What Works and What Doesn’t with Managing Offshore Engineering Data  
(AIM: Asset Integrity Management)


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"the stone age did not end because we ran out of stones"  
–Sheikh Yamani, former OPEC oil minister
Presentation content

- Introduction: Asset Integrity Management and role of human factor
- Offshore assets and data sources
- Need for Statistical and Empirical Science
- Use of statistical engineering science
- Role of KBD and asset integrity
- Example data sources and guidelines
- Tailor made criticality matrix and KBD
- Use of Algorithms for managing data
- Data and Information Management of MMO and EPCIC Projects
- Roles and contents of an industrial organization
Integrity

...integrity is mostly understood as a characteristic that only human beings can have.

...management gurus treat integrity as the quality of management.
Source: Van Maurik, 2001

...operationalization of integrity at different levels of an organization remains vague...
Source: Van Maurik, 2001

...integrity... “application of technical, operational, and organizational solutions to reduce risk of uncontrolled release of formation fluids throughout the life cycle of the well”...
Source: NORSOK D-10 (2004)
Asset Integrity Management
[Source: Ratnayake (2013d)]

**Asset management:** … set of disciplines, methods, procedures and tools derived from business objectives aimed at optimizing of an organization’s assets.

**Integrity management:** … application of qualified standards, by competent people, using appropriate processes and procedures throughout the plant life cycle, from design through decommissioning.

**Asset Integrity:** … ability of the asset to perform its required function effectively and efficiently whilst safeguarding life and the environment.

**Asset integrity management (AIM):**
… means of ensuring that the people, systems, processes and resources which deliver the integrity, are in place, in use and fit for purpose over the whole life cycle of an asset.
Asset Intensive Organization: Relationship of Physical Assets to Financial, Human, Information and Intangible

[Source: BSI PAS 55 1&2, (2004)]
Unwanted events: The role of human errors vs. equipment failures

[Source: DOE Standard (2009); Ratnayake (2013a&d)]

(a). Causes of unwanted events

- 80% Human errors
- 20% Equipment failures

(b). Causes of human errors

- 70% Organizational weaknesses
- 30% Individual mistakes

Organizational Weaknesses, Equipment Failures, and Individual Mistakes

- 56% Organizational weaknesses
- 20% Equipment failures
- 24% Individual mistakes

Sophisticated technology cannot completely be compensated for human errors and organizational weaknesses.
Example of an Unwanted Event and Related Human & Organizational Factors: ‘Hercules Military Flight Crash’

[Source: Newsinenglish (2013)]

The ‘Hercules military flight’ crashed onto this mountainside in northern Sweden, killing all five officers on board.

According to the Swedish accident investigation board- Havarikommisjonen, • “poor routines in planning the flight”, and • “the Hercules’ crew on board relied too heavily on air traffic controllers” • crew “wasn’t aware of how dangerous the landscape was that they were flying into” • “on duty at the time of the crash were said to be relatively new on the job and inexperienced” • “letting employees with limited experience have responsibility for considerable traffic …” • 22-recommendations for improvements; including better flight preparation routines and measures to ensure competence among air traffic controllers
Asset Integrity Perspective: Physical assets in relation to other critical kind of assets

[Source: Ratnayake (2013a&d)]
Asset Integrity: Design, operational and technical integrity

[Source: Ratnayake, (2010)]

E.g. Design for operation
E.g. Design for maintenance
E.g. MMO Maintenance, Modification, & Operation

Asset intensive organization
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Offshore Assets and Data Sources

Physical Assets - Offshore

56% Organizational weaknesses
20% Equipment failures
24% Individual mistakes

Physical Assets - Offshore

Static

Structural Components
Structural Inspection and Maintenance

Static Process Equipment
Risk Based Inspection and Maintenance

Dynamic

Rotating Equipment
Condition Monitoring and Reliability Centered Maintenance

[Source: Ratnayake, 2013a&d]
Data Sources: Static and Rotational Process Equipment

Static Process Equipment

Rotating Process Equipment

Different degradation behaviors or rates

Virtual failure state

Minimum wall thickness according to ASME B31.3, including safety limits

Installed pipe wall thickness ($T_{\text{nominal}}$) according to available pipe dimensions and pipe class

Defined potential failure condition

Characteristic that will indicate reduced functional capability

Defined functional failure condition

Corrosion allowance

Pipe wall thickness (mm)

$T_{\text{nominal}}$, $T_{\text{minimum}1}$, $T_{\text{minimum}2}$, $T_{\text{minimum}3}$
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Need for Statistical and Empirical Science

Age related = 11%

Random = 89%

Failure rate patterns

- Bathtub
  - Pattern A = 4%
- Wear Out
  - Pattern B = 2%
- Fatigue
  - Pattern C = 5%
- Initial Break-in period
  - Pattern D = 7%
- Random
  - Pattern E = 14%
- Infant Mortality
  - Pattern F = 68%

e.g. Overhauled Reciprocating Engine

e.g. Reciprocating Engine, Pump Impeller

e.g. Gas Turbine, Steel structures, piping

e.g. Complex equipment under high stress with test runs after manufacture or restoration such as hydraulic systems

e.g. Roller/ball bearings

e.g. Electronic components

[Source: Nowlan and Heap (1978)]
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Components Fail => Operational Impact => Reliability

Engineer Solutions

Core Principles

$F = f(t)$

$USL = \text{Upper specification Limit}$

$LSL = \text{Lower Specification Limit}$

$(75 \pm 10) \text{ gpm} \quad (100 \pm 10) \text{ gpm}$

Demand for the function

Functional capacity

Demand for the function

Resistance to failure or Functional Capacity

Increasing demand for the function

Reducing resistance to failure

Increasing demand for the function and reducing resistance to failure

Risk = Probability x Consequence

Failure criticality = f(Severity of a failure effect, frequency of occurrence the failure, other attributes of the failure)
Core Principles

Components Fail => Operational Impact => Reliability Engineering Solutions

Risk = Probability x Consequence
Failure criticality = f(Severity of a failure effect, frequency of occurrence the failure, other attributes of the failure)

Characteristic that will indicate reduced functional capability

Defined potential failure condition

Defined functional failure condition

31.10.2013
Challenge: How to Reduce ‘High variability’ in the performance? How to Reduce ‘Waste’?

**USL** = Upper specification Limit  
**LSL** = Lower Specification Limit
Improving asset ‘reliability performance’ via ‘increased awareness’: Aim - reduce variability (or variation)

Effect of increasing the understanding of system parameters and behavior via standardized work

Effect of increasing the understanding of stakeholder requirements (i.e. via balanced performance)

Target reliability performance

Asset reliability performance

Required reliability performance limits of the system

- Increased awareness via standardized work results reduced ‘system variability’ increasing the assets’ overall ‘reliability performance’

The process variables (e.g. people’s skills/knowhow, equipment, information/training, procedures/documentation, conditions in the work place, etc.) can affect the system variability

[Source: Ratnayake and Markeset (2011)]
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Role of Knowledge Based Development (KBD) and AI

KBD: ‘Standardized recycling of existing knowledge’

- Continuous improvement (with KBD)
- Anticipated level
- Threshold level
- Product development, modifications, etc.
- Change and/or relaxation of procedures, standards, etc.
- Lack of systems thinking, change management, awareness of stakeholder requirements, etc.
- Changes in product complexity, operating and environmental conditions, customer requirements, etc.
- Lack of competence, system integration, knowledge recycling, etc.

At Present

Future

Anticipated level

Threshold level

Improvements in an isolated fashion

New

Time
The three purposes of Knowledge Based Development (KBD)

[Source: Ratnayake (2013d); Laszlo and Alexander (2007)]
Personnel Performance and Global Shift in Percentage Value of an Organization’s Assets

[Source: Ratnayake (2013); Sajja & Akerkar (2010)]

The global shift in percentage value of an ‘Organization’s Assets’ vs. ‘Time’

Factors pertaining to personnel performance
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Example of Knowledge Based Development (KBD): Citicality Analysis Guideline: Norsok Z-008

[Source: NORSOK Z-008 (2011)]

Table 1. NORSOK standard Z-008 suggested risk matrix for criticality analysis and RBM decisions

<table>
<thead>
<tr>
<th>Frequency category</th>
<th>Frequency per year (**)</th>
<th>MTBF (year)</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>F4</td>
<td>&gt;1</td>
<td>0-1</td>
<td>M</td>
</tr>
<tr>
<td>F3</td>
<td>0.3-1.0</td>
<td>1-3</td>
<td>M</td>
</tr>
<tr>
<td>F2</td>
<td>0.1-0.3</td>
<td>3-10</td>
<td>L</td>
</tr>
<tr>
<td>F1</td>
<td>&lt;0.1</td>
<td>Long</td>
<td>L</td>
</tr>
</tbody>
</table>

Loss of function leading to:

<table>
<thead>
<tr>
<th>Consequence category</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consequence containment</td>
<td>Non-flammable media</td>
<td>Flammable media below flashpoint</td>
<td>Flammable media above flashpoint</td>
</tr>
<tr>
<td>Consequence, Environment, restitution time (***)</td>
<td>No potential for pollution (specify limit) &lt;1 month</td>
<td>Potential for moderate pollution. 1 month – 1 year</td>
<td>Potential for large pollution. &gt;1 year</td>
</tr>
<tr>
<td>Consequence production</td>
<td>No production loss</td>
<td>Delayed effect on production (no effect in x days) or reduced production</td>
<td>Immediate and significant loss of production</td>
</tr>
<tr>
<td>Consequence other</td>
<td>No operational or cost consequences</td>
<td>Moderate operational or cost consequences</td>
<td>Significant operational or cost consequences</td>
</tr>
</tbody>
</table>

(*) Based on failure mode
(**) Typical failure rate ref OREDA(®): 1-100 * 10^-6 for rotating equipment (0.01-1 1/yr)
(***) The consequences to the external environment differ significantly depending on the chemical composition of the released substance, volume and the recipients (open sea, shore, earth or atmosphere). Here restitution time is used as a common denominator.
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Example: Tailor Made Criticality Analysis Matrix – Quantitative and Qualitative Data

[Source: Ratnayake (2013c)]

<table>
<thead>
<tr>
<th>RANGES, RANKS AND LINGUISTIC TERMS FOR CONSEQUENCES AND MTBF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consequences</strong></td>
</tr>
<tr>
<td>Factors</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Rank</td>
</tr>
<tr>
<td>LT</td>
</tr>
<tr>
<td>PS</td>
</tr>
<tr>
<td>ED</td>
</tr>
<tr>
<td>DTC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Failure frequency</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank</td>
</tr>
<tr>
<td>LT</td>
</tr>
<tr>
<td>MTBF</td>
</tr>
</tbody>
</table>
Example of KBD: Criticality Analysis - Incorporation of Fuzziness of the data

[Source: Ratnayake (2013c)]
Example Illustration: Tailor made Rule Base for Criticality Matrix
[Source: Ratnayake, 2013c]

<table>
<thead>
<tr>
<th>Input membership functions</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PS Fatality Permanent injury Serious personnel injury Medical treatment First aid</td>
</tr>
<tr>
<td>ED  &gt; 200 m³</td>
<td>(20-200) m³ (2-20) m³ (0.2-2) m³ &lt; 200 litres</td>
</tr>
<tr>
<td>DTC &gt; 20 million</td>
<td>(4-20) million (0.4-4) million (0.125-0.4) million &lt; 0.125 million</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure frequency</th>
<th>Rank</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTBF</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Less than 1 month</td>
<td>1</td>
<td>VH</td>
<td>VH</td>
<td>VH</td>
<td>VH</td>
<td>VH</td>
</tr>
<tr>
<td>1 month to 1 year</td>
<td>2</td>
<td>VH</td>
<td>VH</td>
<td>H</td>
<td>M-H</td>
<td>M-H</td>
</tr>
<tr>
<td>1 year to 5 years</td>
<td>3</td>
<td>VH</td>
<td>H</td>
<td>M-H</td>
<td>M-L</td>
<td>L</td>
</tr>
<tr>
<td>5 years to 30 years</td>
<td>4</td>
<td>H</td>
<td>M-H</td>
<td>M-L</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td>More than 30 years</td>
<td>5</td>
<td>M-H</td>
<td>M-L</td>
<td>L</td>
<td>VL</td>
<td>VL</td>
</tr>
</tbody>
</table>
Example ‘Membership Functions’: Incorporation of Quantitative and Qualitative Knowledge

[Source: Ratnayake (2013c)]

Table 4. Gaussian MF parameters for input and output variables

<table>
<thead>
<tr>
<th>Input variable</th>
<th>VH</th>
<th>H</th>
<th>M</th>
<th>L</th>
<th>VL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTBF</td>
<td>(0.5, 1)</td>
<td>(0.3, 2)</td>
<td>(0.3, 3)</td>
<td>(0.4, 4)</td>
<td>(0.2, 4.85)</td>
</tr>
<tr>
<td>ED</td>
<td>(0.5, 1)</td>
<td>(0.4, 2)</td>
<td>(0.4, 3)</td>
<td>(0.4, 3.75)</td>
<td>(0.3, 4.75)</td>
</tr>
<tr>
<td>Output variable</td>
<td>VH</td>
<td>H</td>
<td>M-H</td>
<td>M-L</td>
<td>L</td>
</tr>
<tr>
<td>Risk</td>
<td>(0.3, 0.15)</td>
<td>(0.3, 1)</td>
<td>(0.3, 2)</td>
<td>(0.3, 3)</td>
<td>(0.3, 3.75)</td>
</tr>
</tbody>
</table>

Fig. 2. MF plots for rank of MTBF.

Fig. 3. MF plots for rank of ED.

Fig. 4. MF plots of criticality.

Membership functions: the ‘heart’ of the ‘rule base’
Example Illustration: Computation of Risk Rank in Relation to MTBF and Potential ED

25-Rules

MTBF = 2.6
ED = 1.7
Criticality = 0.818
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Data Analysis for Welder Qualification: Interaction of ‘Welding Procedure’, ‘Imperfection Groups’ and ‘Quality Deterioration Factors’
Illustration: A Consistent Approach for Welding Quality Data Analysis
[Source: Ratnayake (2012)]

Step 1: Prioritize WPSs in relation to their contribution to high welding defects.

Step 2: Select a cut-off level based on the company quality philosophy and select k number of WPSs that are attributed to high welding defects.

Step 3: For each SWPS perform analysis to prioritize imperfection groups (as specified in BS EN ISO 8528-1) that are attributed to higher quality deterioration.

Step 4: Using the most significant imperfection groups identified in Step 3 (i.e. based on cut-off level), prioritize the most significant causes that can lead to high welding defects.

Recognize most significant Welding Procedure Specifications (SWPSs) based on the ‘company quality philosophy’: cut-off level

Note: WPS = welding procedure specification
Prioritization of welding quality deterioration factors: An Algorithm

[Source: Ratnayake (2013b)]

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**WIDB**

**Step 1:** Determine 'N' number of SWPSs that cause higher percentage of welding quality deterioration (cutoff point is determined according to the quality control philosophy of the fabrication organization).

**Step 2:** Select a WPS from 'Step 1' and determine 'n' imperfection groups (i.e. the NS-EN ISO 6520-1 classifies imperfections into six main groups) that cause higher percentage of welding quality deterioration.

- All 'N' number of WPSs are chosen. **No**
- Yes

- **Step 3:** Select an imperfection group from 'Step 2' and determine the factors that are prone to highest imperfection varieties.

- All 'n' number of imperfection groups are chosen. **No**
- Yes

---

\[
PDW_{WPS_i} = \sum_{j=1}^{k} \frac{(d_{WPS})_j}{N} \times 100
\]

\[
CPD_{WPS_i} = \sum_{i=1}^{n} PDW_{WPS_i}
\]

\[
PDW_{SWPS_j} = \sum_{j=1}^{n} \frac{(d_{IG})_j}{N_{SWPS}} \times 100
\]

\[
CPG_{SWPS_j} = \sum_{i=1}^{k} (PDW_{IG}^{SWPS})_i
\]

\[
PDW_{SWPS_i} = \sum_{j=1}^{k} \frac{(d_{E})_j}{N_{SWPS}} \times 100
\]

\[
CPD_{SWPS_i} = \sum_{i=1}^{n} (PDW_{SWPS}^{E})_i
\]

An algorithm for optimized welder training actions to improve welding quality.
Final Outcome:
Prioritization of Welding Quality Deterioration Factors of Group-5 with WPS P150-05

[Source: Ratnayake, 2013b]
Final Outcome:
The factors that led to group-4 (i.e. lack of fusion and penetration) defects in WPS R410-05 during 2008-2010

[Source: Ratnayake, 2013b]
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Current Status: Data/Information Management of MMO/EPCIC Projects

**History**
- Different projects with different client requirements
- Past experience; e.g., verification of document for operation (DFO) for Marathon, Statoil, Shell, CopNo, NSB, Eurocopter, Talisman, etc.
- Focus on all safety critical DFO/LCI delivered from Engineering contractor/suppliers to client.
- Review is based on Norwegian legislation and client internal requirements

**Requirements**
- Supplier documentation of equipment (NS5820)
- Documentation for Operation (Z-001)
- Client specific requirements for documentation

**Quality & inconsistency of data/information**
- Absence of technical information (documents & drawings)
- Inconsistent numbering and classification of documentation
- Lack of tag references in drawings
- Missing link between tag and documentation
- Inconsistent information on document/drawing compared to client management system

**Best practice**
- Establish follow up meetings with regards to contract requirements and specifications
- Establish a workflow procedure (tool) for verification/follow up on deliveries from contractor/supplier
- Establish a team of experienced personnel to perform reviews of all deliveries
- Make detailed review reports for each system/PO and use it as a basis for improvement of the quality.
Current Challenges in Retrieving/Receiving/Requesting Data/Information for MMO/EPCIC Projects

[Source: Raza and Ratnayake (2012)]

Challenges:
- Many parties involved
- Most part-time contracts/jobs
- Coordination responsibilities
- Effective communication
- Many time plans/milestones to be followed
- Information flow and management

Documentation for Operation (DFO) (according to Z-001)

Challenges:
- Many parties involved
- Most part-time contracts/jobs
- Coordination responsibilities
- Effective communication
- Many time plans/milestones to be followed
- Information flow and management
Tag-Manager System: Handling Data/Information

TAG Manager System manages tags and tags-related technical information for small- and large-scale modification projects. Provides;

- **Common platform** for all involved parties responsible for modification projects
- **Common database** for all maintainable and non-maintainable items (e.g. cables and lines)
- **Automatic administration** of new and modified tags with ‘minimum human interaction’
- **Time-stamped communication** with in-built reminders to the contractor/supplier
- **Quick and effective import and export** of referenced tag-related information to and from the contractor/supplier
- **Automatic export of tags** with As-Built status to the project
- **Updated tag status**, reference technical information and tag-history
- **Common mail box** for all users for effective communication and follow-ups
- **Support standardization** of tags/related information for all the assets (e.g. different production & process facilities) within a company

Advantages:

- **Less** possibility of making **errors**
- **Flexible user-accesses** on multiple levels
- **Flexible audit** trail
- **Live and interactive** overview of tag history and tag-related technical information
- **Tidy and up** to date tag master-register
- **User-friendly interface** with advanced search capabilities
Tag-Manager System Work-flow: Handling Data/Information

**Step 1:**
Tag information received with project start-up

**Step 2:**
Reservation of tags
Tag status: Reserved

**Step 3:**
Updated tag information
Tag status: Planned

**Step 4:**
Issue tags to the project
Tag status: As built

---

**Operator**

**Project start**

**Contractor/Supplier**

**Engineering**

**Installation/commissioning**

**As-Built**

**Ready For Commissioning Certificate (RFCC)/Mech. Completion check lists/LCI check lists**

**Ready For Operation Certificate (RFOC)**

**Tag registered in CMMS**

**Follow up tag information with contractor/supplier**

**Tag functional hierarchy, criticality evaluation, PM programs, spare parts evaluation**

**Testing, verifications & red markups**

**Quality checks**

**X weeks**

**XX days**

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Structured Information Management System (SIMS)
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Summary: Roles and contents in an industrial organization

Internal elements

Execution of goals, strategies and policies

Alignment gaps

Stakeholder demands and requirements

External elements

"people and their managers are working hard to be sure things are done right, they hardly have time to decide if they are doing the right things" (Stephen Convey)
Summary: Effective and Efficient Data/Information Management helps ‘Organizational Alignment’

Level 1: Parent company
Level 2: Divisional
Level 3: Departmental
Level 4: Functional
Level 5: Intra-functional

Broad operational focus

Narrow operational focus

31.10.2013
(c) RMCR, IKM, UiS
References


References


References


All birds find shelter during a rain. But Eagle avoids rain by flying above the Clouds.

Problems are common, but attitude makes the difference!

Thank you!
Focus of the Conference

How can we do more with offshore engineering data to get a better understanding of production and offshore asset integrity?

This event is a meeting place for people who work with;

- all kinds of data and information management with offshore operations - including data for asset integrity, design, documentation, safety, maintenance, inventory and supply chain - and
- want to hear about the latest ideas for how data can be better gathered and managed.

Attend this event to learn about:
- New strategies with offshore information management
- Making better use of design data during asset lifecycle
- Optimizing maintenance data
- Improving offshore data collection
- Techniques for document control and governance

Read more:
http://www.digitalenergyjournal.com/event/Improving_offshore_engineering_data_and_information_management/ac97a.aspx#ixzz2hynHFDh4