How to implement and measure the effects of Robust Design

Martin Ebro
Robust Design Specialist (Valcon) & PhD Candidate (DTU)
“How can your method be implemented in an organisation?”

“What is the cost/benefit of implementing your method?”
Agenda

• Why RD is necessary
• Why RD is not used
• How RD can be used
• The effects of using RD
• ~7 years product development
• ~5 years process development
• ~3 years Ph.D. candidate
Why Robust Design?

**Visible costs of non-quality:**
- Customer complaints
- In-market service
- Product recalls

**Hidden costs of non-quality:**
- Rework of inventory and production equipment
- High scrap rates
- Increased quality control
- Launch delays
- Increased R&D costs
- Wrong use of R&D resources
- Tight tolerances
- Variation in performance

Image: stocktouch.com
R&D Resource Expenditure
Index 100 = Expenditure @ Design Verification

Consumer Electronics Company

PROJECT A
PROJECT B
PROJECT C
PROJECT D
Change Notes

- Analysed 8 projects:
  - 800 Change Notes (Design changes after Design Verification)
  - 65% related to Mechanical Design
  - 63% of Mechanical Change Notes related to Robust Design (41% of total)

### Change Notes by Class

- **M Design Clarity**: 32%
- **M Tolerances**: 31%
- **M Process**: 11%
- **M Noise**: 8%
- **M Unknown**: 7%
- **M DFA**: 5%
- **M Structural**: 4%
- **M Usability**:
- **M Moulding**:
- **M Stability**:

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**ISoRD14 Key Note**

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August 2014
Agenda

• Why RD is necessary
• Why RD is not used
• How RD can be used
• The effects of using RD
To which extent is RD used in industry

**Surveys**

Swedish industry

[Gremyr et al, 2003]

UK industry

[Araujo, 1996]

US Industry & Military

[Thornton, 2000]

The extent to which robust design methods are known in the Swedish manufacturing industry. [87 respondents] [Gremyr et al, 2003]
To which extent is RD used in industry

**Surveys**

Swedish industry  
[Gremyr et al, 2003]

UK industry  
[Araujo, 1996]

US Industry & Military  
[Thornton, 2000]

The extent of use of robust design methods in the Swedish manufacturing industry. [24 respondents]  
[Gremyr et al, 2003]
To which extent is RD used in industry

Experience from industry

• Testing
• Tolerance Analysis
• FMEA
Reasons

“major part of research on RDM has focused on developing statistical techniques”.
- Gremyr [2003]

“lack of quantitative models that enable a design team to make quick and accurate decisions”
“that there is large body of literature but the tools are too complex”.
- Thornton [2000]

“tools require experienced or trained staff”
- Araujo [1996]

“Easier to use testing, quality control and high-precision production than analyses and simulations”
Agenda

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Some have success!

1. What have they done
2. What were the effects

4 case companies
1. Medical devices
2. Automotive
3. Defense
4. Aerospace
**TQM&BE: How to implement and apply Robust Design: Insights from industrial practice** [Lars Krogstie, Martin Ebro, Thomas J. Howard – 2014]

<table>
<thead>
<tr>
<th>MEDICAL DEVICES</th>
<th>DEFENSE</th>
<th>AEROSPACE</th>
<th>AUTOMOTIVE</th>
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</thead>
<tbody>
<tr>
<td><strong>WHY</strong></td>
<td>Internal cost of poor quality</td>
<td>Cost of Non-Quality:</td>
<td>Cost of Non-Quality:</td>
</tr>
<tr>
<td>Delays in late design stages</td>
<td>Resources tied up in control and inspection.</td>
<td>Expensive “in service” changes</td>
<td>Avoid failures in market</td>
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<tr>
<td>Shorter and more predictable lead-time.</td>
<td></td>
<td>Cost of redesign due to validation procedures.</td>
<td>Maintain brand reputation.</td>
</tr>
<tr>
<td><strong>HOW</strong></td>
<td>Gradual implementation of Six Sigma and DFSS-practices</td>
<td>Training of engineers + chief design engineers</td>
<td>Toolbox of 15+ RD tools</td>
</tr>
<tr>
<td>Defined roles and responsibilities</td>
<td>Defined System Engineer role.</td>
<td>Certification scheme with robustness.</td>
<td>Training and coaching (after failed attempt using external trainers).</td>
</tr>
<tr>
<td>Robustness Cockpit with 6 KPI’s and requirements.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CHALLENGES</strong></td>
<td>Resistance to change</td>
<td>Different perception of the novelty in the initiative</td>
<td>Unsuccessful ‘tool-pushing’ by external consultants</td>
</tr>
<tr>
<td>RD seen as an add-on to existing development activities.</td>
<td>Lacking adoption of RD-tools and methods</td>
<td>The initial process towards RD was over-formalised.</td>
<td>No acknowledgement of need for change.</td>
</tr>
<tr>
<td>Visualising the usefulness of DoE after to initial unsuccessful use.</td>
<td></td>
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</tr>
<tr>
<td><strong>SUCCESS FACTORS</strong></td>
<td>Gradual implementation of Six Sigma practice Consistency in definitions of framework.</td>
<td>Training and courses focus on chief design engineers</td>
<td>Engagement and training of middle management</td>
</tr>
<tr>
<td>Personal qualities and competencies of chief / lead engineers</td>
<td></td>
<td>Having tools that are used on daily basis.</td>
<td>Transition from external “tool-pushers” to internally driven processes.</td>
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<tr>
<td>Coaching and support of lead engineers.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>EFFECTS</strong></td>
<td>Cross-functional collaboration</td>
<td>More insight into their own design &amp; understanding of the product behaviour</td>
<td>Stronger focus on knowledge and facts</td>
</tr>
<tr>
<td>Guidance on how to develop good designs</td>
<td>Design reviews increased insight in design features.</td>
<td>Saved time in PD-process.</td>
<td>Increased understanding of the root causes of failures.</td>
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<td>Increased transparency for management.</td>
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Training, roles and responsibilities

Substantial training – typically 5+ days for all engineers

Ongoing coaching and support from internal consultants

Dedicated roles and responsibilities:
- Chief engineer
- Lead engineer
- Belting system (green/black belts)
# Processes, methods and tools

Integration into product development manual

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<tr>
<td>• 6 KPI’s</td>
<td></td>
<td>Cross-functional reviews</td>
<td>Projects required to use RD tools, but can choose which ones</td>
<td>Projects required to define strategy for dealing with variation and noise.</td>
</tr>
<tr>
<td>• KPI’s presented at gate review meetings.</td>
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<td></td>
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</tr>
<tr>
<td>Tools</td>
<td>Specific procedure and tools for each KPI.</td>
<td>DfSS-tools</td>
<td>Toolbox with 40+ tools</td>
<td>Robust Design Toolbox (15+ tools) provided and supported</td>
</tr>
</tbody>
</table>
## Success factors

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<td>• Competencies of chief / lead engineers</td>
<td>• Gradual implementation of Six Sigma practice</td>
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Agenda

• Why RD is necessary
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Effects

- Increased transparency for management
- Insight into own designs & root cause of failures
- Stronger focus on knowledge and facts
- Guidance on how to develop good designs
- Cross-functional Collaboration
- Fewer specs on drawings
- Fewer milestone delays
- Shorter product development time
Expected effects and how to measure them

- Shorter leadtime
- Fewer milestone delays
- Fewer mould iterations
- Fewer QC resources
- Fewer R&D resources after Design Verification
- Improved First Time Yield
- Reduced Customer Complaint Rate
- Reduced number of Change Notes
- Lower tolerance demand on production drawings
- ...
Effect measurements

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DTU Mechanical Engineering
ISoRD14 Key Note
August 2014
Effect measurements – first results
Summing up

- Why RD is necessary
- Why RD is not used
- How RD can be used
- The effects of using RD
ISoRD14 Proposal

• How do we develop a Robust Design paradigm that will be adopted by industry?

• How do we measure and quantify the effects of Robust Design?
Questions and comments