Complexity Management in Engineering Design – a Primer

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Foreword

Product Development is struggling with an increasing complexity due to requirements, regulations, technologies, supporting digital tools, etc. The handling of an increasing quantity of data is supported by PDM and PLM systems; requirements are managed with the help of databases. However, design engineers have hardly any support for obtaining a transparent overview in a holistic way, including products, processes, data, organization, means, etc.

The starting point of Dr. Maik Maurer's research in the field of complex systems was the vision of individualized physical products based on mass production. Out of the large number of questions arising, he focused on more transparency and understanding of the interdependencies that lead to difficulties in generating solutions. Based on his research questions related to this vision, he started to evaluate the possibilities of modeling elements and interdependencies in and between different domains: requirements, products, and processes etc., based on mathematical models. Methods as well as graph theory deliver the required input. Existing methods and newly developed ones have been linked together to build a framework for the management of structural complexity. Interdependencies and patterns out of these interdependencies across domains are the basis for the analysis.

Strategies and methods for data acquisition and quality assurance of the structural data, together with possibilities for visualization by strength-based graphs, complete the approach.

Several research projects funded by the German Science Foundation as well as a technology-transfer project with applications in different industries and organizations formed an excellent basis for improvement and further development, as well as an evaluation of the methodological framework. The associates in the technology transfer range from some well-known international corporate groups to medium-sized companies. The framework developed also formed one of the building blocks of a start-up consulting firm.

Because of the strong link between our research and the education of degree students, an increasing number of theses on the subject were written. A specific lecture for master's-degree students about structural complexity started with about 30 students and continuously grew to well over 100 per year. An intensive practical course in systems engineering complemented this lecture for master's-degree students.

An international summer school on systems engineering initiated by Maik Maurer started in Germany; it since became Europe-wide, and about 20 doctoral students participated per year.

Based on these activities and experiences, Maik Maurer wrote this book as his habilitation thesis, entitled "Complexity management in engineering design—a primer." Complexity, and the lack of transparency due to it, is one of the most demanding aspects of engineering design and beyond. Maik Maurer addressed this in his thesis, based on a unique overview of the historical development of complexity management. He presents a classification of approaches and develops a management framework for handling complexity, especially in engineering design.

Based on a number of years of research, and its successful transfer to industry, Maik Maurer presents an impressive work for teaching that is relevant for both students and practitioners.

Garching Udo Lindemann
August 2016

Acknowledgement

This work is the result of extensive study of the topic of complexity from various perspectives in research, teaching, and industrial applications in an always positive and inspiring work environment. Without the support, suggestions, and contributions of many people, I would not have been able to create this work in its existing form.

First of all, I would like to thank Prof. Udo Lindemann for his many years of support and mentorship in a variety of research, teaching, and industrial projects. His support enabled me to attack even unconventional and risky projects with the greatest confidence and commitment.

I would also like to express my highest gratitude to all of my colleagues at the Institute of Product Development for their cooperation. It has been the key to the successful application for and conducting of research projects and for designing, conducting, and continuously improving lecture courses and programs.

Special thanks also go to all the students I was allowed to teach and supervise during various courses and theses. Their critical questions, proposed alternative solutions, and well-considered feedback to my lecturing helped me to develop and improve as a teacher. The need to not only comprehend a topic myself but also to be able to transfer this knowledge to others has deepened my understanding of matters substantially.

Finally, I would particularly like to thank my family for always supporting me throughout the time of creating this thesis and for their understanding of my long evenings or weekends spent in the office.

Stoneham, MA
February 2016

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