What Works and What Doesn't with Managing Offshore Engineering Data

(AIM: Asset Integrity Management)

Norwegian Petroleum Museum: Wednesday, October 30, 2013.

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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
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- Roles and contents of an industrial organization

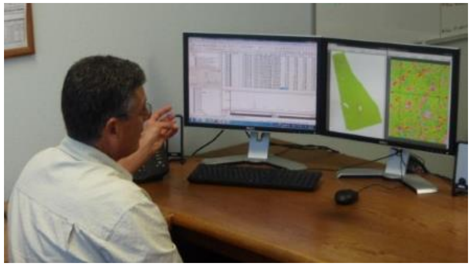
Integrity

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

Source: Taylor, 1981; Becker, 1998

*…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)

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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.**

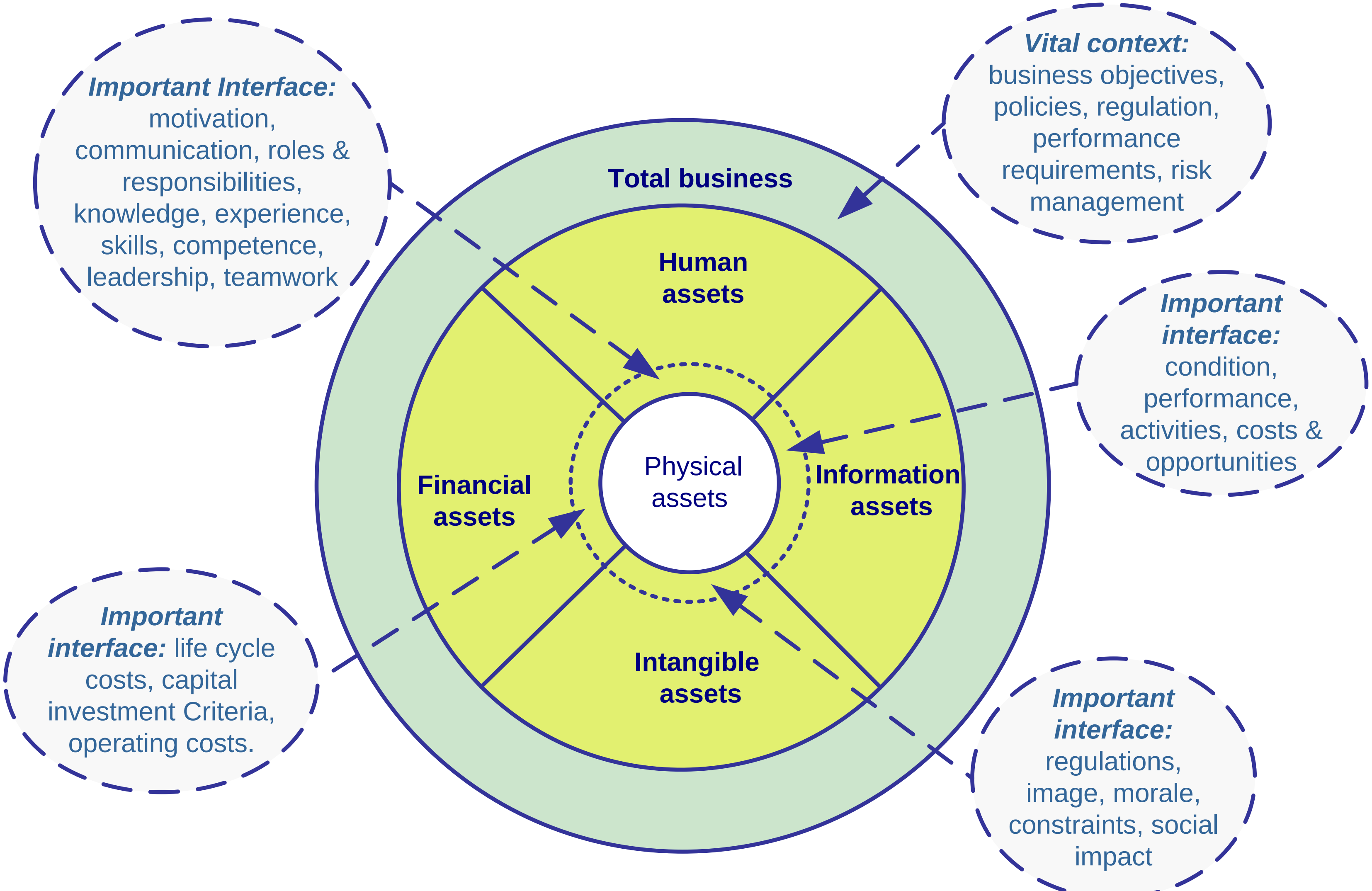
Asset Integrity: … **ability of the asset** to perform its required function **effectively** and **efficiently** whilst safeguarding **life** and the **environment**.

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.

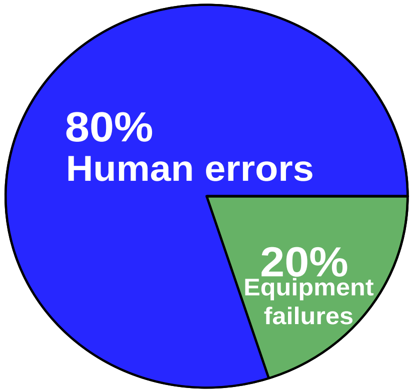
Asset Intensive Organization:
Relationship of Physical Assets to Financial, Human, Information and Intangible

[Source: BSI PAS 55 1&2, (2004)]



Unwanted events: The role of human errors *vs.* equipment failures

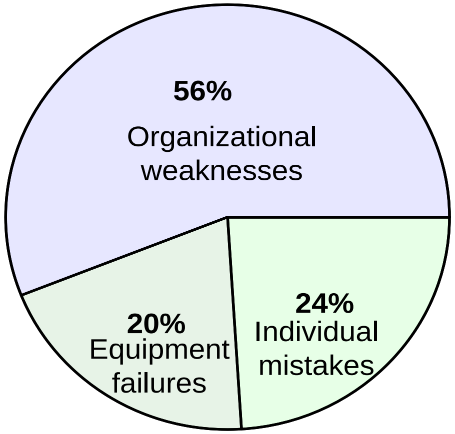
[Source: DOE Standard (2009); Ratnayake (2013a&d)]



(a). Causes of unwanted events

(b). Causes of human errors

Organizational Weaknesses, Equipment Failures, and Individual Mistakes



Sophisticated technology can not **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.

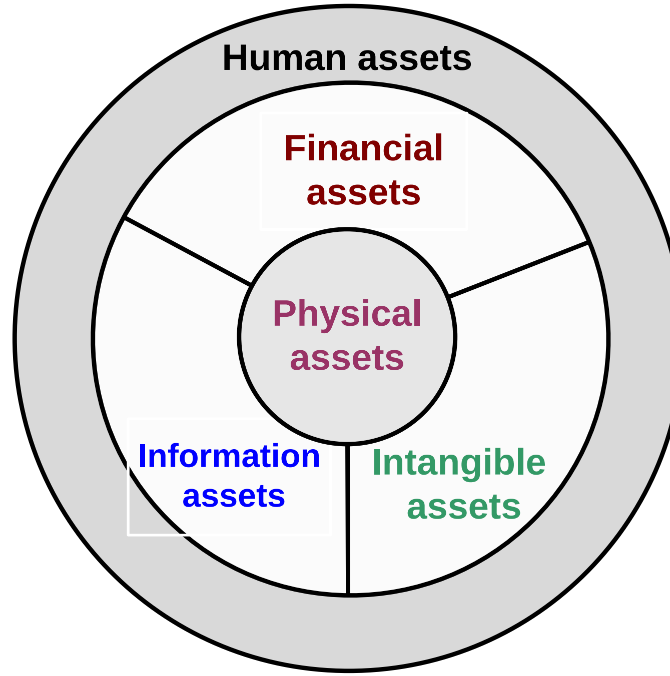
According to the Swedish accident investigation board-*Havarikommisjonen*,

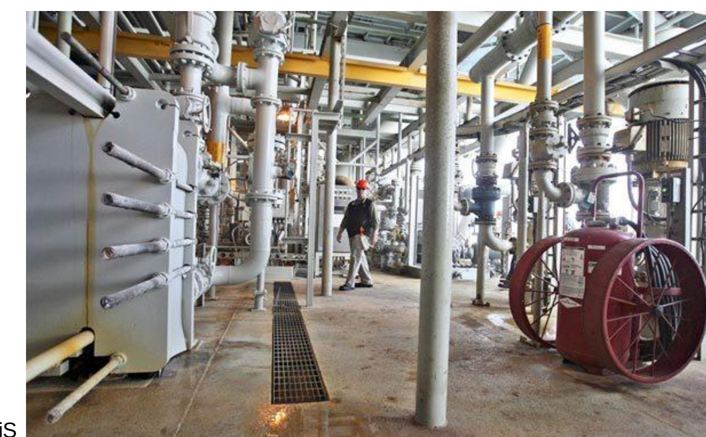
- "poor routines in planning the flight", and
- "the Hercules' crew on board relied too heavily on air traffic controllers"
- crew "wasn't aware of how dangerous the landscape was that they were flying into"
- "on duty at the time of the crash were said to be relatively new on the job and inexperienced"
- "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)]





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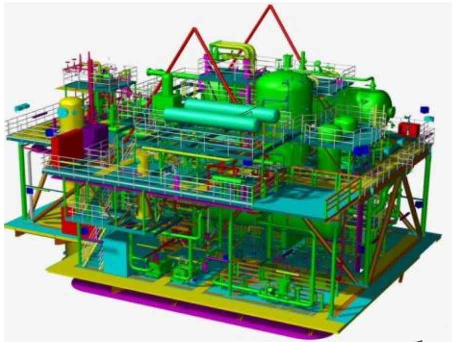
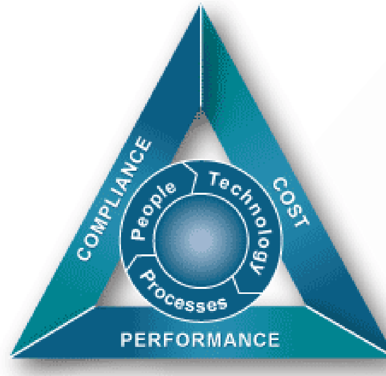
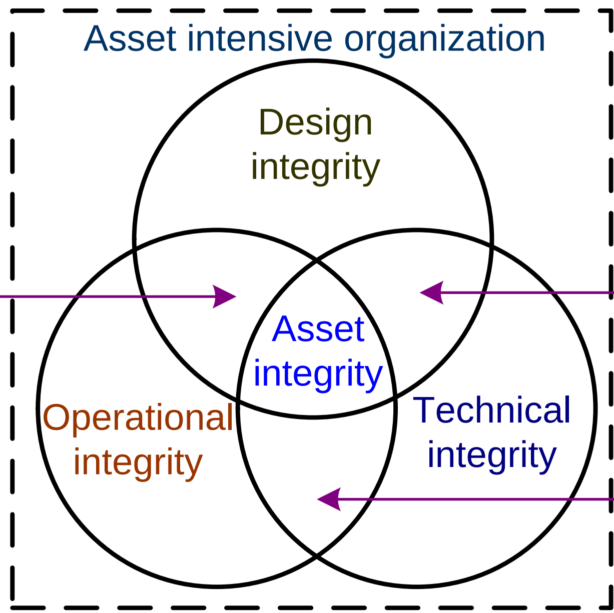
Asset Integrity: Design, operational and technical integrity

[Source: Ratnayake, (2010)]



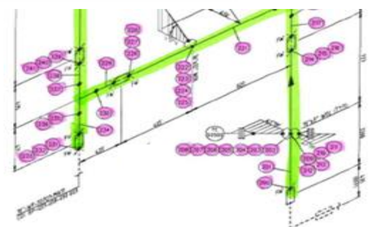


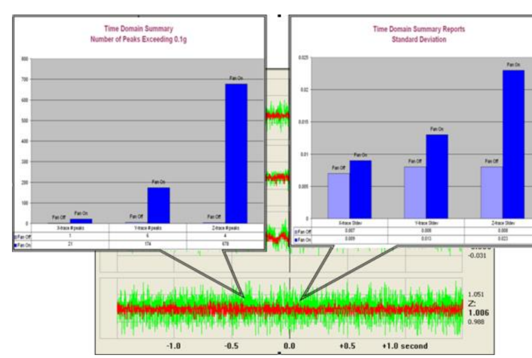


E.g. Design for operation

E.g. Design for maintenance

E.g. MMO Maintenance, Modification, & Operation





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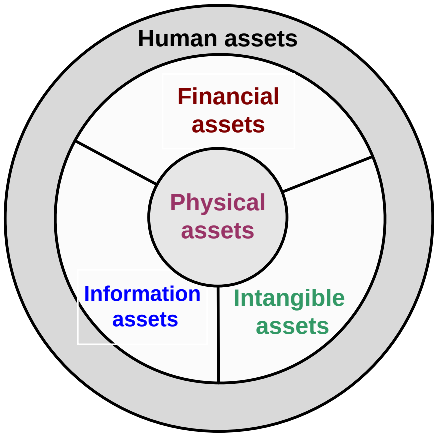
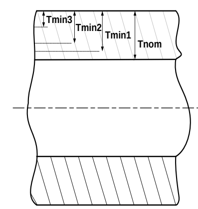
Offshore Assets and Data Sources

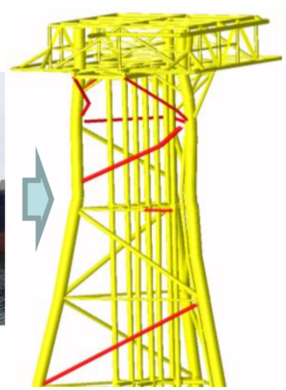


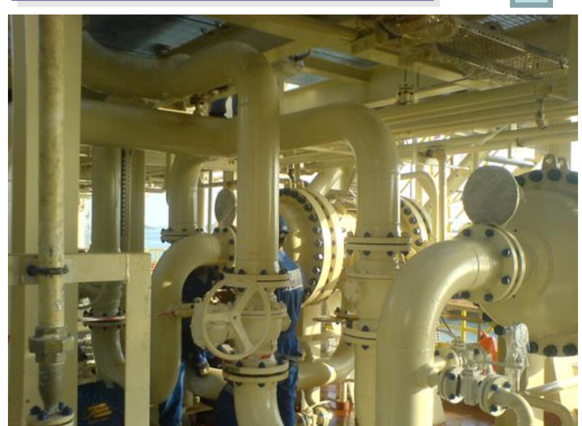
[Source: Ratnayake, 2013a&d]

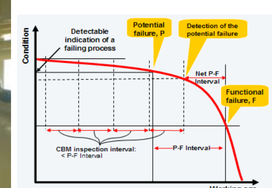
Physical Assets - Offshore

- **Static**
  - **Structural Components** → **Structural Inspection and Maintenance**
  - **Static Process Equipment** → **Risk Based Inspection and Maintenance**
- **Dynamic**
  - **Rotating Equipment** → **Condition Monitoring and Reliability Centered Maintenance**



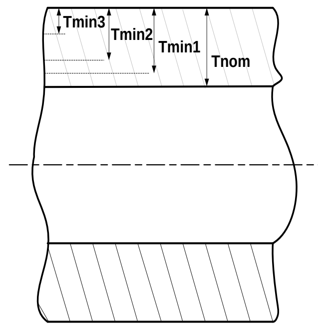


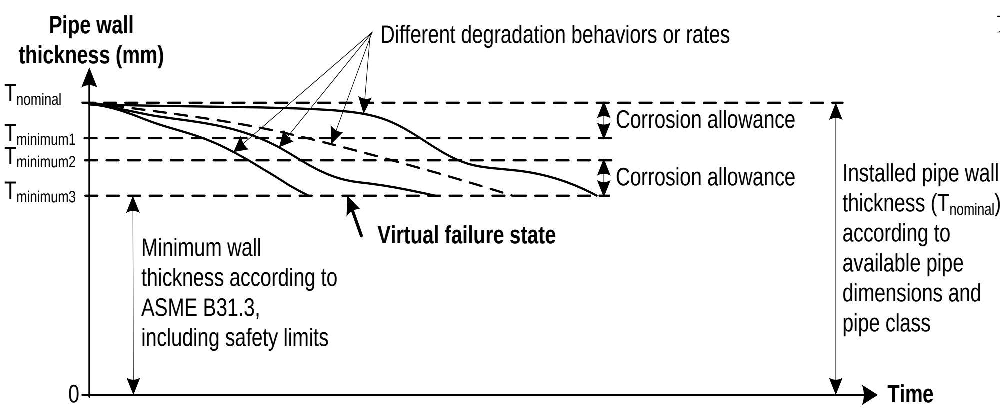




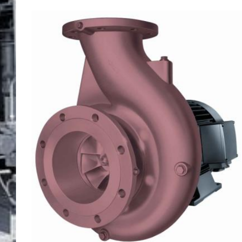
Data Sources: Static and Rotational Process Equipment

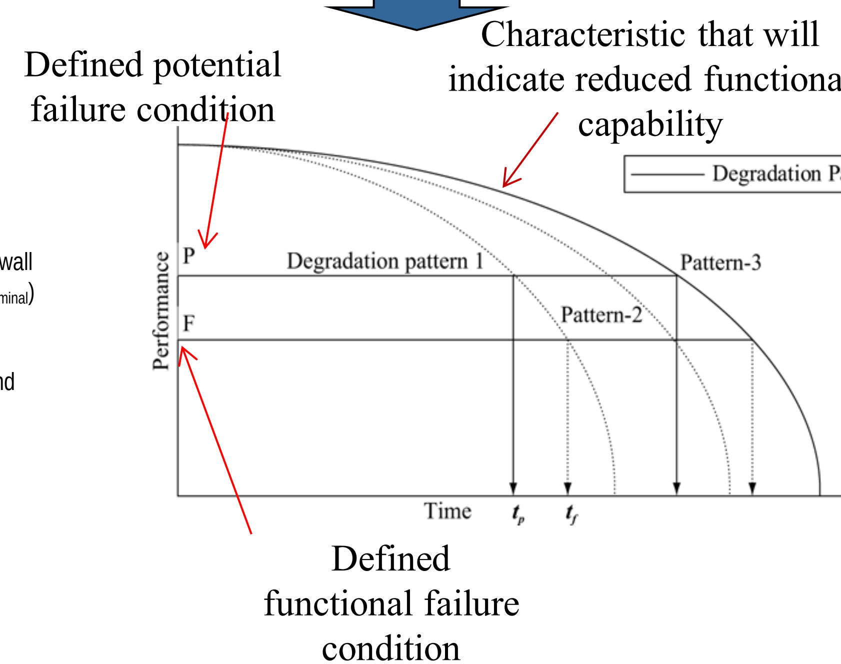
Static Process Equipment



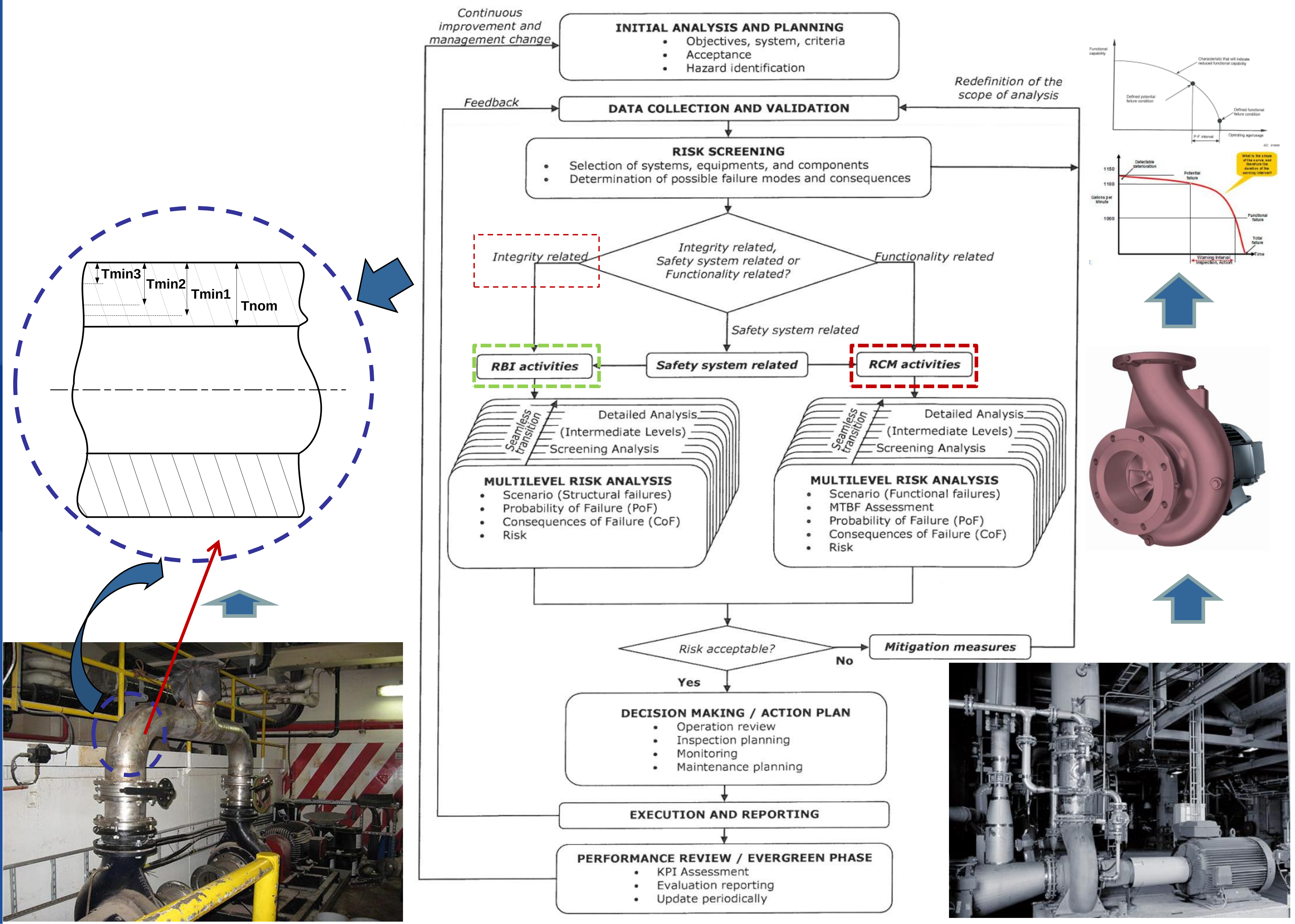


Rotating Process Equipment





RIMAP Procedure: Risk Based Inspection and Maintenance Analysis



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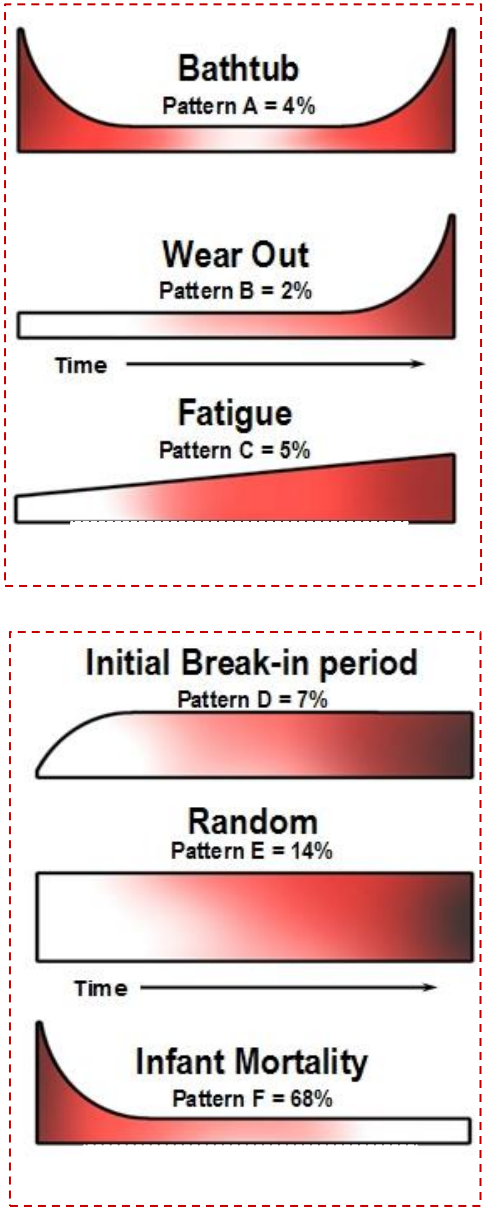
Need for Statistical and Empirical Science

Failure rate patterns

Age related = 11%

Random = 89%



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

Need empirical and statistical engineering science

[Source: Nowlan and Heap (1978)]

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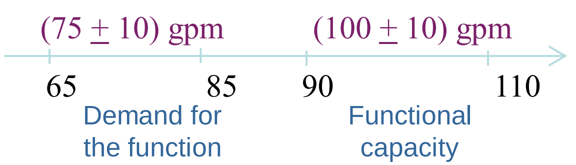
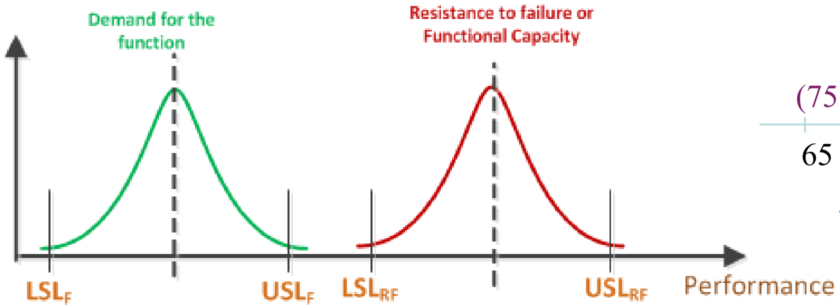
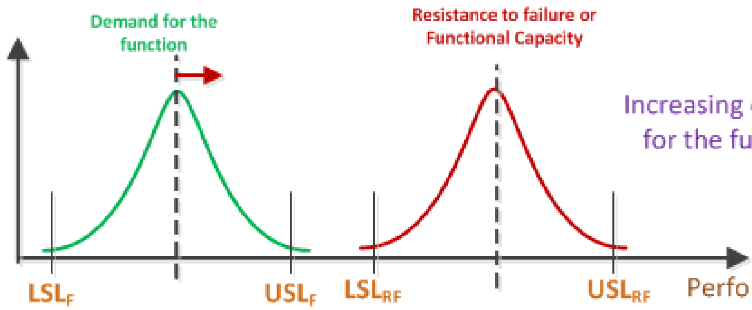
Core Principles

Components Fail => **O**perational Impact =>**R**eliability **E**ngineering Solutions

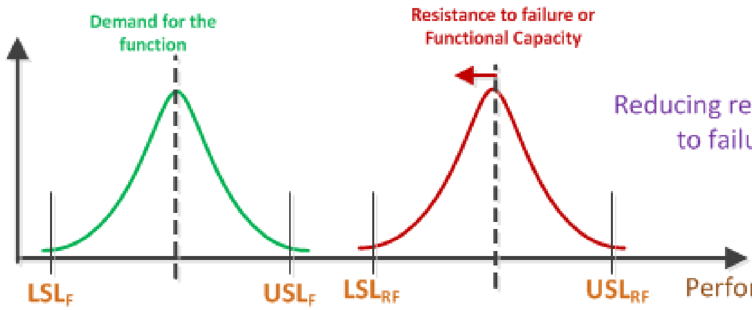
USL= Upper specification Limit
LSL = Lower Specification Limit



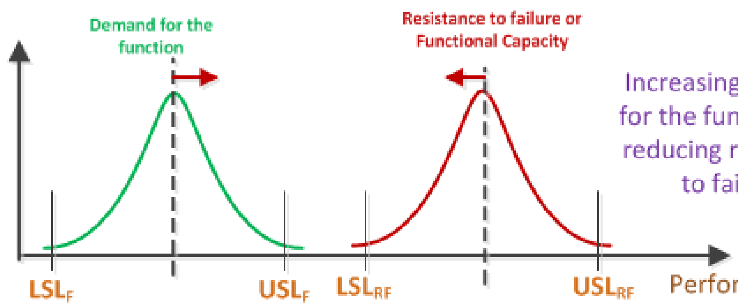




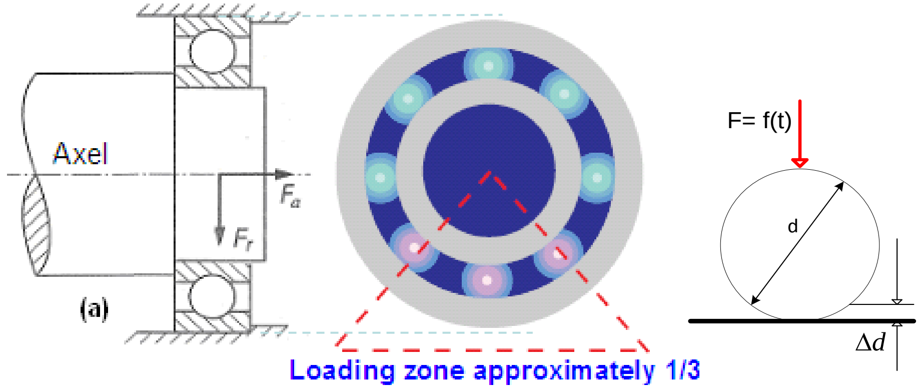
Increasing demand for the function

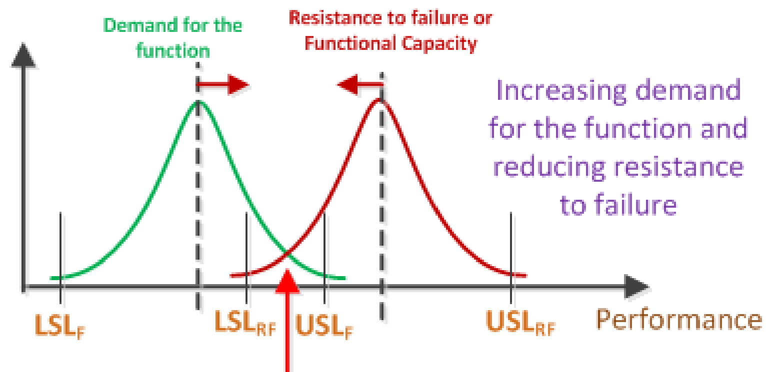


Reducing resistance to failure



Increasing demand for the function and reducing resistance to failure



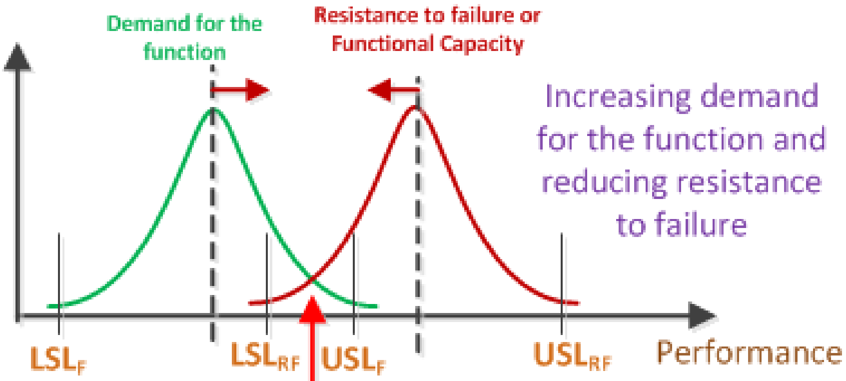


Risk = Probability x Consequence

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

Core Principles

Components **F**ail => **O**perational **I**mpact => **R**eliability **E**ngineering **S**olutions



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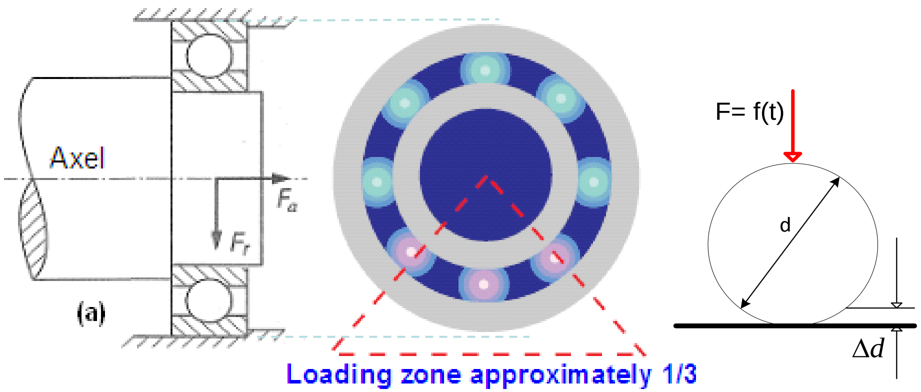
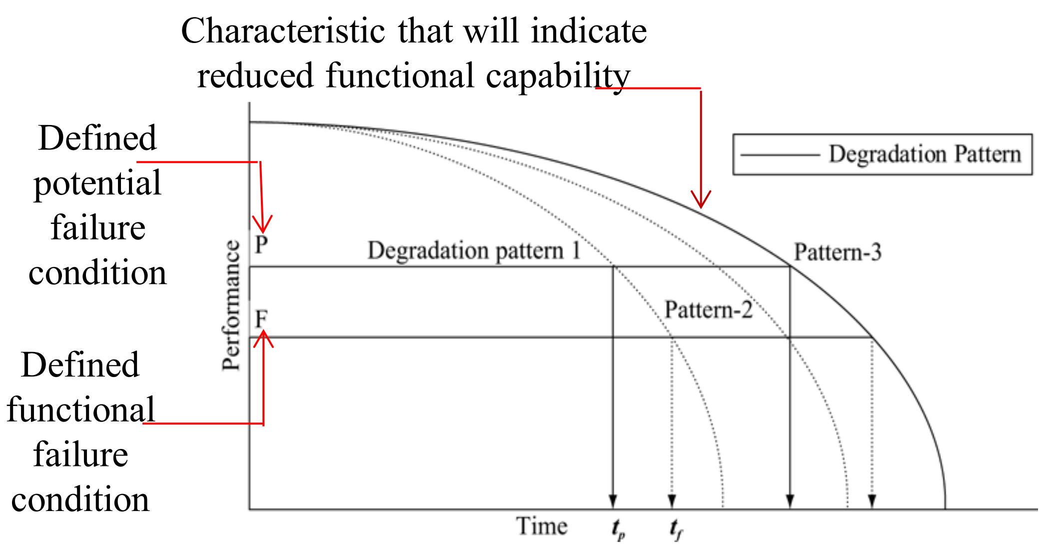
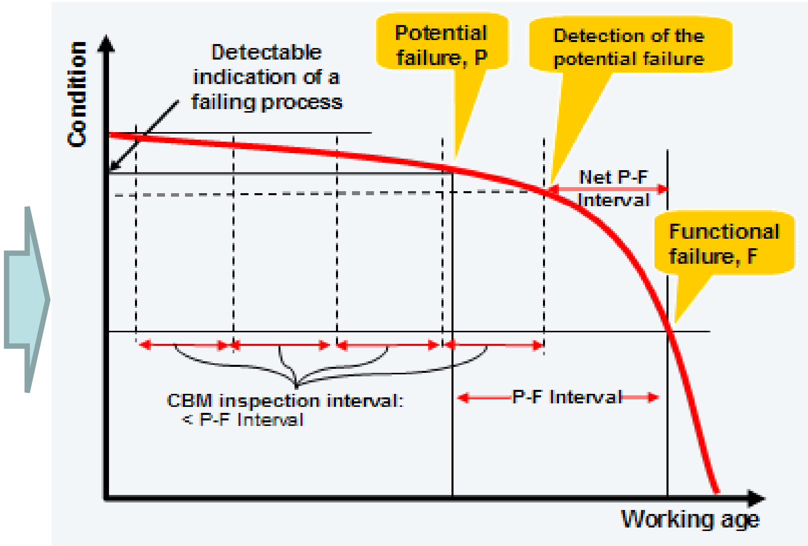
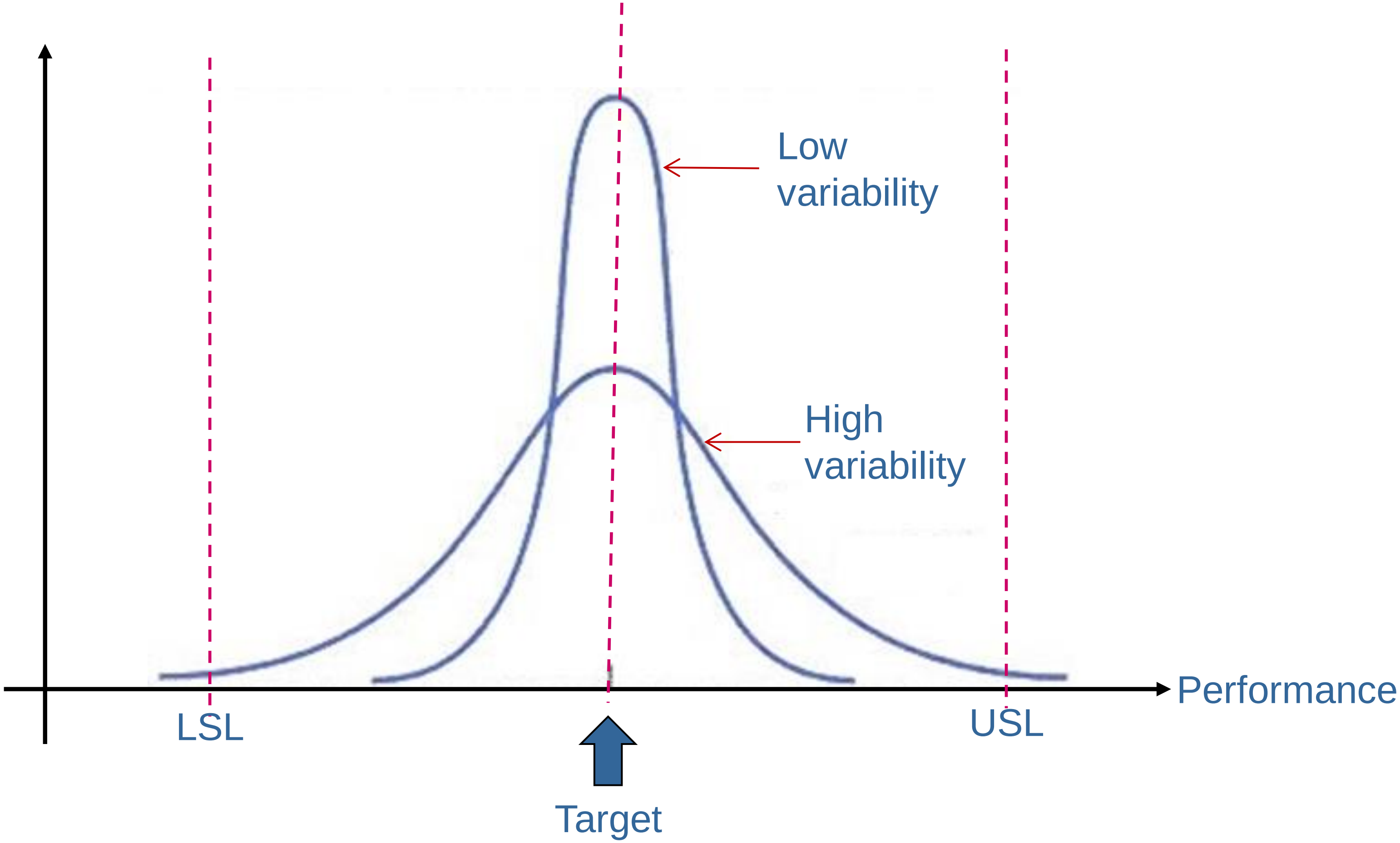






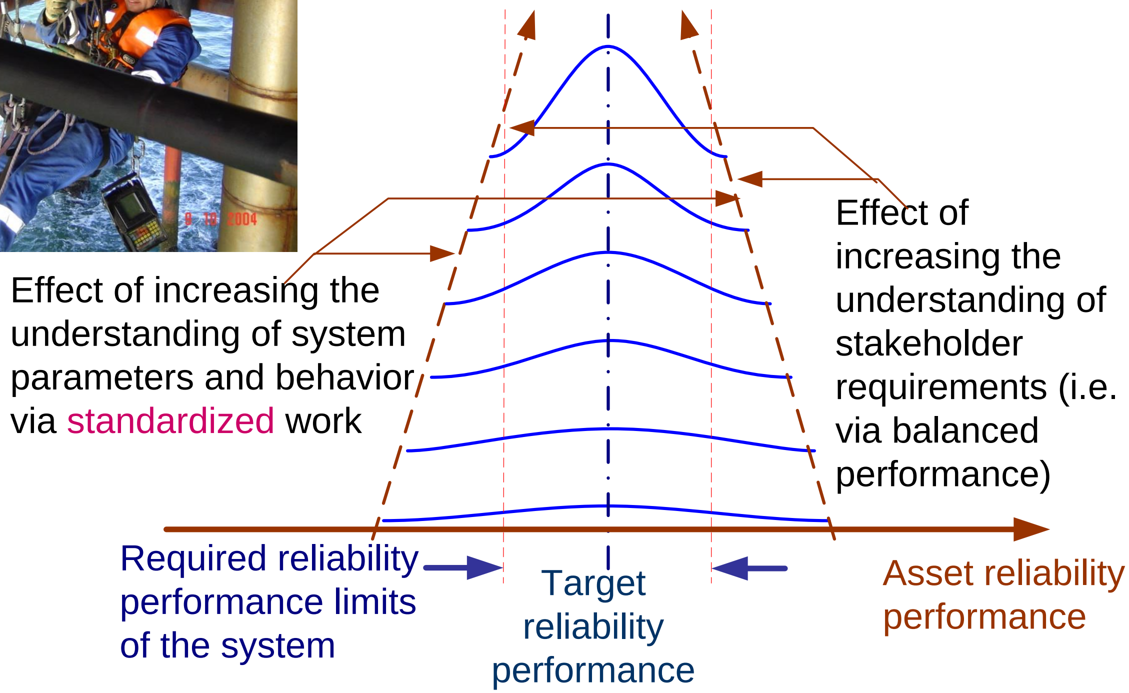
Challenge: How to Reduce 'High variability' in the performance? How to Reduce 'Waste'?

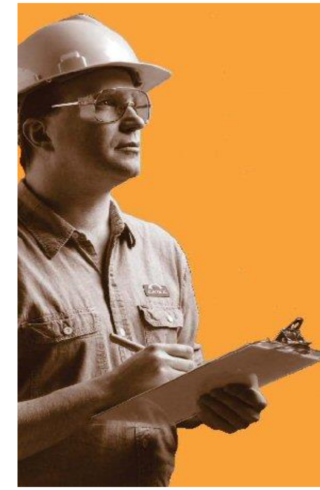


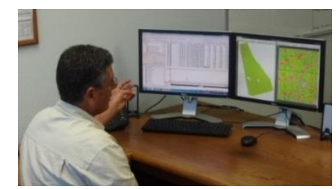
USL= Upper specification Limit
LSL = Lower Specification Limit

Improving asset 'reliability performance' *via* 'increased awareness': Aim - reduce variability (or variation)

[Source: Ratnayake and Markeset (2011)]







- 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**

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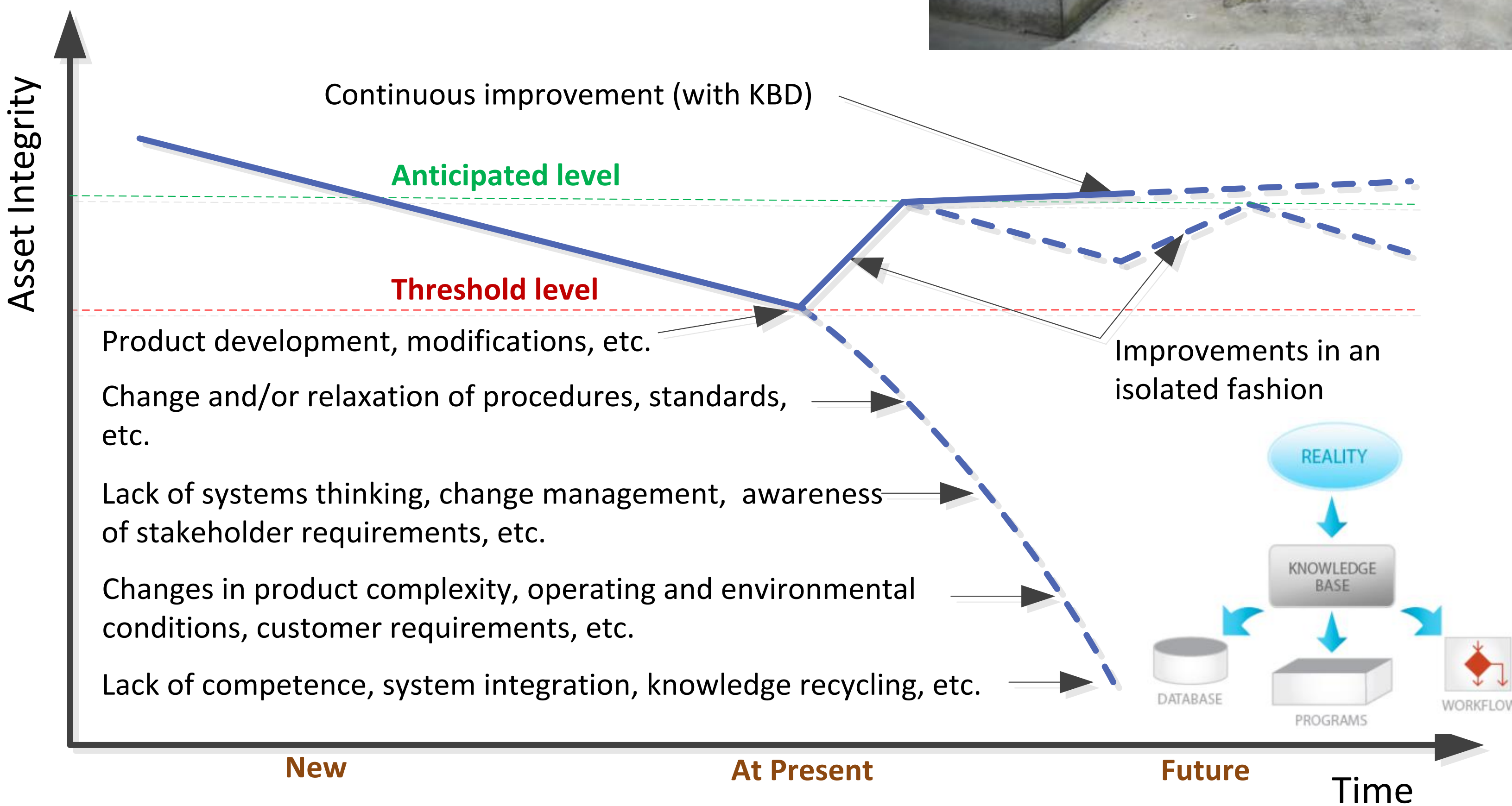
Role of Knowledge Based Development (KBD) and AI

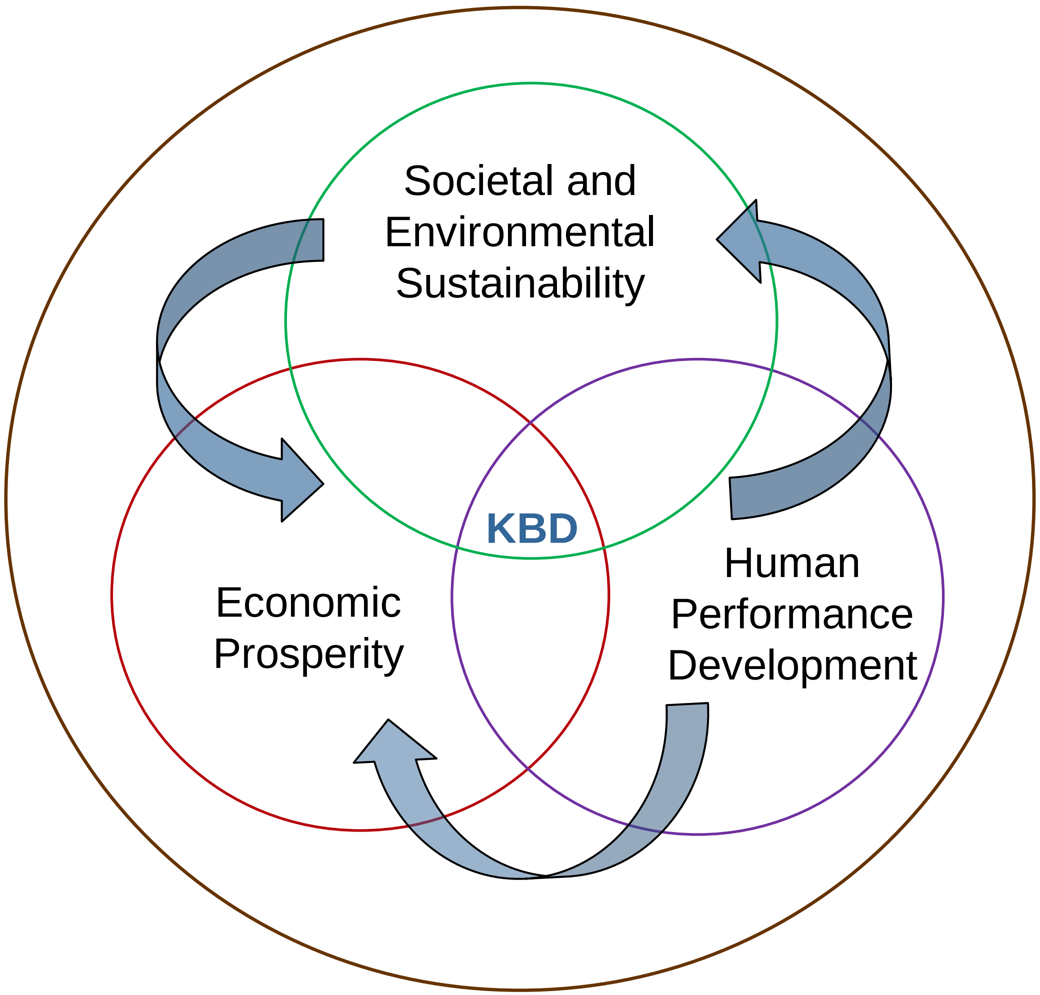
[Source: Ratnayake (2013d)]

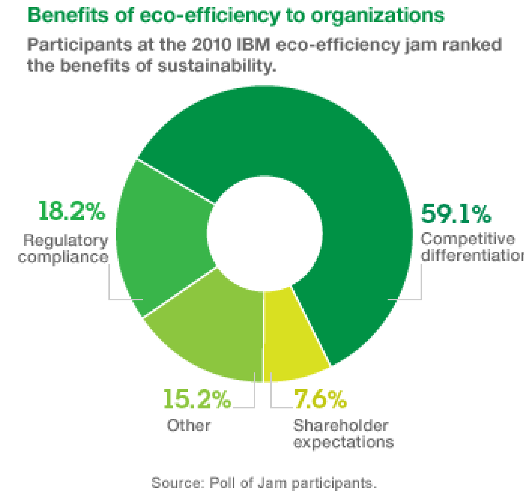
KBD: 'Standardized recycling of existing knowledge'



The three purposes of Knowledge Based Development (KBD)

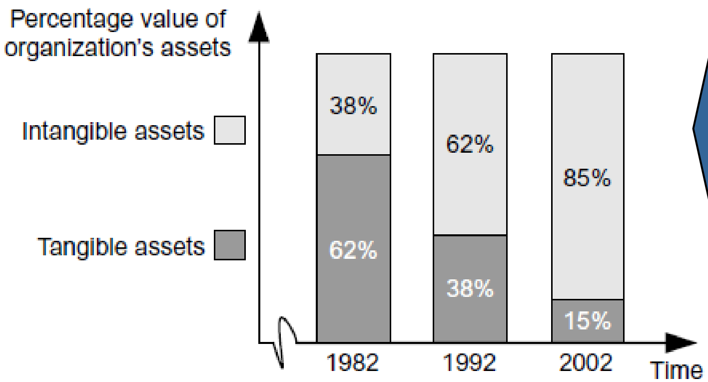
[Source: Ratnayake (2013d); Laszlo and Alexander (2007)]



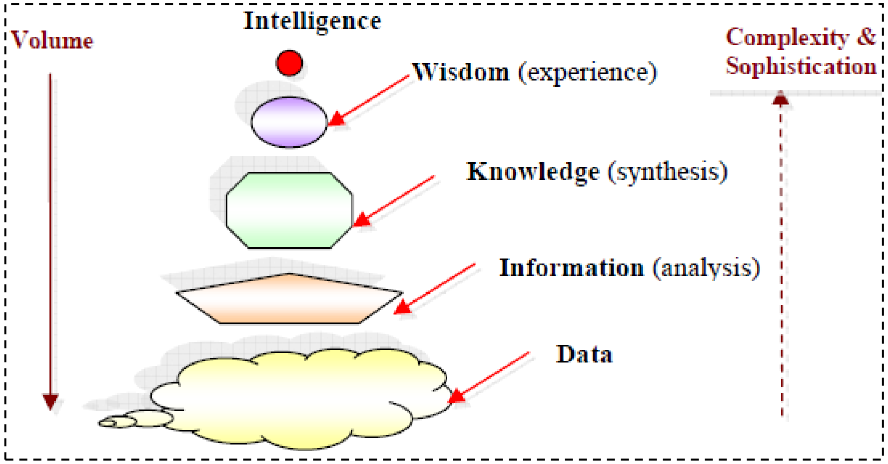


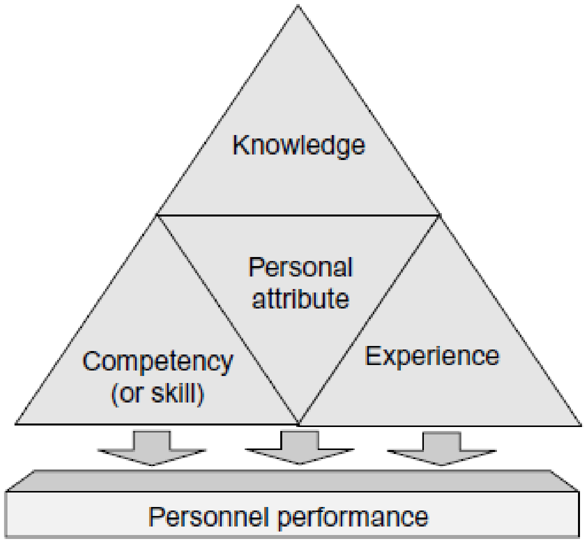
Personnel Performance and Global Shift in Percentage Value of an Organization's Assets

[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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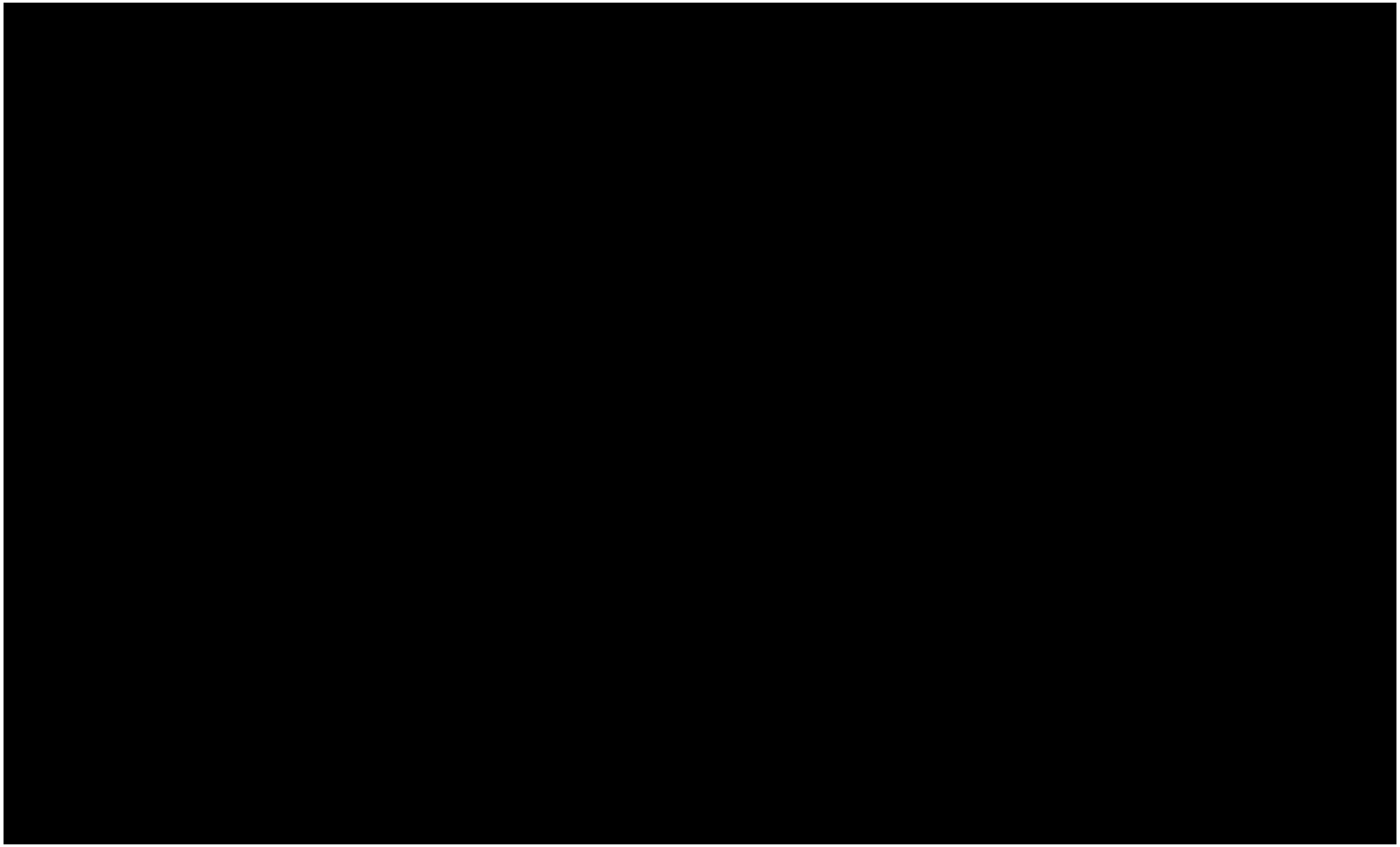
Support Data Sources: OREDA Hand Book (5th Edition)



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

Frequency category	Frequency per year (*). (**)	MTBF (year)	Risk		
F4	>1	0-1	M	H	H
F3	0.3-1.0	1-3	M	M	H
F2	0.1-0.3	3-10	L	M	M
F1	<0.1	Long	L	L	M
			Loss of function leading to:		
Consequence category			**C1**	**C2**	**C3**
Consequence safety			No potential for injuries. No effect on safety systems.	Potential for injuries requiring medical treatment. Limited effect on safety systems.	Potential for serious personnel injuries. Render safety critical systems inoperable.
Consequence containment			Non-flammable media Non toxic media Natural/normal pressure /temperature media	Flammable media below flashpoint Moderately toxic media High pressure/ temperature media (>100 bar/80 °C)	Flammable media above flashpoint Highly toxic media Extremely high pressure /temperature media
Consequence, Environment; restitution time (***)			No potential for pollution (specify limit) < 1 month	Potential for moderate pollution. 1 month – 1 year	Potential for large pollution. > 1 year
Consequence production			No production loss	Delayed effect on production (no effect in x days) or reduced production	Immediate and significant loss of production
Consequence other			No operational or cost consequences	Moderate operational or cost consequences	Significant operational or cost consequences

(*) 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)]

RANGES, RANKS AND LINGUISTIC TERMS FOR CONSEQUENCES AND MTBF

Input variable_2	**Consequences**					
	Factors	**Levels of consequence due to a functional failure**				
	Rank	**1**	**2**	**3**	**4**	**5**
	LT	Very high	High	Moderate	Low	Very low
	PS	Fatality	Permanent injury	Serious personnel injury	Medical treatment	First aid
	ED	> 200 m^3	(20-200) m^3	(2 - 20) m^3	(0.2 - 2) m^3	< 200 litres
	DTC	> 20 million	(4 – 20) million	(0.4 – 4) million	(0.1 – 0.4) million	< 0.1 million
Input variable_1				**Failure frequency**		
	Rank	**1**	**2**	**3**	**4**	**5**
	LT	Very high	High	Moderate	Low	Very low
	MTBF	Less than 1 month	1 month to 1 year (12 months)	1 year (12 months) to 5 years (60 years)	5 years (60 months) to 30 years (360 months)	More than 30 years (360 months)

Example of KBD: Citicality Analysis - Incorporation of Fuzziness of the data

[Source: Ratnayake (2013c)]

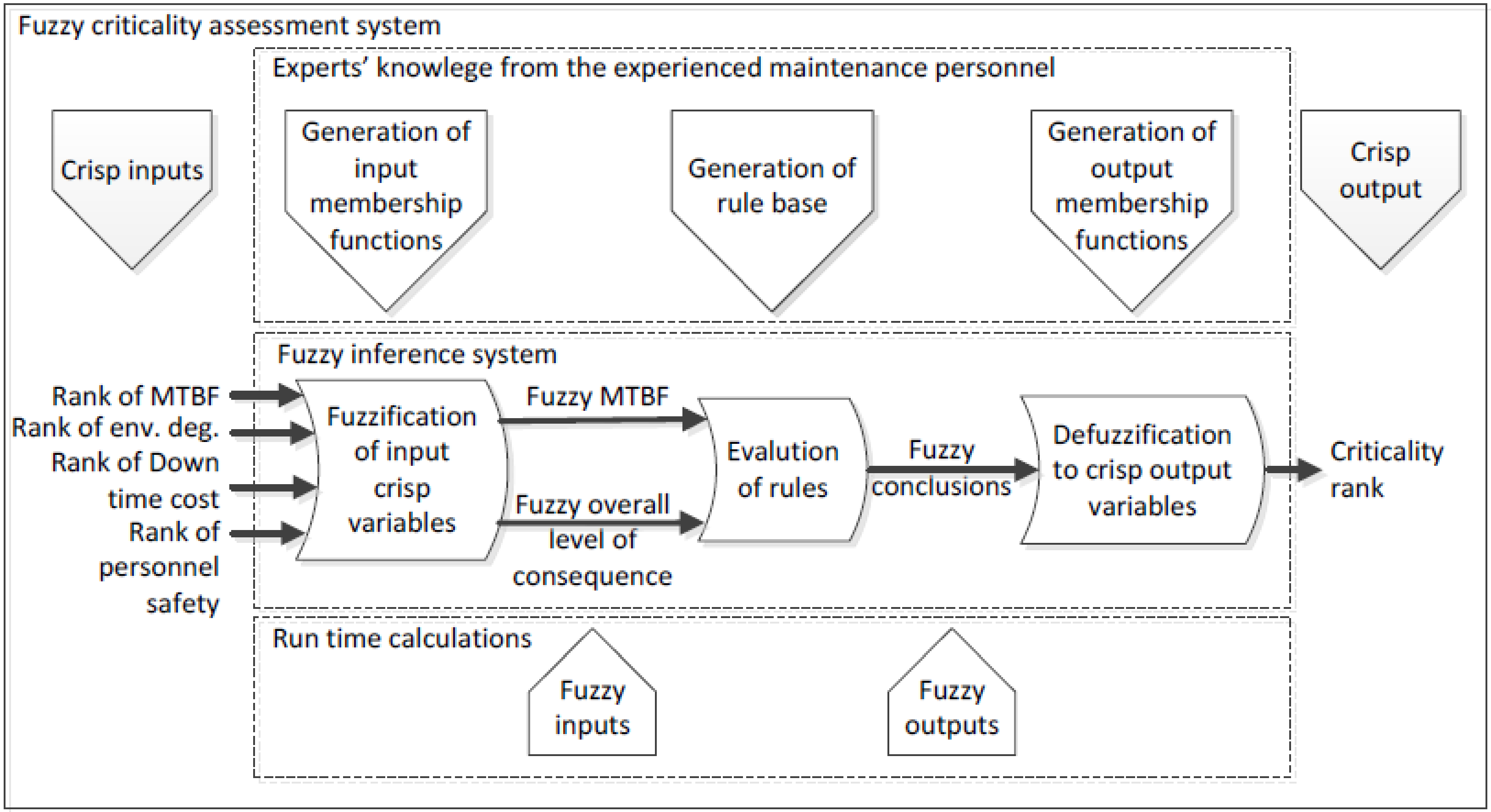


Figure 1. Fuzzy criticality ranking system

Example Illustration: Tailor made Rule Base for Criticality Matrix

[Source: Ratnayake, 2013c]

TAILOR MADE RULE BASE FOR CRITICALITY ANALYSIS AND RBM DECISIONS

Failure frequency	**Input membership functions**	Consequences					
		PS	Fatality	Permanent injury	Serious personnel injury	Medical treatment	First aid
		ED	> 200 m³	(20-200) m³	(2-20) m³	(0.2-2) m³	< 200 litres
		DTC	> 20 million	(4-20) million	(0.4-4) million	(0.125-0.4) million	< 0.125 million
	MTBF	**Rank**	**1**	**2**	**3**	**4**	**5**
	Less than 1 month	**1**	**VH**	**VH**	**VH**	**VH**	**VH**
	1 month to 1 year	**2**	**VH**	**VH**	**H**	**M-H**	**M-H**
	1 year to 5 years	**3**	**VH**	**H**	**M-H**	**M-L**	**L**
	5 years to 30 years	**4**	**H**	**M-H**	**M-L**	**L**	**VL**
	More than 30 years	**5**	**M-H**	**M-L**	**L**	**VL**	**VL**

Example 'Membership Functions': Incorporation of Quantitative and Qualitative Knowledge

[Source: Ratnayake (2013c)]

Table 4. Gaussian MF parameters for input and output variables

	Gaussian MF parameters (σ, c)					
Input variable	VH	H	M	L	VL	
MTBF	(0.5, 1)	(0.3, 2)	(0.3, 3)	(0.4, 4)	(0.2, 4.85)	
ED	(0.5, 1)	(0.4, 2)	(0.4, 3)	(0.4, 3.75)	(0.3, 4.75)	
Output variable	VH	H	M-H	M-L	L	VL
Risk	(0.3, 0.15)	(0.3, 1)	(0.3, 2)	(0.3, 3)	(0.3, 3.75)	(0.3, 4.75)

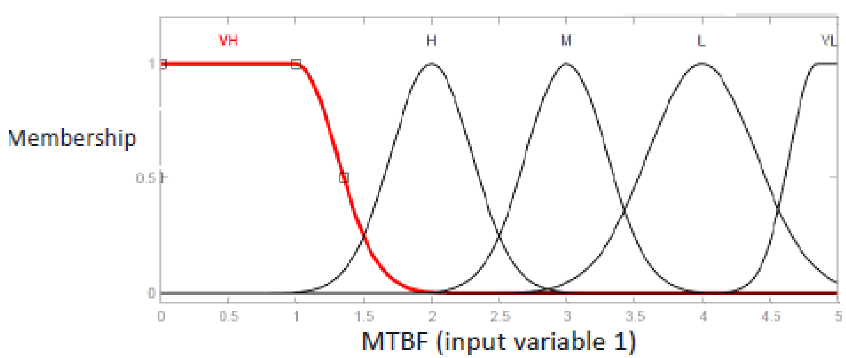


Fig. 2. MF plots for rank of MTBF.

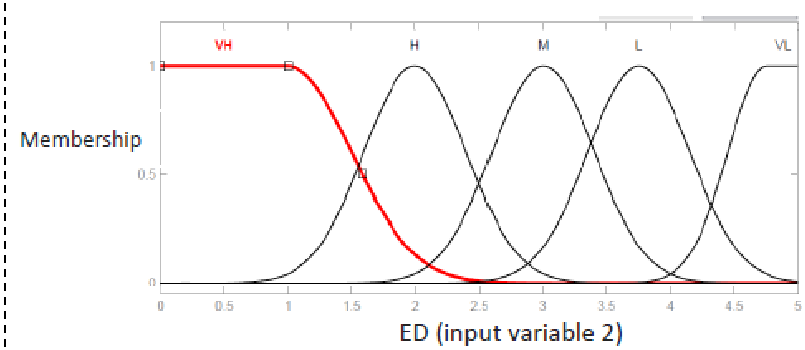


Fig. 3. MF plots for rank of ED.

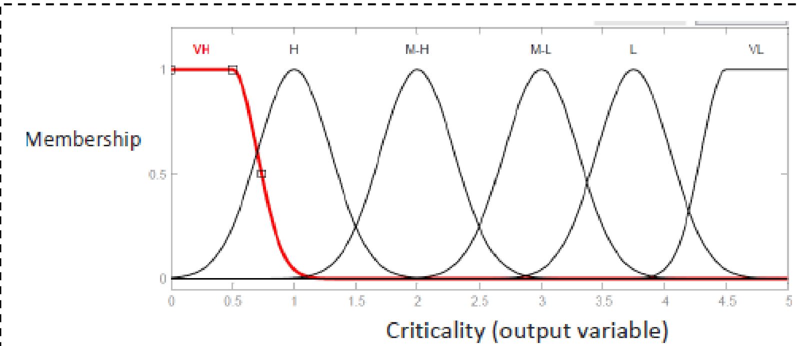
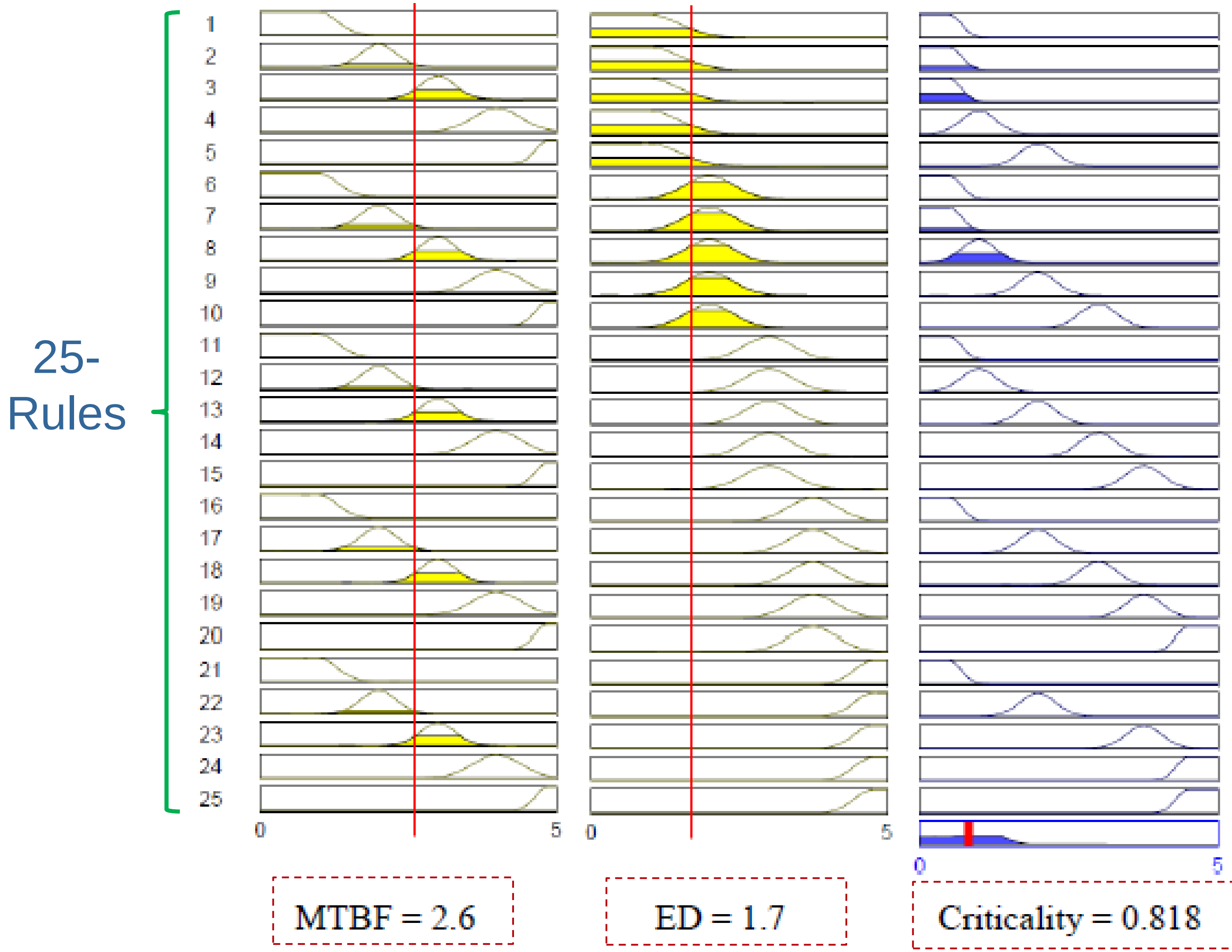


Fig. 4. MF plots of criticality.

Membership functions: the 'heart' of the 'rule base'

Example Illustration: Computation of Risk Rank in Relation to MTBF and Potential ED



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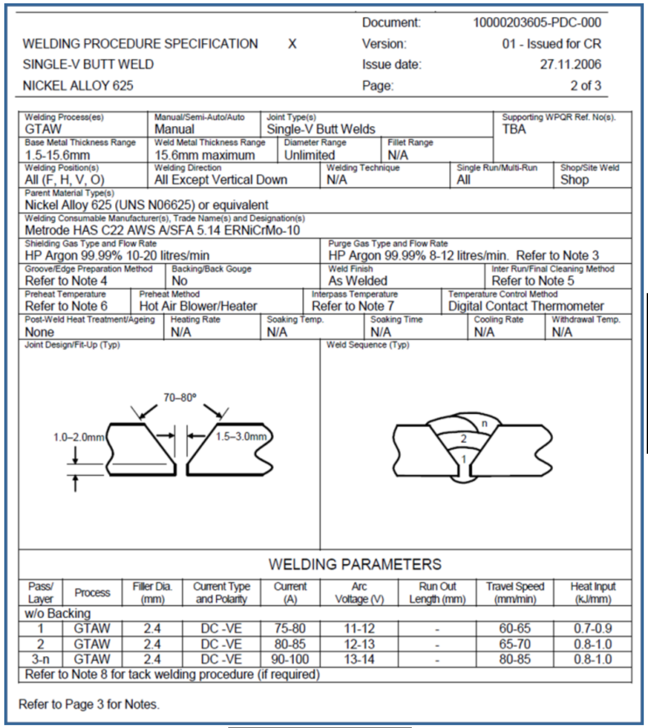
Data Analysis for Welder Qualification:
Interaction of 'Welding Procedure', 'Imperfection Groups' and 'Quality Deterioration Factors'



WELDING PROCEDURE SPECIFICATION	X	Document:	10000203605-PDC-000
SINGLE-V BUTT WELD		Version:	01 - Issued for CR
NICKEL ALLOY 625		Issue date:	27.11.2006
		Page:	2 of 3

Welding Process(es): GTAW | Manual/Semi-Auto/Auto: Manual | Joint Type(s): Single-V Butt Welds | Supporting WPQR Ref. No(s).: TBA

Base Metal Thickness Range: 1.5-15.6mm | Weld Metal Thickness Range: 15.6mm maximum | Diameter Range: Unlimited | Fillet Range: N/A

Welding Position(s): All (F, H, V, O) | Welding Direction: All Except Vertical Down | Welding Technique: N/A | Single Run/Multi-Run: All | Shop/Site Weld: Shop

Parent Material Type(s): Nickel Alloy 625 (UNS N06625) or equivalent

Welding Consumable Manufacturer(s), Trade Name(s) and Designation(s): Metrode HAS C22 AWS A/SFA 5.14 ERNiCrMo-10

Shielding Gas Type and Flow Rate: HP Argon 99.99% 10-20 litres/min | Purge Gas Type and Flow Rate: HP Argon 99.99% 8-12 litres/min. Refer to Note 3

Groove/Edge Preparation Method: Refer to Note 4 | Backing/Back Gouge: No | Weld Finish: As Welded | Inter Run/Final Cleaning Method: Refer to Note 5

Preheat Temperature: Refer to Note 6 | Preheat Method: Hot Air Blower/Heater | Interpass Temperature: Refer to Note 7 | Temperature Control Method: Digital Contact Thermometer

Post-Weld Heat Treatment/Ageing: None | Heating Rate: N/A | Soaking Temp.: N/A | Soaking Time: N/A | Cooling Rate: N/A | Withdrawal Temp.: N/A

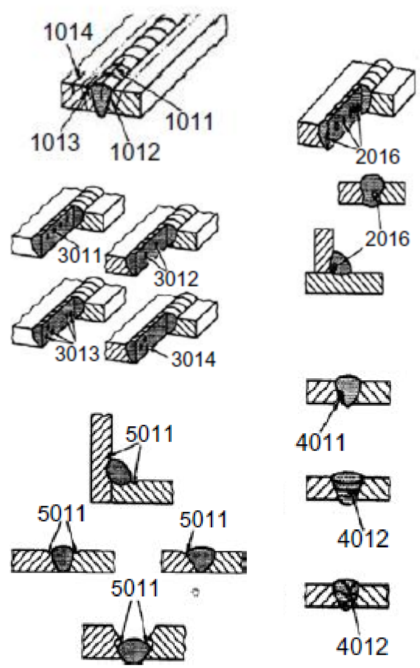
Joint Design/Fit-Up (Typ) | Weld Sequence (Typ)

WELDING PARAMETERS

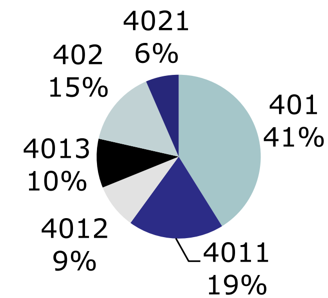
Pass/ Layer	Process	Filler Dia. (mm)	Current Type and Polarity	Current (A)	Arc Voltage (V)	Run Out Length (mm)	Travel Speed (mm/min)	Heat Input (kJ/mm)
w/o Backing								
1	GTAW	2.4	DC -VE	75-80	11-12	-	60-65	0.7-0.9
2	GTAW	2.4	DC -VE	80-85	12-13	-	65-70	0.8-1.0
3-n	GTAW	2.4	DC -VE	90-100	13-14	-	80-85	0.8-1.0
Refer to Note 8 for tack welding procedure (if required)								

Refer to Page 3 for Notes.

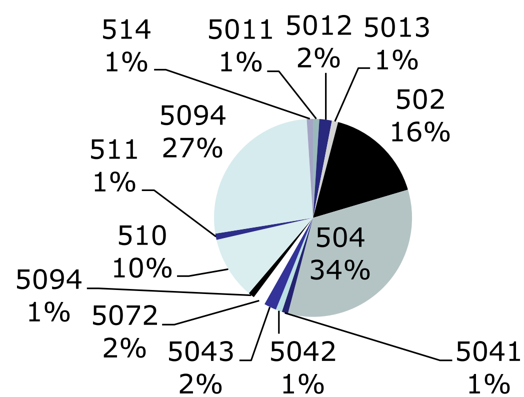
Imperfection group	Description
100	Cracks
200	Cavities
300	Solid inclusions
400	Lack of fusion and penetration
500	Imperfect shape and dimension
600	Miscellaneous imperfections

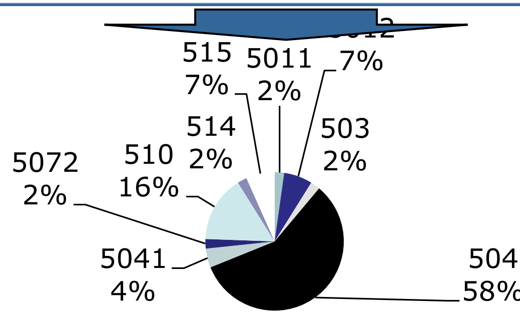


Average P150-05 *vs.* Group-4 defects 2008



P410-05 vs. Group-5 defects in 2009

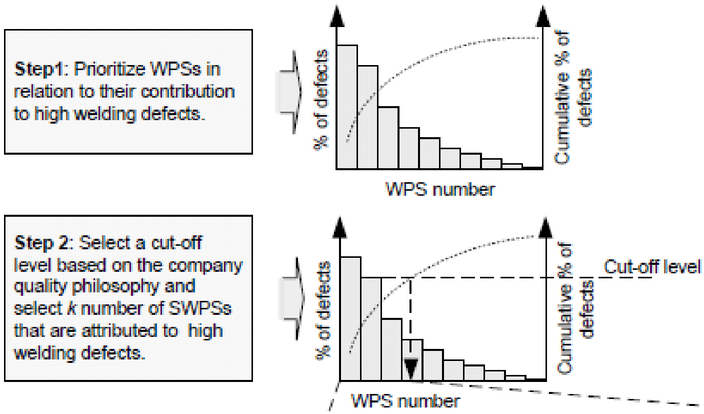




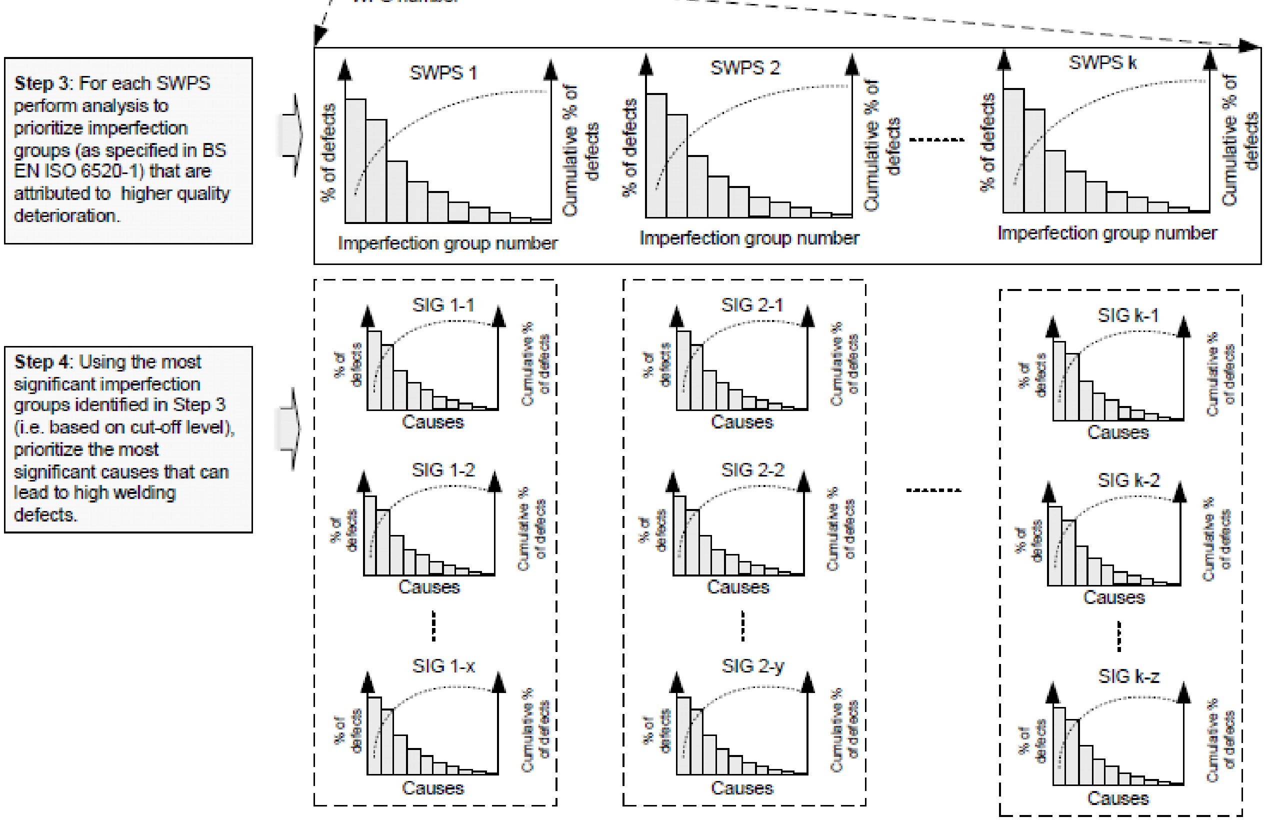
P150-05 *vs.* Group-5 defects in 2010

Illustration: A Consistent Approach for Welding Quality Data Analysis

[Source: Ratnayake (2012)]



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



Note: WPS= welding procedure specification

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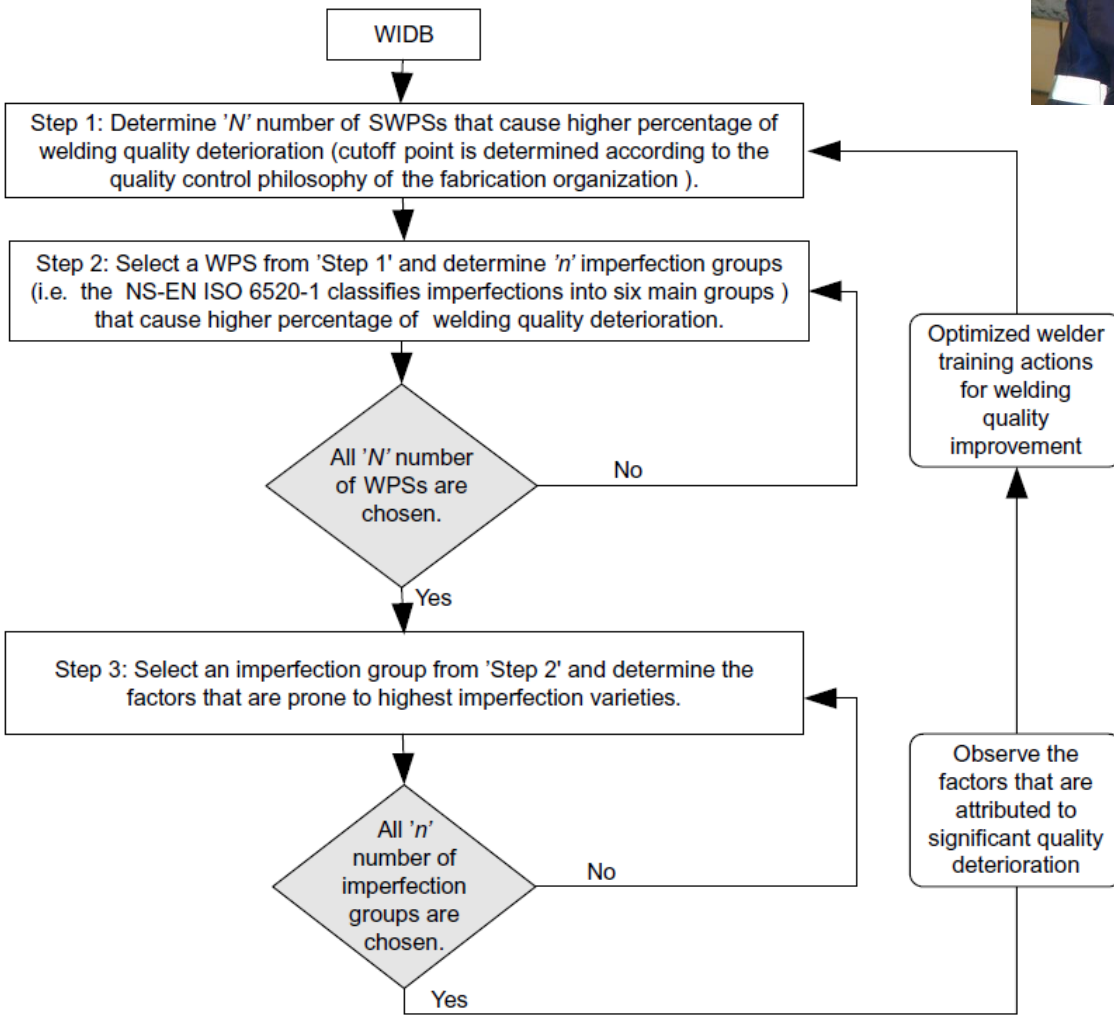
Prioritization of welding quality deterioration factors: An Algorithm

[Source: Ratnayake (2013b)]



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

$$CPDW_{WPS_n} = \sum_{i=1}^{n} PDW_{WPS_i}$$

$$PDW^{IG_i}_{SWPS} = \sum_{j=1}^{n} \frac{(d_{IG_i})_j}{N_{SWPS}} \times 100$$

$$CPIG^{IG_k}_{SWPS} = \sum_{i=1}^{k} \left(PDW^{IG}_{SWPS}\right)_i$$

$$PDW^{F_i}_{SWPS} = \sum_{j=1}^{k} \frac{(d_{F_i})_j}{N_{SWPS}} \times 100$$

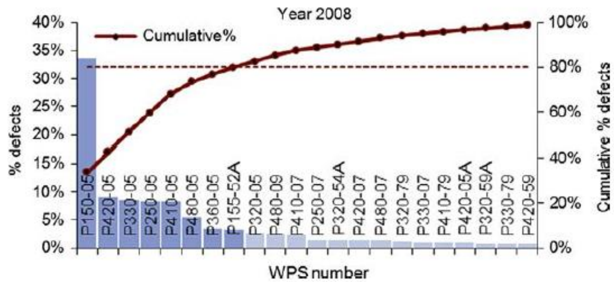
$$CPDW^{F_n}_{SWPS} = \sum_{i=1}^{n} \left(PDW^{F}_{SWPS}\right)_i$$

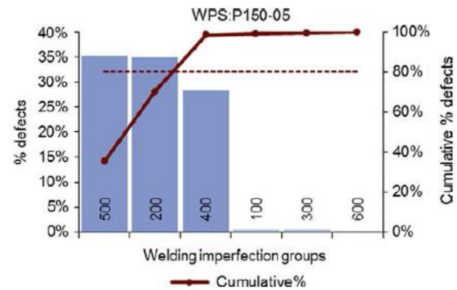
An algorithm for optimized welder training actions to improve welding quality

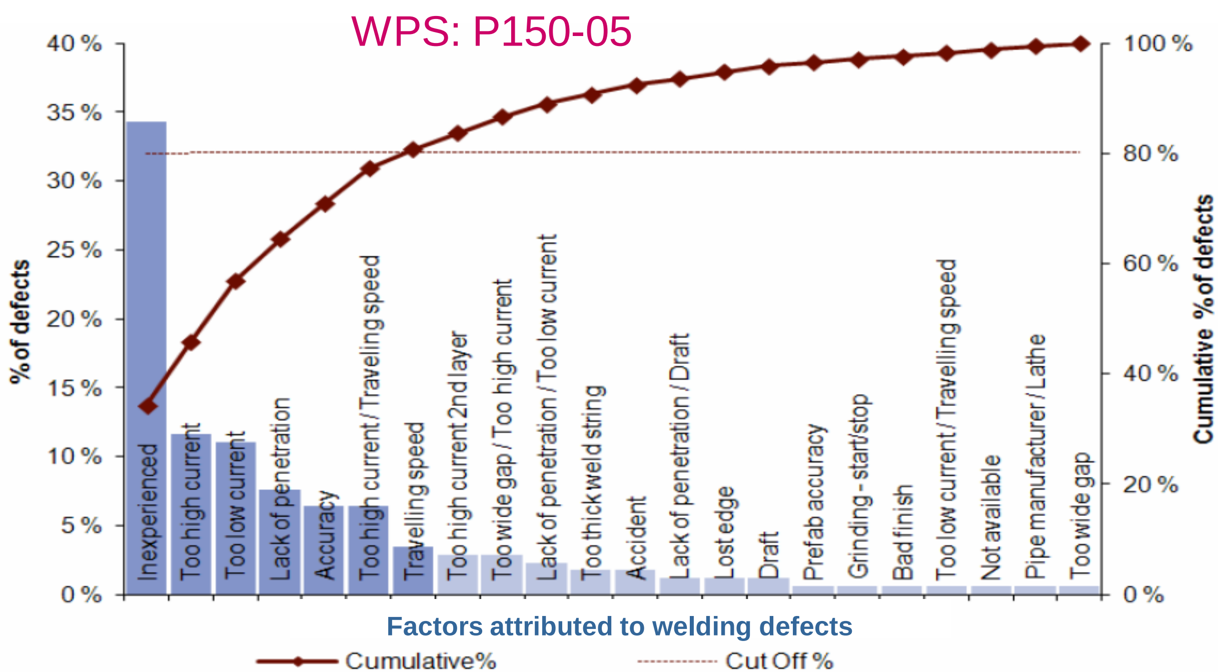
Final Outcome:

Prioritization of Welding Quality Deterioration Factors of Group-5 with WPS P150-05

[Source: Ratnayake, 2013b]





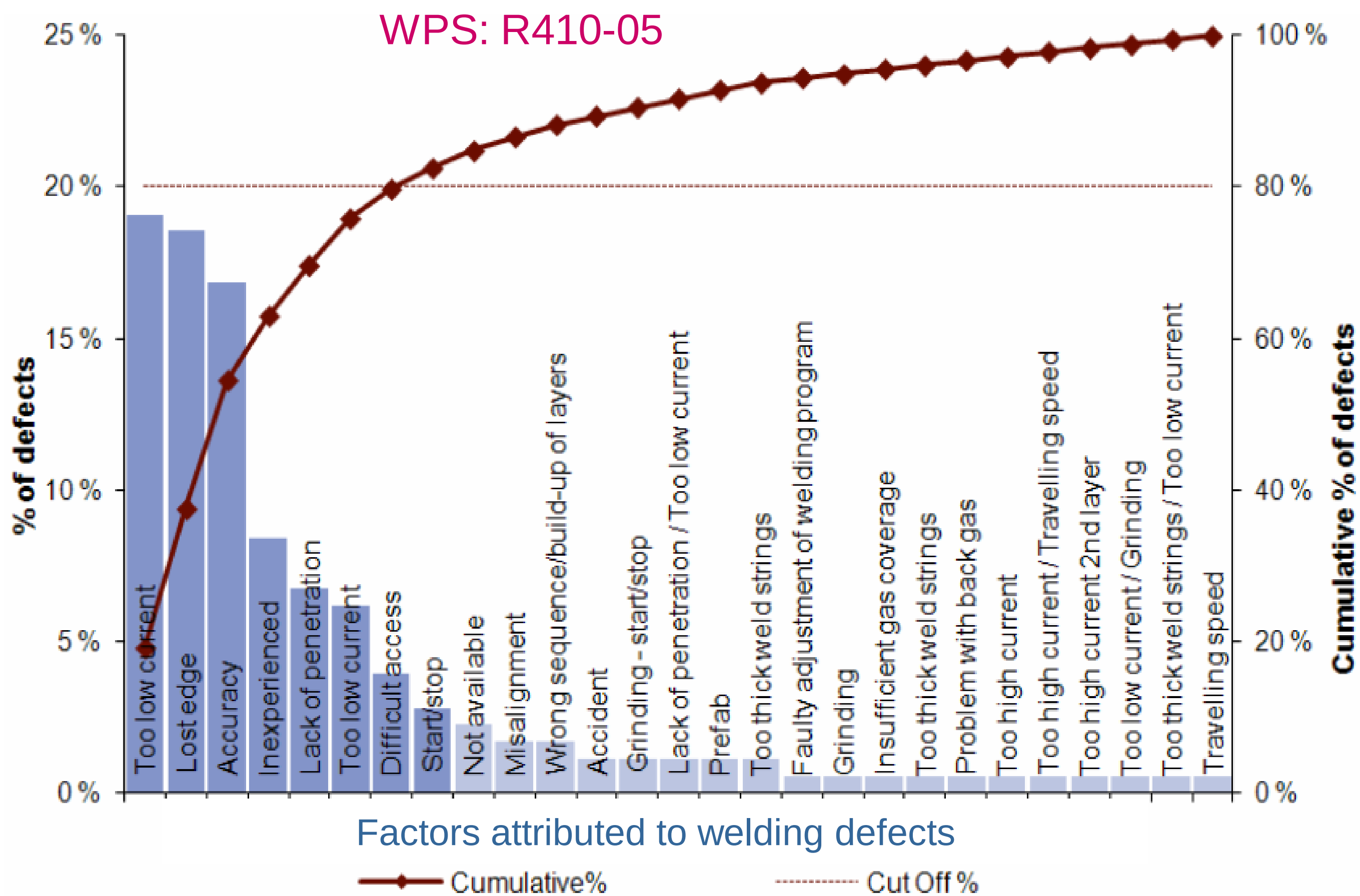


Factors attributed to welding defects vs average value of percentage and cumulative percentage defects attributed to WPS p150-05

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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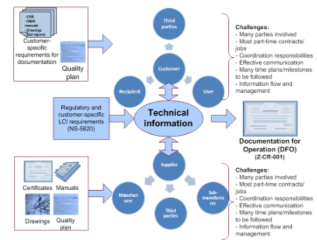
Current Status: Data/Information Management of MMO/EPCIC Projects

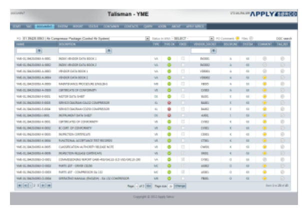
History

- 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

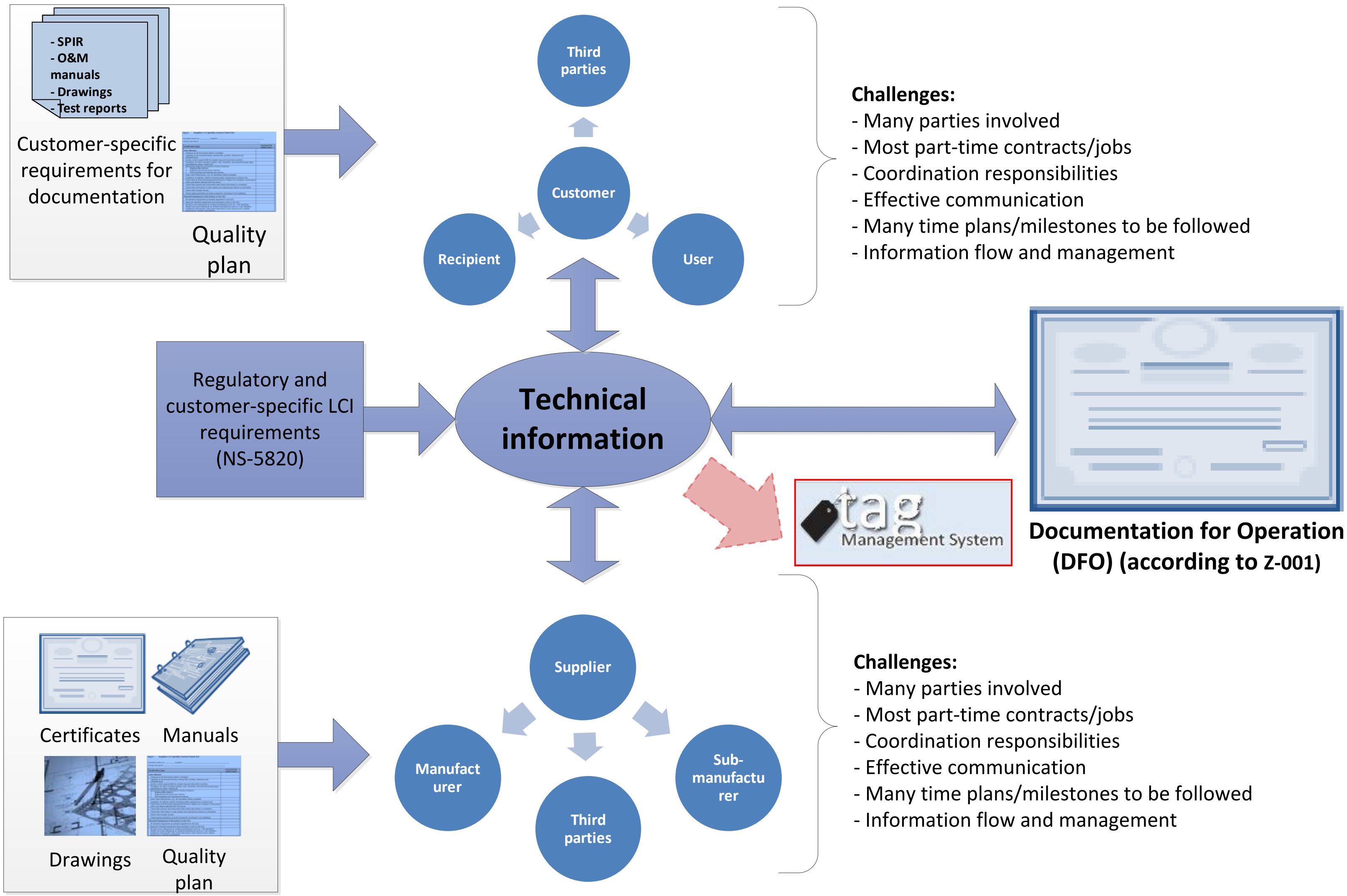
Best practice

- 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.

EPCIC => Engineering, Procurement, Construction, Installation & Commissioning-services
MMO => MMO - modification, maintenance and operational-support services

Current Challenges in Retrieving/Receiving/Requesting Data/Information for MMO/EPCIC Projects

[Source: Raza and Ratnayake (2012)]



Tag-Manager System: Handling Data/Information

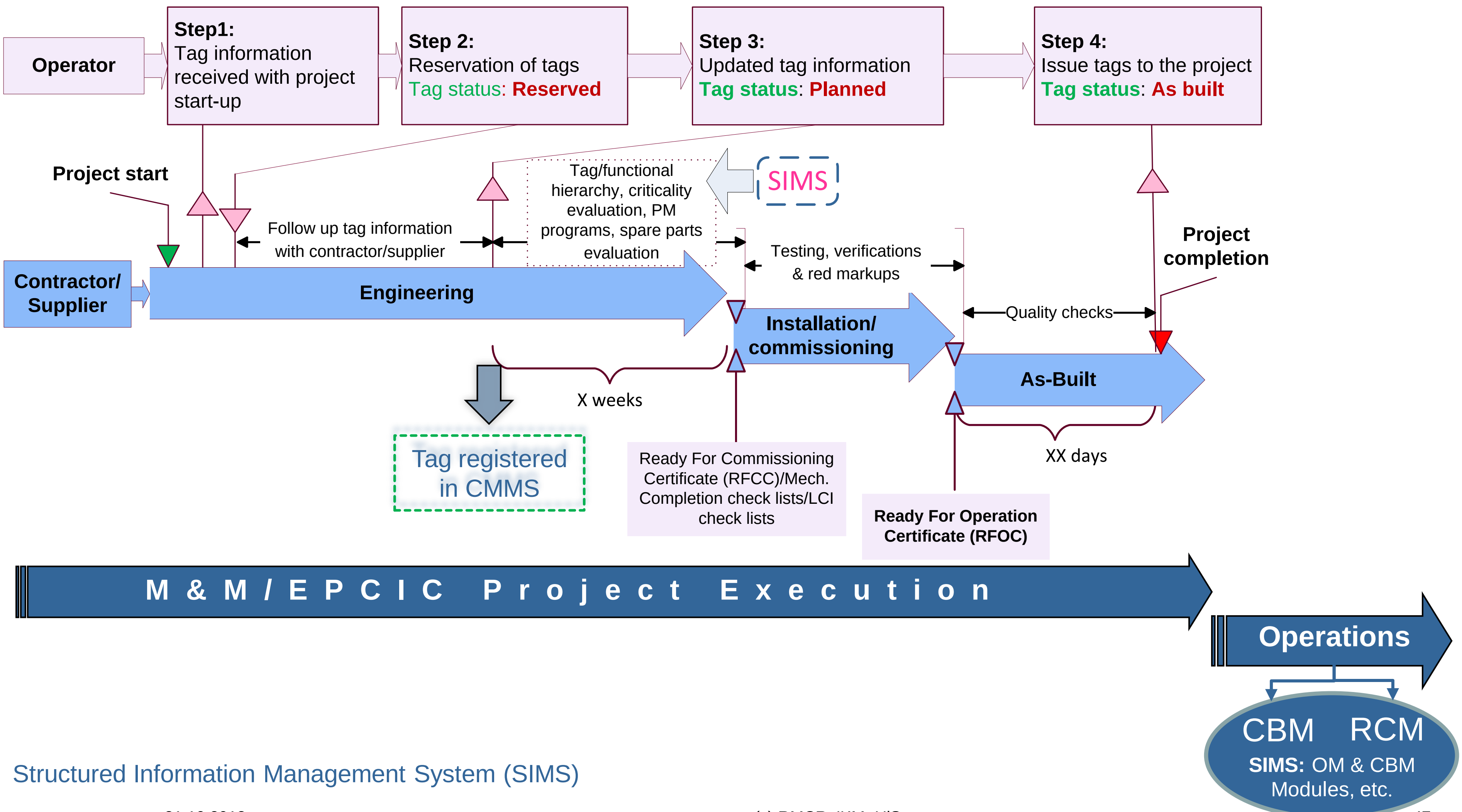
TAG Manager System manages tags and tags-related technical information for small- and large-scale modification projects. Provides;

- **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



Structured Information Management System (SIMS)

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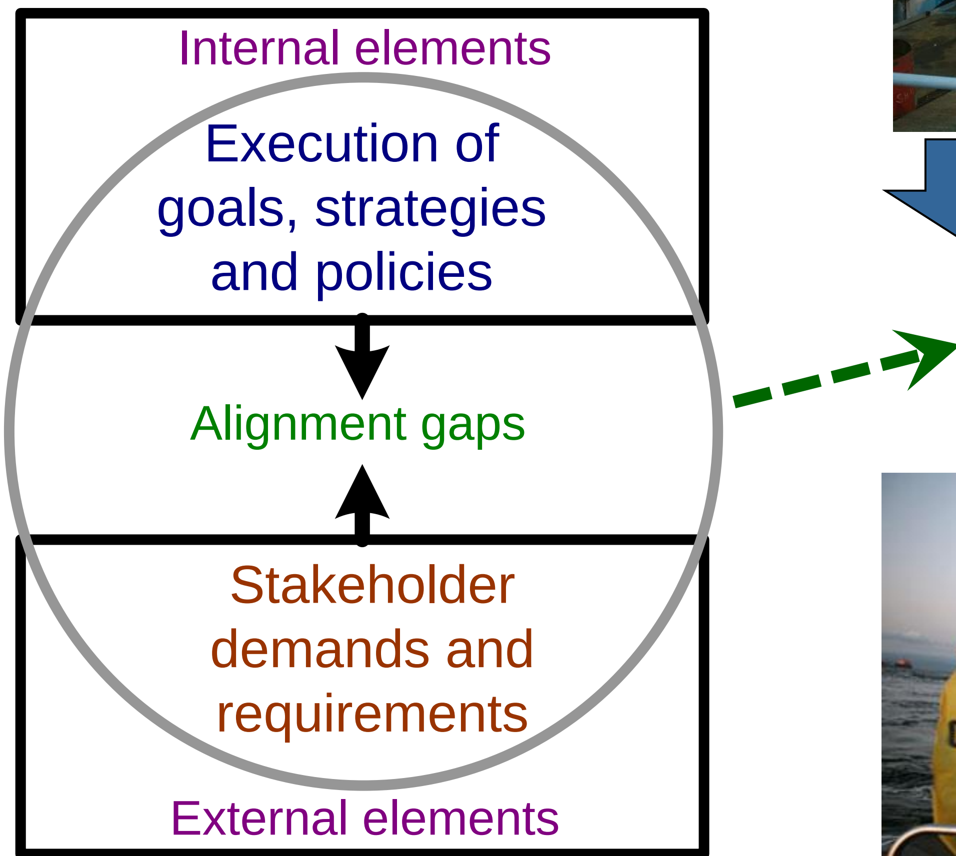
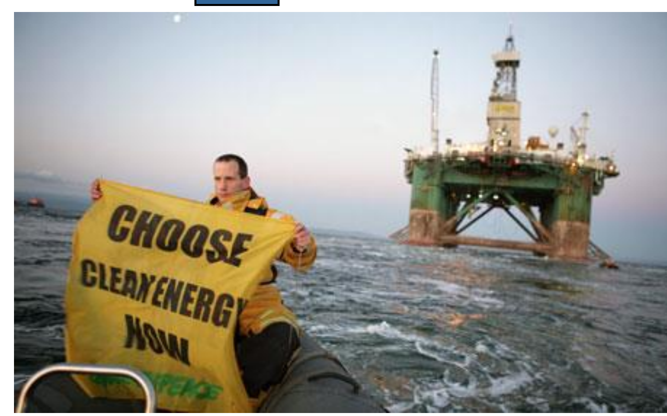
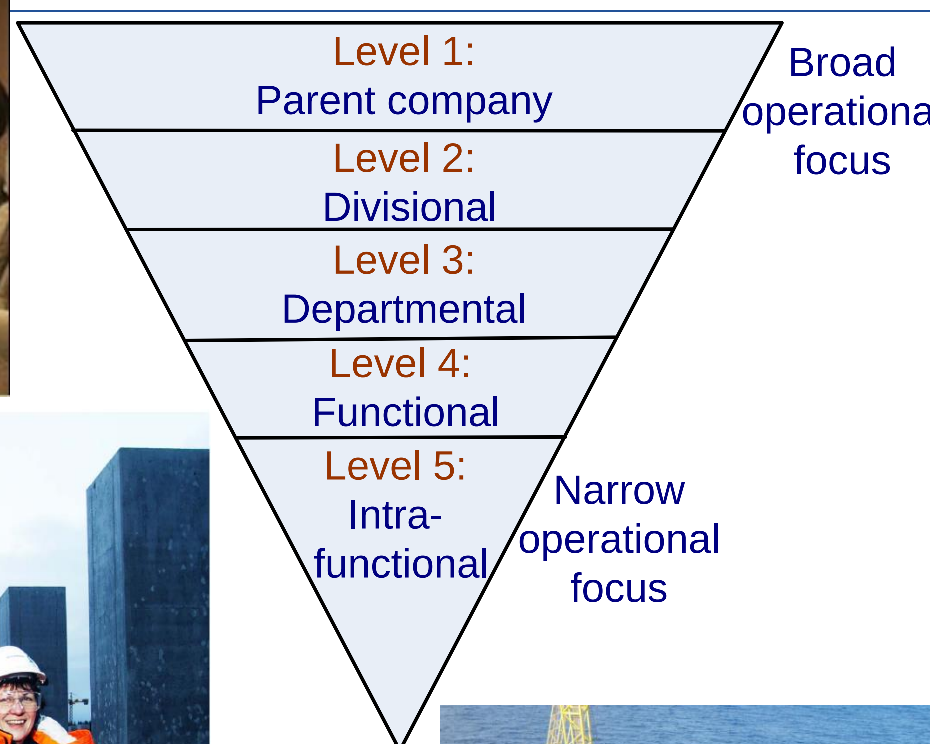
Summary: Roles and contents in an industrial organization





“**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*'



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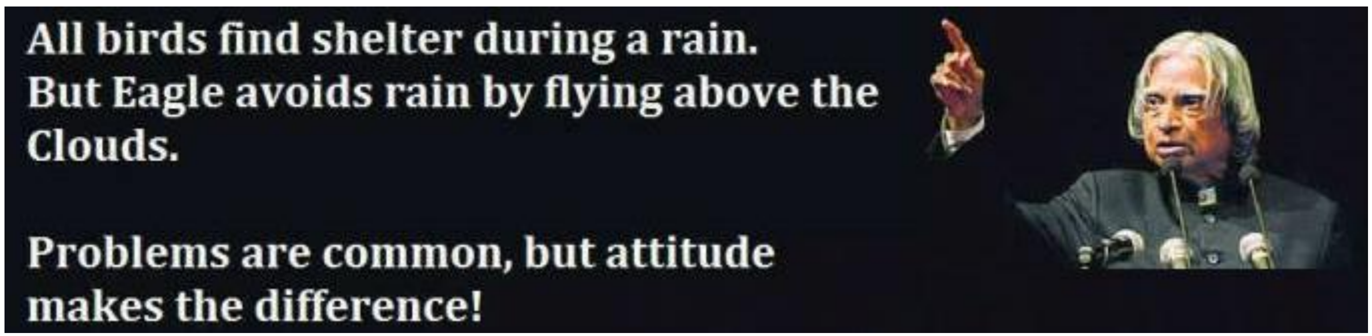
Thank you!



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APPLY SØRCO

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