Local craft shops designed and handcrafted the earliest cars. Vehicles such as the 1911 Springfield were custom-made but exorbitantly priced.

In mass producing automobiles, Ford sacrificed individualism but was able to slash prices. Consumers got identical models, but productivity soared.

Today’s production methods give buyers the best of both worlds—low prices and custom design.
Henry Ford vs. Michael Dell

“"The consumer can have any color he wants as long as it’s black."" ""I will build a motorcar for the great multitude... It will be so low in price that no man... will be unable to own one.""

""Companies that are successful today... are those that can get closest to their customers’ needs."" ""Building a business solely on cost or price... [is] not a sustainable advantage.""

Cars were produced before they were sold, then shipped to dealerships that held huge inventories. Models changed once a year, at most. The Model T’s exterior went unaltered for 19 years.

Computers are sold over the Internet, then produced and shipped to the individual customer. No inventory kept. Models change continuously as new technologies becomes available.

Modularity is a tool to adopt to the companies main strategies

Exemple SMART

Modularity is a tool to provide mass customization
Dagens situation

Snabb ökning av antalet produktvarianter
Tiden ofta kritisk

Variantexplosionen

The trend is that customer expect to have customized product
Variantexplosionen, forts.

Komplex verksamhet

- För stort sortiment
- För många varianter
- Många artiklar i ett omfattande MPS-system
- Små volymer per produkt/detalj och svårt att öka volymen på grund av alla varianter
- Inga eller små skaleffekter
- Ej rationell tillverkning
- Inga eller små möjligheter till automatisering eller mekanisering
- Hög tillverkningskostnad
- Svårigheter att konkurrera
- Otillräcklig lönsamhet
Produktplattformar och gemensamhet

All three aircraft share common height and width...

...but their fuselage lengths are different:

Boeing 737-300  Boeing 737-400  Boeing 737-500

It is critical to understand where flexibility is needed to deliver necessary customization.
• Each passenger door (8 total) has different sets of parts with subtly different shapes and sizes for its position on the fuselage
• Challenge: make the hinge common for all of the doors
• Result: not only a common hinge but also a common door mechanism

777 Passenger Door (Sabbagh, 1996)

In vast product portfolio it may be just possible to modularize a few sub-systems

• VW plans for 19 vehicles based on A-platform
• VW estimates development and investment cost savings of $1.5 billion/yr using platforms

A modular system facilitate Brand Architectures even though it normally drives variety
Modulindelade plattformar

1. Hantera varians
2. Minska komplexitet

Modularisering

Kinds of Parts
Before SD. After SD.
Casing 3 → 3
Terminal 13 → 4
Bimetal 8 → 4
Voltage regulator 20 → 3
Base 2 → 1
Shaft 2 → 2

288
Gränssnitten avgörande

Exempel – Hytter - Scanias 4-serie
Exempel – Scania lastvagnshytter

Modulsystem  Hyttvianter

Exempel – Scania instrumentbräda

Samtliga konsoler är lika för höger- och vänsterstyrda bilar utom mittkonsolen som finns i två utföranden.
**Exempel – Scania instrumentbräda**

Stor frihet vid val och placering av instrument

60 varianter av reglage, strömställare och kontrollampor

---

**Effekter, Scania hytter**

<table>
<thead>
<tr>
<th></th>
<th>Scania</th>
<th>GPRT</th>
<th>4-serien</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plåtartiklar</td>
<td>1400</td>
<td>380</td>
<td>250</td>
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<tr>
<td>Inredningsdetaljer</td>
<td>1800</td>
<td>600</td>
<td>360</td>
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<tr>
<td>I-panel</td>
<td>310</td>
<td>220</td>
<td>170</td>
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<td>Pressverktyg</td>
<td>1600</td>
<td>280</td>
<td>350</td>
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<td>Resningslinjer</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Monteringslinjer</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Effekter, Scania hytter

<table>
<thead>
<tr>
<th></th>
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<th>GPRT</th>
<th>4-serien</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varianter</td>
<td>&lt;1000</td>
<td>50.000</td>
<td>&gt;50.000</td>
</tr>
<tr>
<td>Monteringstid</td>
<td>100%</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>Lager (max)</td>
<td>4 mån</td>
<td>30 d</td>
<td>10 d</td>
</tr>
<tr>
<td>Lager (genomsnitt)</td>
<td>2 mån</td>
<td>15 d</td>
<td>5 d</td>
</tr>
<tr>
<td>Robotiserad svets</td>
<td>0%</td>
<td>60%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Exemplet Scania

"Med ett minimum av komponenter har vi lyckats med konststycket att ha ett väldigt flexibelt utbud av slutprodukter."

Leif Östling, VD för Scania AB
To reduce complexity it is sometimes necessary to over specify some modules.

"Varianthävstången"

Möjliga slutvarianter
1x5x4x3=60

Antal modulvarianter
1+5+4+3=13

Möjlig "vinst"
60-13=47 varianter

Once a modular system is in place the "gain" from each new variant will be vast.
Geotronics

Electrolux commercial dish washer
Exempel

<table>
<thead>
<tr>
<th>Time (years)</th>
<th>Variants</th>
<th>Number of different parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-modular design</td>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td>Modular design</td>
<td>2</td>
<td>7000</td>
</tr>
</tbody>
</table>

All symbols in the “Line Dings” font are variants of the same basic module

A module is defined by its interfaces
Line Dings module
Attachment interface
Spatial interface

All these Module Variants comply with the same Attachment and Spatial interfaces, e.g., they are instances of the same Module.

Variant d  Variant b  Variant c
"Utvecklingshävstången"

Exemplet Sony Handycam®

<table>
<thead>
<tr>
<th>Model</th>
<th>Date</th>
<th>Optics</th>
<th>Optical to Electronic</th>
<th>Recording</th>
<th>Sound</th>
<th>Power Supply</th>
<th>Casing</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-8</td>
<td>12/85</td>
<td>Viewer</td>
<td>Lens</td>
<td>CCD Circuit</td>
<td>Drive</td>
<td>Battery</td>
<td>Adapter</td>
</tr>
<tr>
<td>M-10</td>
<td>7/88</td>
<td>Optical Viewer Finder</td>
<td>15 mm Fixed Lens</td>
<td>220,000 Pixels CCD</td>
<td>M-series Circuit Board</td>
<td>8 mm Double-Head</td>
<td>Electro Condenser</td>
</tr>
<tr>
<td>V-30</td>
<td>4/87</td>
<td>2.7 inch B/W CRT</td>
<td>12-30 mm Zoom Lens</td>
<td>V-series Circuit Board</td>
<td>Playback Feature Added</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V-50</td>
<td>10/87</td>
<td>12-72 mm Zoom Lens</td>
<td>V-series Circuit Board</td>
<td>V-series Casing</td>
<td></td>
<td></td>
<td>ACP-88UC</td>
</tr>
<tr>
<td>V-90</td>
<td>1/88</td>
<td>Smaller 12-72 mm Zoom Lens</td>
<td>220,000 Pixels CCD</td>
<td>V-90 Circuit Board</td>
<td>8 mm Triple-Head</td>
<td>NP-55</td>
<td>AC-V53 Adapter Pack</td>
</tr>
</tbody>
</table>

New Component / Module Design

Modification of Existing Component / Module Design
Modul- och gränssnitts drivare

<table>
<thead>
<tr>
<th>Product Life Cycle</th>
<th>Module Driver</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development &amp; Design</td>
<td>Carry Over</td>
<td>to be re-used in next generation</td>
</tr>
<tr>
<td></td>
<td>Technology Push</td>
<td>to enable new solutions from suppliers</td>
</tr>
<tr>
<td></td>
<td>Planned Development</td>
<td>to be improved separately</td>
</tr>
<tr>
<td>Marketing</td>
<td>Technical Spec</td>
<td>to isolate spec-driven variance</td>
</tr>
<tr>
<td></td>
<td>Styling</td>
<td>to isolate design &amp; brand differentiation</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Common Unit</td>
<td>to achieve high volumes &amp; scale</td>
</tr>
<tr>
<td></td>
<td>Process/Organisation</td>
<td>to protect scarce resources/processes</td>
</tr>
<tr>
<td>Quality</td>
<td>Separate Testability</td>
<td>to be tested separately</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Strategic Supplier</td>
<td>to be developed, produced, etc by partner</td>
</tr>
<tr>
<td>After-sales</td>
<td>Service/Maintenance</td>
<td>to be replaced easily in the field</td>
</tr>
<tr>
<td></td>
<td>Upgrading</td>
<td>to increase after-sales</td>
</tr>
<tr>
<td></td>
<td>Recycling</td>
<td>to protect environment</td>
</tr>
</tbody>
</table>

Modulindelning

Indelning av en produkt i byggblock (moduler) med fastställda gränssnitt, driven av valda, företagsspecifika skäl.
Modul

• A *module* is a physical unit containing a discrete functionality and well-defined interfaces. The module is chosen by specific, strategic reasons. Thus, a module is a gathering of encapsulated Technical Solutions that will be regarded as a unit giving strategic advantages.

• In the development of a modular concept the objective is to find building blocks (modules) in which the contained Technical Solutions have similar properties regarding development, variety, processes, etc.

Produktstrategier

*After Porter*
Samspelet mellan strategier

- Processledande
  + Hög produktivitet
  + Jämn kvalitet
  + Låg kostnad
  - Oflexibel
  - Prispress

- Nära kund
  + Lojala kunder
  + Ökad marknadsandel
  - Instabila processer
  - Hög indirekt kostnad

- Produktledande
  + Prispremie
  + Förmåga att förändra
  - Stora processförändringar
  - Hög utvecklingskostnad

Modulindelad produkt

- Produktledande
- Processledande
- Nära kund

After Porter
Varför modulindelning?

Olika aspekter på modulindelning

- Manufacturing
- Marketing
- Purchasing
- Design and Development
Olika aspekter på modulindelning

- Manufacturing
  - Reduce final assy time

- Marketing
  - More variants

- Purchasing
  - Black box engineering

- Design and Development
  - Reduced TTM

Modul- och gränssnittsdrivare

- **Development & Design**
  - Carry Over
  - Technical push (external)
  - Planned design changes (internal)

- **Marketing**
  - Different specification
  - Styling

- **Manufacturing**
  - Common unit
  - Process & Organisation

- **Quality**
  - Separate testability

- **Purchasing**
  - Supplier available

- **After-sales**
  - Service & Maintenance
  - Upgrading
  - Recycling

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Modulindelad produkt

Produktledande  Processledande  Nära kund

After Porter

Produktionshävstången

Source:
• Shimokawa et al. 1997
"Produkter i produkten – fabriker i fabriken"

Modular Function Deployment

1. Clarify customer requirements
   - QFD analysis
   - Product value for the future
   - Product specification

2. Select technical solutions
   - Functional architecture
   - Select technical solutions

3. Generate concepts
   - Identify possible
   - Develop
   - Sketch concepts

4. Evaluate concepts
   - Analyse
   - Evaluate concepts
   - Calculate effects

5. Improve each module
   - Monitor specifications
   - Improve each module

MFD
Clarify customer requirements

**Step 1**
- Define market segments
- Make Business oriented decision on goals (cost, etc)
- Establish Requirements per segment
- Rank requirements per segment
- Analyze and select segments
- Develop Product Properties
- Analyze in QFD-matrix
- Target values and variance/development needs of Product Properties

Select technical solutions

**Step 2**
- Analyze functions and technologies
- Evaluate and select concepts
- Connect technologies and markets in DPM-matrix
**Generate module concepts**

**Step 3**
- Define modules with the help of the module drivers. Every technical solution from step 2 is evaluated against the module drivers.
- What expected future developments do we foresee?
- How big variance do we have to manage and where?

**Evaluate module concepts**

**Step 4**
- Identify Interfaces
- Define and describe the Interfaces
- Generate a Product Management Map, PMM
Describe and specify modules

Step 5
• Specify and describe modules
• Perform economic and technical evaluations
• Balance module property requirements and cost
• Plan for Implementation

Braun "AromaSelect" family

"Like your furniture, your coffeemaker says a lot about your personal style and taste. With the right coffee maker, you can set a perfect accent in your kitchen or office." *

Oral-B family, cont.

"More Angles, More Action, More Effective. Consumers want a toothbrush that does the best cleaning job - one that most effectively removes plaque, the bacterial film that causes tooth decay and gum disease"

[Image of Oral-B toothbrushes]

* Source: http://www.braun.com

Oral-B family, alternative

"Brushing your teeth is a natural part of living from the very early years of the life – should be fun, easy, and entertaining"

[Image of Oral-B toothbrushes]

* Source: http://www.braun.com
Vi behöver marknadsdata som beskriver det kompletta sortimentet för hela plattformens livslängd.

**Market Structure electrical toothbrush**

- **Usage Situation Young people**
  - Home: 80%
  - Travel: 18%
  - Other: 2%

- **Usage Situation Family**
  - Home: 90%
  - Travel: 9%
  - Other: 1%

- **Usage Situation Businessman/woman**
  - Home: 8%
  - Travel: 92%
  - Other: 2%
Customer Requirements

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Young people</th>
<th>Parent</th>
<th>Businessman/woman</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Home [1]</td>
<td>80</td>
<td>90</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Traveling [2]</td>
<td>18</td>
<td>9</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Other [3]</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Highest ranking: 19
Lowest ranking: 1

- Not taken into consideration
- Profile young people
- Profile family
- Profile businessman/woman
- Common most important customer demands

Customer Requirements

- Effective bristles/plaque remover
- Replacement brushheads
- Generate little vibration
- Quiet operation
- Easy to clean
- Impact resistant
- Long lifetime
- Long lasting brushing performance
- Easy to handle
- Quick charging
- Low price
- Recyclable
- Low operating cost
- Easy to personalize
- Easy to upgrade
- Easy to dispose

Weight

Segment analysis

- Young & Trendy
- Careerist & Premium
- Family & Practical

- Easy to dispose
- Easy to carry & wear
- Reliability
- Long operating time
- Attractive look
- Always reachable
- Many or new functions
- Easy to personalise
- High finish
- Good mechanical fit
- High acoustical performance
- Low price
- Easy to use
- Good mechanical fit
- High finish
- Easy to carry & wear
- Reliability
- Long operating time
- Attractive look
- Always reachable
- Many or new functions
- Easy to personalise
- High finish
- Good mechanical fit
- High acoustical performance
- Low price
- Easy to use
Prerequisites for Modularisation

- Segments/customer needs input
- Company strategy input
- Development of product families (not individual products)
- Prepared anticipated improvements during the lifecycle of the family

Collecting customer needs

- Must be more efficient than doing it by hand!
- I drooped it once and it never worked again!
- I do not like to wake the whole family when I get up early.
- The battery is always empty when I need it.
- Too expensive for my taste.
- Why does it have to feel like using a pneumatic road driller?
- Why do I get wet all over when I use it?
- My battery wears out too quick.
Translating to properties

Customer needs
“Fluffy” statements

- More efficient than doing it by hand
- Doesn't wake the whole family when I get up early
- Why does it feel like using a pneumatic road drill?
- Why do I get wet all over when I use it?
- Why does it feel so cold when I use it?
- I do not like to wake the whole family when I get up early.
- More expensive than I expected.
- I don’t like it when it gets dirty.
- Why does it need to be charged so often?
- Why does it refuse to work again?
- Why does it feel like using a pneumatic road drill?
- The battery is always empty when I need it.

Product property
Measurable

- Weight
- Dimension
- Form
- Color
- Surface texture
- Power consumption
- Lifetime
- Shock resistance
- Number of functions

Must be more efficient than doing it by hand!

To be more efficient than doing it by hand!

Translating to properties

Produktegenskapen skall vara möjlig att påverka och mäta på konstruktions- eller prototy斯塔det.

Behaglig inomhus luft

- Luftförd Rahmen Luft
- Luftförd Rahmen Luft
- Luftförd Rahmen Luft
- Luftförd Rahmen Luft

© 2007 Gunnar Erixon
Quality Function Deployment

Customer Demands

<table>
<thead>
<tr>
<th>Design properties</th>
<th>Encapsulation</th>
<th>Battery capacity</th>
<th>No. of functions</th>
<th>Rechargeable</th>
<th>Communication coverage</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfortable design</td>
<td>6</td>
<td>4</td>
<td>14</td>
<td>73</td>
<td>80</td>
<td>15</td>
</tr>
<tr>
<td>Easy to place in pocket</td>
<td>4</td>
<td></td>
<td>89</td>
<td>83</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Water resistant</td>
<td>3</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>No lead inside</td>
<td>3</td>
<td></td>
<td>100</td>
<td>11</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Easy to use / buy</td>
<td>2</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Solid, rugged</td>
<td>2</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Select various ring signals</td>
<td>1</td>
<td></td>
<td>89</td>
<td>83</td>
<td>14</td>
<td>18</td>
</tr>
</tbody>
</table>

Product Properties

<table>
<thead>
<tr>
<th>Design properties</th>
<th>Encapsulation</th>
<th>Battery capacity</th>
<th>No. of functions</th>
<th>Rechargeable</th>
<th>Communication coverage</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic quality</td>
<td>6</td>
<td>4</td>
<td>14</td>
<td>73</td>
<td>80</td>
<td>15</td>
</tr>
<tr>
<td>Easy to place in pocket</td>
<td>4</td>
<td></td>
<td>89</td>
<td>83</td>
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<td>18</td>
</tr>
<tr>
<td>Water resistant</td>
<td>3</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>No lead inside</td>
<td>3</td>
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<td>10</td>
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<td>18</td>
</tr>
<tr>
<td>Easy to use / buy</td>
<td>2</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Solid, rugged</td>
<td>2</td>
<td></td>
<td>98</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Select various ring signals</td>
<td>1</td>
<td></td>
<td>89</td>
<td>83</td>
<td>14</td>
<td>18</td>
</tr>
</tbody>
</table>
Select goal values

**Product properties**

<table>
<thead>
<tr>
<th></th>
<th>Value(s)</th>
<th>future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>&lt;1 kg</td>
<td>&lt;1,5 kg</td>
</tr>
<tr>
<td>Dimension</td>
<td>&lt;5 dm³</td>
<td>&lt;7 dm³</td>
</tr>
<tr>
<td>Form</td>
<td>“Vase 1,2,3”</td>
<td>“Wine box” “Cylinder”</td>
</tr>
<tr>
<td>Color</td>
<td>5 color schemes</td>
<td>6</td>
</tr>
<tr>
<td>Surface texture</td>
<td>“Smooth”</td>
<td>“Shining” Not important</td>
</tr>
<tr>
<td>Power consumption</td>
<td>750 W</td>
<td>1000 W 1250 W</td>
</tr>
<tr>
<td>Lifetime</td>
<td>500 h</td>
<td></td>
</tr>
<tr>
<td>Coffee temperature</td>
<td>Adjustable</td>
<td>70-80 °C</td>
</tr>
<tr>
<td>Volume</td>
<td>4 cups</td>
<td>4 to 8 4 to 12</td>
</tr>
<tr>
<td>Set up time</td>
<td>&lt;30 sec</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>+ cappuccino</td>
<td>Just Coffee Brew-class</td>
</tr>
<tr>
<td>Level of automation</td>
<td>Level 1</td>
<td>No</td>
</tr>
</tbody>
</table>

Technology input

We need to start working with functions rather than defined solutions to open up for innovations and to meet market demand for variance and development in new ways.
Functions and possible solutions

- Make coffee
- Hold filter
- Heat water
- Transmit water to nozzle
- Contain coffee
- Etc
- Heated water over grounded coffee beans in filter
- Filter holder cone
- Throughout heater
- Steam pressure and non-return valve
- Carafe

Customer Value – Properties – Technical Solutions

- Expected Customer Requirements
- Future Customer Values
- Technica Solutions
- Realisation of Values Based on Property profiles
- Properties
- Interpretation of Values into measurable Properties
Module/Interface drivers

Module drivers are reasons for separating things with interfaces:

- **Development & Design**
  - Carry Over
  - Technical Push
  - Planned Development
  - to be re-used in next generation
  - to enable new solutions from suppliers
  - to be improved separately

- **Variance**
  - Technical Spec
  - Styling
  - to isolate variance
  - to isolate design, brand, etc

- **Manufacturing**
  - Common Unit
  - Process/Organisation
  - to protect high volume
  - to protect scarce resource/process

- **Quality**
  - Separate Testability
  - to be tested separately

- **Purchasing**
  - Strategic Supplier
  - to be developed, produced, etc by partner

- **After-sales**
  - Service/Maintenance
  - Upgrading
  - to be easy to replace in the field
  - to increase after sales
  - Recycling
  - to protect environment

Assessing Module Drivers

Water container:
- Styling
- Technical spec

Water filter:
- Service / Maintenance
- Common Unit

Heating coil:
- Carry Over
- Technical Specification

Heating plate:
- Carry Over
- Common Unit

Filter holder:
- Planned Design changes
- Styling

Carafe:
- Styling
- Technical Specification

Timer:
- Technical Specification
- Strategic Supplier

Chassis:
- Carry Over
- Technical Specification

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Grouping (or splitting) to modules

- **Water container:**
  - Styling
  - Technical spec

- **Filter holder:**
  - Planned Design changes
  - Styling

- **Water filter:**
  - Service / Maintenance
  - Common Unit

- **Heating coil:**
  - Carry Over
  - Technical Specification

- **Heating plate:**
  - Carry Over
  - Common Unit

- **Carafe:**
  - Styling
  - Technical Specification

- **Timer:**
  - Technical Specification
  - Strategic Supplier

- **Chassis:**
  - Carry Over
  - Technical Specification

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**PMM, a tool for documentation and analysis**

- **Product Properties and Values**
- **Technical Solutions or Functions**
- **Customer Demands**
- **Module Drivers**