A Physical Asset Modelling framework to guide implementation of computerised asset management systems (CAMS)

Craig Henry Pr Eng
Group Manager: Facilities
No shortage of world-class CAMS

Reality – Poor utilisation & ROI

Configuration
Asset modelling
Major parallel streams/disciplines

- **Building environment**
  - Facilities Management

- **Public/Economic infrastructure**
  - Infrastructure Asset Management

- **Industrial assets**
  - Reliability and Maintenance Management

- **All asset types**
  - Physical Asset Management
Effective management of physical assets

Effective decision support outputs

Right data structure, collection and analysis
Continuous Improvement – The Data to Decision Loop

Enabled by purposefully designed computerised management systems (IWMS/CAFM/EAMS/CMMS)
Survey results on CAMS benefit/returns
2004 independent CMMS benchmarking*
( Reliabilityweb.com, Cmmcity.com and Maintenancebenchmarking.com)

• 600 respondents
• 57% of all respondents considered the return on investment in the CMMS was achieved
• Less than 50% of respondents considered their CMMS to be effectively enabling its core functions

CMMS – the Black Hole*

<table>
<thead>
<tr>
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<td>£1k+</td>
<td>£10k+</td>
<td>£30k+</td>
<td>£40k+</td>
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</table>

*A Black Hole*

Applications of CMMS Modules

- Maintenance budgeting
- Predictive maintenance data analysis
- Equipment failure diagnosis
- Inventory control
- Spare parts requirements planning
- Material and spare parts purchasing
- Manpower planning and scheduling
- Work-order planning and scheduling
- Equipment parts list
- Equipment repair history
- Preventative Maintenance planning and scheduling

Source: From Swanson (1997)

Emerging educational and training needs to support an adaptive approach to maintenance planning and improve decision support, 5th International Conference on Condition Monitoring and Machinery Failure Prevention Systems, 2008.
2012 Asset Health Management survey*

Software (SW) supporting asset health management data

<table>
<thead>
<tr>
<th>% of respondents</th>
<th>Needed SW exist</th>
<th>SW insufficient</th>
<th>SW Lacking</th>
<th>No SW</th>
<th>Other</th>
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<tr>
<td></td>
<td>33%</td>
<td>16%</td>
<td>17%</td>
<td>14%</td>
<td>3%</td>
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2012 Asset Health Management survey*

<table>
<thead>
<tr>
<th></th>
<th>Machinery</th>
<th>Electrical</th>
<th>Infrastructure</th>
<th>Instrument</th>
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<tr>
<td>Excellent to good</td>
<td>50%</td>
<td>42%</td>
<td>25%</td>
<td>41%</td>
</tr>
<tr>
<td>Poor to very poor</td>
<td>22%</td>
<td>28%</td>
<td>45%</td>
<td>32%</td>
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</table>

2012 Asset Health Management survey*

Use of asset health management tools

<table>
<thead>
<tr>
<th>% respondents</th>
<th>Risk analysis</th>
<th>FMEA</th>
<th>PM Optimisation</th>
<th>RCA</th>
<th>Asset Health Report</th>
<th>Pre-planning</th>
<th>Std Ops Plans</th>
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<tr>
<td>0 - 25%</td>
<td>49%</td>
<td>54%</td>
<td>35%</td>
<td>44%</td>
<td>45%</td>
<td>27%</td>
<td>24%</td>
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<tr>
<td>25% - 75%</td>
<td>29%</td>
<td>32%</td>
<td>43%</td>
<td>35%</td>
<td>31%</td>
<td>44%</td>
<td>38%</td>
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<td>75% - 100%</td>
<td>22%</td>
<td>14%</td>
<td>22%</td>
<td>21%</td>
<td>24%</td>
<td>29%</td>
<td>38%</td>
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</tbody>
</table>

No shortage of world-class CAMS

Reality –

Poor utilisation & ROI
CAMS is an empty box with potential

Potential realisable if properly configured

Critical aspect - Correct asset modeling
Considerations in physical asset modelling

Reliability management theory
Reliability engineering process

Design analysis techniques
- QFD
- LSA
- HAZOPS
- FMECA
- Human reliability
- Non-material failure modes

Areas of uncertainty identified from design analysis

Testing required to reduce uncertainty?
- Test for multiple variables, their variances and effects
- Stress testing for effects on reliability and durability
- Reliability testing
  - Statistical experiments
  - Highly Accelerated Life Testing (HALT)

Reliability modelling and prediction

Iterative design improvement
- Development of corrective actions
- Analysis of reliability data
- Multiple test and failure data recording
- FRACAS

Design satisfies all requirements?
- No
- Yes
- Design Review
- Configuration control
- Failure and test data

FINAL DESIGN FOR PRODUCTION

Reliability specification

Reliability engineering process

1. Design
2. Development testing
3. Manufacture
4. In-service use
5. FRACAS
6. Reliability modelling and prediction

Data for analysis of reliability

Industry data bases, e.g.

Data is recorded and stored in suitable media

Data analysis engines

Product life-cycle

Data is accessed for analysis

Key reliability management outputs for asset modelling

• Functional analysis –
  – Clear definition of the mission or function
  – Decomposing the system function into successive level of functions

• Partitioning:
  – Partitioning the system into sub-systems and lower level components by grouping related functions identified in preceding functional analysis
Key reliability management outputs for asset modelling

• Reliability Block Diagrams (RBDs)
  – Uses the output of system partitioning to model the system in reliability sense;
  – Used to downward-cascade reliability performance targets to successive asset system levels and visa versa for upward-cascading of actual performance
Key reliability management outputs for asset modelling

• FMECA, FTA and HAZOPS
  – Identifies mechanism or mode and causes of failure and their effect on system functions, performance, safety of people, environment and assets as examples.

• Life cycle cost analysis
Considerations in physical asset modelling

Logistics engineering and management theory
Logistics Engineering considerations

• Level of maintenance
  – As the asset hierarchy is developed, the level at which maintenance is performed, i.e. organisational, intermediate or depot level should be confirmed.

• Repair policy
  – Partially or fully repairable may be retained as an element in the asset hierarchy.
Logistics Engineering considerations

- Organisational responsibility
  - Considerations given to warranty and other performance or contractual accountabilities for which history must be retained.

- Maintenance and logistic support facilities
  - Site utilities and maintenance facilities
  - Test, measurement, handling and support equipment
Considerations in physical asset modelling

Combined reliability and logistics engineering considerations
Asset modelling framework applying considerations from reliability and logistics engineering theory

- Outcome of system partitioning and RBD analysis creating hierarchy of physical assets which are grouped to perform one or more functions
- Assets are structured in a availability, reliability and cost sense such that performances and costs can be logically cascaded upwards or targets allocated downwards
- Number of levels to which the hierarchy develops is influenced by the Maintenance support design considerations and outcomes of failure and criticality analysis during FMECA, FTA and HAZOP analysis as examples

Lowest level of repair

Replaceable items
Industry physical asset modelling
Organizational strategic goals

Capital investment optimization and sustainability planning

Sustained performance, cost and risk optimization

Optimize life cycle activities

Create acquire

Manage assets

Utilize

Maintain

Renew dispose

Corporate/organisation management

Manage asset system

Manage asset portfolio

Outcome of functional analysis to a level preceding definition of physical/asset resources

Outcome of system partitioning and RBD analysis creating hierarchy of physical assets which are grouped to perform one or more functions

Assets are structured in a availability, reliability and cost sense such that performances and costs can be logically cascaded upwards or targets allocated downwards

Number of levels to which the hierarchy develops is influenced by the Maintenance support design considerations and outcomes of failure and criticality analysis during FMECA, FTA and HAZOP analysis as examples

Reference Designation System for Power Plants RDS-PP


Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations Part 2: Classification of objects and codes for classes (BS EN 81346-2:2009)


FIFTY FIVE The way to integrated asset management
## Industry models comparison

<table>
<thead>
<tr>
<th>Purpose of asset model</th>
<th>ANSI/ISA-95&amp;88</th>
<th>BS EN 81346-2</th>
<th>NORSOK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Facilitate integration between manufacturing enterprise and control systems.</td>
<td>Classification scheme for objects regardless of technical area or branch of industry for use in design processes</td>
<td>Standardised coding and communication between engineering and operations teams</td>
</tr>
</tbody>
</table>

| Summary of the asset model | | | |
|-----------------------------| | | |
| 7-level model is defined: | | | |
| • Enterprise | | | • Systems hierarchy relates to type of service rendered and grouped in primary mission and support/utility and safety systems. |
| • Site | | | • Equipment hierarchy is based on function and type. |
| • Area | | | |
| • Process Cell/Production unit | | | |
| • Unit | | | |
| • Equipment module | | | |
| • Equipment control module | | | |
# Industry models comparison

<table>
<thead>
<tr>
<th>Purpose of asset model</th>
<th>RDS - PP</th>
<th>IIAMM</th>
<th>PAS 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent use by planning, construction and operations teams in the power plant industry</td>
<td>Structure asset data in an information management system to enable effective decision-making</td>
<td>Framework to collect data, report and enable effective decision-making related to an assets’ life cycle</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summary of the asset model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identification of site, power plant and plant units</td>
</tr>
<tr>
<td>• Functional hierarchy of system, sub-system and equipment</td>
</tr>
<tr>
<td>• Product hierarchy of equipment or technology types</td>
</tr>
<tr>
<td>• Asset type/group which relates to the services been rendered, e.g. water supply</td>
</tr>
<tr>
<td>• Facility complex/Site</td>
</tr>
<tr>
<td>• Parent Assets</td>
</tr>
<tr>
<td>• Assets</td>
</tr>
<tr>
<td>• Child assets / Components / Maintenance-Managed Items</td>
</tr>
<tr>
<td>• Asset portfolio</td>
</tr>
<tr>
<td>• Asset systems</td>
</tr>
<tr>
<td>• Assets, can be further segmented to components (MSI)</td>
</tr>
</tbody>
</table>
## Industry models comparison

<table>
<thead>
<tr>
<th></th>
<th>ISO 55000</th>
<th>IAS 16</th>
<th>AAQS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose of asset model</strong></td>
<td>Structures asset data and information to enable asset performance, risk and cost management</td>
<td>To prescribe the accounting treatment of Property, Plant and Equipment (PPE) (assets)</td>
<td>To provide uniform standard for building element costing</td>
</tr>
</tbody>
</table>
| **Summary of the asset model** | • Asset portfolio  
  • Asset systems  
  • Assets | PPE is recognised as an asset  
  • Realise economic benefit, cost can be reliability determined  
  • In use for more than one accounting period  
  • Cost is significant to total cost | • Building sections  
  • Elements  
  • Sub-elements  
  • Components  
  • Sub-components |
Industry model similarities - Motivation

- Assures **consistent identification, codification and communication between organisations** active in assets’ conception, design development, manufacture, construction, operation, maintenance and/or eventual disposal.

- Assures both enterprise business management systems and asset control and **management systems** integrate/inter-operate

- Enable standard **asset costing, comparisons and benchmarks**.

- **Consistent framework** within asset information management systems **to record** and analyse data and report on asset performance, costs and risks.
Interested parties

- Business Managers: Profitability, Investment returns and risk management
- Designers and technology providers: Post design performance and continuous design improvements
- Accountants: Annual remaining useful life and carrying value reviews
- Operations asset managers: Asset performance, cost and risk management
- Legislators: Assurance and demonstration of compliance
ASSET MODELLING APPLIED TO SABS
Organisation – Core/Primary

SABS Group

SABS Commercial

- Standards Development & Sales
- Testing

SABS Corporate Support

- Systems Certification
- Training

Mining and Minerals Division

- Chemicals and Bio Division
- Mechanical & Automotive Division
- Electro-technical Division

SABS Group

- Fibre & Polymers Lab
- Pesticide Trials Lab
- Chromatography Lab
- Rubber, Plastics & Paints Lab
- Industrial & Petrochemicals Lab
- Food & Water Chemistry Lab
- Pharmaceutical Food & Microbiology Lab
Critical consideration for Laboratory functioning

Lab fails to perform tests to its accredited standards and within committed turnaround time

- Indoor environmental conditions deviates from prescribed standards
- Laboratory test equipment failure
- Lab Information Management Systems (LIMS) failure
- Logistics failure to supply test materials/consumables
- Utilities supply failure (gasses, demineralised water, compressed air, etc.)

- Temperature deviates from standard
- Humidity deviates from standard
- Pressure control deviates from standard
Assets directly associated with laboratory processes

Rubber, Plastics & Paints Lab

Sample Preparation
- Band Saw
- Band Saw
- Drop Tester
- Fly Arm Press
- Grinder
- Hand Press
- Oven
- Oven
- Pedestal Drill
- Rubber Press
- Shredder
- Tensile Test
- Tensile Test

Paint Testing
- Automatic Scratch Tester
- Balance Top Pan
- Deep Freeze
- Digital Ionometer
- Drill Stand
- Hot Plate
- Impact Tester
- Impact Tester
- Paint Conditioner
- Paint Conditioner
- Shaker
- Skid Resistance Tester
- Stirrer
- Vacuum Oven
- Viscometer
- Viscosity Krebstormer
- Water Bath
- Water Bath
- Wet Scrub Machine
- Wet Scrub Machine

Weathering testing
- Drop Tester
- Fracture Toughness Rig
- UP Accelerated Weathering Tester
- UP Accelerated Weathering Tester

Corrosion testing
- Abraser
- Abraser
- Abrasive Cabinet
- Salt Fog
- Salt Fog Chamber

Rubber & Plastics testing
- Abraser
- Balance Floor
- Bending Machine
- Crock Tester
- Cutter for Instron
- Dead Load Hardness Tester
- Deep Freeze
- Density Meter
- Differential Scanning Calorimeter
- Dimensional Stability Rig
- Fume Hoods
- Gas Burner
- Hot Plate Stirrer
- Hot Plate Stirrer
- Impact Tester
- Indenter
- Indenter
- MultiFlow Controller/Tester
- Micro Hardness System
- Micro Tomer
- Notching Machine
- Oven
- Paper Cutter
- Plastic Gloves Tester
- Refrigerator Kelvinator
- Residual Identification Rig
- Small Press
- Tensile Tester
- Tensile Tester Instron
- Thermogravimetric Analyser
- Thickness Gauge
- Toolmakers Microscope
- Visc
- Wallace Stress Relaxation Tester
- Water Flow Test Apparatus
- Water Seal Test Apparatus
- Waterbath

Logistic area

Administrative support

SAAMA 2014 Conference

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Organisation – Support

SABS Corporate Support

- Human Capital Group
  - Asset & Facilities Management
    - Planning and Projects Delivery
    - Laboratory Equipment Support
  - Finance Management
    - Property, Building & Infrastructure Management
- Finance Group
- Corporate Services
  - Procurement Management
  - Facilities Support Services
  - Health, Safety & Environment Management
Mechanical utilities

- Hot water
- Chilled water
- Demineralised water
- Compressed air
- Indoor environmental control
- Gasses

Utilities
Production/Supply
Indoor environmental control – Reliability Block Diagram
## Maintenance Significant Item - Identification

<table>
<thead>
<tr>
<th>Sub-System</th>
<th>Equipment Assembly</th>
<th>Equipment sub-assembly</th>
<th>Component</th>
<th>Legislative compliance</th>
<th>Safety / Environmental impact</th>
<th>Production / Operations impact</th>
<th>Significant capital cost relative to whole</th>
<th>Repairable</th>
<th>Interchangeable</th>
<th>Interval or strategy significantly different</th>
<th>Hidden failure</th>
<th>Outsourced and subject to warranty</th>
<th>Serialised</th>
<th>Maintenance Significant Item</th>
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<td>Chilled Water (CW) production &amp; distribution</td>
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<td>Reticulation pipework and valves</td>
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</table>
Process & Asset Systems – Support

Mechanical utilities Provision

- Demineralised water supply system
- Internal space environmental control system
- Compressed air supply system

Filtered fresh air supply

- Chilled water (CW) production & distribution
- Indoor Environmental Control
- Air extraction

CW make-up water

- CW chemical treatment
- CW Production
- CW distribution
- Control system

Primary pump unit

- Compressor
- Compressor oil heater

Condenser

- Condenser heat exchanger

MSIs

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SUB-PROCESS

ASSET SYSTEM

SUB-SYSTEM

EQUIPMENT ASSEMBLY

EQUIPMENT SUB-ASSEMBLY

COMPONENT
Modelling framework influence on cost aggregation and apportionment
Concluding remarks

• Data is the ‘lifeblood’ of physical asset management and notably decision support, and the asset model the ‘skeleton’ to which data is attached
• Reliability and Logistics Engineering theory and industry asset models promote a three-cluster multi-level asset model comprising organisation, process and asset systems hierarchy
• The level to which the model develops is a function of criticality analysis, maintenance/logistic support strategy, legislative compliance and asset accounting standards
• A long term, lifecycle view must be taken when developing the asset model as implications goes years beyond our brief association with the asset systems
• Correct modelling, right data collection and analytics supported by well-configured CAMS will yield returns
Thank you

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