Digital Modular PLM
Product Architecture Day - DTU

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Vice President Global Operations & Head Modularization

6th November 2018
ELECTROLUX COMPANY

MODULARIZATION JOURNEY

INNOVATION – PROCESS & GOVERNANCE

DIGITAL MODULAR PLM

SUM UP – IMPLEMENTATION JOURNEY

Q & A
A long history of innovations, acquisitions and strong brands -> 100 years 2019

1912: Lux 1 – first vac

1919: AB Elektrolux founded

1925: World’s first absorption fridge

1926: Elektro Helios (Sweden)

1959: Round jar bench dishwasher

1959: Zanussi (Italy)

1962: Frigidaire (USA)

2001: World’s first robotic vac

2001: AEG (Germany)

2004: World’s most silent vac

2004: First Ergorapido

2004: Refrippar (Brazil)

2011: Olympic Group (Egypt)

2012: World’s first robotic vac

2012: Grand Cuisine, first professional kitchen for consumers

2013: CTI (Chile)

2013: Sous-vide oven

2016: World’s first connected oven with camera

2016: Masterpiece tilted blender

2017: Anova, (US)

2017: Vintec (AUS)...

Key acquisitions

1919: AB Elektrolux founded

1926: Elektro Helios (Sweden)

1959: Zanussi (Italy)

1962: Frigidaire (USA)

2001: AEG (Germany)

2004: Refrippar (Brazil)

2011: Olympic Group (Egypt)

2012: Grand Cuisine, first professional kitchen for consumers

2013: CTI (Chile)

2016: World’s first connected oven with camera

2017: Anova, (US)

Vintec (AUS)...

Axel Wenner-Gren

3
Electrolux Group

Net sales SEK 122 bn
Sales in 150 countries
People 56,000 in 60 countries
Products +60 million Products sold annually
* Include the rapidly growing areas of air-conditioning equipment, water heaters and heat pumps, as well as consumables, accessories and service.
Superior Products.. To create best in class consumer experiences.

...Example Kitchen

Ovens
Perfectly medium rare

Hobs
Every day flexibility

Hoods
Harmony in the kitchen

Specials
Fresh coffee. wine for every occasion

Cold
Best in class freshness

BI Dish
Your best glasses for those unforgettable moments
Electrolux sales by region and Competitor Landscape

- 35% in Asia
- 30% in Europe
- 6% in North America
- 9% in Latin America
- 15% in South America
- 5% in Oceania

Competitors:
- Whirlpool
- Samsung
- LG
- Haier
- Midea
The Strategic Change……

Global Operations 2.0 2015-2020

- Cross functional optimization/integration
  - Modularization 2.0
  - Internal Productivity
  - Automation
  - Consumer Quality

Global Operations 1.0 2010-2015

- Cross functional optimization/integration
  - Modularization 2.0
  - Internal Productivity
  - Automation
  - Consumer Quality

- Cost
- Quality
- Capital Footprint optimization
- R&D consolidation
- Modularization 1.0
- Functional alignment
- Product Lines

Manufacturing engineering company
… within an era of massive footprint optimization and restructuring...

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th></th>
<th>2014</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>• 17 closures</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 6 factories downsized</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 10 new factories</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 9 acquired factories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Capacity</td>
<td>46 M</td>
<td>• From 46 M Units to 52 M Units</td>
<td>52 M</td>
<td></td>
</tr>
<tr>
<td>Share of LCC Capacity</td>
<td>28%</td>
<td>• Approximately 35% of production moved</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>Capacity Utilization</td>
<td>77%</td>
<td>• 10,000 employee reduction</td>
<td>66%</td>
<td>• 7,000 new employees hired</td>
</tr>
</tbody>
</table>
and strong contribution from first part of our Modularization Journey

Design for assembly
Product cost savings through design for assembly, supplier productivity and cross-functional cost excellence

Modularized products
Modularized products in automated and digital manufacturing set-up with maximum efficiency and quality

Outstanding service
Outstanding service levels through integrated digital supply chain for efficiency, flexibility and short lead times
MODULARIZATION JOURNEY AT ELECTROLUX
Modularization at Electrolux

When looking at the Modularization Journey that started in Electrolux back in 2010, it is clear that Modularization created strong results within the company. Modularization helped reduce complexity, harmonized architectures, and created opportunities for manufacturing improvements.

These results were achieved through collaborative effort and all had a real and structural impact on our bottom line. Results we as Electrolux can be proud of. Not only when looking at where we came from but also when we compare ourselves to other companies on a similar journey.

In spite of, or perhaps because of, these excellent results, our journey is far from over. Improvements in our supply base and in bringing modularity to the market still lay on the horizon before us. And opportunities exist to continuously improve our existing efforts. We as Electrolux look forward to continuing this journey.
Our Journey / 2010 – 2018

MOD 1.0 – 2010
Generate efficiencies in the component and module levels by leveraging our global scale

Results
- Modular Structure 40+3 MA
- Complexity reduction
- Major annual savings

IMPACTED AREAS

MOD 2.0 – 2014
Scope extension to modular products, modular manufacturing, and design for assembly

Results
- Harmonized Architecture
- Manufacturing efficiency
- Major annual savings

IMPACTED AREAS

MOD 3.0 – 2018
First focus will be on our supply base: capitalize on potential to buy more modules than parts

Results:
- Modular Digital PLM
- Efficient Supply base
- Speed of Innovation

IMPACTED AREAS
Modularization…a Pillar in Company Strategy
……starts and ends with the consumer
Modularization Benefits

**MARKET NEEDS**

- Lead time
- Customerization
- Performance Steps

**PRODUCT**

- Time-to-market
- Variant creation time
- Innovation impact

- Product cost
- Complexity reduction
- Quality
- Optimized modules
- # module variants
- Warranty cost

**MANUFACTURING**

- CAPEX optimization
- Asset “light”
- Complexity reduction
- #components
- Productivity
- Line output
Modularization 1.0

500+ people from all Sectors, Product Lines and Functions - 20/20 Process

<table>
<thead>
<tr>
<th>Module Areas</th>
<th>Food preparation</th>
<th>Food preservation</th>
<th>Data care</th>
<th>Fabric care</th>
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<tbody>
<tr>
<td>Cross product line</td>
<td>✬</td>
<td>✬</td>
<td>✬</td>
<td>✬</td>
</tr>
<tr>
<td>-</td>
<td>Automotive &amp; Commercial</td>
<td>Electrical &amp; Electronics</td>
<td>Packaging</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product line specific, but similar</td>
<td>✬</td>
<td>✬</td>
<td>Door</td>
<td>Body</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product line specific</th>
<th>Carpet</th>
<th>Interior</th>
<th>Tub</th>
<th>Drive train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling system</td>
<td>✬</td>
<td>✬</td>
<td>Basket/Drum</td>
<td>Hydraulic</td>
</tr>
<tr>
<td>Hot</td>
<td>✬</td>
<td>Cooking system</td>
<td>Hydraulics/Hot</td>
<td>Wash group</td>
</tr>
<tr>
<td>Cold</td>
<td>✬</td>
<td>Ice and water</td>
<td>Hot water</td>
<td>Wash tap</td>
</tr>
<tr>
<td>Compartment</td>
<td>✬</td>
<td>Spray system</td>
<td>Heat pumps</td>
<td>Heat pumps</td>
</tr>
<tr>
<td>Control</td>
<td>✬</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Module Areas</th>
<th>11</th>
<th>9</th>
<th>6</th>
<th>11</th>
</tr>
</thead>
</table>

40 Module Areas
Books signed (43 incl XPL)
Modularization 2.0 - Product Architectures and Automation

Key priorities for competitiveness

- Short-term push on smart automation
- Long-term reduction in number of architectures
- BIC Products
- Increased consumer choice
- Strategic/program/global sourcing

![Diagram showing the transition from manual to automated manufacturing with a focus on MOD 2.0.]

<table>
<thead>
<tr>
<th>No of architectures</th>
<th>2014</th>
<th>2017</th>
<th>2023 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>99</td>
<td>89</td>
<td>≤60</td>
</tr>
<tr>
<td>Modular</td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>
Electrolux - Journey to Industry 4.0

Operational Excellence
- Industry 4.0

Improved operational efficiency & product quality
Introduction of appliance customization

Enabling best-in-class consumer experiences
through flexible appliance customization
at the right cost and quality

Digital Modular PLM - Digital Twin
Automated Modular Assembly
Supply Base Consolidation
"Standard" Process (REF)

"Standard" Product (REF)
Module Consolidation (MAB)
Modular Product Architecture (MPA)
Connected MPA
Modular Products - Connected Experience

MOD 1.0
MOD 2.0
MOD 3.0
MOD 4.0 - INDUSTRY 4.0

START
Manufacturing improvements – Modular Product Architecture

Virtual Manufacturing Simulation

Modular (Fish bone) assembly

Automated manufacturing

Apply to all new product platforms

Standard sub-modules instead of single component assembly

Robots & Cobots
Next step in our journey – MOD 3.0

We have created and optimized our module areas and modular product architectures
And our manufacturing facilities have been automated

Our foundation is strong enough to kick off our next phase of modularization;
Where the focus will be on our supply base and digitalization.

Going forward, we will increase partnership with our suppliers to benefit from increased module value purchasing.
3 IA Process and PLM tools
Innovation Activation (IA) is our streamlined and collaborative process to ensure more innovations that consumers prefer will be brought to the market faster.
Governance and Project Documentation

• Dedicated workspace on new eGate

• Reworked document folders

• search terms & spot on top menu of eGate for easy access
From identified opportunities we decide next step...

• To transform an opportunity into a new product or service for the market
  - Using our **Product Development** process
    • Which uses a tried and trusted Stage Gate methodology
    • Refined through our vast experience in bringing products to the market
  - Or our **Connected Product Development** process
    • For connected products and services
    • Which combines our traditional PD process with an agile App process

• To capitalize on the benefits of modularization by
  - Using our **Module Development** Process to
    - generate a supporting subsystem (module) that can be used and re-used in receiving product architectures.

• To develop a new technology for future products or modules using **Advanced Development**
Modularization and Modular Product Architectures improves time-to-market and capital efficiency

**Module Development:**

Lead project
- Product development: Time 100% Capex 100%

Module development

2nd wave
- Product development: Time 80% Capex 85%

3rd wave
- Product development: Time 70% Capex 80%
Module Development:
Modules and interfaces need to be clearly documented in both the module area book as well as in a modular catalogue.

- Module area book
  Last chapter in module area book will cover high-level description of interfaces...

- Modular catalogue
  ... which gets further detailed and documented using same template during respective project..

- Tracking of interface
  ... and activity tracking regarding the detailing of technical specifications and definition on Interface before CP0

In CP0 interface should be defined and feed back into module area book.
And we recognize the need for different processes to support different Business models.
But we are still facing several challenges

• In a more connected, global environment with
  — Stronger competition
  — increasing complexity
  — Faster and faster changes
  — And lower switching costs for consumers

• We need to improve our ways of working to
  — Understand our users and customers better
  — Speed-up capitalization of emerging opportunities
  — Look beyond traditional market data that is available to everyone
  — Iterate more often and faster to develop better, more robust solutions
  — Engage and retain our consumers after they purchase our products
  — Leverage our global and local presence
  — Shape living for the better
Digital transformation and the Digital PLM program

Digital PLM 2018-2019
The Digital Modular Journey at Electrolux

- Definition of module areas and modules across product lines
- Component standardization

- Market offerings through module performance steps
- Architecture and interface definition
- Assembly setup and module manufacturing

- Implementation of Modularization in PLM
- Definitions of common approach through modular EBOM in Teamcenter

MOD 1.0

MOD 2.0

Modularization PDM From Poster to PDM
Digital Twin Product

Design, simulate and verify products digitally, including mechanics and multiphysics, electronics and management of software
Digital Twin Production

Plan, simulate and optimize production digitally
Digital Twins continuously improving product and production in the real world
Digital Twin – IT Landscape

Observations

**CAD**
Computer Aided Design
- Mechanical design
- Electrical design
- Mechatronic design
- Simulations and testing

**PLM**
Product Life Cycle Management
- Approval and release of parts
- Engineering Change Process

**MRP**
Manufacturing Resource Planning
- Production planning and scheduling
- Inventory and purchasing

...x20

![CAD logos]
![PLM logos]
![MRP logos]
Data Flow of the Digital Twin vs the Current State

**CAD systems**
- Designers use various CAD systems
- Designers design modules
- Design structure is plant neutral

**Teamcenter**
- DBOM and EBOM is plant neutral and owned by R&D
- MBOM and Plant BOP is plant/line specific and owned by ME
- TC collects design data from various CAD systems
- TC collects simulation data etc. from various functions in the company

**Simulations, Purchasing, Compliance etc.**
- Pulls product data from the Digital Twin in Teamcenter
- Stable structure in EBOM makes it easier to find data across different functions in the company

**MRP**
- Receives data from Teamcenter
- Production planning and scheduling
- Inventory and purchasing

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**Current State:**
- Improvements needed

**Current state:**
- Improvements needed
Digital PLM in Electrolux – Transformation program

Threats, Goal and Solution

**Threats**
- Puzzling to find and understand product data
- Data flow across functions is cumbersome (e.g. from design to purchasing)
- Difficult sharing of solutions globally

**Digital transformation → Electrolux company strategy**
- Digitalization of product design in all phases → Design, Simulations, Manufacturing, Testing, Purchasing, Compliance, Quality, etc.
- Digitalization of other life cycles as Marketing, Industrial design, Service, etc.

**Modular EBOM concept**
- Common data structure
- Common data flow
- Global sharing of solutions
Introducing Modular EBOM in Teamcenter

Motivation

- EBOM is the backbone of a digital twin in all lifecycles → collects data from all CAD systems
- EBOM structure based on Modularity 1.0 as foundation for global modularization
- One stable EBOM structure optimizes the linking between DBOM-EBOM-MBOM-BOP
- Overloaded EBOM create a simpler overview of a product family
- Configuration on the overloaded EBOM creates specific product variants/PNCs
Modular EBOM Concept

Modularity
- The Upper Structure of the Modular EBOM is based on the Modular Books from MOD 1.0
- The structure of the EBOMs will therefore be generic across all architectures and products within the same product line
- This results in a stable structure over time

Overloaded EBOM
- An EBOM is created for each Master Model in a project
- A Master model is defined by the main physical scaling, i.e., the footprint
- Each EBOM is overloaded with all the content need to create all the PNCs
- This results in fewer BOMs to maintain

Configuration
- A Product Configurator in Teamcenter is used to derive the lower level BOMs, e.g. PNCs, from the overloaded EBOM
- The configuration rules are handle through the Sharing Matrix
- The design is now decoupled from the viability resulting in easier maintenance
# Digital Twin - Data Flow Observations

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>Manufacturing Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>PLM</td>
</tr>
</tbody>
</table>

**Framework: ERP**

### CAD (Digital Twin)
- **Master Model Owner**
  - DBOM: Design work structure
    - Designer
      - 3D CATIA
        - Master
        - Master Model
        - Master Model Owner
      - NX
        - Master
        - Master
        - Master Model
      - Zuken
        - Design work structure
        - Designer
        - Master
        - Master Model
        - Master Model Owner
      - Orcad
        - Design work structure
        - Designer
        - Master
        - Master Model
        - Master Model Owner
- **ANCs**
  - Panel
  - Base
  - Worktop
  - Drain pump
  - Recirculation system
  - Detergent dispenser
  - Valve system
  - Tub
  - Drum
  - Counter weight

### PLM (Teamcenter)
- **ANCs**
  - Panel
  - Base
  - Worktop
  - Drain pump
  - Recirculation system
  - Detergent dispenser
  - Valve system
  - Tub
  - Drum
  - Counter weight

### Manufacturing Engineering
- **MBOM (Electronics)**
  - Master
    - Body
    - Panel
    - Base
    - Worktop
    - Door lock
    - Hydraulics
      - Drain pump
      - Recirculation system
      - Detergent dispenser
      - Valve system
    - Tub
    - Drum
    - Counter weight
  - **Wire harness**
    - Connectors
  - **PCB**
    - Sensors
  - **ANCs**
    - Panel
    - Base
    - Worktop
    - Drain pump
    - Recirculation system
    - Detergent dispenser
    - Valve system
    - Tub
    - Drum
    - Counter weight
  - **MBOM (Electronics)**
    - Wire harness
      - Connectors
    - PCB
      - Sensors
Digital Twin - Data Flow

Result

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>PLM</th>
<th>Manufacturing Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>Master Model Owner</td>
<td>Master</td>
</tr>
<tr>
<td>DBOM Design work structure</td>
<td>EBOM Modular structure</td>
<td>MBOM Assembly structure</td>
</tr>
<tr>
<td>Body</td>
<td>Body</td>
<td>Body</td>
</tr>
<tr>
<td>Panel</td>
<td>Body structure</td>
<td>Panel</td>
</tr>
<tr>
<td>Base</td>
<td>Body structure variant 1</td>
<td>Base</td>
</tr>
<tr>
<td>Worktop</td>
<td>Part</td>
<td>Worktop</td>
</tr>
<tr>
<td>Door lock</td>
<td>Drain and Recirc. System</td>
<td>Door lock</td>
</tr>
<tr>
<td>Hydraulics</td>
<td>Drain and recirc. sys v.1</td>
<td>Hydraulics</td>
</tr>
<tr>
<td>Drain pump</td>
<td>Part</td>
<td>Drain pump</td>
</tr>
<tr>
<td>Recirculation system</td>
<td>Tub</td>
<td>Recirculation system</td>
</tr>
<tr>
<td>Detergent dispenser</td>
<td>Tub variant 1</td>
<td>Detergent dispenser</td>
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<tr>
<td>Valve system</td>
<td>Part</td>
<td>Valve system</td>
</tr>
<tr>
<td>Wash group</td>
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<tr>
<td>Tub</td>
<td>Tub</td>
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<tr>
<td>Drum</td>
<td>Drum</td>
<td>Drum</td>
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<td>Counter weight</td>
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<tr>
<td>Wire harness</td>
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<tr>
<td>First surface interface</td>
<td>Sensors</td>
<td>Sensors</td>
</tr>
<tr>
<td>First surface interface variant 1</td>
<td>PCB</td>
<td>PCB</td>
</tr>
</tbody>
</table>

Designer

DBOM Design work structure

DBOM Design work structure

DBOM Design work structure

CAE | Quality | Purchasing | Compliance | Marketing Design Service Etc.
## General Challenges Related to the Digital Twin

### Data Flow
- Investigations needed on link between DBOM-EBOM-MBOM-Plant BOP → Introduction of Modular EBOM and MBOM+BOP must be coordinated since both are relying on each other
- Today all parts are not in TC (E.g manuals, wire harness, software etc.)
- Link between TC and MRP (Future ownership of the MBOM – MRP vs. TC)

### Designing Modules
- Need for 2D manufacturing drawings drives CATIA+DBOM structure → Manufacturing assemblies should be handled in TC MBOM
- Manufacturing assemblies are not always aligned with designing modules and a plant neutral DBOM
- CATIA structure philosophy is not aligned across different R&D

### Product Line – R&D
- Missing link from market requirements to performance steps of modules
- Link between Product Line and R&D needs to be more structured

### Implementation
- Pilots asks for implementation strategy including:
  - Roles, processes and responsibilities for project and production has to be defined moving forward
  - Modularization is a Design Philosophy a new way of working
  - More training in Teamcenter
Sum up – Implementation Journey

4

DIGITAL MODULAR PLM
Electrolux Digital Modular PLM

Design for Manufacturability and Assembly

eBOM

mBOM

Internet Of Things

dBOM

Bill of Process

Modular Assembly

4.0
Our Global Strategy

We reinvent taste, care and wellbeing experiences for more enjoyable and sustainable living around the world.

Act sustainably  Create better experiences  Always improve

Taste, Care & Wellbeing Innovation
Best-in-Class Consumer Experiences
High-Quality Connected Ownership Experience

Operational Excellence
Talent & Teamship
Continuous Improvement  Digital Transformation  Sustainable Development

1  Stability & Focus
2  Sustainable Profitability
3  Targeted Growth

Profitable Growth
Q & A

ELECTROLUX COMPANY
MODULARIZATION JOURNEY
INNOVATION - PROCESS & GOVERNANCE
DIGITAL MODULAR PLM
SUM UP – IMPLEMENTATION JOURNEY