System Engineering as the Lynchpin of a PD Transformation Effort

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Whirlpool Corporation: a great and successful company...with opportunities in Product Development

Dishwasher: an opportunity to create a Systems Engineering burning platform

Going Big: system engineering as a fundamental capability for Lean PD

Reflections and next steps
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Reflections and next steps
A GLOBAL COMPANY

NORTH AMERICA #1
LATIN AMERICA #1

EMEA #1
WESTERN COMPANY IN ASIA #1
$1B R&D ANNUAL SPEND

70 MANUFACTURING AND R&D CENTERS
Whirlpool Corporation
1911-2017

1911-1948
• Manufacturing
• One Product
• One Customer

1948-1970
• Product Expansion to Full-line
• Whirlpool Brand

1970-1980
• U.S. Trade Expansion
• #1 U.S.

1980-1990
• Multi-Brand: Whirlpool, KitchenAid, Roper, Estate
• #1 N. America

1990-2000
• Globalization: Europe, Latin America, Asia
• #1 Globally

2000-2007
• Innovation
• Maytag

2007-2015
• Global Financial Crisis
• Volatile Global Marketplace
• Indesit & Hefei Sanyo
STRATEGIC ARCHITECTURE

VISION
The Best Branded Consumer Products... in Every Home Around the World

MISSION
Create Demand and Earn Trust Every Day

STRATEGY
Product Leadership                  Brand Leadership
Operating Excellence               People Excellence

VALUES
Respect, Integrity, Diversity & Inclusion, Teamwork, Spirit of Winning
ENVIRONMENT + HISTORY + STRATEGY REQUIRE AN EVER INCREASING LEVEL OF PERFORMANCE

Quick and predictable time-to-market is even more essential to win

Control architectures and parts proliferation to create global leverage

Maximize re-use on product designs to maximize engineering efficiency

Even more innovation at an even faster pace is required, with interproduct connectivity (IoT) to create distinctive consumer experiences
TODAY’S DISCUSSION

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OPPORTUNITIES EXIST ALONG 3 DIMENSIONS

Impact on organization: throughput workload

Time

Product Planning Opportunities + Project Management Opportunities + Engineering Execution Opportunities

And their interactions…!!!
# SOLUTIONS WERE OBVIOUS... MAYBE TOO OBVIOUS!

## Issues and Solutions

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<tr>
<th>Issue</th>
<th>Train PM</th>
<th>Accelerate Lean PD</th>
<th>Increase planning workshops</th>
<th>Strengthen risk mgt process</th>
<th>Do more simulation</th>
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<tr>
<td>Late discoveries on project</td>
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<td>Regular scope creep</td>
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<td>Late disagreement on targets between functions</td>
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<td>Work done in large batches</td>
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<td>Lack of real time project status understanding</td>
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...TO NOT REQUIRE A SECRET INGREDIENT: STRONG SYSTEM THINKING!

<table>
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<th>Status as of 2014-2015</th>
<th>Train PM</th>
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<td>Several PM’s are certified</td>
<td>Team trained in tools</td>
<td>lack of rigor in requirements definition</td>
<td>Existing process with marginal opportunities for improvement</td>
<td>Many good micro physical models</td>
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<td>Long experience as PM</td>
<td>Mindset largely in place</td>
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Hypotheses

Project management is not as much a problem as the functional expertise?

does not know how to achieve “compatibility before completeness”?

Don't understand how to translate marketing rqts into engineering targets?

Team does not know how to detect risks until they are issues even when they try?

Simulation provides the right answers to the wrong questions?

Conclusion

We may be dealing with a lack of understanding of the product as a system?
OUR INTUITION WAS CONFIRMED BY MANY CLUES!

FPY for the overall product is about several points below components’ and subsystems’, showing clear integration challenges.

A large share of customer satisfaction problems are not understood and cannot be traced back to a component or even a malfunction of the product. Many such incidents result in NTF components and multiple visits.

Software is used late in the programs as a glue resulting in proliferation and some lack of robustness.

Late discoveries happen when the component variations are experienced showing potential for more functional robustness.

Cycle design is very iterative and empirical. These cycles are not predictable until the full product is tested in lab adding a risk on predictability of performance, robustness and time adherence.

Problem solving feels at times like a whack-a-mole game. One attribute improvement results in an unpredicted change of another.

Constant focus on these failure modes to create high agreement on our ailment!
The approach was tentative at times with a mix of document-based and model-based...
After a few months of slow progress, several key team members (looked upon as opinion makers by the team!) went to MIT training to bring up-to-date tools and approaches...

Our journey accelerated quickly after the training as our approach was a lot clearer...and thus explainable!
...BRING OUTSIDE HELP TO THE TEAM...

...Which we brought to the team through week-long OPCAT modeling workshops supported by Prof. Dori...

“This workshop is exactly what we need to get to the next step” (workshop participant)
It is unfair and unsustainable to ask the team to change its way without clear leadership.
...AND SELL THE BENEFITS TO THE TEAM MEMBERS

- **Flawless Project Execution**
  - Risk management
  - Much higher confidence that the sub-system will integrate and emergence will happen
  - Increased robustness of product attributes with the right targets

- **Faster Quality improvement**
  - Product failures and attribute weakness

- **Foundational Knowledge**
  - System decomposition,
  - Functional stack-ups and interactions
  - FMEA’s...

- **Relevant Portfolio planning**
  - Architecture, Sub-System and tech. roadmaps
  - How far can a given architecture deliver an attribute roadmap
  - Where have I over-designed the product due to poor understanding of functional variation and requirements?

- **Larger cost improvement**
  - Over-designed functions and attributes

- **The best and most Sr engineers can focus on fundamental system engineering (e.g., architecture work)**

**Proper system engineering is a more interesting and engaging way of working for everyone!**
DRYING FUNCTION GLOBAL ROADMAP

OPCAT model is fully integrated into product planning process

Connecting Voice of Customer & Voice of Engineer

Analysis using OPCAT helped to identify:
All Design & Environmental Factors to run a stack analysis

Stack Analysis Helped to:
- Correlate Customer satisfaction vs Metrics
- Define/Quantify Trade offs with Energy, Cost Sound & Aesthetics
- Improved predictability by setting targets for Water Retention, Thermal Mass & Drying configuration
- Improved Competitive Analysis
- Developed a solid, Global Drying Roadmap
OPCAT MODEL APPLICATION TO DISHWASHER DRY

System Engineering approach used to map the Drying function in Opcat

Mapping drying process helped to:
- Identify critical interfaces/interactions
- Identify potential root causes
- Identify other sources of variation

OPCAT model is integrated in the Lean PD A3-based problem solving and design review processes

Identified a negative impact from increased thermal mass, retained water in the structure and the temperature drop from the addition of features. Some actions taken:
- Changed Drying algorithm to improve thermal performance
- Modifying Silverware basket design to reduce water retention
- Set the baseline to expand the analysis to other architectures and brands globally.
THEN, ENJOY AND ADVERTISE MEANINGFUL BUSINESS RESULTS

Very high team engagement in 2015 and 2016 as a result of “working the right way”

Predicted improvement in all 3rd party reviews of our products (NAR + EMEA) has come true over the last 18 months

Improved technology roadmap with reduced industrial complexity will enable significant gain of speed to market

Improved quality and customer satisfaction which will support our many brands
A FEW TAKEAWAYS FROM THE DISHWASHER EXPERIENCE

Systems engineering is at the heart of what we do and certainly an essential organization capability to enable Lean PD. A lot of value can be unleashed.

Vision trumps the perfection of the path forward: the team chose to believe in the end state and accepted “building the plane as we flew it.” Don’t worry if everything is not perfect at once.

Leadership matters, and not just from the hierarchical leader but also other thought leaders, as role models!!

- Admit when you are not sure of the path and recognize quickly when something does not work
- Bring outside help if and when necessary: there are plenty of smarter people than yourself
- Support the team and be in the trenches especially when things get tough (e.g., whiteboard sessions)

There was also a right place - right time effect! The sponsor was also the main beneficiary while the team had many elements in place and only needed the “glue.” This facilitated greatly the change management.
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Reflections and next steps
WE ORGANIZED OUR TEAM TO DESIGN AN ORGANIZATIONAL SYSTEM

PD system Architecture: Make sure that all the processes, tools and metrics interact positively to deliver the right organizational capabilities

- **Consumer Value planning**
- **Innovation and technology planning**
- **Architecture creation and Management**
- **Portfolio management, optimization**
- **Product development capacity planning**
- **Concurrent, simultaneous and modular engineering**
- **Project execution**

**Processes and Tools:**
- Recommended tools to simplify the analyses, the proper documentation to standardize the process and its usage

**Governance system:**
- Set the metrics to measure improvement
- Design a new organization structure with the right responsibilities and incentives
- Implement IT systems to facilitate the dissemination and standardization of the processes and metrics

**Mindsets & Behaviors:**
- Define the new expectations for all leaders (role model the new expectations, both managerial and thought leaders)
- Create the right reward & recognition for the PD teams
- Support the change effort with a strong capability building effort
System of Systems: We had many good building blocks but they needed to be put together. We started by linking our conceptual models to the physics-based ones.

First priorities were requirements management and system conceptual modeling.
Requirements and documentation needs to be organized and traceable.

First priorities were requirements management and system conceptual modeling.
NEW METRICS TO DRIVE THE RIGHT WORK

FROM

1. Architectures are proliferated to respond to point problems and their number is a plug
2. Product capability evaluated through validation tests which are subsystem and component focused
3. In home product quality assessed through failure rates
4. Lack of correlation between:
   a. customer satisfaction and failure rates
   b. lab standard testing and failure rates

TO

1. Architecture number monitored by business unit and part of business planning process
2. Consumer satisfaction criteria broken down to product performance metrics
3. Product performance evaluated as a process capability to predict consumer satisfaction
4. Subsystem level performance measures built as a decomposition of product performance requirements
NEW IT ARCHITECTURE IS BUILT FOR MB SYSTEM ENGINEERING

- Portfolio, Project, Resource mgmt
  - Transition to Model-based enterprise with MBSE & PLM integration
- Requirements Management (incl. SysML modeler & Lab requests manager)
  - Control Project scope
  - Control requirements & Verification methods
- ERP

One version of the truth + rigorous data control + actionable knowledge management
NEW ROLES ARE CREATED TO ENABLE SYSTEM ENGINEERING

- Define architecture roadmap to deliver the right level of attributes
- Owns the system model for the business units
- Maintain the complexity at optimum level
- Create and use system model for the business unit products
- Define technology roadmap to support the architecture roadmap
- Define fundamental trade-offs defining the architecture(s)
- Leverage the system model on a specific project to ensure seamless integration of sub-systems and delivery of attribute performance

Words and titles convey the new expectations with respect to system engineering
DRIVING CHANGE

What percentage of change efforts reach their target?

28-32%

And yet the method for driving change seems to have been documented in many books...

Kotter, ’95
Strebel, ’96
Miller, ’02
Gartner Group, ’02
Higgs and Rowland, ’05
Burns ’05
McKinsey & Co ‘06
AND WHY DO THEY FAIL?! 

- Leadership is not role-modeling the new desired behavior
- Employees fear the change due to a perceived lack of skills
- Employees do not understand the need for the change
- Employees don’t see anything for them in the change

Outcome of change effort:
- Success: 30%
- Lack of leadership support: 25%
- Employee resistance: 25%
- Lack of resources: 10%
- Other: 10%
AMBITIOUS AND COHERENT TRAINING PROGRAM TO BUILD SKILLS

Introductory System Engineering Class, focus on:
- Fundamental concepts of function and form
- Interactions and degrees of freedom
- Concepts of Emergence and trade-off curves

Advanced class, focus on:
- Architecture decisions
- Requirements management
- Functional decomposition and target setting

Modeling class, focus on:
- SysML and OPM
- Create actual models

More Selective Audience

Must graduate from previous training to move on to the next level:
- <500
- ≥1,000
- >3,000
THE ROLE OF THE GLOBAL SPONSOR IS COMPLICATED

Sr Leadership

SPONSOR(S)

Working staff in PD areas

Role of the sponsors

- Create and share a vision to align the organization
- Provide support when things are difficult
- Ensure resources are available when necessary
- Manage Sr leaders’ expectations (e.g., timing of improvement)
- Support experiments
- Emphasize early wins to create more excitement
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REFLECTION: CHANGE ON A LARGE SCALE IS HARDER...

More support required to accompany the change despite good buy-in from organization due to operational constraints => Answer: Re-shift the focus of training in short term

Going big so fast is stretching the proficient change agents/thought leaders past the point where they can support all the teams => Answer: Create communities of practice

Must stay ahead of the change curve to anticipate potential pitfalls as the larger organization will not be as patient as the dishwasher team was => Answer: Leverage outside sources to minimize risk of wrong turn/dead end in the change journey

Attempting Big and Good at the same time is a stretched endeavor that requires tight expectation management
NEXT STEPS ARE ALL ABOUT DELIVERING

Accelerate projects execution by leveraging the system decomposition: small-batch work with high confidence in future system integration will increase speed

Build robust technology roadmaps by understanding trade-offs and technological ways to break them: the technology-driven innovation is then created

Reduce drastically the number of architectures: Understanding and planning of functional roadmaps prevents early replacement of still-capable architectures

The hard work is beginning: the organization has just built the foundations!
Laurent Borne
Vice President
Global Dishwasher Platform
Product Development Excellence

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