Improving Product Development Projects by Matching Product Architecture and Organization

Bas Oosterman

Uitgever: Labyrint Publication P.O.Box 662 2900 AR Capelle a/d Ijssel The Netherlands fax +31 (0) 10 2847382

Print: Offsetdrukkerij Ridderprint B.V., Ridderkerk

Layout binnenwerk: Dick Rutgers BNO, Haren

ISBN: 90-72591-99-2

Drukwerk:

© 2001, B.J. Oosterman

Alle rechten voorbehouden. Niets uit deze uitgave mag worden verveelvoudigd, opgeslagen in een geautomatiseerd gegevensbestand, of openbaar gemaakt, in enige vorm of op eniger wijze, hetzij elektronisch, mechanisch, door fotokopieën, opnamen, of enig andere manier, zonder voorafgaande toestemming van de uitgever.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system of any nature, or transmitted in any form or by any means, electronic, mechanical, now known or hereafter invented, including photocopying or recording, without prior written permission of the publisher.

Hoewel bij deze uitgave uiterste zorg is nagestreefd, kan voor de aanwezigheid van eventuele (druk)fouten en onvolledigheden niet worden ingestaan en aanvaarden auteur en uitgever deswege geen aansprakelijkheid.

RIJKSUNIVERSITEIT GRONINGEN

Improving Product Development Projects by Matching Product Architecture and Organization

Proefschrift

ter verkrijging van het doctoraat in de Bedrijfskunde aan de Rijksuniversiteit Groningen op gezag van de Rector Magnificus, dr. D.F.J. Bosscher, in het openbaar te verdedigen op dinsdag 18 december 2001 om 13.15 uur

door

Bas Jeroen Oosterman geboren op 5 augustus 1972 te Meppel

Promotores:	Prof. dr. ir. G.J.C. Gaalman Prof. dr. ir. F.P.J. Kuijpers
Beoordelingscommissie:	Prof. dr. ir. L.T.M. Blessing Prof. dr. ir. J.M.L. van Engelen Prof. dr. ir. A.C.J. de Leeuw

Je afzonderlijke delen zijn niet zo bijzonder Maar als geheel ben je een wonder Salman Rushdy

Preface

Je afzonderlijke delen zijn niet zo bijzonder, maar als geheel ben je een wonder'. Broadly speaking this means: 'The whole is more than the sum of the parts alone'. This not only relates to the topic of this dissertation, but also refers to the PhD. project itself. One might have the opinion that this book is the main result of my project. For me though it is only a part of it. I consider the experience of exploring the scientific field as being equally important. Especially the sum of the final book and all trial and error during the process make the last 5 years complete and a valuable and unique happening for me.

Unfortunately for the reader, the best memories and stories of the scientific journey cannot be found in this book. In order to provide the reader a glimpse of it, I will take the opportunity to mention some of the many people who played an important role. Without them the dissertation would not have been completed. I like to express my enormous gratitude to them.

First of all I would like to thank Wim Klein Haneveld and Martin Land who were my supervisors during my master thesis in econometrics and inspired me to further explore the world of science.

I was lucky to have Gerard Gaalman and Frans Kuijpers as supervisors. In their own way, they intensely guided me in doing research: theoretically, practically, and personally. I think the match between them made the overall supervision even more powerful with respect to this project. The things I learned will play an important role within my future years. Many thanks for your always direct and personal involvement!

I am very grateful to Jannes Slomp who was greatly involved in starting up this project.

I thank the reading committee for their effort and their useful comments on the draft.

Many people at the faculty helped and inspired me during my research. In particular I express my gratitude to Hen van de Water for his thorough and detailed comments on my paper. I would like to thank Dirk-Pieter for the many fruitful discussions, his broad interest, and last but not least his chewing gum!

I thank Julia Harvey for improving my English.

Dick Rutgers professionally has helped me with the layout of this book. It is impressive how he, under high time-pressure, changed my rough layout into a form that I had (implicitly) in mind.

The shaving company is acknowledged for spending two years there. It was a great time! Cees Wesdorp and Michiel Hillen thank you for allowing me to do the research and for your support. Bart Velthuizen and Ton van Veen helped me from the beginning till the end of my stay. I learned a lot from your 'So What' questions, and your skills presenting findings in a clear fashion. Moreover, you made my stay a pleasant one. Maarten Rijken, Oedilus Bisschop, Sint Baron, Johan Beugels, and Johan van Toor thanks for your time, openness and knowledge. Furthermore, I would like to extent my gratitude to the architecture team: Jan Otter, Bernard Hekstra, Ton van Veen, Per Ambrosiussen, Anne van de Meer, and Pieter Oosting. We worked together intensely with high effort, but there was never lack of humor. Wilfred Ruijsch and Seakle de Vries thank you for your company and transport every day.

I would like to mention Sonny Kwok. I met Sonny at the shaving company and from that time we got along really well. He arranged that I could apply the analysis within Singapore, and from January 2002 we will be colleagues over there. I especially thank Andre Krebbers, Ferdinand Coehoorn, Gan T.B., Choy K.W. for the invitation and their support during my stay there. I look forward to working with you.

My colleagues at the faculty of Management and Organization made my stay a pleasant one. It was always a pleasure to be a member of the cluster OPS and the cluster Business Development. Linda, Hanny, Nynke, and Henny thank you for the secretary support. Furthermore, I thank the eight floor, the VF, the aio's, my room mate Henrico, the THW-people (fl. 6,-), the successful SPR-volleyball team (second again...), the 'Thompson-discussion-group', SOM, Bram van Dam, and Nelie Schouten.

I would like to mention my friends and family for my life next to work. My volleyball teammates and the people around (Veracles and Lycurgus) played an intense role. It was a pleasure! Hans Geene, and Gerard Smit thank you for your skillful training and coaching. Furthermore, I thank all 'Stadspark' soccer players for the fun of just playing soccer.

The friends of econometrics, Jeroen, Gerrit, and obviously the 'Warmoesstraat': Koos, Henriette, Birgitte, Mark, and partners thanks for all great moments and friendship.

Jos, Loes, and Mari-janne. You were always there. I dedicate this book to you...

Bas Oosterman Groningen, 2001.

BasOosterman@hotmail.com

Table of Contents

1 Introduction to the research problem *1*

- 1.1 Research area and scope 1
 - Design literature in general 1
 - Concurrent Engineering 1
 - The 'underlying design structure' 2
 - Product architecture 2
 - Organization of design projects 2
 - Linking product architecture and Organization: the gap 5
- 1.2 Research questions and objectives 5
- 1.3 Research method 7
- 1.4 Outline of the thesis 8

2 Product Architecture: Key Concepts and Implications 11

- 2.1 Problem solving in general *11*
- 2.1.1 *Problem-solving basics 12*
- 2.1.2 Hierarchies 13
- 2.1.3 Link with product development 15
- 2.2 Design methods 16
- 2.2.1 Introduction to engineering design models 16
- 2.2.2 Prescriptive design models 17
- 2.2.3 Axiomatic design 22
- 2.2.4 Discussion 26
- 2.3 Product architecture 29
- 2.3.1 Definition of product architecture and modularity 30
- 2.3.2 *Representing architecture 34*
- 2.3.3 Comparison 36
- 2.4 The implications of architecture *37*
- 2.5 Summary 38

3 Organization of design processes: principles and applications *41*

- 3.1 Classic organizational theory 41
- 3.1.1 Introduction: tasks and coordination 42
- 3.1.2 Structuring organizations according to Galbraith 43
- 3.1.3 Structuring organizations according to Thompson 45
- 3.1.4 Alternative structures of organization 47
- 3.1.5 Discussion 47
- 3.1.6 Lessons 49
- 3.2 Organization of design project 50
- 3.2.1 Types of innovation: scope 50
- 3.2.2 Design project teams 51

- 3.2.3 Design Structure Matrix studies 53
- 3.2.4 Discussion of the DSM approach: strengths and weaknesses 56
- 3.2.5 Summary 58
- 4 Coupling Product Architecture and Organization 59
- 4.1 Organizing tasks around building blocks 59
- 4.2 The consequences of architecture for coordination *61*
- 4.3 Detailed analysis of architecture and system-level coordination 62
- 4.3.1 Sosa and Eppinger: main idea 62
- 4.3.2 Discussion 63
- 4.4 The consequences of organization for architecture 65
- 4.5 Formulation of the problem *66*
- 5 Proposed taxonomy 70
- 5.1 Introduction to the taxonomy's main concept 70
- 5.2 The three types of interactions proposed 71
- 5.2.1 The functional type of interaction between building blocks 71
- 5.2.2 The mapping type of interaction between building blocks 72
- 5.2.3 *Physical interactions* 72
- 5.2.4 The relationship between the types: discussion 73
- 5.3 Impact on coordination per interaction type 74
- 5.3.1 *Functional interaction and coordination* 75
- 5.3.2 *Mapping interaction and coordination* 76
- 5.3.3 *Physical interactions and coordination* 77
- 5.4 Discussion of the taxonomy: its role, comparison, and restrictions 78
- 5.4.1 *The role of the taxonomy* 78
- 5.4.2 Comparison with Pimmler and Eppinger 79
- 5.4.3 The taxonomy's limitations 80
- 5.5 Summing up and field of application 82

6 The results of the case study 83

- 6.1 The research setting *84*
- 6.1.1 *Case study setting: theory* 84
- 6.1.2 Case study setting: the characteristics of the case 85
- 6.1.3 Data collection: tactics and protocol 89
- 6.1.4 Summing up 93
- 6.2 The interactions between the building blocks *95*
- 6.2.1 *The functional interactions* 95
- 6.2.2 Mapping interactions 96
- 6.2.3 The physical interactions 96
- 6.2.4 Final remarks 97
- 6.3 System-level coordination 97
- 6.3.1 System-level coordination for functional type interactions 97
- 6.3.2 System-level coordination for mapping type interactions 98
- 6.3.3 System-level coordination for the physical type of interactions 100
- 6.3.4 Summing up and overall remarks 101

- 6.4 Towards options for improvement *101*
- 6.4.1 Introduction 101
- 6.4.2 Improvement in general awareness of system-level interactions 102
- 6.4.3 Improvement per interaction 104
- 6.4.4 The contingencies behind the interactions 108
- 6.5 The implications of the analysis *109*
- 6.5.1 The effects within the design teams 109
- 6.5.2 *The architecture team 110*
- 6.5.3 *Measuring performance* 111
- 6.5.4 Summing up 113
- 6.6 Discussion of the results 113
- 6.6.1 The validity of the interaction constructs: discussion 114
- 6.6.2 Discussion of the relationship between the interaction types and required coordination 114
- 6.6.3 *The generation of options for improvement: discussion 118*
- 6.6.4 Methodological considerations 120
- 6.6.5 Measuring of the effect on improvement: discussion 122

7 Conclusions and suggestions for further research 125

- 7.1 Conclusions 125
- 7.1.1 *Theoretical conclusions 126*
- 7.1.2 *Conclusions of the application* 128
- 7.2 Directions for further research *132*
- 7.2.1 External validation 132
- 7.2.2 Refinement or extension of the taxonomy 133
- 7.2.3 Alternative interpretations 134
- 7.2.4 A guide to design new architectures 135
- 7.2.5 Broadening the scope of the taxonomy 135

References 137

Summary (in Dutch) 141