GAP

Gesellschaft für angewandte Prozesslenkung

Digital Process Planning for SMEs

The Modular Principle

“…missing standards in data structures and widespread data redundancy prevent the introduction of a cross-departmental digital process control in SMEs.“

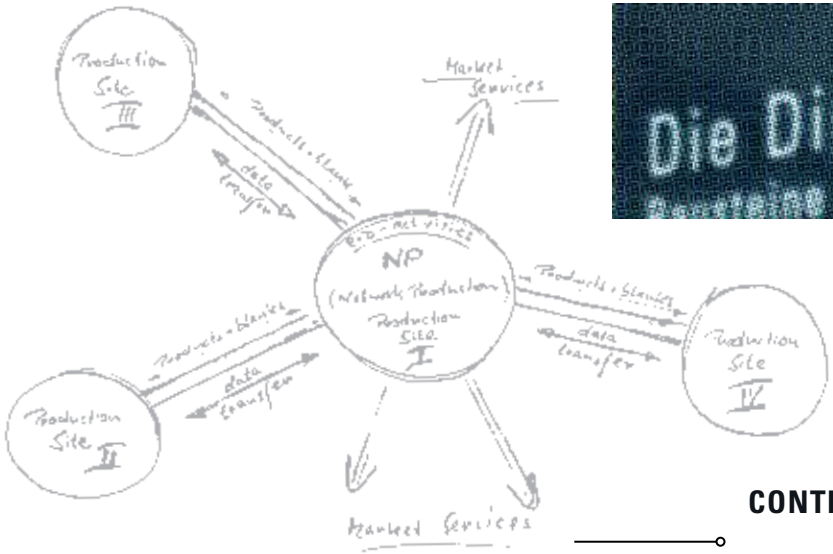
Dr.-Ing. Bernd Schniering
Shareholder and Managing Director

1.0 PREFACE

GAP, the Gesellschaft für angewandte Prozesslenkung (association for applied process control) has cooperated with technical universities including Aachen, Dortmund, Stuttgart, and Bochum since 1988. As part of a cooperation that bridges the gap between science and industry, GAP has developed management tools and digital control systems for small and medium-sized enterprises (SMEs) in various research projects.

The foundation of GAP has created a new field of work in addition to the development and production of management tools by Schumacher Precision Tools. GAP focuses on the development of digital control systems for SMEs and provides counseling for international companies in the field of digital process optimization. Moreover, GAP works in close partnership with various research facilities, organizations, and service companies. As a result, we have gained detailed information about the demands of SMEs from the collaboration with the RWTH Aachen; the German Engineering Association VDMA, Frankfurt; and other partners. We analyze the insights we have gained about deficits in industrial process control in SMEs and combine this information with our practical experiences in the manufacturing industry.

Dr.-Ing. Bernd Schniering



CONTENT

Process Planning
Planning Analysis

RWTH AACHEN UNIVERSITY

SCHUMACHER
PRECISION TOOLS SINCE 1918

2.0

SCOPE OF WORK
RESEARCH AND DEVELOPMENT BY GAP

GAP's research focuses on the practical application of new control systems in industrial SMEs. In the last two decades, the demand for a cross-departmental system has defined new standards for SME data structures and introduced a modular design that comprises all departments of a company.

In this context, the environment of Cutting Tool Producer Schumacher Precision Tools proved to be beneficial, as they allowed us to contribute ideas and research input. Our partnerships with SMEs, mainly from Germany and Europe, provided inspiration and helped us to create concepts for GAP. Asian precision tools manufacturers have also participated in this process, for example one of the industry's market leaders, YG-1 Tool Co. from South Korea.

At GAP, we lay the foundation for an application-oriented cooperation between industry and science by coordinating our experiences in the industry with a research network consisting of partners such as RWTH Aachen; TU Dortmund; EDB (Education and Development Board), Singapore; UTM (University of Technology Malaysia), in Kuala Lumpur, Malaysia.

Moreover, our membership in the executive board of VDMA, Frankfurt provided us valuable insights into the adjustments that SMEs need to make in order to adapt to the globalized market of engineering.

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Process Optimization

GAP'S SCOPE OF WORK IN THE FIELD OF MANAGEMENT TOOLS:

Area of PROCESS CONTROL

- Order Processing – CAP/PPS
- Optimization of set-up costs
- Data management – product and process-oriented
- Cross-departmental digital process control for SMEs in accordance with **‚Industry 4.0'**

Area of CONSTRUCTION

- Databank-based parameterization
- Variant construction
- Automated CAD-construction using algorithms
- Product application simulation using FEM– Rapid Prototyping

Area of COSTS AND FINANCE MANAGEMENT

- Cost center planning
- Product group profit analysis
- Break-even analysis
- Calculation of direct and full costs
- Liquidity planning

Area of MACHINE CONTROL

- Databank-based parameterization – macros
- Performance Control
- Tool wear analysis – neural networks

“… focusing future serial production in mechanical engineering with digital models from the ToolDesign System and digital 3D-Printer Units – supported by Laser Melting or Electron Beam Melting Technology…“

3D-Model - Cutting Tool

3D-Model - Component

3.0

EXAMPLES
OF GAP DEVELOPMENTS

ToolDesign | CAD-construction using algorithms for Variant Construction

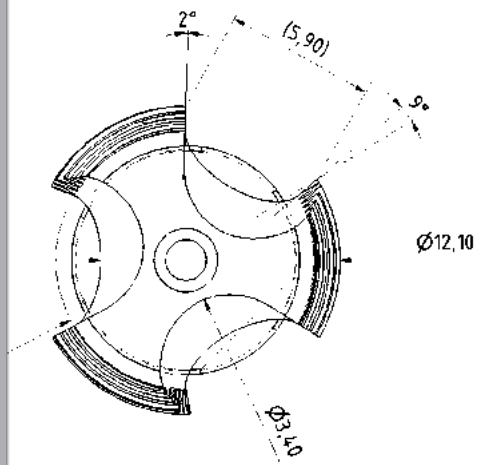
ToolSimulation | Simulated application of products using the Finite Elements Method (FEM)

ToolProduction | Digital process control for industrial SMEs in accord with **‚Industry 4.0‘**

ProfitAnalysis | Automated cost and profit analysis of product groups based on full and direct costing

3.1

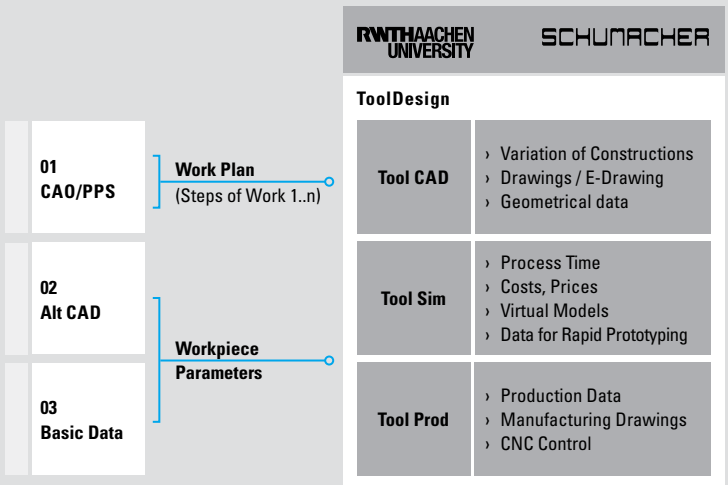
DEVELOPMENT
ToolDesign



The market conditions in the industry of precision tools have changed in recent years. Triggered by this change, GAP has developed a new management tool over the past ten years called **ToolDesign.**
As a control module, **ToolDesign** uses algorithms to automatically construct Precision Tools such as Taps, Drills and Endmills. The construction of these tools requires highly complex geometry-parameters – up to 190 different data are required per tool variation.

The development of **ToolDesign** was based on a standardized GAP-data structure that comprises all of Schumacher Precision Tools' technology data in the sections product, production and process control. The data is then used to generate the necessary CAD-models for production.

When a user chooses the conditions for application in the menu, **ToolDesign** generates the complete data set of new tool variations including the volume model. At the same time, it creates the required working parameters for CNC turning, milling and grinding machines needed for the manufacturing of the new tool. The modular design of the GAP-data structures allow a cross-departmental and redundant-free networking of all processes.

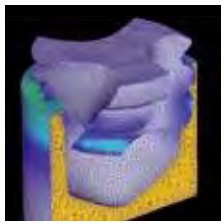


FUNCTIONAL SCHEMATIC
ToolDesign

Thus, precision tool manufacturers can use **ToolDesign** to accomplish the work necessary for planning and constructing complex products in a manageable and reproducible fashion – regardless of the fact that the diversity of High-End Cutting Tool variants is increasing, while batch sizes are decreasing.

Digital Measuring Process

Digital Measuring Process
FEM Simulation



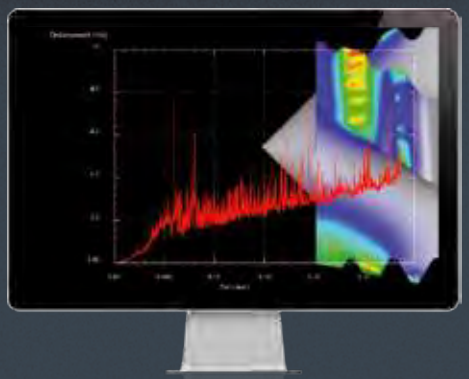
3.2

DEVELOPMENT
ToolSimulation

The module **ToolSimulation** simulates and quantifies the performance of 3D tool models - that were digitally constructed with **ToolDesign** - as they are used in pre-defined work piece models with their respective properties.

These CAD-3D-models of tool variants are then used in the new system for simulating their performance in **ToolSimulation**. In this GAP development project, the simulation process is realized with a high processor performance through complex modifications of a standard simulation software. As a start of the process, the user of **ToolSimulation** is guided through an interactive description of the work piece. This digital work piece obtains all properties that are required for the simulation from a programmed database.

This way, new tool variants are being tested in simulation before they enter production or further optimized by modifying the 3D models in **ToolDesign**. This procedure reduces development cycles of new tool variants and moreover minimizes expenditures for field testing.



Torque Devolpment by FEM Simulation

ToolSimulation – CHARACTERISTICS:

- Digital processing of 3D volume models for simulation
- Data transfer of tool 3D volume models from **ToolDesign**
- Development of work piece 3D volume models
- Classification of work piece and tool model substrates
- Simulation – testing new tool variants
- Result analysis

Process Optimization
IT Networking

3.3

DEVELOPMENT
ToolProduction/Industry 4.0

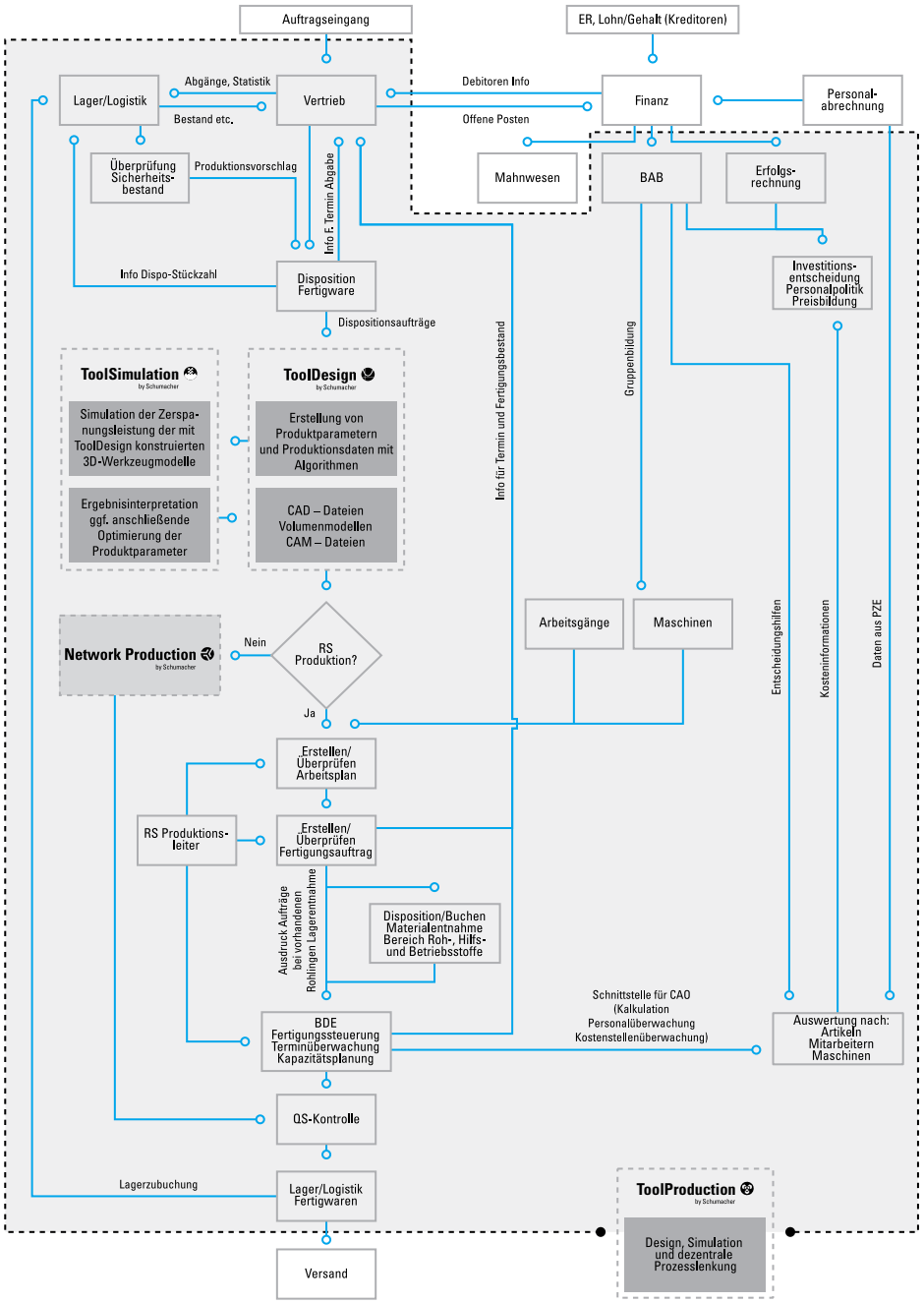
The German government's initiative **'Industry 4.0'** reacts to the current challenges of the manufacturing industry. These challenges forced the advancement of CIM-strategy (Computer Integrated Manufacturing), which was initially introduced in the 1980s. The 'fourth industrial revolution' utilizes cyber-physical systems to link physical objects with virtual models. Essentially, the product to be manufactured is designed to operate its production processes on its own. The potential of this futuristic project is revealed in the value chain of production lines with decentralized process control, which organize themselves drawing upon concept **'Industry 4.0'**. By contrast, the 'predecessor' CIM had the disadvantage of using a centralized and thus inflexible process control.

These new factors of digitalization are considered drivers of significant innovation in Mechanical Engineering and the Machine Tool Industry.

The target of the new GAP-project is to develop an all-encompassing system that plans and controls processes according to **'Industry 4.0'**. The project focuses on the production of rotation-symmetric precision tools. **ToolProduction (TP)** is the name of a GAP project that digitally models the whole process of precision tool manufacturing from an incoming order to design, simulation, production, quality management, controlling, as well as warehouse and distribution logistics. This sector-overlapping interconnectivity is enabled by **TP's** modular design, which also works across borders, regardless of the respective production location. The modules **ToolDesign** and **ToolSimulation** are the centerpieces for the digital construction and simulation of tools.

THE RESULTS OF ToolProduction

By developing **ToolProduction**, GAP draws upon a CIM-concept that was developed by Schumacher Precision Tools in cooperation with the Aachen University of Technology in the 1980s. The centralized process control in CIM is supposed to be upgraded through **ToolProduction**, **ToolDesign**, and **ToolSimulation**. Together, these systems will allow for a digital and decentralized process control of all departments in tool manufacturing.



Result Interpretation

3.4

DEVELOPMENT
ProfitAnalysis

Management Controlling and the Results Analysis
The modular design system for cross-departmental process control, in accord with**'Industry 4.0'**, allows the expansion of process structures into business accounting. In the context of digital process control, it allows a value-oriented management accounting system, which channels data to

1. Operating Machinery | 2. Product | 3. Human Resources

for economic analysis. This accounting and management control system is being realized as part of the GAP-module **'ProfitAnalysis'**. The evaluations by these systems support the management in decision-making processes. The quality of decisions particularly depends on correct, up-to-date, and redundancy-free information from the digital process control. **ToolProduction** collects production data and signals the progress of processes, thereby serving a key role by providing product, resource, and personnel-related data. Thus, **TP** establishes the groundwork for utilizing collected data, which is analyzed according to different criteria, repeatedly and in various applications. The modular design, which covers all departments, interconnects technical processes, i. e. the production, with the respective cost centers of financial management. This way, the control system evaluates the costs of the individual steps of processes with help of the GAP module **'ProfitAnalysis'**.

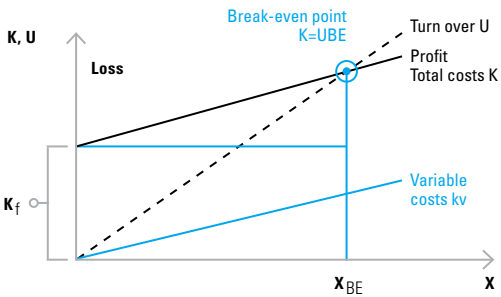
Companies drawing upon these systems benefit significantly from the information on costs and time-investments. On one hand, the information is necessary for a quick evaluation of the different steps of a process. On the other hand, through the incorporation of accounting, the control system lays the foundation for management decisions based on the resulting full and direct costing analysis of the manufactured products. In addition to individual evaluations of products, the modular design allows earning analysis of defined product groups and detailed insight such as contribution margin analysis.

As part of '**ToolProduction**', the process control system provides any financial analysis without requiring additional staff resources.

Structure and Steps of Management Accounting

BREAK-EVEN ANALYSIS

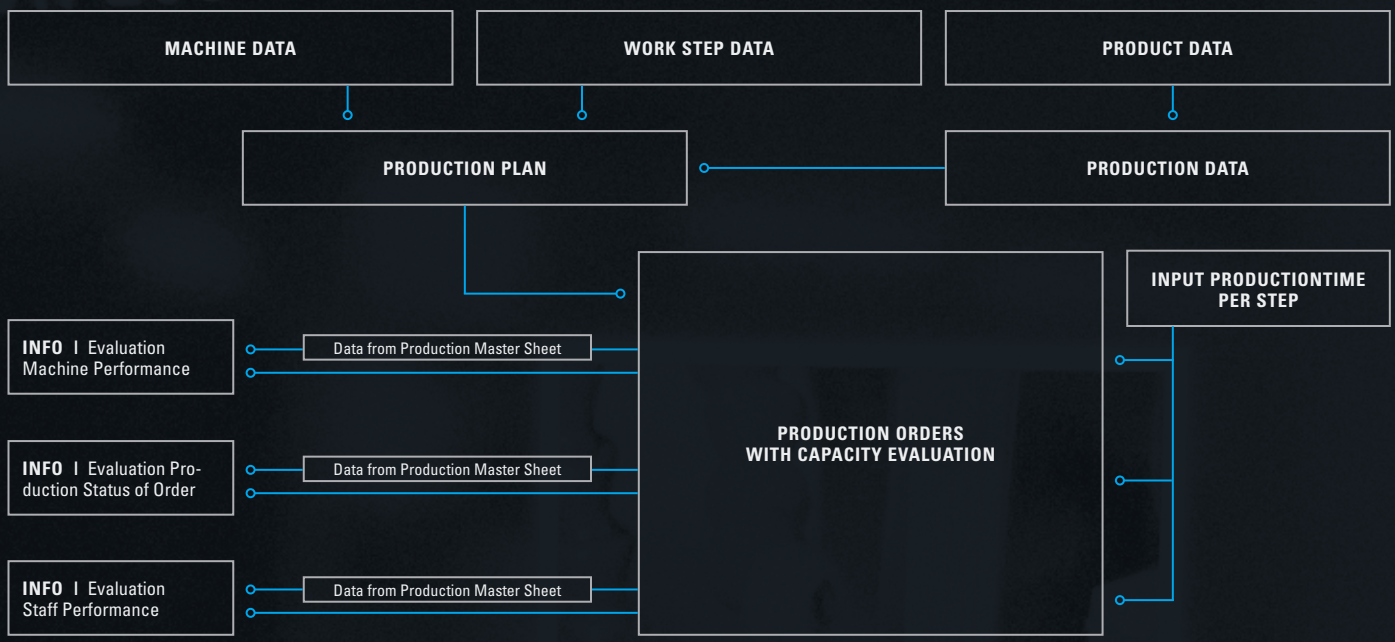
Total-Turn-Over-Cost-Model



K = Kf + kv x X	U = p x X	X = No. of Products
Kf = Fixed Costs	U = Turn Over	
Kv = Variable Costs	p = Price	

Die Digitale Produktion
Bausteine der Umsetzung

BASIC STRUCTURE



4.0 GAP AND SMALL AND MEDIUM-SIZED BUSINESSES

Contacts in Politics and Economic Decision Makers

STATE LEVEL

July 2015 – exchanging experiences with industrial SMEs alongside the Minister-President of North Rhine-Westphalia, Hannelore Kraft.



COMMUNITY LEVEL

June 2015 – The mayor of Remscheid visits GAP's research location.



MEDIA RELATIONS

August 2014 – The South Korean television network KBS films a report on the digital networking of Schumacher Precision Tools and GAP.



ECONOMIC LEADERS

March 2014 – German-Korean conference in Berlin entitled "Korea-Germany – Hidden Champion Conference" with the involvement of GAP and Schumacher Precision Tools' Korean partner.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