gave me assistance for my work and this thesis.

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*Mathias Oppelt, July 2015*

# ABSTRACT

Today the mega trend of digitalization starts to transform markets and businesses towards much higher volatility in demand and resource availability. Therefore, higher flexibility and efficiency for future production plants is necessary to continue a sustainable growth and development of businesses within a fast changing surrounding. This requires also more flexible and efficient engineering and operational methods than established today, to deal with the rise in complexity of these future production plants. This complexity will massively complicate the engineering and operational decision making process, because multi variable optimization problems arise, which can no longer be answered by experience.

One possible technology to support the decision making process is simulation, which can be used to answer engineering and operational questions earlier and with lower risks. Further, simulation will be one key element of a successful digitalization strategy, because it enables the virtual representation of a production plant or product within a digitalized supply chain. Thus, simulation should gain significant importance across all industries in the future. Also within the life-cycle of a process plant, simulation is vital to cope with the challenges of digitalization and a more flexible production. Therefore, within this thesis the pathway for simulation within the process industries is investigated.

A global online survey with more than 200 participants and more than two dozen expert interviews reveals deep insights about the current and future use of simulation within the process industries. Today simulation is already an accepted technology to support engineering and operational decision making. But simulation strongly depends on individual persons regarding how it is used and if it is used at all. Thus, today a scattered use across the life-cycle is state of the art, with four main use cases which are design simulation, virtual commissioning, operator training and optimization. An important finding is also, that simulation is not only used by simulation experts, but often by domain experts like automation engineers as supporting technology.

The expectations within the process industry are that simulation will gain major importance over the next years and the target is a continuous use along the life-cycle. Further, in future simulation will be used systematically as an integrated part of the normal engineering and operational workflows along the full plant life-cycle. The center piece of engineering and operations will be a complete virtual representation of the real plant, a virtual plant, being able to evaluate engineering and operational questions in a realistic and reliable manner. A simple use of simulation

and a high degree of reusability of existing models will ensure an efficient and flexible use of simulation throughout the complete plant life-cycle.

For the realization of the identified vision requirements and fields of actions are derived within this thesis, being the foundation for a technology roadmap describing a possible way into the future. Important fact is that the successful use of simulation is no pure technical aspect; multiple non-technical aspects like e.g. management acceptance have to be considered. The pathway towards an integrated use of simulation is evolutionary and stepwise, first integrating virtual commissioning and operator training, and then adding design simulation before last adding optimization, to reach a concurrent use.

The first integration step is investigated within a detailed technical prototype. The prototype shows that even today a much more integrated use of simulation can be realized based on an available set of tools. Thus, an evolution towards an integrated use of simulation within the life-cycle of a process plant is possible. Even though some time is required for a complete integration of simulation into the life-cycle of a process plant, because existing workflows needs to be adapted and continuously improved.

Future work can focus on an even better integration of available tools through standardized interfaces. In addition, a big advantage is provided, if for all devices appropriate simulation models are delivered by the device manufacturers. Thus, the integrated use of simulation can become a reality sooner rather than later and lead to the fully virtual plant.

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