PROCEEDINGS
INTERNATIONAL CONFERENCE ON
COMPETITIVE MANUFACTURING

COMA '07
The Challenge of Digital Manufacturing

31 JANUARY - 2 FEBRUARY 2007
STELLENBOSCH, SOUTH AFRICA

Organised by
Departments of Industrial Engineering & Mechanical Engineering
PROCEEDINGS

International Conference on Competitive Manufacturing

COMA '07

31 January – 2 February 2007

Organised by
Departments of Industrial Engineering and Mechanical Engineering

Editor:
Dimitri Dimitrov
© 2007 by:

Global Competitiveness Centre in Engineering
Department of Industrial Engineering
Stellenbosch University
Private Bag X1
Matieland 7600
Stellenbosch, South Africa
Tel: +27 21 808 4241
Fax: +27 21 808 4126
E-mail: dimitrov@sun.ac.za

All rights reserved. No part of this publication may be translated, reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the written permission of the publisher.

About CIRP

CIRP was founded in 1951 with the aim to address scientifically, through international co-operation, issues related to modern production science and technology. The International Academy of Production Engineering takes its abbreviated name from the French acronym of College International pour la Recherche en Productique (CIRP) and includes ca. 500 members from 46 countries. The number of members is intentionally kept limited, so as to facilitate informal scientific information exchange and personal contacts. In a recent development, there is work under way to establish a CIRP Network of young scientists active in manufacturing research.

CIRP aims in general at:
- Promoting scientific research, related to manufacturing processes,
  production equipment and automation,
  manufacturing systems and product design and manufacturing
- Promoting cooperative research among the members of the Academy and creating opportunities for informal contacts among CIHP members at large
- Promoting the industrial application of the fundamental research work and simultaneously receiving feed back from industry, related to industrial needs and their evolution.

CIRP has its headquarters in Paris, staffed by permanent personnel and welcomes potential corporate members and interested parties in CIRP publication and activities in general.

Foreword

Welcome to this third South Africa International Conference on Competitive Manufacturing hosted by the University of Stellenbosch and organised jointly by the Departments of Industrial Engineering and Mechanical Engineering.

In a small world where global trade is the new driving force conquering countries and continents alike, international competitiveness is becoming the ultimate challenge of the new millennium. It requires high quality products manufactured with state-of-the-art technologies at low cost under the assumption of highly efficient operations management as well as clear corporate goals and strategy. This in turn is facilitated by and dependent on improved engineering training, education, and relevant applied research, fueled by active interaction between academia and industry.

The main objective of the International Conference on Competitive Manufacturing (COMA ‘07) is to present recent developments, research results and industrial experience accelerating improvement of competitiveness in the field of manufacturing. The 70 papers selected to be delivered at the Conference deal with wide aspects related to rapid product development, agile manufacturing, operations management as well as enterprise design and integration. The worldwide participation and range of topics covered indicate that the Conference became truly a significant meeting of people striving similar aims. The event is an additional opportunity for communication between paper authors and attendees, which undoubtedly will serve as a further step towards exciting developments in the future. It also provides ample opportunities to further exploit international collaboration.

The Chairman and the Organising Committee express heartfelt thanks and gratitude to the Members of the International Programme Committee, who have given their help and expertise in refereeing the papers and will chair the technical sessions during the Conference, as well as to the authors for participating and ensuring that the high standards required on an International Conference were maintained. These thanks and gratitude is extended to our highly regarded keynote speakers.

The Chairman conveys sincere thanks to the conference sponsors for their generous support, which made this event possible, as well as to our exhibitors.

The International Academy of Production Engineering (CIRP) and the South African Institution of Mechanical Engineering are gratefully acknowledged for the scientific sponsorship given to the Conference.

Finally, the tremendous effort of the Organising Committee is appreciated. Grateful thanks are due particularly to the Conference Secretariat for ensuring the success of COMA ‘07.

We hope that you will find the Conference interesting and stimulating!

Prof. DM Dimitrov
Conference Chairman
ACKNOWLEDGEMENTS

Sincere thanks to our distinguished sponsors, whose generous support has contributed to success of the Conference.

National Research Foundation

International Academy of Production Engineering

The South African Institution of Mechanical Engineering

KWV

DISTELL

SASOL

reaching new frontiers

DALIFF

PRECISION ENGINEERING (PTY) LTD

INDUTECH

Your Key to Manage Innovation

RGC

RGC Engineering Sales Division (Pty.) Ltd.

amts

advanced manufacturing technology strategy

UNIVERSITEIT, STELENBOSCH, UNIVERSITY

jou kennisvennoot • your knowledge partner
Conference Chairman

D Dimitrov - Stellenbosch University, South Africa

Co-Chairmen

AH Basson - Stellenbosch University, South Africa
ND du Preez - Stellenbosch University, South Africa
CJ Fourie - Stellenbosch University, South Africa

International Programme Committee

AH Basson, Stellenbosch University, South Africa
A Bernard, IRCCYN-Nantes, France
H Bley, Saarland University, Germany
D Cattrysse, KULeuven, Belgium
L Cser, Corvinus University of Budapest, Hungary
ND du Preez, Stellenbosch University, South Africa
W Eversheim, Aachen University of Technology, Germany
CJ Fourie, Stellenbosch University, South Africa
M Geiger, University of Erlangen, Germany
M Janssens, Materialise, Belgium
HJJ Kals, University of Twente, The Netherlands
F Klocke, Aachen University of Technology, Germany
T Knöthe, FHG-IPK Berlin, Germany
D Kochan, APT, Germany
J-P Kruth, KULeuven, Belgium
G Levy, University of Applied Sciences, St. Gallen, Switzerland
MC Leu, University of Missouri-Rolla, USA
D Luttorre, University of Twente, The Netherlands
R Neugebauer, Technical University of Chemnitz, Germany
J Ni, University of Michigan, USA
W Sihn, Technical University of Vienna, Austria
V Stich, Aachen University of Technology, Germany
R Teti, University of Napoli, Italy
D Tchakarsky, Technical University of Sofia, Bulgaria
H van Brussel, KULeuven, Belgium
FJAM van Houten, University of Twente, The Netherlands
E Westkämper, University of Stuttgart, Germany

Organizing Committee

N de Beer - Stellenbosch University, South Africa
N Treurnicht - Stellenbosch University, South Africa
C Schutte - Stellenbosch University, South Africa
A van der Merwe - Stellenbosch University, South Africa
K von Leipzig - Stellenbosch University, South Africa

Conference Secretariat

Marilie Oberholzer - Stellenbosch University, South Africa
Karina Smith - Stellenbosch University, South Africa
Anêl Uys - Stellenbosch University, South Africa
Table of Contents

Plenary Session: Innovative Manufacturing – State of the Art

Virtual Factories Between Clusters and Joint Ventures
G Schuh, M Schönung
Aachen University of Technology, Germany.................................................................3

Rapid Product Development – From Rapid Prototyping to Rapid Manufacturing
C Levy
University of Applied Sciences, St Gallen, Switzerland...............................................11

Plenary Session: Intelligent Manufacturing Systems

Development and Design of Compact High Precision Machine Tools
C Brecher, R Klar, C Wenzel
Aachen University of Technology, Germany.................................................................25

Three-Dimensional Optical Measurements for Automotive Manufacturing
Z Huang, AJ Shih, J Ni
Conexx Inc., Ann Arbor, Michigan, USA
University of Michigan, Ann Arbor, USA .....................................................................35

Plenary Session: The Way Ahead

International Collaboration in Applied Research – Fraunhofer and Manufuture
A Gossner
Fraunhofer-Gesellschaft, Munich, Germany.................................................................41

Managing the Knowledge Supply Chain to Support Innovation
ND du Preez, L Louw
Stellenbosch University, Stellenbosch, South Africa.....................................................65

STREAM A: RAPID PRODUCT DEVELOPMENT

Session A1: Product Modelling and Design Optimisation

Invited Paper: Design in the Era of Mass Customisation
FJAM van Houten
University of Twente, The Netherlands.................................................................61

Development of a High-Speed Sawing Machine through a Global Engineering Team
C Scheffer, DA Frew, T Valle França, M Del Guerra, JH Müller
Stellenbosch University, Stellenbosch, South Africa
Agência de Inovação Fabrica do Milênio
University of São Paulo, São Carlos, Brazil ...............................................................101
Domain Integration by Means of Features
I Lutters-Weustink, D Lutters, FJAM van Houtan
University of Twente, Enschede, The Netherlands ........................................ 107

Modelling of Thermal Stresses in Thermo-abrasive Blasting Nozzles
I Gorlach
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa .................. 113

Session A2: Medical Applications of Rapid Technologies

Invited paper: Rapid Technologies in Medicine
M Janssens
Materialise, Belgium .................................................. 119

New Developments in Application of Rapid Manufacturing Process Chains in Medical Fields
J Dietrich, N Kochan, R Schonnerlein
University of Applied Sciences, Dresden, Germany
APT Dresden, Germany
GLASFOTO.COM Dresden, Germany ........................................ 125

Platform Design for the Capillary Assembly by Optical Tweezers
C Tseng, H Hocheng, LS Fan
National Tsing Hua University, Hsinchu, Taiwan ........................................ 131

Session A3: Competitive Tooling and Product Realisation

Invited Paper: Challenges for Tool Making Industries - a German Perspective
T Bergs
Fraunhofer Institute for Production Technologies (IPT), Aachen, Germany .............. 137

Blow Moulding Process Performance Improvement using Conformal Cooling in Mould Design
D Dimitrov, A Bester
Stellenbosch University, Stellenbosch, South Africa ........................................ 159

Edge Detection and Draft Angles in Feature Based Reverse Engineering
K Schreve, A Basson
Stellenbosch University, Stellenbosch, South Africa ........................................ 165

Rapid Product Development Methodology and Technologies for Performance Improvement in Foundry Industry
A Bernard, N Perry
Ecole Centrale de Nantes, France ........................................ 171
STREAM B: AGILE MANUFACTURING

Session R1: Intelligent Process Design

Invited Paper: Development of Process Chains for Micro-fabrication
A Schubert
Chemnitz University of Technology, Germany ..............................................185

Mathematical Modelling of the Flow Behaviour of Hot Stamping Steels for a FE-based Process Design
M Merklein, M Geiger, J Leicher
University of Erlangen-Nuremberg, Germany .............................................191

Optimisation of Machining Parameters using Taguchi Design of Experiments Technique
A Dev, YS Negi, DK Dutta
Defence Electronics Applications Laboratory, Dehradun, India ....................197

An Innovative Proposal for the Automated Manipulation of Products in Leather Industry
G Dini, F Faili, F Sebastiani
University of Pisa, Italy.................................................................................205

Session B2: Innovative Processes Chain Optimisation

Invited Paper: Innovative Process Chain Optimization with TRIZ and TOC to Increase the Added Value within the Production
T Pfeifer, T Grundmann
Fraunhofer Institute for Production Technology IPT, Aachen, Germany...........211

Dual Sensor Quality Control and Reverse Engineering System for Agile Manufacturing Systems
G Bright, J Eganza
University of Kwa-Zulu Natal, South Africa ...............................................217

Modular Mechatronic Control of Reconfigurable Manufacturing System for Mass Customization Manufacturing
B Xing, G Bright, N Tlale
University of Kwa-Zulu Natal, South Africa
CSIR, Pretoria, South Africa .....................................................................223

Solving a Real-World Three-Stage Two-Dimensional Bin Packing Problem
PY Tabakov, M Walker
Durban University of Technology, Durban, South Africa ............................229
Session B3: Intelligent Manufacturing

Invited Paper: Molecular Dynamic Simulation of Plastic Material Deformation in Micro-Machining
JR Mayor, CJ Kim, J Ni
Georgia Institute of Technology, USA
SM Wu Manufacturing Research Center, University of Michigan ..................................................235

Experimental Determination of Yielding of the Aluminium Wrought Alloy AA6016 for Biaxial Loading
W Hußnätter, M Merklein, M Geiger
Friedrich-Alexander-University of Erlangen-Nuremberg, Germany ..................................................243

Mathematical Modelling of Thermal Area in Cutting Process
L Daschievici, D Ghelashe, I Gorlach, C Simionescu
University of “Dunarea de Jos” Galati, Romania
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa ..................................................249

Industrial Drilling Process Optimisation by Intelligent Manufacturing System
GH Kruger, TI van Nierkerk
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa ..................................................253

Session B4: Modern Manufacturing Concepts

Random Linear Problems in Manufacturing
I Deák, L Cser
Corvinus University of Budapest, Hungary .................................................................259

A Model for XeF₂ Isotropic Gaseous Chemical Milling of Silicon
G Floarea, I Stiharu, M Packirisamy
Concordia University, Montreal, Canada .................................................................263

Modern Concepts for the Railroad Wheel Set Manufacturing and Maintenance
HJ Naumann
NILES-SIMMONS-HEGENSHEIDT GmbH, Chemnitz and Erkelenz, Germany.................................269

Session B5: Laser as Manufacturing Tool

Invited Paper: Lasers in Today’s Manufacturing
J Meijer
University of Twente, Enschede, The Netherlands .................................................................279

Autonomous Production Cell for Laser Beam Welding
S Kaierle, M Dahmen, S Mann, R Poprawe
Department for Laser Technology, Aachen University, Aachen, Germany
Fraunhofer-Institute for Laser Technology, Aachen, Germany .................................................................287

Improvement of the Surface Finish Obtained by Laser Ablation with a Nd: YAG Laser on Pre-ablated Tool Steel
J Steyn, K Naidoo, K Land
National Laser Centre, CSIR, Pretoria, South Africa .................................................................293
Session B6: Software for Agile Manufacturing

Walking Worker Assembly Lines – A Contribution to Lean Production
H Bley, C Zenser, M Bossmann
Institute of Production Engineering / CAM, Saarland University, Saarbrücken………………297

Remote Maintenance of Manufacturing Systems via Internet
G Gruhler, T van Niekerk, T Hua
Reutlingen University, Germany
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa………………………303

Software for Agile Manufacturing Factory
I Botef
University of the Witwatersrand, South Africa ……………………………………………………309

Adaptive Fuzzy Force Regulation in Friction Stir Welding Process
TJ van Niekerk, T Hua, KE Majara
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa………………………315

Session B7: Mechatronics and Robotics

Invited Paper: High-Precision Robots and Micro Assembly
A Raatz, J Hesselbach
Technical University Braunschweig, Germany………………………………………………321

Mechatronic Sensor System for Robotic and Automated Machines
A Shaik, G Bright, W Xu
University of Kwa-Zulu Natal, South Africa
Institute of Technology and Engineering, Massey University …………………………………327

Modular Mechatronic Navigation and Guidance Systems for Cooperation of Mobile Robots
G Bright, A Pancham
University of Kwa-Zulu Natal, South Africa ……………………………………………………333

Reconfigurable Material Handling System for Part Customization
P Naidu, G Bright
University of Kwa-Zulu Natal, South Africa ……………………………………………………339

STREAM C: OPERATIONS MANAGEMENT & ENTERPRISE ENGINEERING

Session C1: Knowledge Management

Knowledge Management Product Projects in the Automotive Industry
W Sihn
Vienna University of Technology, Austria…………………………………………………………349
Organizational Knowledge Management: From Strategy to Operational Implementation
K Mertins, I Finke, R Orth, M Will
Fraunhofer Institute for Production Systems and Design Technology, Berlin, Germany

Improved Utilisation of Organisational Documents Using a Conceptual Framework
JW Uys, EW Uys, ND du Preez
Stellenbosch University, Stellenbosch, South Africa
Indutech (Pty) Ltd, South Africa

Design(er) Support based on Conceptual Frameworks
D Lutters, W Uys, ND du Preez
University of Twente, Enschede, The Netherlands
Stellenbosch University, Stellenbosch, South Africa
Indutech (Pty) Ltd, South Africa

Session C2: Product Life Cycle

A Benchmarking Service for Manufacturing Control
P Valckeniers, B Saint Germain, P Verstraete, Hadeli, H van Brussel
Katholieke Universiteit Leuven, Belgium

The ‘Gestaltung’ of Products Integrated into the Rapid Product Development of Innovative Products by Design for Manufacturing
S Roth-Koch, R Becker, E Westkämper
Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Stuttgart, Germany

Shredding versus Disassembly
B Willems, JR Dufliou
Katholieke Universiteit Leuven, Belgium

Competitive Sustainable Products and Processes
G Seliger, R Gegusch, D Odry
Technical University of Berlin, Germany

Session C3: Enterprise Engineering Tools

QuickScan – An Assessment Tool for SME Based on the EFQM Excellence Model
P Kuhlang, J Jäger
Vienna University of Technology, Austria
Excellence Coaching & Consulting, Austria

Virtual Reality Technology as an Innovative Engineering Tool for Enterprises
R Neugebauer, D Weidlich, H Zickner
Chemnitz University of Technology, Chemnitz
Fraunhofer Institute for Machine Tools and Forming Technology, Chemnitz
The Implementation of a Conceptual Framework Based Approach for the Improved Viewing and Utilisation of Organisational Information
DJ Kotze, JW Uys, C Schutte, ND du Preez
Indutech (Pty) Ltd, Stellenbosch, South Africa
Stellenbosch University, Stellenbosch, South Africa .............................................413

Reliability Engineering: Comparative Analysis between Defence and Commercial Industries
RWA Bamard
Lambda Consulting, South Africa .................................................................419

Session C4: Production Planning and Simulation

Integrated Sheetmetal Production Planning for Laser Cutting and Air Bending
B Verlinden, D Cattrysse, D van Oudheusden
Katholieke Universiteit Leuven, Belgium ......................................................425

Assessment of the Lifetime Prolongation Capabilities of Discarded Products
B Willems, JR Duflou
Katholieke Universiteit Leuven, Belgium ......................................................431

Potential for Adopting Operating Curves in Ramp-up Management
M Heins, J Pachow, P Nyhuis
University of Hanover, Germany ..............................................................437

Batch Size Reduction in Automobile Manufacturing – a Production Engineering Challenge
R Neugebauer, E Kunke, A Goeschel
Fraunhofer IWU, Chemnitz, Germany .........................................................443

Session C5: Business Modelling and Re-engineering

Surveys on Production and Collaboration Aspects in the Automotive Supply Chain
D Palm, W Sihn
Fraunhofer Project Group for Production Management and Logistics, Vienna, Austria
Vienna University of Technology, Austria ..................................................449

Collaboration among SMEs through Open-source ERP-Solutions
A Imtiaz, M Auerbach, V Stich
Aachen University of Technology / FIR, Germany .......................................455

Enterprise Modelling Approach Based on Maturity and Business Scope Perspectives
T Knothe, R Jochem
Fraunhofer IPK Berlin, Germany
University Kassel, Germany .................................................................461

Business Modelling for Large Scale Collaborative Networks
A Imtiaz, A Quadt, P Laing
Aachen University of Technology / FIR, Germany ........................................469
Session C6: Enterprise Engineering Practice

Innovative Learning Environment for Factory Planning and Improvement
V Hummel, E Westkämper
University of Stuttgart, Germany .................................................................473

Introducing the Roadmap Concept to Inexperienced Users: A Case Study
D Lutters, M Johnson, ME Toxopeus, ND du Preez
University of Twente, Enschede, The Netherlands
Indutech (Pty) Ltd, South Africa
Stellenbosch University, Stellenbosch, South Africa ..................................481

Applying SCOR to Dutch Small and Medium Enterprises
J Goedegebuur, JW Proper
Utrecht University for Professional Education
Breda University for Applied Sciences .........................................................487

Human Centered Product Data Exchange in Manufacturing Environments
THJ Vaneker, D Lutters, FJAM van Houten
University of Twente, The Netherlands ..........................................................493

Session C7: Soft Issues in Manufacturing Environment

Life-cycle Dependency of Models for Product Development Processes
H Nieberding, E Lutters, N du Preez
Stellenbosch University, Stellenbosch, South Africa
University of Twente, Enschede, The Netherlands ........................................499

The Application of Necessary but not Sufficient Principles to the Implementation of Product Lifecycle Management Software
D Dimitrov, L van der Walt
Stellenbosch University, Stellenbosch, South Africa .....................................505

Case Study: The Implementation of a Radical Innovation Project
N du Preez, BR Katz
Stellenbosch University, Stellenbosch, South Africa
Indutech (Pty) Ltd, Stellenbosch, South Africa .............................................511
Knowledge Management in Product Projects in the Automotive Industry

Wilfried Sihn
Institute of Management Sciences, Dept. of Industrial and Systems Engineering, Vienna
University of Technology, Austria

Abstract
Global mergers and acquisitions in the automotive industry have left only a few companies offering a variety of brands. Shorter product life cycles have increased the number of product launches for each brand, raising the number of new product projects for companies in the automotive sector. In a new vehicle project, covering all product creation stages, the knowledge about product and production process gained by vehicle and production tests increases as the new product project approaches the start of production. The approach in this paper focuses on potential changes to product and production process that do not go through the change management process.

Keywords
Knowledge Management, New Product Projects, Automotive Industry, Knowledge Transfer

1 INTRODUCTION
The rapid technological development and the increasing market requirements due to global competition are forcing companies in the automotive industry to offer their customers an ever growing range of diversified products despite shorter product life cycles and higher quality demands. Key to corporate success is the ability to launch new products as soon as possible in great quantities until the market. This extends the payback period for a product and makes customers more willing to pay higher prices. To ensure business success it is therefore essential to manage the start of production fast and effectively [2]. According to a study of Magna Steyr, an automotive supplier, the shortened product life cycles in the automotive sector total less than seven years. Compared to 1990, when product life cycles used to last nine years, this means a reduction by nearly a quarter within a decade (Figure 1) [1].

Persons involved in a new product project often have a good knowledge of potential improvements although these cannot be included into the change process for lack of time, and therefore are not utilized. To exploit this knowledge for subsequent new product projects, an approach for ‘Knowledge transfer between new product projects in the automotive industry’ was developed. It structures insights gained about products and the production process that did not go through the change management process, and evaluates their potential for change before integrating them into the business processes and methods applied in subsequent new product projects. Product creation processes refer to areas that generate insights into opportunities and focus on activities that help to prevent failures.

2 OPPORTUNITIES AND SOLUTION CONCEPT
2.1 Opportunities during product creation
A short payback period for investments into the development of new products or building new production sites is vital to competitiveness. To this end, companies must cut the time from start of product development to market launch (time-to-market). On the other hand, they need to reduce the time for producing a product in sufficient volume, appropriate quality and at competitive prices (time-to-volume). Shortening both periods, however, goes hand in hand with reducing the useful life of products [5]. In consequence, production starts become more frequent. The profit accumulated over the life of the new product may be reduced by 30% if the market launch is delayed by 6 months. Figure 2 shows additional effects on profit.
2.2 Solution Concept

The developed approach addresses the following problems in a new product project:

- Knowledge gained from product and production tests in new product projects is not immediately available in subsequent projects.
- In the product creation process no measures are taken that ‘force’ project members to integrate their knowledge.
- Potential changes that could not be implemented in time are not documented and cannot be considered in subsequent projects.
- Independently working development and production teams prevent cross-fertilization.
- Only a sporadic knowledge transfer occurs between development and production.
- Loss of experience due to project member turnover.

To resolve the problems described above, this approach makes use of knowledge sources in the product creation process from which insights on products and the production process are gained. Only insights that have not gone through the change management process and therefore represent potential changes are considered. For example, the results of tests at certain points in the new product project provide insights on product prototypes, while the production tests offer insights on production processes. In addition, experiences are exchanged at project milestones or quality gates. Then, the potential and benefits these insights offer to future new product projects are evaluated before the knowledge is prepared for use in subsequent new product projects and linked to the relevant product and production process structure. Key to the future utilization of knowledge is that it gets integrated with product and process improvement methods and procedures embedded in the product creation process (Figure 3).

State of the art in corporate new product projects are defined, standardized product creation processes using, for example, performance specifications and methods of fault prevention. The aim is to ensure the transfer of knowledge by making it part of the product creation process so that existing insights from previous new product projects are taken into account.

Therefore, knowledge needs to be classified so that it can be integrated by ‘information frontloading’ with the fault prevention processes and activities in the product creation process. New product project members must automatically integrate their acquired knowledge into the applied procedures or methods. This is to ensure that knowledge is transferred to subsequent new product projects according to need.

Insights into products and the production process result in changes that go through the change management process. But there are also many potential changes that could decisively improve the product by correcting deficiencies, or optimize the production process. The time needed, however, for carrying out potential changes would delay the start of production. Also, potential changes involve the risk of not achieving the desired result, creating an even greater need for change (Figure 4). At certain points in the new project, the knowledge carriers know what improvements could be made, and even communicate this knowledge. However, since these potential changes cannot go through a change management process any more, they are not documented and the potential for change is not reflected in benefits or altered performance measures. Thus the acquired insights do not result in an added value to other new product projects with different players at different sites. The potential for improvement remains untapped and many mistakes are repeated.
3 APPROACH TO TRANSFER KNOWLEDGE BETWEEN NEW PRODUCT PROJECTS

3.1 Learning processes in new product projects

On the path to maturity, products and production processes pass through different 'learning phases' that systematically improve the design states [4]. In a new product project, testing plays an important role. During testing, the real maturity level of a product and the production process becomes apparent. The logic of how to translate these insights into a new design state is shown in Figure 5.

![Figure 5 - Systematic learning process in a new product project.](image)

A product is designed, manufactured and tested. The test findings provide the basis for further learning. The transfer of product-related knowledge builds only on tests of complete vehicles with components made by production tools. This is because the results of simulating, calculating and validating vehicle modules on test benches have already been fully integrated into the delta design. The closer the new product project comes to the start of production, the more findings will be generated by complete vehicle tests. Defective parts identified by reliability tests (e.g. 100,000 km run) only a few months before the start of production will not go through the change process any more. The time-to-start of production is too short for any tool changes. Here, defective parts only refer to those that do not pose a risk to the customer (unlike safety-related parts, such as vehicle steering equipment).

With regard to production tests, a distinction is made between insights from pre-production and final production tests (or try-outs). Vehicle components from pre-production tests are made with mass production tools, but not under mass production conditions (e.g. a component is made with a mass-production punching tool but not on a serial press). The pre-production tests can provide first insights into the production processes. For final production tests, components and vehicles must be made with mass production tools and under mass production conditions (e.g. at an assembly line).

![Figure 6 - Process overview.](image)

Potential changes are identified along the product creation process based on the structure of the product and the production process. Insights into a product are gained within a new product project by vehicle tests (Figure 6), while insights into the production processes are based on pilot and mass production tests. Acquired knowledge that has not passed through a change process, must be assessed for its potential and structured for the transfer of knowledge to subsequent projects. The knowledge transfer focuses on methods and procedures of fault prevention and is incorporated to that effect into the business process for a new product project (Figure 7).

![Figure 7 - Methods in the new product project to detect faults and deficiencies.](image)

3.2 Transferring knowledge about the production process

Within the production process of a new product project, pre- and final production tests are used as elements of fault detection and correction for mass production equipment. The tests refer to the production of individual components, modules and subsystems, down to the assembly of complete vehicles. These production tests enable the project members in charge to identify deficiencies and remove them during the 'learning phase' before the next production test.

To structure the knowledge and assess the future knowledge transfer, the value streams of product families are analyzed. For example, a value stream may cover the final assembly line of a vehicle. The value stream mapping approach [7] structures the
knowledge in order to visualize the production process chain and determine performance measures at individual process steps.

Customer order decoupling points in a value stream serve to organize this value stream into sub-areas (value stream segments) to reduce its complexity and facilitate the knowledge transfer. A performance specification, for example, details the process features for a to-be process that the development engineers need to take into account.

The features and performance measures really accomplished for a production process can be identified during the production tests.

![Value stream](image)

**Figure 8** - Effects of potential improvements within the value stream segments.

From a production point of view (i.e. of the project’s production members), opportunities to improve the individual processes are to be included in the value stream map, provided they could not go through the change management process for lack of time. The effects of these opportunities are to be assessed not only vertically for the individual processes but also horizontally for the entire value stream segment with regard to lead time (Figure 8).

To avoid faults and deficiencies, the following methods and procedures are used for the knowledge transfer related to the production processes: Measurement at quality gates, system FMEA ‘production process’, fault tree analysis, Design for Manufacturing/Assembly, and development of process performance specifications.

The acquired knowledge is structured and visually displayed by the ‘Potential matrix of the production process’ (Figure 9), based on the structure of the value stream segments. The matrix of a value stream segment consists of three dimensions with sub-areas:

**1st Dimension: Performance measures/deficiencies**

If the performance measures (cycle time, setup time, lead time, quality failure, machine breakdown) at a process step can be improved, then the potential changes to the performance measures have to be expressed as a percentage. Identified deficiencies and faults are described separately. If the source of the fault has been identified, this is also documented.

**2nd Dimension: Process steps**

The value stream segment is divided into single process steps described by the technologies used for them.

**3rd Dimension: Opportunities for knowledge transfer**

The improvement potential at the process step is assigned to the relevant opportunities for knowledge transfer (development of performance specifications, system FMEA ‘Process’, fault tree analysis, measures at Quality Gates, Design for Manufacturing/Assembly) to other new product projects.

3.3 Transferring knowledge about the product

To acquire knowledge, the person responsible for the ‘Potential matrix of the product’ supports the product testing members in evaluating the test results for the complete vehicle. Based on the individual process steps, defectives parts and deficiencies are visualized. Deficiencies of the product which can be corrected in time through learning phases as delta designs in the change management process are not to be included in the knowledge transfer. If potential improvements are identified that cannot be implemented before the start of production, the projected warranty and goodwill costs are compared to the potential change costs to assess the potential. Moreover, when knowledge is processed, the potential improvements are allocated to the ‘Potential matrix of the product’. When distributing the knowledge, the process owner decides what performance targets for product improvements are included in which of the new product projects, or at what stage of the process the use of methods and procedures (e.g. development of a test plan) leads...
to preventive measures (Figure 10). The person responsible for the 'potential matrix' must constantly watch if the potential improvements of a product are put into practice.

![Figure 10 - Possible transfer of product insights.](image)

After changes in the product have reduced the projected warranty and goodwill costs, the relevant building blocks (for specific components) are to be dotted.

4 SUMMARY

The 'Knowledge transfer between new product projects' approach is based on the integration of methods and procedures for fault prevention, detection and elimination in new product projects in the automotive industry. The need for actions was identified by the BMBF 'Fast Ramp-Up' study, as well as by workshops on ramp-up management held at the Fraunhofer IPA in the area of knowledge management. Another important aspect of this approach—apart from acquisition and distribution of knowledge—is that it evaluates the potential of insights about product and production processes to be transferred.

5 REFERENCES


Prozessorganisation, Produkterstellung und Konstruktion, Hanser, Wien, pp. 246.


6 BIOGRAPHY

Professor Wilfried Sihn was born in Pforzheim, Germany, in 1955. He earned his doctorate from the university of Stuttgart in 1992.

In September 2004 he joined the Vienna University of Technology to work as Professor for Industrial and Systems Engineering at the Institute of Management Goonoo. He is the head of the Fraunhofer project group for production management and logistics in Vienna.

In February 2006, Professor Sihn was invited to become a member of the International Academy For Production Research (CIRP).