Migration Manufacturing©
A New Approach for Automotive Factory Planning

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Karmann – more than 3,3 million cars produced since 1949

[Image of various car models representing the production history of Karmann]
Selected Reference Projects...

SLK
Audi Cabrio
A6
MAN
Crossfire
A3 Sportback
Sprinter
Megane
Scania
Vaneo
Bentley
CLK
<table>
<thead>
<tr>
<th>Market Development Niche Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>60er</strong></td>
</tr>
<tr>
<td>Cabrio/Roadster</td>
</tr>
<tr>
<td>Coupé</td>
</tr>
<tr>
<td>Limousine</td>
</tr>
<tr>
<td><strong>70er</strong></td>
</tr>
<tr>
<td>Cabrio/Roadster</td>
</tr>
<tr>
<td>Coupé</td>
</tr>
<tr>
<td>Limousine</td>
</tr>
<tr>
<td>Flow Tail</td>
</tr>
<tr>
<td>Off-Road</td>
</tr>
<tr>
<td><strong>80er</strong></td>
</tr>
<tr>
<td>Cabrio/Roadster</td>
</tr>
<tr>
<td>Coupé</td>
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<tr>
<td>Limousine</td>
</tr>
<tr>
<td>Flow Tail</td>
</tr>
<tr>
<td>Station Wagon</td>
</tr>
<tr>
<td><strong>90er</strong></td>
</tr>
<tr>
<td>Cabrio/Roadster</td>
</tr>
<tr>
<td>Coupé</td>
</tr>
<tr>
<td>Limousine</td>
</tr>
<tr>
<td>Flow Tail</td>
</tr>
<tr>
<td>Station Wagon</td>
</tr>
<tr>
<td><strong>2005 - 2010</strong></td>
</tr>
<tr>
<td>Cabrio/Roadster</td>
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<tr>
<td>Coupé</td>
</tr>
<tr>
<td>Limousine</td>
</tr>
<tr>
<td>Flow Tail</td>
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<tr>
<td>Station Wagon</td>
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<tr>
<td><strong>MPV</strong></td>
</tr>
<tr>
<td>Off-Road</td>
</tr>
<tr>
<td><strong>SUV</strong></td>
</tr>
<tr>
<td>Compact-MPV</td>
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<tr>
<td><strong>SAV</strong></td>
</tr>
<tr>
<td>Sports Tourer</td>
</tr>
<tr>
<td>Tall Wagon</td>
</tr>
<tr>
<td>Coupé-Limousine</td>
</tr>
<tr>
<td>Cabrio Coupé</td>
</tr>
</tbody>
</table>

[Polk Studie 2006]
Market Development – Example Compact SUV

[Graph showing market development of various SUV models from 1999 to 2006, including brands like Mercedes ML, Toyota RAV 4, Honda CR-V, Hyundai Santa Fe, Nissan X-Trail, BMW X5, BMW X3, VW Touareg, Hyundai Tucson, and Audi Q7. The x-axis represents years from 1999 to 2006, and the y-axis represents units sold per year ranging from 0 to 20,000.]
Platform Strategy
Assembly Sequence Body-in-White Platform Strategy

Production Steps

I. Underfloor  II. Underfloor with Side Panels  III. Body-in-White Frame  IV. Body-in-White

Basis: Limousine

- Rear section
- Main Floor
- Front Section

Example: Cabrio Variant

- Side Panel
- Roof
- Doors
- Closures
- Hood
- Fender
Changeability Typs of Production Plants
Levels of the Body-in-White

- **Product level**
- **Body-in-White**
- **Assemblies**
  - Floor
  - Assembly
  - Roof
  - Hatches
- **Underfloor groups**
  - Robots, Welding guns, Tension sequences

- **Station**
- **System**
- **Plant**

**Body-in-White**
Reference Life-Cycle Curve and Requirements of a migrating Body Shop

Reference Curve Volume Development

Requirements

• Reduction of investment >30%
• Multi-Model-Ability min. 3 models
• Scalability ± 30%
• Smooth integration of new models
• High degree of re-integration
• Quick return of capital

SOP: Start of Production; EOP: End of Production

S_Average

S_End

Start-up angle

End of production angle

S_Peak

S_Level

S_Volatil

S_Spread

α

Time

Units

Ω

Reference Life-Cycle Curve and Requirements of a migrating Body Shop

Migration Manufacturing

Dr.-Ing. M.S.M. Thomas P. Meichsner

Wilhelm Karmann GmbH
Requirements and Targets for the Migration Concept in the Body-in-White Production

Changeability Typs
- Universality
- Modularity
- Compatibility
- Mobility
- Scalability

Migration Principle
- Multi-Model and Scalable Production Volume
- Flexible Framing Station
- Geo Handling
- Part
- Variant
- Typ
- Volume
- Process
- Re-Integration

Flexibility Typs

Requirements and Targets for the Migration Concept in the Body-in-White Production
Flexibility through Movability
Re-Use of Production Equipment

The re-use of production equipment is in principle possible. However change-over strategies and adaptation is difficult and often not possible. After end of production (EOP) the integration of a new model is possible.

Therefore EOP and SOP are directly related to each other.
Production Layout
Body-in-White Production (Example)
Framing Station

An expansion of the line ist hardly possible.
Manufacturing Principles of the Body-in-White Production

**Solitude Principle**
- Production for one Body-In-White-Model

*Characteristic*
- Stable sales
- Low flexibility
- No variants

*Focus*: Line tact

*Example*
- E-Class (old)

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**Flexible Principle**
- Production for many Body-in-White Variants of on Model

*Characteristic*
- Dynamic sales
- Compensation of volume Changes through additional B-I-W Variants
- Flexibility only with same platform

*Focus*: Line balancing

*Example*
- Audi A3

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**Migration Principle**
- Production for many Models with additional Variants each

*Characteristic*
- Life Style Sales
- Different B-I-W/Models
- No common platform
- Production equipment can follow demand on short termin

*Focus*: Moveable, scalable work contents

*Example*
- Karmann
Structure of the Migration Concept

Specific Changeability Enablers
Principle
Structure
Sub-Systems
Special Flexiblity Types

Migration Concept
Solutions for the Concept Structure

Types of Flexibility
- Product Mix
- Successor
- Volume
- Space

Logistic

Infrastructure ➔ Technology ➔ Control

Human Resources

Structure of the Concept

- Universality
- Mobility
- Scalability
- Modularity
- Compatability

Versatile
Type-Related and Type-Unrelated Components and Sub-Systems

$T_g$ : Type-related

$T_u$ : Type-unrelated

Rotary Fixture ($T_u$)

Jigs and Fixtures ($T_g$)

Welding Gun ($T_u$)

Robot ($T_u$)

Turn Table ($T_u$)

Safety Fance and Equipment ($T_u$)

Controller Network ($T_u$)

Storage ($T_u$)
Types of Production Cells

**Content:**
- Jigs and Fixtures
- Robots
- Gripper Technology
- Welding Guns with/without changing

**Invest-relation:**
- Geometry: 100% (Basis)
- Welding: 20%
- Special Tasks: up to 200%

**Geometry:**
- Diagram showing geometric setup.

**Welding:**
- Diagram showing welding setup.

**Special Tasks:**
- Diagram showing special tasks implementation.

- Measurement Technology
- Touch and Pierce
- Assembly Technology
- Laser Technology
# Body in White System Components (Examples)

<table>
<thead>
<tr>
<th>Handling</th>
<th>Location and Clamp Systems</th>
<th>Joining Technology</th>
<th>Forming and Processing</th>
<th>Transport and Buffer Systems</th>
<th>Control Systems</th>
<th>Peripheral Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
<td>• Clamp systems (LCS) - flexible LCS - adaptive LCS - modular LCS - dynamic LCS</td>
<td>• Welding - Spot welding - MIG welding - MAG welding - WIG welding - Laser welding - Riveting - Bolting - Adhesive</td>
<td>• Soft touch form and pierce - Hemming - Roller hemming - Table top hemmer - Milling - Drilling - Piercing - Parting</td>
<td>• Portal systems - Mobile Systems - Conveyor systems - Stationary buffers - Combined Buffer / Conveyor systems - Loading station for material - Unloading station - manual - automatic</td>
<td>• Networks - LAN - WAN - Control - Regulate - Measure</td>
<td>• Safety and protective systems - Media - Identification systems (RFID)</td>
</tr>
<tr>
<td><strong>Type-Specificity</strong></td>
<td><strong>low</strong></td>
<td><strong>high</strong></td>
<td><strong>low - middle</strong></td>
<td><strong>high</strong></td>
<td><strong>low</strong></td>
<td><strong>middle</strong></td>
</tr>
<tr>
<td><strong>Re-usability</strong></td>
<td><strong>good</strong></td>
<td><strong>middle</strong></td>
<td><strong>good</strong></td>
<td><strong>middle</strong></td>
<td><strong>middle</strong></td>
<td><strong>good</strong></td>
</tr>
</tbody>
</table>
Capacity Increase of Roller Hemming Cell (Example)

**Layout 1**
- Door front/left
- Door front/right
- Door rear/left
- Door rear/right
- Hemming fixture
- Robot

**Layout 2**
- Door front/left
- Door rear/left
- Door rear/right
- Door front/right
## Technical Changeability Concept of the Core Competence of the Migration Principle

<table>
<thead>
<tr>
<th>Changing element</th>
<th>Basis</th>
<th>Alternatives</th>
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</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td><img src="image" alt="Structure Basis" /></td>
<td>Multiplication</td>
</tr>
<tr>
<td><strong>Station</strong></td>
<td><img src="image" alt="Station Basis" /></td>
<td>Parallel</td>
</tr>
<tr>
<td><strong>Sub-System</strong></td>
<td><img src="image" alt="Sub-System Basis" /></td>
<td>Multiplication</td>
</tr>
<tr>
<td><strong>Components</strong></td>
<td><img src="image" alt="Components Basis" /></td>
<td>Magazine</td>
</tr>
<tr>
<td><strong>Sub-Components</strong></td>
<td><img src="image" alt="Sub-Components Basis" /></td>
<td>Exchange</td>
</tr>
<tr>
<td><strong>Routing</strong></td>
<td><img src="image" alt="Routing Basis" /></td>
<td>Repetition</td>
</tr>
<tr>
<td><strong>Work Contents</strong></td>
<td><img src="image" alt="Work Contents Basis" /></td>
<td>Doublication</td>
</tr>
<tr>
<td><strong>Sourcing</strong></td>
<td><img src="image" alt="Sourcing Basis" /></td>
<td>Purchase (external)</td>
</tr>
</tbody>
</table>
Reduction of the Production Equipment for a Front and Rear Closure
Modular Equipment for the Production of Front and Rear Closures
Migration Path from outer to inner

Phase 1
Model A

Growth section of the equipment
Core production line

Phase 2
Model A
Model B

New core production line

Direction of the migration
Migration Concept on 3 Levels
Migration on Plant Level

Plant 1

Capacity

body-in-white  paint  assembly

100%

Plant 2

Capacity

body-in-white  paint  assembly

100%
Layout Concept Chess

a) Layout

- e.g. Geo-Cell
- e.g. Wedding-Line

b) Volume Development

- Volume
- Time
- Base
- Additional Cells
- Step 1
- Step 2
- ... Additional Transport-Systems
- Step N
Layout Concept Meander

a) Layout

Welding Line
Step 1

Base Line
Main Geometric Line

Step 2
Welding Line

b) Volume Development

Volume

Zeit

Step 2
Additions to Welding Line

Base

Step 1

Characteristics: tact-free definition, free choice of cells, scalable, defined growth paths
Mäander Layout – One Car Model

mögliche Platzierung der Fertigung Boden vst. (Layout lt. Anfrage)

Layoutvariante:
- solitär, Neuanlagen
- Brownfield, Hallen Shedbau
- 16,6 EH / h

Produktions-szenario
Integration von:
- 6 Roboter Respot 2,
- 1 Roboter Taping 2
- 1 Roboter Dachstation, div. Stauförderer und Behälter

Layoutvariante:
- Mix, Integration
- Brownfield, Hallen Shedbau
- 16,6 EH / h

Produktionsszenario
Details of the Layout

Aufgabe Boden vst.

Kommissionierung Spiegel

Kleben Seitenrahmen

Taping

Geo

Framingstation bis 3 Typen erweiterbar. Zunächst nur Basiseinheit mit kurzer Linearachse, 1 Laufwagen und Zustelleinheit verbaut
Details of the Layout with Additional Equipment

1 neue Kleberanlage
2 neue Spannrahmen
5 neue Greifer
1 neue Bauteilablage
2 neue Bauteilbehälter

Framingstation auf 2. Typ erweitert.
Verlängerung Linearachse,
1 Laufwagen neu hinzu, 1+1 Spannrahmen hinzu
### Comparison of Space and Investment

**Production Space and Investment (direct und normed)**

<table>
<thead>
<tr>
<th>Model A solitary</th>
<th>Model A Mäander</th>
</tr>
</thead>
<tbody>
<tr>
<td>4500 m²</td>
<td>4300 m²</td>
</tr>
<tr>
<td>100% Basis Mio. €</td>
<td>102% Basis Mio. €</td>
</tr>
<tr>
<td>Model B solitary</td>
<td>Model A and Model B Mäander</td>
</tr>
<tr>
<td>3100 m²</td>
<td>4300 m²</td>
</tr>
<tr>
<td>95% Basis Mio. €</td>
<td>41% Basis Mio. €</td>
</tr>
</tbody>
</table>

$\Sigma = 7600$ m²
Production Volume Scenarios for 3 Models of different OEMS

Assumption:
2 shifts/day, each 8 hours

Volume
Units / day

Time

Model A
Model A + B
Model A + B + C

Scenario 1
Scenario 2
Scenario 3
Scenario 4
Simulation Result

Total performance in average 172 units/day

Model A (~60%)
Model B (~30%)
Model C (~10%)
Evaluation of Investments (Price Tree)

- Production unit development
  - S_{11} Meander
  - S_{12} Solitude
- Model integration
  - A
  - B
  - C
- Production lines
Comparison of Investments of the Solitude and Migration Concept

Solitude concept

Meander concept

Investments

[€ Mio.]

Start scenario

Model A

Model B

Model C

Scenario 1

4,22

Scenario 2

5,32

Scenario 3

7,42

Scenario 4

8,12

Integration Model B

Integration Model C

Production technology

Robotics

Processtechnology

others

ProductionSystems

Others
Cash Flow of a Migration Production Structure Compared to a Solitude Production

Cumulated Cash Flow [Mio. €]

Cash Positive

Cash Negative

- 10 months

- 6 M

- 4 M

Start Cash Flow Model A

Start Cash Flow Model B

SOP(A)

SOP(B)

SOP(C)

Base

Meander base

Interest effect

Expansion of investment for volume and/or Model B

Investment single-line Model B

Interest effect
Economic Development in Case of Volume Deviation

Case A: High volume with high investment in order to minimize unit cost, decreasing units produced.

Case B: Medium production with lower investment, increasing units produced.

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**Investment**
- Raising fixed production cost
  - High
  - Medium
  - Low

**Volume**
- Low
  - New volume
- Medium
  - Planned volume
- High
  - New volume after appr. 2 years

Case A: for decreasing volume over-invested high fixed unit production cost

Case B: For increasing volume under-invested high variable unit production cost
Economic Development of Production Volume Deviations

Case A: avoidance of high fixed production cost

Case B: avoidance of high variable production cost

Investment

Maximal fixed production cost

De-investment path

Investment step

Optimal migration path

Volume

low  medium  high

Vehicle A

Vehicle B

Low volume with migrating investment in order to minimize unit cost

Increasing volume; under invested high variable production cost

High volume with migrating investment in order to minimize unit cost

Maximum variable production cost

Overinvested for low volume, low profitability
High fixed production cost

Investment path

De-investment path
## Production Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Founder</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulare plant</td>
<td>Wildemann</td>
<td>1988</td>
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<tr>
<td>Fractal plant</td>
<td>Warnecke</td>
<td>1991</td>
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<tr>
<td>Bionic manufacturing</td>
<td>Okino</td>
<td>1993</td>
</tr>
<tr>
<td>Holonic manufacturing</td>
<td>HMS</td>
<td>1994</td>
</tr>
<tr>
<td>Network plant</td>
<td>Wiendahl</td>
<td>1996</td>
</tr>
</tbody>
</table>

**Migration Manufacturing**
Summary

- Life-style effects in the market and technical innovations require continuously new car models in short sequence and with decreasing product life-cycle.

- A high competitive pressure requires low cost and low budget production concepts.

- The Body-in-White production is a key element in the automotive manufacturing process.

- A Body-in-White production based on the new Migration Concept is much more advanced compared to the existing production concepts in respect of flexibility, economics and investment and market risks.

- Migration Manufacturing is a new concept for factory planning. It reflects the idea that plant layouts are a living organism that pro-acts with market and technology changes.
Thank you for your attention!