Business case – Cost of Poor Quality (COPQ)

Cost of Poor Quality (COPQ) is one of the largest cost items for manufacturing, estimated at 15% to 30% of revenue *

- $72Bn pa warranty-related (c. 4% revenue)
- Internal costs (right first time and yields) $950Bn lowest estimate**
- Excludes non-warranty service e.g. maintenance and PLM costs

* International Journal of Engineering Dec-12 average was 20%, Wang, Bhote, Juran and Crosby cite up to 40% in some cases
** Warranty costs apply to certain industries, internal costs apply to all manufacturing industries, globally $6.8 Trillion market

Manufacturing Priorities

- Improve quality/right first time
- Warranty cost reduction
- Avoid recalls/protect brand

Warranty Related Spending

Manufacturing Challenges

- Increasing complexity of products and processes
- Fault-finding as a manual hypothetical process
- Data issues – both overload and quality

* Mostly aerospace. Note that this excludes service costs post-warranty
Background

Warwick Analytics’ disruptive patented technology stems from over a decade of academic research in the US and UK originating from six-sigma failures in complex manufacturing.

Initial deployments in electronics, the automotive sector and aerospace. However it has also been applied to the provision of healthcare services, utilities and other services.

The Technology

Core technology is rapid root cause analysis (RCA) for product faults and process bottlenecks:

- Zeros in on fault cause regions without knowing what the fault is
- Detects fault region in either the manufacturing process or the design even where No Fault Found (NFF)
- Non statistical, non-hypothesis – can deal with dirty and/or incomplete data
Warwick Analytics “RCASE“ analyses disparate data to rapidly zero on fault, and recommend best-fix

### Critical Parameter Identification
- Key Product/Design Measurements
- Key Process Measurements

### Fault Types
- Out-of-Tolerance Failures
- In-tolerance Failures

Corrective action dependent on ROI and Value Chain

1. Adjust manufacturing/supply chain
2. Redesign product
3. Predictive Maintenance and Test/Service/Field Strategies

### RCASE
- OEM MES Databases
- Supplier MES Databases
- Test/Field/Warranty Databases
- Design Models

### HANA
**Increased Yield and Reduced Cost of Manufacture**

- Increase yield of specific/multiple product lines
- Reduce scrap, wastage and increase profitability
- Free up resources

**Reduced Maintenance/Service Costs**

- Reduce time to resolve problems
- Validate genuine warranty costs
- Prevent warranty costs and recalls with predictive maintenance

**Internal Cost of Poor Quality** (excluding warranty)

<table>
<thead>
<tr>
<th>Costs of Poor Quality</th>
<th>Current State</th>
<th>Possible State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework Time</td>
<td>75% + reduction</td>
<td></td>
</tr>
<tr>
<td>Scrap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem &amp; Root Cause ID</td>
<td>10% to 30% of Revenue</td>
<td></td>
</tr>
</tbody>
</table>

**Warranty Resolution Lead Time** (typical automotive)

<table>
<thead>
<tr>
<th>Time to Process a Claim</th>
<th>Current State</th>
<th>Possible State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Resolution</td>
<td>160 – 220 days</td>
<td></td>
</tr>
<tr>
<td>Problem &amp; Root Cause ID</td>
<td>50% + reduction</td>
<td></td>
</tr>
<tr>
<td>Claim Settlement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Indicative Savings - EWAP**

**Percent of Overall Sales**

- Fault Analysis & Redesign
- Yield Wastage
- RFT Wastage
- Downtime/delays due to quality
- Warranty Related Costs
- Warranty Claims

**Better Lifecycle: Quicker Launch, Costs, Safety & Environment**

**The “Bathtub Curve”**

- Early failures in infant mortality period
- Random failures occur during the “useful life” period
- Failure rates grow as the product wears out
• Data silos; disparate and unstructured
• Systems not all online
• Cannot resolve problems or optimize each part in isolation
• HANA data warehouse = ‘real-time knowledge repository’
• Use case benefits in own right
• Further use case benefits from global problem solving and optimization Apps
• Not just cost savings: Further revenue opportunities
  • extended warranty
  • Quicker product launch/innovation
  • Quicker customer fulfillment, even with customization
Enhanced Prognostics and Real-Time Recommended Action

Root Cause Analysis

Predictive and Preventative Maintenance

HANA data warehouse

Operations/Service Center

EARLY WARNING AND PREVENTION (EWAP)

Maintenance 4.0
Utilities

**Asset Maintenance**
- Provides additional profitable revenue streams as well as cost-saving
  - e.g. customer premise predictive and preventative maintenance
  - Maintenance strategies and real-time tactical responses
  - Doesn’t wait for ‘statistical significance’
- Longer-term optimisation of design of assets and parts

**Grid Management**
- Quasi real-time, data driven root cause analysis for faults and issues
- Optimisation and capacity planning
- Energy trading – looking for the causes of prices/demand-supply inequalities

**Insight Beyond Other Techniques in Complex Issues**
- Statistical techniques are limited
- Warwick Analytics technology (RCASE) benefits:
  - doesn’t require hypotheses or setting up multivariate statistics
  - Works with incomplete/dirty data
  - Will always narrow down searchspace (i.e. always provide a result)
Asset Maintenance

- Predictive and preventative maintenance
  - Prognostics + root cause to assess what needs fixing and when
  - Maintenance strategies and real-time tactical responses
  - Doesn’t wait for ‘statistical significance’
- Longer-term optimisation of design of assets and parts

Resource Prospecting

- Complements the many sophisticated software packages and specialist companies
  - The more complex the problem, the greater utility and synergy with these
- Looking for causes/signals of resource assets and potential issues
  - Assist location of resources by root cause of contributing data/factors
  - Ditto in terms of issue identification (e.g. fracking or drilling issues)

Additionally: Insight Beyond Other Techniques in Complex Issues

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Healthcare

**Improve Quality**

- Healthcare organisations are under increasing pressure to increase quality targets and service delivery whilst at the same time saving costs.

- **PathwayClear** from Warwick Analytics is software that identifies and fixes operational bottlenecks in care pathways from care data.
  - Derived from manufacturing R&D at Warwick University Digital Healthcare Lab
  - Proven in Stroke, ED (A&E), theatre and other care pathways at hospitals and elsewhere

**Case Study**

- University Hospitals Coventry & Warwickshire (UHCW) failing on stroke target
  - Less than a year later was above standard

- As well as achieving targets and improving outcomes, financial benefit:
  - £408,011 per annum
  - Savings across A&E, Stroke Unit and Direct Care
  - Trust very happy
  - One of largest improvements for single project
  - Looking to extend to other areas A&E and other acute
Many situations looking for analytical edge

- Trading: quicker identification of indicators/events
- Investing: better insight/understanding of fundamentals
- Infrastructure: greater efficiency

Key is looking for **causality** while using dirty and incomplete data – Information Theory not just statistics

Provide prediction of shocks/events/step-changes not just trends

<table>
<thead>
<tr>
<th>Methods</th>
<th>Problem data structure</th>
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<tbody>
<tr>
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<td>Regression using GLM (logit, probit)</td>
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<td>Root cause analysis (Warwick Analytics)</td>
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Retail

- Analytical edge for understanding and predicting consumer behavior beyond statistical modeling – complimentary
  - What products are bought together and influencing behavioral factors
  - Customer segmentation/cluster analysis without hypotheses
  - Optimize store, web, supply chain, marketing
  - Fraud detection and prevention by cause

- Key is looking for **causality** while using **dirty and incomplete data** – Information Theory not just statistics
- Provide prediction of shocks/events/step-changes not just trends

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<tr>
<th>Methods</th>
<th>Non-normal distribution, Different covariance structure</th>
<th>Multiple and disjoint fault regions</th>
<th>Interpretation of result</th>
<th>Uncertainty and error in data classification</th>
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<td>Regression using GLM (logit, probit)</td>
<td>×</td>
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Public Sector

Security and Policing
- Identifying parameters of behaviour
  - criminology – real time analysis for prevention and tactical monitoring
  - External factors causality – economy, weather etc.
  - Linking together disparate sources – web/comms/profile

Citizen Behaviour
- Citizen segmentation – policy making
- Reducing risk/fraud by cause identification

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Why SAP HANA for Warwick Analytics

• WA solution is computationally intensive as well as big data
  • Quasi-real-time with HANA
  • Algorithms optimised for HANA
  • Use case from 36 hours to 35 seconds!
  • Reduces load times

• Roadmap based on HANA capabilities
  • Native algorithm (further speed/performance)
  • R integration (statistical reporting on our non-statistical rules)
  • Other features on roadmap – streaming and parallelism/distributed architecture

• Cloud deployment pathway (HANA One) moving to on-premise

• Enhanced ‘data warehouse’ – Early Warning and Prevention System
CASE STUDIES
No-Fault Found Battery Issue (Mobile Industry) - Background

Process
Mobile phone assembly process

Data
(i) Manufacturing Data
(ii) Service Data

Pareto Analysis
Illustration of Top-5 Warranty failure out of 23 reported failure
Data associated with NFF-battery failure

Critical parameter identification

- FREQ_OFFSET_FX
- FREQ_OFFSET_FY
- WARP_RESOLUTION
- AVG_PWR_NL_F5
- RXBER_111_F1_0_0K
- AUTOPWRSP_F1
- AGC_TR_TUNING

Out of 170 Parameters 2 parameters which explains the NFF-battery problem are identified

Identified Parameter

Fault Region

- Boundary Region (BND)
- Warranty Fault Region (WFR)
- Normal Region (NR)

Warranty Fault Region is Identified based on Data Mining Kernel

Design was rectified and SPC controlling process to eliminate failure