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Asset Integrity and Risk Management Practices for Subsea Equipment

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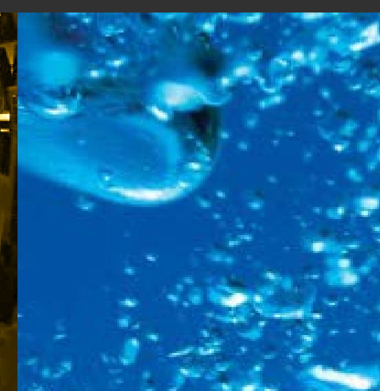



Presentation outline

1. What….Why…Asset Integrity ?
2. Asset Integrity Management in Subsea
3. Technical Risk Management Practices in Subsea
4. Challenges in Asset Integrity Management

1. What…Why…Asset Integrity ?

- Classically, [***Reliability***] is defined as probability that a system or equipment will perform its intended function, under stated operating conditions, over a period of time.

- In API 17N RP, ***Asset Integrity*** is defined as the ability of a system or equipment will perform its intended function while preventing or mitigating incidents that could pose a significant threat to life, health and the environment over its operating life.

1. What…Why…Asset Integrity ?

In essence, Asset Integrity is an extension of Reliability, taking into consideration that the operations do not have an impact on life, health and the environment.

Comparison of failure modes

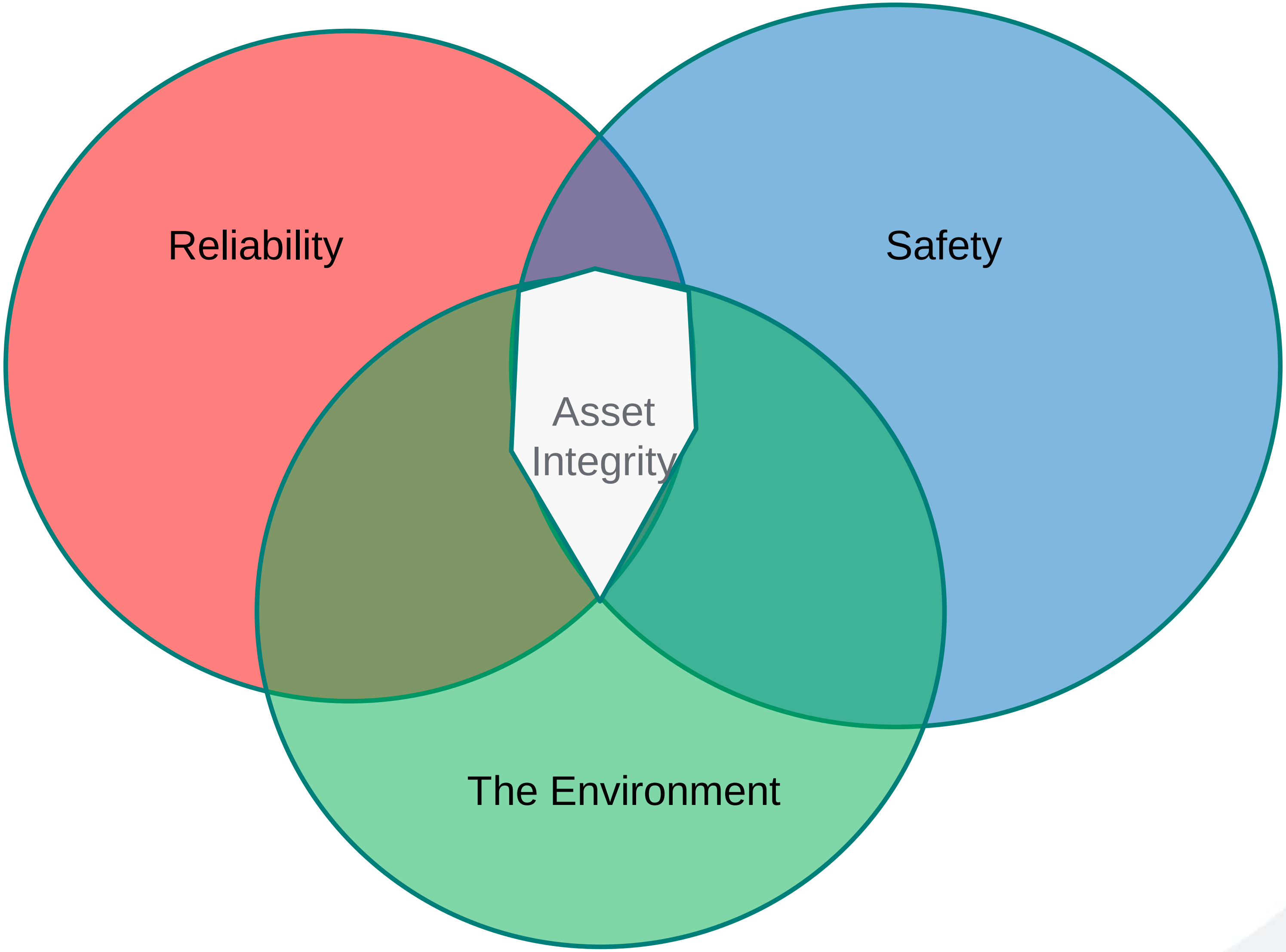
In classical *Reliability* :

- So long as intended function(s) is/are not met, the system is deemed to have failed.

In *Asset Integrity* :

- The system would have been deemed to fail not only due to function, but also if there are significant threats to *life, health and the environment*, regardless if the system is delivering it's intended function or otherwise.

1. What…Why…Asset Integrity ?



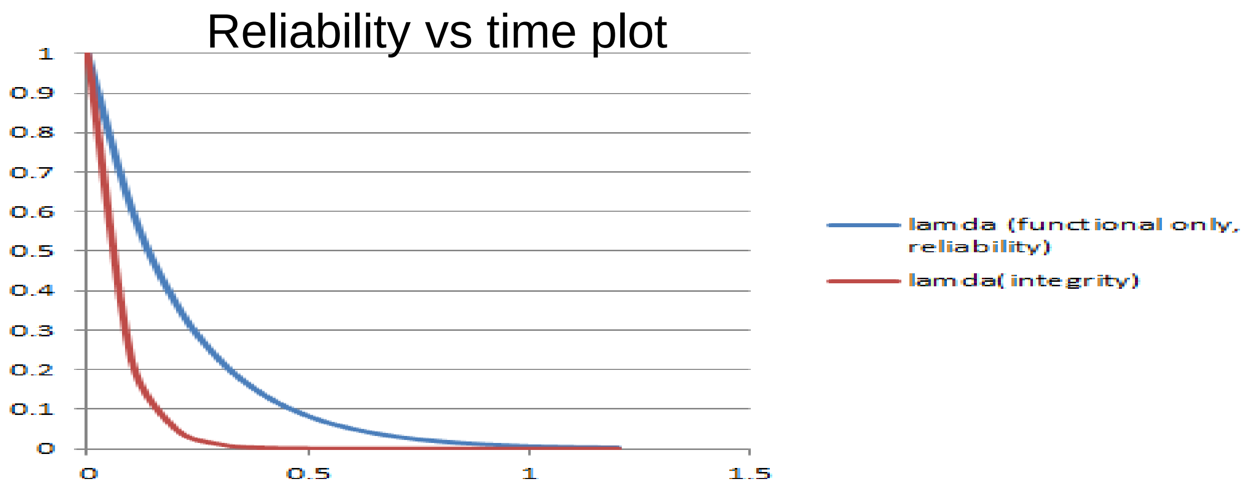
1. What…Why…Asset Integrity ?

Assuming an exponential distribution for the reliability function,

$$R = \exp(-\lambda t)$$

$$\lambda = \lambda_{functional} + \lambda_{safety} + \lambda_{environment}$$

- Increase in the weightage of the failure rate, potentially increasing the probability of failure.



1. What…Why…Asset Integrity?

- In 2010 – Macondo happened.
- Gulf of Mexico : Concern for Safety and Security
- Deeper waters, higher costs for intervention
- Lack of balance between

i. Reliability – production

ii. Integrity – isolation and containment

API 17N RP is undergoing a second revision to address this gap.

2. Asset Integrity Management

Asset Integrity Management is therefore a systematic implementation of activities necessary to ensure that systems installed will perform it's intended function (fit-for-use) and pose no threat to safety and the environment (safe-for-use) over it's operating life.

High production availability

- Maximise up time
- Minimise down time

INCOME

Best value field development

- Maximise Production
- Minimise CAPEX
- Minimise OPEX

PROFITABILITY

No loss of containment

- High level of integrity
  - Hardware
  - Software
  - Human
  - Organisational

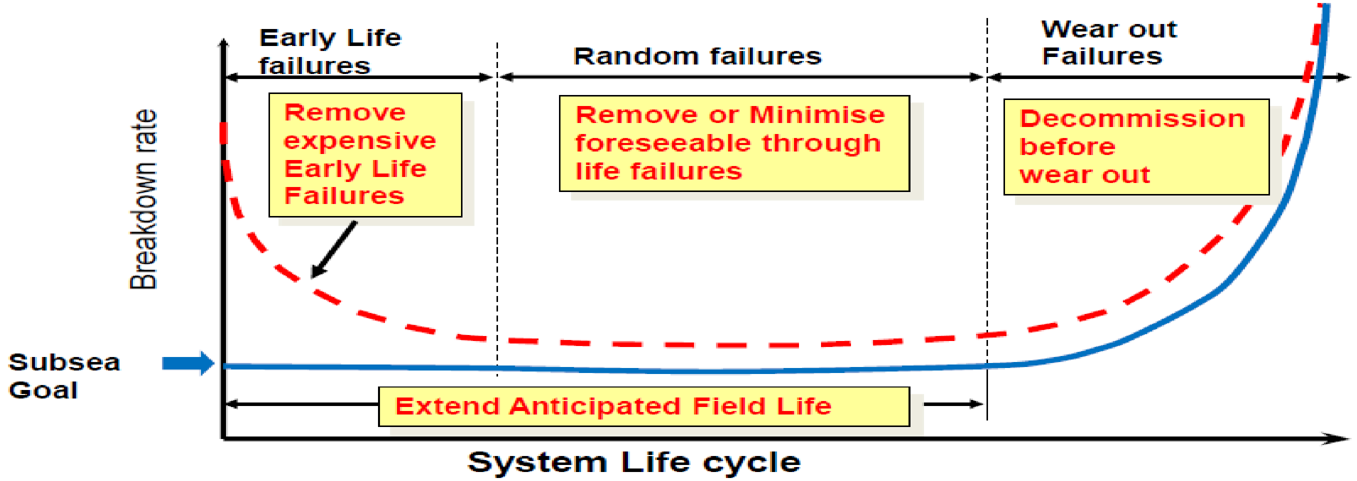
ENVIRONMENTAL REPUTATION

2. Asset Integrity Management

Strategy :

- Use of field-proven technology
- Increased focus on qualification of technology
- Risk management tools

(identify potential risks and mitigation as early as possible)



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2. Asset Integrity Management

Strategy : (continued)

- Failure/Reliability data collection
- Lessons learned and organisational learning
- Preventive Maintenance and Reliability-Centred-Maintenance

3. Technical Risk Management Practices in Subsea

- Review of Lessons Learned

- Technical Risk Categorisation (TRC)

  As per API 17N, 5 change risk factors were identified:-

❖ Reliability
❖ Technology
❖ Architecture
❖ Environment
❖ Organisation

- Assessment of maturity of technology via Technology Readiness Level (TRL)

Table B.19—Definition of Technology Readiness Levels (TRLs)

	TRL	Development Stage Completed	Definition of Development Stage
Concept	0	**Unproven Concept** (Basic R&D, paper concept)	Basic scientific/engineering principles observed and reported; paper concept; no analysis or testing completed; no design history
Proof of Concept	1	**Proven Concept** (Proof of concept as a paper study or R&D experiments)	a) Technology concept and/or application formulated b) Concept and functionality proven by analysis or reference to features common with/ to existing technology No design history; essentially a paper study not involving physical models but may include R&D experimentation
	2	**Validated Concept** Experimental proof of concept using physical model tests	Concept design or novel features of design is validated by a physical model, a system mock up or dummy and functionally tested in a laboratory environment; no design history; no environmental tests; materials testing and reliability testing is performed on key parts or components in a testing laboratory prior to prototype construction
Prototype	3	**Prototype Tested** (System function, performance and reliability tested)	a) Item prototype is built and put through (generic) functional and performance tests; reliability tests are performed including; reliability growth tests, accelerated life tests and robust design development test program in relevant laboratory testing environments; tests are carried out without integration into a broader system b) The extent to which application requirements are met are assessed and potential benefits and risks are demonstrated
	4	**Environment Tested** (Pre-production system environment tested)	Meets all requirements of TRL 3; designed and built as production unit (or full scale prototype) and put through its qualification program in simulated environment (e.g. hyperbaric chamber to simulate pressure) or actual intended environment (e.g. subsea environment) but not installed or operating; reliability testing limited to demonstrating that prototype function and performance criteria can be met in the intended operating condition and external environment
	5	**System Tested** (Production system interface tested)	Meets all the requirements of TRL 4; designed and built as production unit (or full scale prototype) and integrated into intended operating system with full interface and functional test but outside the intended field environment
Field Qualified	6	**System Installed** (Production system installed and tested)	Meets all the requirements of TRL 5; production unit (or full scale prototype) built and integrated into the intended operating system; full interface and function test program performed in the intended (or closely simulated) environment and operated for less than 3 years; at TRL 6 new technology equipment might require additional support for the first 12 to 18 months
	7	**Field Proven** (Production system field proven)	Production unit integrated into intended operating system, installed and operating for more than three years with acceptable reliability, demonstrating low risk of early life failures in the field

3.0 Technical Risk Management Practices in Subsea

- Review of the System Availability Goal

  Based on current trends, the targetted availability by operators observed in most subsea projects have ranged from 95.0% - 99.95% over an operational life of 15 – 30 years.

  Some operators broke down further the availability requirements to specific sub-systems. (Controls System, Chemical Injection System, Water Injection System, etc…)

- System Level Failure Modes, Effects and Criticality Analysis (FMECA) to identify critical-to-availability/safety components.

  Operational Spares to be recommended based on criticality analysis

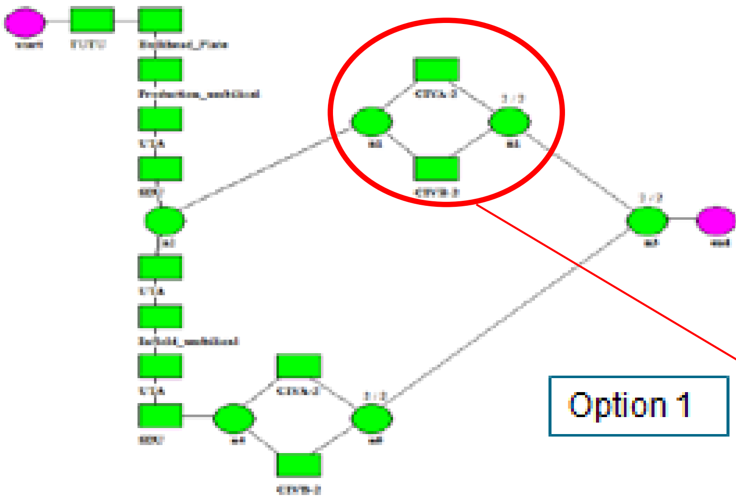
- Component level FMECA, where applicable and necessary

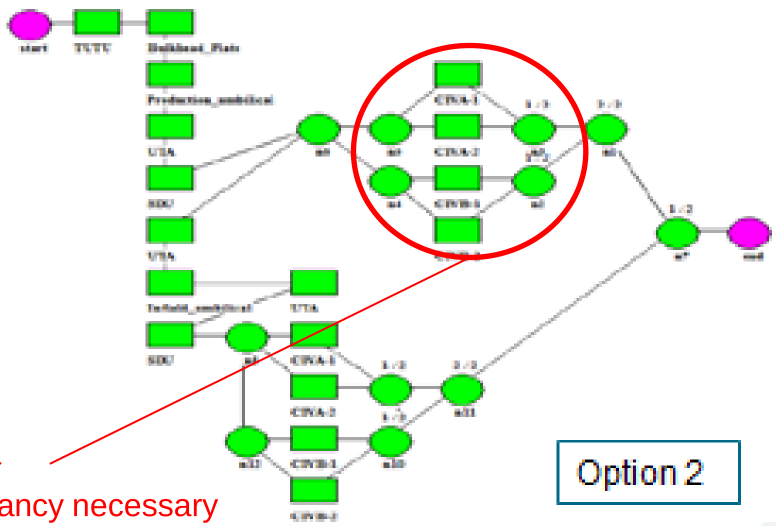
  For critical components identified in the system level FMECA, or as per recommended based on the ratings given in API 17N TRC assessment.

3.0 Technical Risk Management Practices in Subsea

- Reliability Block Diagram (RBD) constructed for Reliability, Availability and Maintanability (RAM) analysis –

  - Operational Spares to be recommended based on criticality analysis
  - Optimisation of the layout may be advised based on outcome of the analysis
    (Eg. Do we require a completely redundant chemical injection line to meet the availability target or is a single line suficient?)





Is redundancy necessary
to meet availability target?

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3.0 Technical Risk Management Practices in Subsea

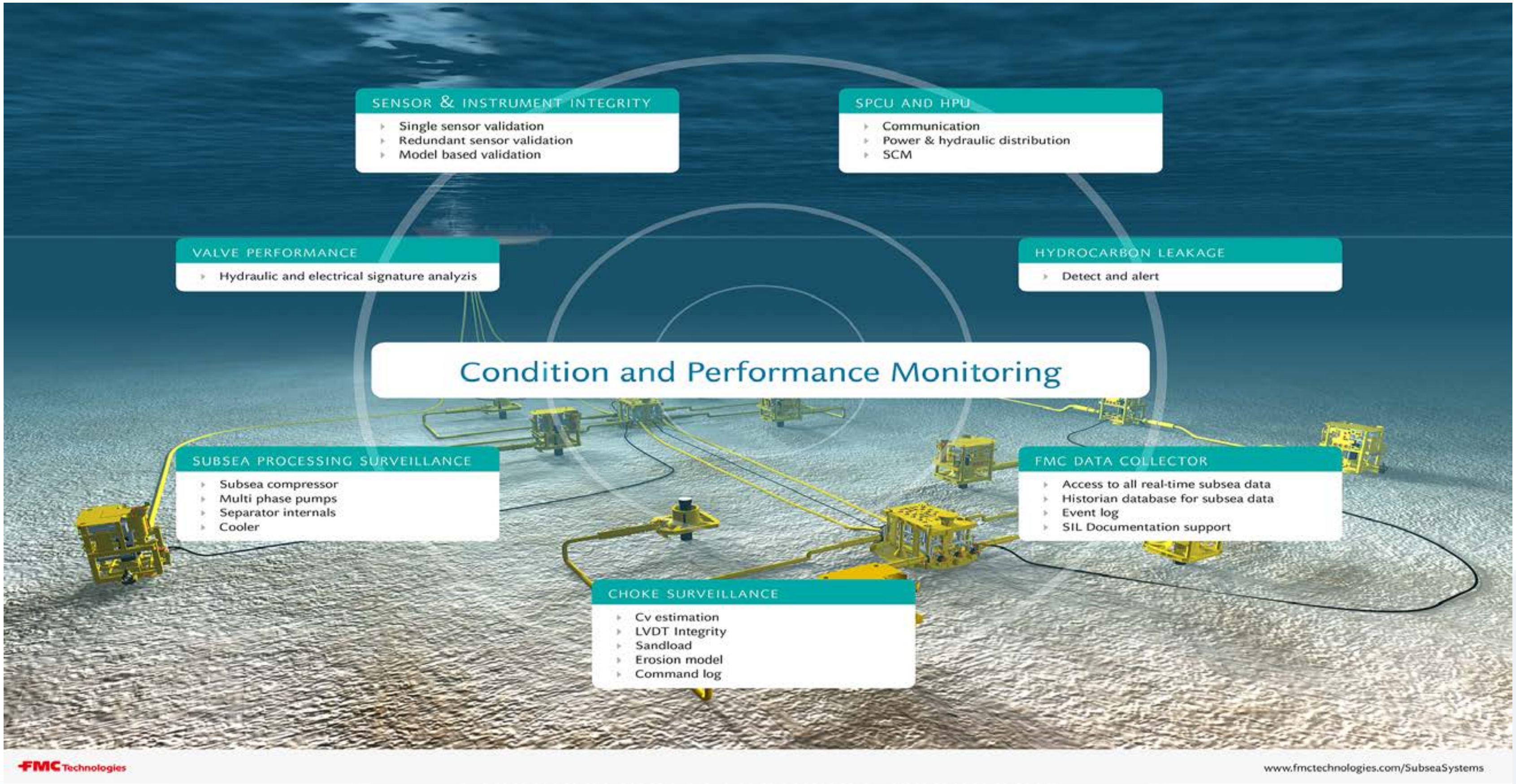
- Hazards Identification (HAZID) review with operator and subcontractors/interfaces

- Hazards and Operability (HAZOP) review with operator and subcontractors/interfaces

Risk Based Inspection (RBI) strategies, optimisation of operational procedures may be developed as an outcome of these reviews to maximise the uptime integrity of the system.

3.0 Technical Risk Management Practices in Subsea

- Condition and Performance Monitoring (CPM)
  The world's 1st subsea CPM system was supplied by FMC for the Gjoa project in 2012.



4.0 Challenges in Asset Integrity Management

- Adequacy of industry/field data
- Managing CAPEX/OPEX ratio
- Optimising of Preventive Maintenance (PM)/ Testing
- Experience/Competency level of operators
- Stretch in operating envelope in Subsea projects (deeper waters, extreme temperatures, higher pressures…)

Thank you for your attention !