Simpler Industrial and Business Process Redesign.

By
Mike Sondalini
Lifetime Reliability Solutions
Biography

Qualifications:
Tradesman Fitter Machinist
Professional Mechanical Engineer (1st Class Honours)
Project Engineer
Maintenance Engineer
Master Business Administration
Maintenance Manager

Engineering and Business Work History:
Nova Machinery – Manufacturer Press Brakes & Guillotines
Swan Brewery – Beverage
Riverton Engineering – Sheet Metal Fabrication
Coogee Chemicals – Mining & Agricultural Chemicals Manufacture
Lifetime Reliability Solutions – Lean, Life Cycle Asset Management, ISO 9001 Quality Consulting
• Three universal problems in business...

1. *Wasted effort* and wasted resources

2. *Wrong business process for the purpose*

3. *Wide and out-of-control process variation*

• Process redesign means finding highly effective solutions that address them.
Need to Achieve Process Control **and** Capability

- **In control and capable**
- **In control but not capable**
- **Out of control**

*Figure 8.3: Progression of a Process to Capability*
The Concept of a Quality Loss Function

Loss Functions can take a range of shapes

A Variable Factor

Minimum Loss

Terrible Quality

Optimal Quality

Excessive Quality

Cost of Loss/Waste
Taguchi ‘Loss to Society’ Function

**Losses from deficient quality**

**Waste from needless quality**

Taguchi Loss Function

- **Lower specification limit**
- **Upper specification limit**
- **Target value**

Concept First Developed in 1960
Bolt Tensioning Loss Function

**Minimum Loss**

**OPTIMUM SERVICE**

**Excessive Bolt Tensioning**

**Bolt Tensioning**

**Cost of Loss/Waste**

- **Terrible Bolt Tensioning**
- **Optimal Quality**
- **Excessive Bolt Tensioning**
The ‘Loss to Society’ of Poorly Kept Machines

- Unbalance: Contamination
  - Geometric Centerline
  - Heavy Spot
- Wrong Fit: Distortion:
- Vibration:

Bad Practice:
- Lower specification limit
- Upper specification limit
- Misalign: driver shaft
- Driven shaft
- LOST VALUE
- Target value
- Optimal Quality
- Excessive Quality

Waste from needless quality

Losses from deficient quality

Optimal Quality

Excessive Quality

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Maintenance Planning Loss Function

OPTIMUM SERVICE

Cost of Loss/Waste

Minimum Loss

Terrible Planning

Optimal Quality

Optimal Service

Excessive Planning

Minimum Loss

Optimal Planning

Excessive Planning

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Maintenance Planning Cost Loss Function

Cost of Loss/Waste

Minimum Loss

Insufficient Time

Optimal Quality

Excessive Time

Cost of Maintenance Planning

OPTIMUM SERVICE

Optimal Quality

Waste/Excessive Time
Distribution of Work Quality Performance

Frequency of Outcome

- Unbalance: Offset Mass Centerline
- Contamination
- Wrong Fit:
- Distortion:
- Bad Practice:
- Misalign: Driver shaft, Driven shaft
- Vibration

Unbalance:
- Geometric Centerline
- Heavy Spot

TERRIBLE RELIABILITY
(Early Life Breakdowns)

TERRIFIC RELIABILITY
( Exceptional Service Life)

Maintenance Work Quality

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Combining Work Quality and Loss Function

Frequency of Outcome

Cost of Loss/Waste

Minimum Loss

Lower

OPTIMUM

Upper

TERRIBLE

TERIFIC

Maintenance

Work Quality
Work Quality that Minimises Loss and Waste

![Diagram showing the relationship between work quality and cost of loss. The x-axis represents work quality categories (TERRIBLE to TERRIFIC), and the y-axis represents frequency of outcome. The cost of loss is minimized at the OPTIMUM QUALITY point.]

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Work Quality that Optimises Reliability

Frequency of Outcome

Cost of Loss

Minimum Loss

TERRIBLE

OPTIMUM RELIABILITY

Upper

Lower

TERRIFIC

Maintenance Work Quality
Work Quality that Makes Money

Maintenance Work Quality

Frequency of Outcome

Cost of Loss

Lower

OPTIMUM

Upper

Minimum Loss

TERRIBLE

TERRIFIC

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Where the Money is in ‘Quality’

More profits from optimum quality

No losses from deficient quality

No waste from needless quality

Optimal Quality

Terrible Quality

Excessive Quality

Frequency of Outcome

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Process Redesign to Improve Efficiency

“Doing things right.”
Process Redesign to Improve Effectiveness

“Doing right things.”
Changing Process Variation and Outcomes

Distribution Curve of Variation in a Process

• Uncoil a paper clip and bend it as instructed by the Presenter. Carefully count the number of cycles until it breaks.

• Develop a distribution of the count of the number of cycles to failure.
Standardised Work means...
‘developing the one best way’
We all need clear Targets that we can SEE.

How do You know You have got full marks?
What do we mean by....

Quality, Precision, Repeatability, Variability

Accuracy

Precision

Specification

Variability = Range of Outcomes

Quality

High Quality

Precision

Accuracy

Range of Outcomes = Variability

Repeatability is low in this process

Unwanted Variability = Unwanted Outcomes
Reliability Creating 3T Error Proof Procedures

Build Mistake Proofing into SOPs

- Set a **target** for each task.
- Specify the acceptable **tolerance**.
- Do a **test** to prove accuracy.

---

**3Ts of Failure Prevention**

- **Target**
- **Tolerance**
- **Test**

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**Bands of Lesser Quality** (Decreasing Accuracy)

- ‘Good, Better, Best’
- ‘Bronze, Silver, Gold’

**Quality improvement occurs when variation is reduced**

**Specification**

**Range of Possible Outcomes**

**Target Precision**

**Frequency of Outcome**

**Output**

**Proof Test for Reliability**

**Tolerance for Quality**

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3T’s: target for quality workmanship

As MAGNIFICENT as it needs to be

As BAD as allowed

![Diagram showing 3T's: Perfect Result, World Class Target, Tolerance Limit]
Redesigning Processes for Intended Outcomes

Promote Attendance at EETD Sessions
PURPOSE: Provide well attended and successful technical sessions in a selected topic.

<table>
<thead>
<tr>
<th>MISSION MANAGEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Marketing provide qualified Prospects</td>
</tr>
<tr>
<td>• Marketing operate profitably</td>
</tr>
<tr>
<td>• Marketing process is in control and capable</td>
</tr>
<tr>
<td>• Marketing improve process results</td>
</tr>
<tr>
<td>• Projects advance on resourcing and internal capability</td>
</tr>
<tr>
<td>• Sales provide committed Customers</td>
</tr>
<tr>
<td>• Sales operate profitably</td>
</tr>
<tr>
<td>• Sales process is in control and capable</td>
</tr>
<tr>
<td>• Sales improve process results</td>
</tr>
<tr>
<td>• Operations Group handle course logistics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEMAND CREATION</th>
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</thead>
<tbody>
<tr>
<td><strong>DEMAND FULFILMENT PROCESS</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>Identify Training Topic</th>
<th>Identify Likely Customers</th>
<th>Select Training Venue</th>
<th>Select the Trainer</th>
<th>Create an Opportunity</th>
<th>Captivate with Benefits</th>
<th>Attendee Inquiry</th>
<th>Attendee Registration</th>
<th>Course Payment</th>
<th>Conduct the Training Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of Total Failure</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
</tr>
<tr>
<td>TARGET</td>
<td>High interest topic to many people</td>
<td>People are excited by the topic</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>TOLERANCE</td>
<td>General interest topic to many people</td>
<td>People want to know more about the topic</td>
<td></td>
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</tr>
<tr>
<td>TEST</td>
<td>Survey results confirm interest</td>
<td>People get value by attending</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>RISK ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk = Consequence x (Opportunity - [1-Chance of Success at each Opportunity])</td>
</tr>
<tr>
<td>Do not know what interests people</td>
</tr>
<tr>
<td>Small number of people interested</td>
</tr>
<tr>
<td>Topic is out-of-date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RISK CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey topics with 20 likely customers</td>
</tr>
<tr>
<td>Survey indicates high interest</td>
</tr>
<tr>
<td>Survey indicates high relevance</td>
</tr>
</tbody>
</table>

| Chance of Success Range | 90% |
Lean and Six Sigma fails Business when they are used for point solutions. For lasting success you need systemic solutions.
The aim of using Lean and Six Sigma practices

**Lean**
- Used to improve Effectiveness: are we doing the right things!
  - 7 Wastes
  - The ‘Hidden Factory’
  - Lean Thinking/Practices
  - Lean Tools
    - Value Stream Mapping
    - 5S: Workplace Management
    - Kaizen

**Six Sigma**
- Used to improve Efficiency: are we doing things right!
  - 6σ accuracy
  - Sigma Levels
  - The Variation Problem
  - Six Sigma Tools
    - DMAIC Process
    - 7 QC Analysis Methods
    - Visual Management
The Lean Concepts

1. Demand = Production = Supply
2. Continuous Flow
3. Use Pull Flow
4. Maximise the Value Stream
5. Demand to Pacesetter
6. Prevention not Rework
7. Apply Statistical Process Control (SPC)
8. Use Single Minute Exchanger of Dies (SMED)
9. Minimise Variation (Supply Chain Demand Amplification)
10. First In First Out (FIFO)
11. Minimise Inventory
12. Link and Match Processes
13. Use 5S Methodology
14. Load Levelling to Capacity
15. Even Mix to Pacesetter
16. Equal Batches Every Time (EBIT)
17. Shorten the Financial Reporting Cycle
18. Team Up (Autonomous Work Teams)
19. Minimise Waste
20. Apply to the Entire Supply Chain
21. Remove need to Sequence Products
22. Optimise Supply (JIT)
23. Optimise Customer Response
24. Measure at the Source
25. Innovate Continuously
26. TPM (Operator Driven Reliability)
Lean for Process Redesign

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Cost Reduction

Variation Reduction

A Quality Variable
Deming’s 14 Points for a Quality Culture

1. Create Consistency of Purpose
2. Remove Variation
3. Build-In Quality at the Source
4. Minimise Total Life Cycle Cost
5. Continuous Improvement
6. Create Learning In the Workplace
7. Servant Leadership
8. Drive-Out Fear from the Workplace
9. Remove Departmental Barriers (Team-Up)
10. Eliminate Slogans and Work Targets
11. Eliminate Imposed Job Quotas and Goals
12. Generate Pride of Craftsmanship
13. Continuous Self-Improvement through Training
14. Take Action to Improve Every Process
14 Points Process Redesign

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Cost Reduction
Variation Reduction

A Quality Variable

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All Our Businesses are Processes in Series

$R_{\text{business}} = R_{\text{process1}} \times R_{\text{process2}} \times R_{\text{process3}} \times \ldots \times R_{\text{process'N'}}$

Reliability ‘R’ is the **chance** of success.
How to Reduce the Chance of Failure

Chance of Failure = 1 – Chance of Success
Chance of Failure = 1 – Reliability

Risk = Consequence $ \times \text{Chance /yr}$

Risk = Consequence $ \times [\text{Freq of Opportunity /yr} \times \text{Chance of Failure at Each Opportunity}]$

Risk = Consequence $ \times [\text{Freq of Opportunity /yr} \times \{1 – \text{Reliability}\}]$

Here are some opportunities...

Excellent Lubricant Cleanliness
Correct Fastener Torque
Proper Fits and Tolerance
No Unbalance

Stop Deformation

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That means that maximizing reliability is not the best business objective. From a business standpoint we want to minimize risk.

Risk = [Consequence] x [Opportunity to Fail x (1 - Reliability)]

1 - reliability = unreliability = P(T ≤ t) at every opportunity for failure = failures/opportunity
opportunity = opportunities/time
consequence = cost/failure

• Risk = cost/time
• Reliability = Chance of success

The full Risk Equation is more Meaningful for examining Risk of Process Failure

Risk = [Consequence] x [Opportunity to Fail x Chance of Failure]

Risk = [Consequence] x [Opportunity to Fail x (1 - Reliability)]

Risk = [Consequence] x [Opportunity to Fail x (Unreliability)]
Business Risk is the Sum of Process Risks

\[ \text{Risk}_{\text{process}1} + \text{Risk}_{\text{process}2} + \ldots + \text{Risk}_{\text{process}n} = \text{Risk}_{\text{business}} \]
We have three ways of minimising Risk

Risk = [\text{Reduce consequence}] \times [\text{opportunity to fail} \times (\text{unreliability})]

\[\textbf{CONSEQUENCE REDUCTION} \quad \textbf{CHANCE REDUCTION}\]

1. Increase reliability = Decrease unreliability = Fewer failures/opportunity
2. Reduce opportunity to fail = Fewer opportunities/time
3. Reduce consequence of failure = Less cost/failure

\[\text{*Reduce Failure Frequency}\]
Reducing Businesses Process Risk

The Business

$R_{\text{business}}$

Receivables → Manufacture → Assembly → Despatch → Customer

$\text{Risk}_{\text{process1}} + \text{Risk}_{\text{process2}} + \ldots + \text{Risk}_{\text{process‘n’}} = \text{Risk}_{\text{business}}$
### Risk Reduction – Reduce Chance, Opportunity or Consequence?

**Risk ($/yr) =** Consequence of Failure \times Frequency of Failure

**Risk =** Consequence of Failure \times \left[ \text{Opportunity to Fail} \times (1 – \text{Chance of Failure}) \right]

#### Consequence of Failure Reduction Strategies

Strategies presume failure event occurs and act to minimise consequent losses

- Preventive Maintenance
- Shutdown Maintenance
- Predictive Maintenance
- Non-Destructive Testing
  - Vibration Analysis
  - Oil Analysis
  - Thermography
  - Motor Current Analysis
- Total Productive Maintenance (TPM)
- Prognostic Analysis
- Criticality Analysis
- Emergency Management
- Computerised Maint Mgmt Syst (CMMS)
- Key Performance Indicators (KPI)
- Risk Based Inspection (RBI)
- Operator Watch-keeping
- Value Contribution Mapping (Process step activity based costing)
- Logistics, stores and warehouses
- Defect and Failure True Cost (DAFTC)
- Maintenance Engineering

#### Opportunity to Fail Reduction Strategies

Strategies prevent opportunities for a failure event arising

- Engineering / Maintenance Standards
- Statistical Process Control
- Degradation Management
- Reliability Growth Cause Analysis (RGCA)
- Lubrication Management
- Hazard and Operability Study (HAZOP)
- Hazard Identification (HAZID)
- Failure Design-out Maintenance
- Failure Mode Effects Analysis (FMEA)
- Hazard and Operability Study (HAZOP)
- Root Cause Failure Analysis (RCFA)
- Precision Maintenance
- Training and Up-skilling
- Quality Management Systems
- Planning and Scheduling
- Continuous Improvement
- Supply Chain Management
- Accuracy Controlled SOPs (ACE 3T)
- Design, Operation, Cost Total Optimisation Review (DOCTOR)
- Reliability Engineering

#### Chance to Fail Reduction Strategies

Strategies reduce probability of failure initiation if failure opportunity present

- Training and Up-skilling
- Oversize / De-rate Equipment
- Hardier Materials of Construction
- Personal Protective Equipment (PPE)
- Segregation / Separation
- Controlled Atmosphere Environment e.g. +ve / -ve pressures, explosion proof atmos

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Interestingly, Chance Reduction choices are best made during design.
The Cross-Hair Game: Observing Business Process Outcomes

How do you hit the bulls-eye every time?

Cross-hairs and 10 mm diameter circle
‘Cross Hair’ Production Process Distribution

![Graph showing frequency distribution with hits inside 10mm circle and performance achieved vs required.]

Performance Achieved

Performance Required

Hits inside 10mm Circle

Frequency

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Where does Failure Start in a Process?

Problems start with ‘chance’ variation... for example

Where does Failure Start in a Process?

Problems start with ‘chance’ variation... for example
How Chance Tricks Us so We think ’Feel’ is Fine

Variation in Torque on a Bolt

- Feel – Operator judgement
- Torque Wrench
- Turn-of-the-Nut
- Load Indicating Washer
- Fastener Elongation
- Strain Gauges

(For ‘Feel’) ±3 Std Devn – 99.7%
±2 Std Devn – 95.5%
±1 Std Devn – 68.3%

Accuracy

Relative Cost

± 35% 1
± 25% 1.5
± 15% 3
± 10% 3.5
± 5 - 10% 15
± 1% 20

Number of Events

Torque

± 1 Std Devn
- 15%
+ 15%

± 2 Std Devn
- 35%
+ 35%

± 3 Std Devn
- 68.3%

± 4 Std Devn
- 95.5%

± 5 Std Devn
- 99.7%

Opportunity!!

± 1 Std Devn – 68.3%

± 2 Std Devn – 95.5%

± 3 Std Devn – 99.7%
# Risk from Fastening Process Choice Variation

$$\text{Risk} = [\text{Consequence}^3] \times [\text{Frequency}]$$

$$\text{Risk} = [\text{Consequence}] \times [\text{Opportunity to Fail}^2 \times \text{Chance of Failure at Opportunity}]$$

$$\text{Risk} = [\text{Consequence}] \times [\text{Opportunity to Fail} \times (1 - \text{Reliability})]$$

## Risk from Fastener Tensioning Method Process Variation

<table>
<thead>
<tr>
<th>No</th>
<th>Tensioning Method</th>
<th>Distribution</th>
<th>Reliability</th>
<th>Unreliability (Area outside ± 10% of 'Feel')</th>
<th>At Risk Fasteners per 100 Bolt/Nut Sets(^2)</th>
<th>Opportunity of Error</th>
</tr>
</thead>
</table>
| 1   | Operator Feel           | ± 35%        | 0.65        | 0.35                                          | 35                                            | 1) From outer distribution of tensioning method choice  

2) Other events not related to tensioning method choice |

| 2   | Torque Wrench           | ± 25%        | 0.8         | 0.2                                           | 20                                            | 1) From outer distribution of tensioning method choice  

2) Other events not related to tensioning method choice |

| 3   | Turn of Nut             | ± 15%        | 0.95        | 0.05                                          | 5                                             | 1) From outliers of tensioning method choice  

2) Other events not related to tensioning method choice |

| 4   | Loading Indicating Washer | ± 10%     | 1\(^{1}\)  | 0                                             | 0                                             | 1) From extreme outliers of tensioning method choice  

2) Other events not related to tensioning method choice |

| 5   | Fastener Elongation     | ± 5%         | 1\(^{1}\)   | 0                                             | 0                                             | Other events not related to tensioning method choice          |

| 6   | Strain Gauges           | ± 1%         | 1\(^{1}\)   | 0                                             | 0                                             | Other events not related to tensioning method choice          |

**Note 1:** Based on research of tension method performance, at around ± 10% of required fastener tension there is substantial reduction in connection failures.

**Note 2:** Each bolted fastener is an opportunity to be incorrectly tensioned

**Note 3:** Consequence is presumed to remain the same for each event (mostly not true, which is why determining Criticality first is vital for good maintenance decisions.

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Lean and Six Sigma fails Business if they do not change the Business System.

THANK YOU.

Mike Sondalini
Lifetime Reliability Solutions