FMECA in Action

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Today

1. Background on Energy Australia
2. What is FMECA?
3. FMECA and OPEX
4. FMECA and Capex

Overview - About us...

• State Owned Corporation
• The largest single electricity network in Australia
• Distributing electricity to the Sydney, Central Coast and Hunter regions
• Services more than 1.6 million customers across a 22,275 square kilometre area
• Distributes more than 28,700 GWh of electricity annually
• Peak demand 5,868MW
Overview - Asset base

• $36 billion Network assets
• Consisting of
  – 4,700 km of sub-transmission voltage conductors
  – 17,000 km of high voltage conductors
  – 28,000 km of low voltage conductors.
  – More than 230 Zone and transmission Substations
  – More than 29,000 distribution substations.
  – More than 550,000 poles
  – Approximately 250,000 street lights

How did Energy Australia’s Asset Management framework mature?

• “Our maintenance is broken, I want you to fix it”
• FMECA / RCM methodology adopted
• FMECA / RCM and Regulatory framework drove the need for information
• Maintenance needs evolved into asset management
  – Defect reporting linked to analysis
  – Maintenance cannot fix it if it’s the wrong asset for the business
  – Development of asset tools and economic models requiring both technical and financial information
  – iAMS
Why Do FMECA?

• The basic approach of regulation is:

   Where the network operator can show that in its circumstances the work is justified, it must be allowed to recover the efficient cost of performing the work.

• So how does FMECA help?
What is FMECA?

• Failure Mode, Effect and Criticality Analysis – a Structured analysis process for:
  – Identification of equipment/system functions
  – Identification of functional failures
  – Identification of Failure Modes
  – Identification of the effects of the failure
  – Assessing criticality of the failure

• Uses
  – Elimination of undesirable failure modes during design
  – Input to RCM Analysis
  – Input to asset condition risk assessment
  – Input into asset safety assessment

What is RCM?

Reliability Centred Maintenance

• An analysis process centred on achieving inherent levels of equipment safety and reliability at minimum cost.

• History:
  – Original reliability work conducted (1945)
  – Logic process first defined by United Airlines (1965)
  – Expanded to support the Boeing 747 program (1972)
  – Adapted by Royal Australian Air Force (1975)
  – Seminal RCM document by Nowlan and Heap for DoD (1978)
  – Adapted from RAAF to the Victorian rail industry (1986)
  – Now accepted practice across all commercial industry
RCM analysis

• Asks seven questions
  – What assets are important to the business?
  – What is the asset’s function(s)?
  – How does it fail to perform that function?
  – Why causes it to fail?
  – What happens when it fails?
  – How can that failure be managed?
  – What can be done if the failure cannot be managed?

FMECA

• Selects maintenance tasks from five possible options
  – examines items to detect potential failures
  – restores items before a maximum age
  – discards items before a maximum age
  – checks items to find failures that are not evident
  – applies default tasks of “run to failure” or “redesign”

• The TMP is the sum of the above tasks for each asset that are applicable and effective in managing the effects of failures.
FMECA/RCM model (maintenance)

<table>
<thead>
<tr>
<th>Function</th>
<th>Failure Mode</th>
<th>Failure Cause</th>
<th>Failure Effect</th>
<th>Valid TASK</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Lubrication/Service</td>
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<td>Condition Monitor</td>
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<td>Hard Time Rework</td>
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<td>Hard Time Replace</td>
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<td></td>
<td>Combination</td>
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<td></td>
<td></td>
<td>Failure finding</td>
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<td></td>
<td></td>
<td>EFFECTIVE</td>
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<td></td>
<td>MTBF</td>
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<td></td>
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<td></td>
<td>Maintenance cost</td>
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<td>Repair cost</td>
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<td></td>
<td>Service loss cost</td>
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<td></td>
<td></td>
<td>Other loss cost</td>
</tr>
</tbody>
</table>

Task Frequency

- Operator Monitored
- Redundancy
- Safety/environmental
- Operational Impact
- Secondary Damage

- Maintenance cost
- Repair cost
- Service loss cost
- Other loss cost
- MTBF

FMECA/RCM

- Asset Register
- Works Orders
- Asset Management
- Strategy

Task analysis
- Repair / Renew Planning
- Planned Frequency
- Asset Renewals

FMECA and RCM
- Corrective Task
- Preventive Task
- Probabilistic Frequency
- Policy Frequency

Maintenance analysis
- Routine Maintenance Planning

Asset Management Strategy
- Defect report
- and work mgt
- Repair/Renew
- tools and plans
FMECA/RCM

FMECA and RCM

Routine Maintenance Planning

Repair / Renew Planning

Asset Renewals → Planned Frequency

Corrective Task → Probabilistic Frequency

Preventive Task → Policy Frequency

Asset Management Strategy

Assets

Function

Failure

Cause
How does this all fit?

FMECA & RCM

Tasks

Trigger

NTMP

Maintenance Standards

Equipment Manual

Worklists

MIMIR, SAP PM
What has been the result?

- 380 New maintenance standards were produced for 99% of the electrical network assets in 4 years.
- Some maintenance periods have been increased and some decreased.
- Reduced rates of ‘in service’ failures
- Inspection task backlogs reduced by 98.4 % over 3 years
- Mature Opex / Capex tradeoff approach
- Solid framework for maintenance requirements reviews

FMECA in OPEX

Regulatory Outcomes

- 1999-2009
  - Increased funding for System OPEX as the need for the work was clearly and objectively articulated
- 2009-14
  - System OPEX funding sustained

Why?

Robust methodology which provides greater transparency to the Australian Energy Regulator
FMECA in CAPEX

• Energy Australia’s capital programme of the 2009-14 period is $8bn of which approx 50% is replacement

• Capital Programme doubles again from 2004-9 including:
  – 50 new Zone/STS substations
  – Retire 40 Zone/STS substations
  – Replacement of 132kV oil cables – 141km
  – Replacement of 33kV cables – 155km
  – Significant replacement of aged 11kV switchgear
    • 1263 panels

• So where does FMECA Fit?

Replacement Strategy

• Our Operations Investment Managers monitor the failure rates and modes on our assets and identify assets which have emerging issues.

• We also monitor the asset performance via specialist committees which draw subject matter experts from the business to review incidents and raise issues

• An investigation is initiated via the replacement manager

• Improved data enables us to move from an age surrogate to an actual condition and risk based combined approach.
Replacement Subprograms

- Risk Assessment Report
  - The assets are identified
  - Risks associated with the asset and its environment are reviewed
  - A sample of assets and sites are visited and a risk assessment worksheet developed
  - The risk assessment worksheet is reviewed by the Operations Investment Team
  - All assets are visited and risk assessed by the one person. (Photos are taken where possible)
  - A risk rating is assigned to each asset

FMECA derived Risk Check List

<table>
<thead>
<tr>
<th>Electrical function</th>
<th>High risk</th>
<th>Medium risk</th>
<th>Low risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer bushings / Cooling</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Under / Transformer tank cover</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Transformer Support bracket / U-wash / Transformer tank</td>
<td></td>
<td></td>
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<tr>
<td>Lighting</td>
<td>Defective / missing</td>
<td></td>
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<tr>
<td>HV tank / PHNFS</td>
<td>Corrosion / Leaking / Insufficient labeling / Damaged</td>
<td></td>
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</tr>
<tr>
<td>LV panel</td>
<td>Corrosion / Damaged / Insufficient labeling / Loose / Aesthetics improper / Damage / All height unstable / Blocked</td>
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<td></td>
</tr>
</tbody>
</table>

| Oil contamination | Missing / inadequate / Cracked / Near waterfront | 1 | 0 |
| Ignitables materials in proximity | Near trees / Overhanging branch / house / piles / rack | 3 | 2 |
| Public in proximity | Near school / park / church / pedestrian walkway / dwellings | 4 | |
FMECA & Risk Assessment

Risk Score calculation & priority

- Total score = weighted sum of the risk rating (weightings determined by the consequence of failure of each failure mode)
- Final priority reflects the urgency of replacement in some locations the safety & environmental risks are the over-riding risk of the whole kiosk.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Total weighted score</th>
<th>Weighting</th>
<th>Threat</th>
<th>Consequence</th>
<th>Frequency</th>
<th>Severity</th>
<th>Likelihood</th>
<th>Final Priority</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>740</td>
<td>3</td>
<td>4</td>
<td>4</td>
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</tr>
</tbody>
</table>

Replacement Subprograms

- Risk Rated List of Assets
  - The assets are listed with their associated risk ratings or scores
  - These scores are sorted from highest to lowest
  - The order and scores are reviewed by a group of OIM team members as a sanity check
  - Priorities are allocated to the final list, with the highest priority for replacement being assigned to the number 1

- Replacement Plan 2009-14
  - $1.49bn + Area Plan projects
**FMECA and Asset acquisition**

- Design FMECA is just the first step
- Eliminates failure modes in appropriate point in asset lifecycle
- Provides a view of the residual risk to be managed by operations / maintenance
- Provides a framework to capture asset performance.
  - maintenance reviews over lifecycle
  - feedback to designers

If FMECA tells us how the asset fails….

And RCM tells us how to manage the failure mode

Then……

O&M manuals can be created to describe all tasks
  - Training requirements can be determined

For a quantified analysis
  - Task periods can be objectively determined
  - Spare parts needs can be objectively determined