OSV design and maintenance optimization in the digital era
Reliability centered engineering solutions

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OSV life-cycle approach

- Balancing capability, operability and reliability vs. cost
  - Total Cost of Ownership: Capex and Opex
  - Assessing different design solutions
  - Fleet management optimisation: maintenance vs. availability
- RAMS (Reliability, Availability, Maintainability & Safety) analysis
  - Inspired by other industries (oil & gas, aerospace, automotive)
  - Connected ship: enhanced effectiveness of Reliability Centered Maintenance (RCM) using condition monitoring (smart sensors)


Condition Based Maintenance (CBM)

- Logical assumption: preventative repair or replacement of machinery components would be optimally timed if they were to occur just prior to the onset of failure
- Objective: obtain maximum useful life from each physical asset before taking it out of service
- If correctly implemented, CBM will result in significant reduction of maintenance cost compared to traditional maintenance strategies
  - Detection of faults outside fixed maintenance intervals
  - Deferral of fixed-schedule maintenance actions
  - Maintaining or increasing production and plant availability
  - Prevention of catastrophic failure

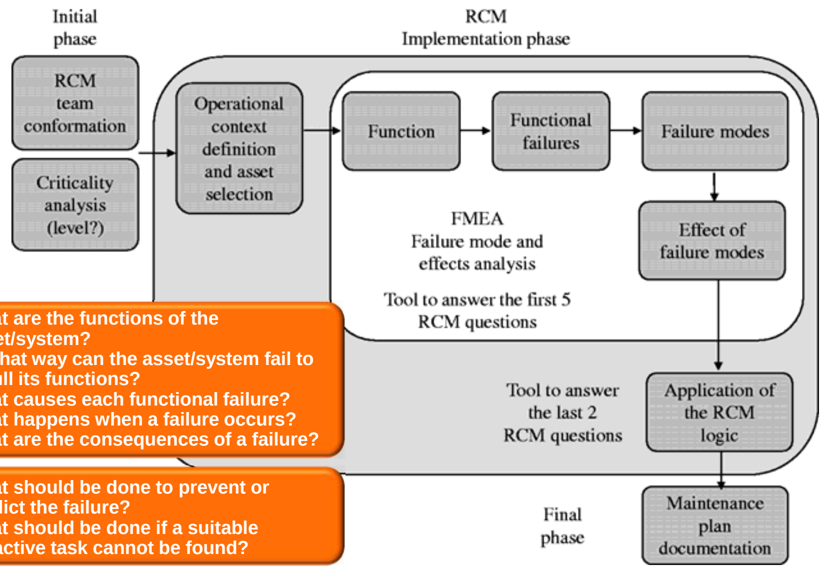
Step by step CBM setup

- Systems criticality assessment
- Definition of fault sensitive parameters
  → question of necessary and sufffficient
  - Vibration
  - Lube oil
  - Bearing temperature
  - Performance/efficiency
  - …
- CBM strategy definition
- Procurement of software and hardware
- CBM training courses

Reliability Centered Maintenance (RCM)

- Main objectives
  - Focus preventive maintenance effort on equipment essential to health, safety, environment and/or operation
  - Implement optimized maintenance plan (what, when, how) making as far as possible use of CBM
  - Increase inherent reliability and availability of asset in its operating context
  - Validate adequacy between design, operation and preventive maintenance
  - Demonstrate commitment to improve reliability, safety and environmental integrity in front of insurers, charterers, regulatory bodies, etc.

RCM process and key questions



1. What are the functions of the asset/system?
2. In what way can the asset/system fail to fulfull its functions?
3. What causes each functional failure?
4. What happens when a failure occurs?
5. What are the consequences of a failure?

6. What should be done to prevent or predict the failure?
7. What should be done if a suitable proactive task cannot be found?

Class renewal survey systems

- Normal Survey system: standard periodical surveys in five-year cycle
- Continuous Survey system (CS)
  - Part of items to be continuously surveyed in rotation over five-year survey cycle
  - Applies to hull (CSH), machinery (CSM) and auxiliary systems covered by class
  - Chief engineer allowed to survey most (machinery) items under his supervision, followed by confirmatory survey/audit carried out by class surveyor (subject to specific class instructions regarding eligible items)
- Planned Maintenance System (PMS)
  - Alternative to CS for items covered by PMS
  - Scope and periodicity of class renewal survey tailored to each individual (machinery) item based on manufacturer recommended overhauls, operator experience (documented) and, if applicable and fitted, condition monitoring
  - BV class notation **STAR MACH SIS**: machinery PMS supplmented with risk analysis of machinery and other equipment (e.g. navigation instrumentation)

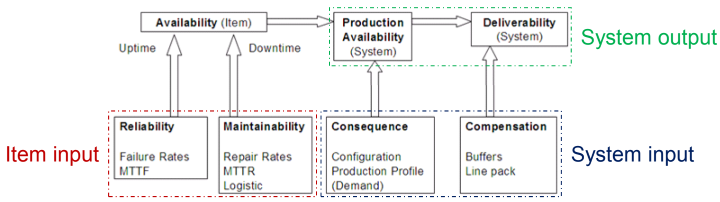
RCM in the digital era

- Sensor technology enables CBM of assets and systems
  → *modern complex OSV* = *integrated system of systems*
- Connectivity allows for remote monitoring, analysis and decision making based on measured data ("big data" if you like)
  - Reliability Centered Maintenance (RCM) using CBM and Predictive Maintenance (PdM) techniques enables development of (cost) optimized maintenance plan and Risk Based Inspection (RBI) regime
  - Scaleable to entire vessels and fleets by appying "digital AIMS"
  - Standardisation and system robustness are key: seek the right partner!
  - Consider 4 P's: Plant, Process, People & Performance

AIMS in the digital era

Holistic approach to reliability engineering

- Objectives of RAM(S) analysis
  - Quantify production availability/efficiency on time varying basis to assess potential performance over asset or project lifetime
  - Identify equipment items and subsystems critical to production
  - Quantifiably compare performance of alternative design solutions
  - Provide guidance for future OPEX allocations in terms of frequency and duration of (planned and unplanned) maintenance activities



Proven reliability engineering models and tools developed by Apsys (Airbus Group) for aerospace industry

BV & APSYS

Bureau Veritas & APSYS collaboration to propose a new framework

Transpose, adapt, and efficiently redimension **best aeronautic practices and tools to Offshore Oil & Gas industry**

Use BV network expertise to implement APSYS solutions and assist clients in **building robust and safe installations while optimising design and operating costs**

From reliability in design to operational performances

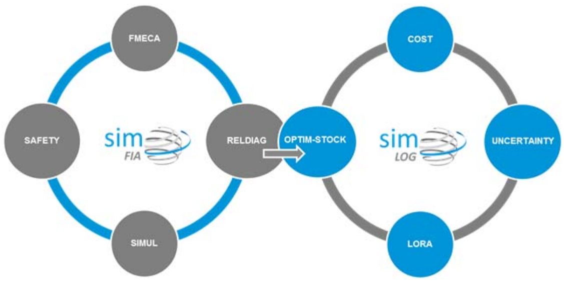
- The value of an asset (Aircraft, Train, Rig, Vessel, etc) is in its **availability** which depends on:
  - **Reliability** (of the system itself)
  - **Maintainability** (**Availability of support)**:
    - Maintenance
    - Sparing
    - Logistics
    - Supply chain

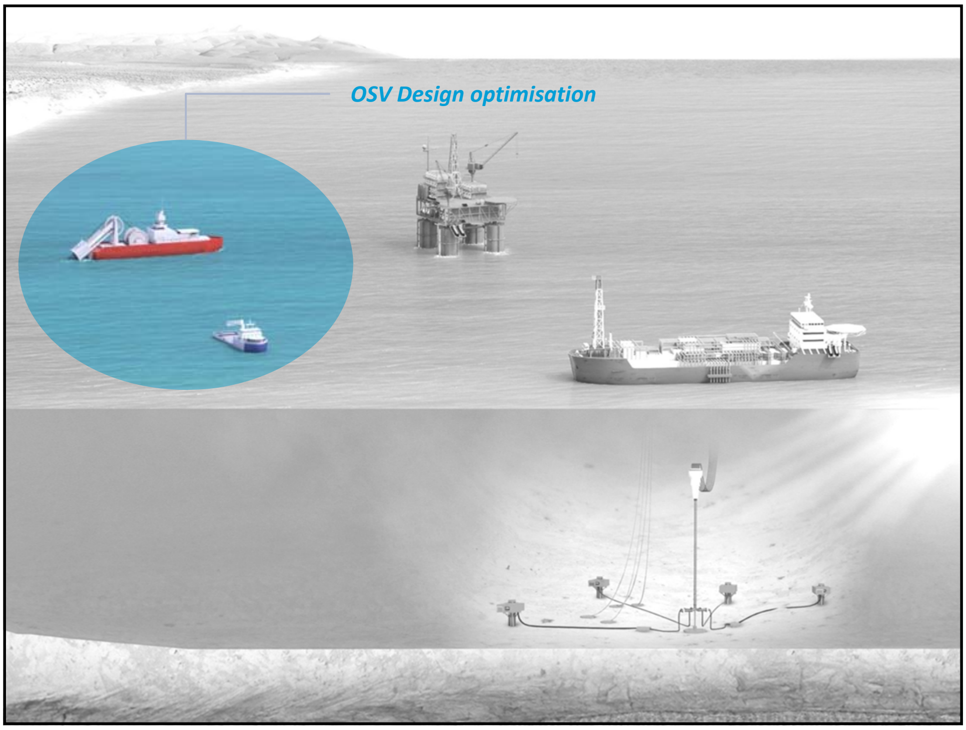
From reliability in design to operational performances

- To address **availability** challenge in design (CAPEX) or in operation (OPEX), aerospace and other industries as automotive or defense have developed and deployed specific approaches:
  - System engineering
    - To support the design of complex and interconnected systems and integrate reliability, availability, maintainability (RAM) at the very beginning of a project
  - Integrated Logistic Support
    - To support operations of complex and interconnected systems during the entire lifecycle, considering cost of ownership

From reliability in design to operational performances

- Such approaches have been supported by **specific tools** to model, simulate, project, anticipate the behavior of such complex systems and support decision making
- Model based tools :
  - Focus on systems design and interfaces
  - Generate RAMS studies
  - Simulate years of operations in seconds and project into the future to determine vulnerabilities and risks



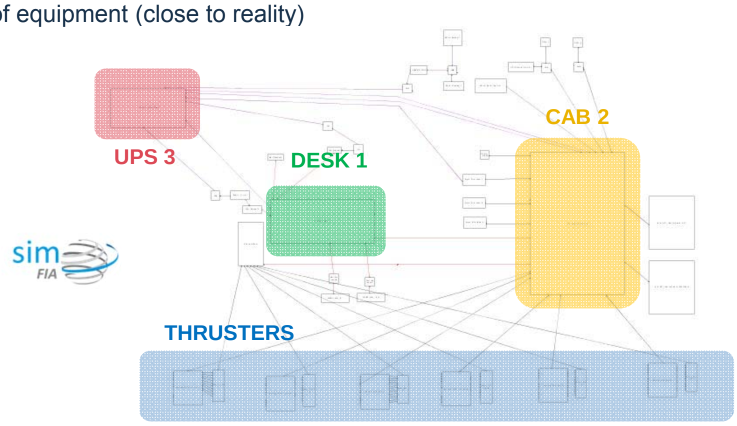


Case study 1: Design optimization

- Optimisation of OSV design based on reliability
  - What are the critical systems (contributors to unavailability)?
  - How can I optimise my system (availability vs cost)?
  - What should be my maintenance strategy?
  - What is the cost of ownership?

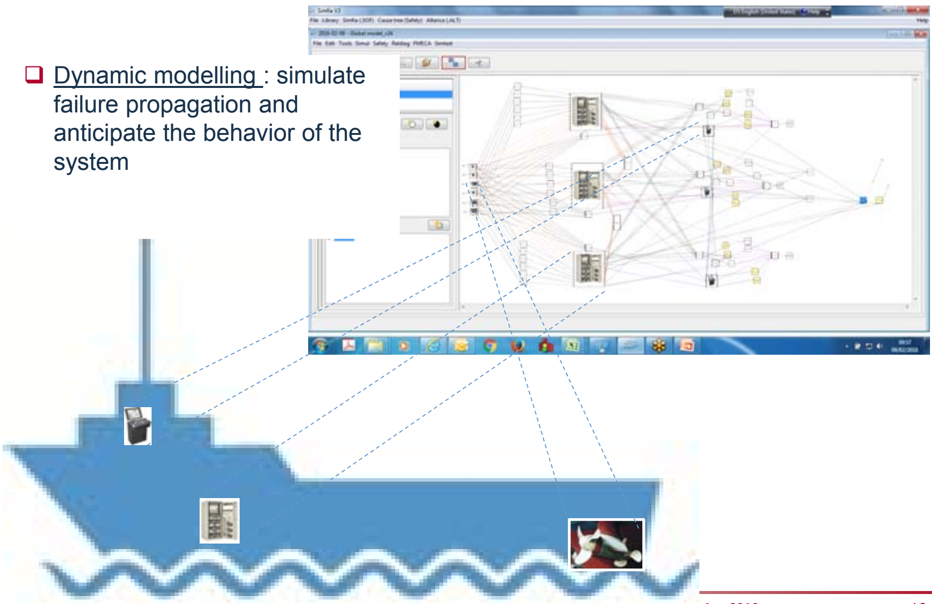
Case study 1: Design optimization

- Model based approach : start from a Functional Analysis (understand the system and interconnections - How it works ?) and model it
- Ability to model transition states (working, standby, under maintenance, failed, etc) of equipment (close to reality)



Case study 1: Design optimization

- Dynamic modelling : simulate failure propagation and anticipate the behavior of the system



Case study 1: Design optimization

BENEFITS:

- Understanding the criticalities within systems and demonstrate interdependency of the critical systems for propulsion, power distribution, positional referencing and DP
- Cover all the systems of a vessel to provide a global availability figure
- Ability to integrate design modification (model based), generate updated RAMS studies (Fmeca, Fault tree, etc) and simulate impact on availability
- Ability to challenge and simplify overdesign and reduce cost

Case study 2: Fleet management optimization

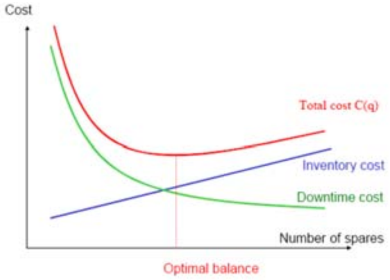
Fleet management : objectives

- Readiness of a vessel on demand
- Minimise downtime
- Anticipate maintenance activities
- Control costs

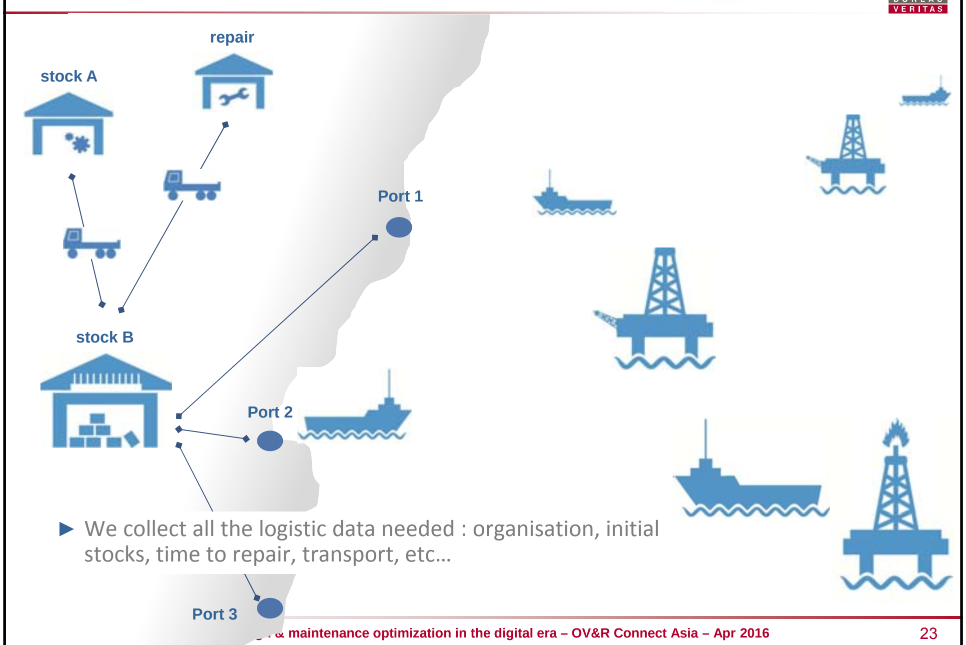
Case study 2: Fleet management optimization

Fleet management : why spare parts optimisation ?

- In the cost efficiency challenge, supply chain with a focus on spare parts management is identified as key
- Unavailability of spare parts is often responsible of Down Time
- Stock of spares is very costly
- It is recognised by ship owners that the value of spares is significant : area of cost saving



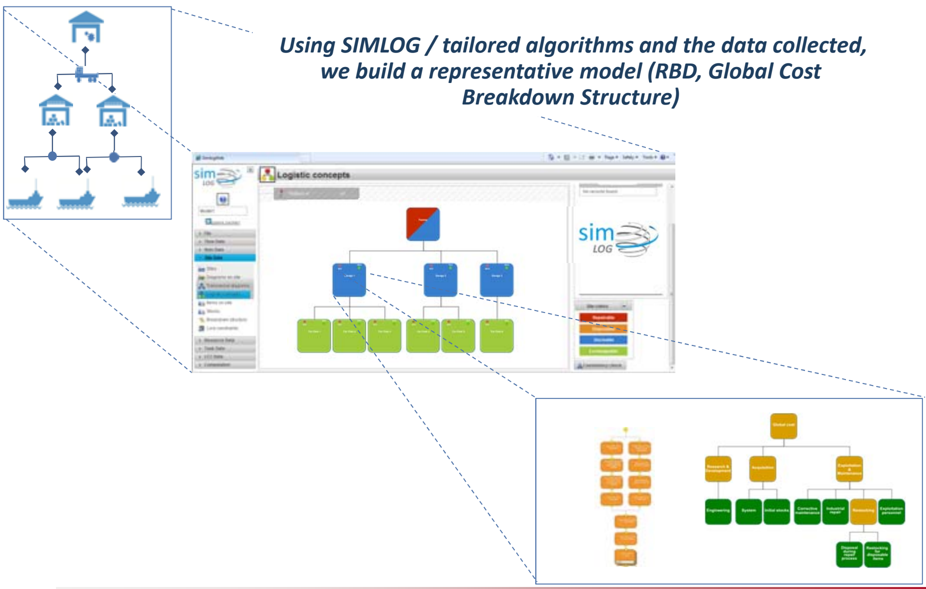
Case Study 2 | We collect



- We collect all the logistic data needed : organisation, initial stocks, time to repair, transport, etc…

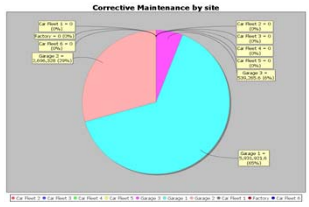
Case Study 2 | We model

Using SIMLOG / tailored algorithms and the data collected, we build a representative model (RBD, Global Cost Breakdown Structure)

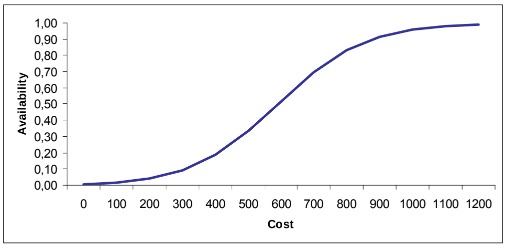


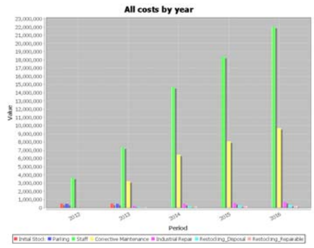
Case Study 2 | We project

Vessel	Availability	Proposed Stock (Nbre items)	Proposed Stock ($)	Variation vs initial stock
A	98.3%	w1	wi1	↘
B	97.1%	x1	xi1	↘
C	99.0%	y1	yi1	↘
D	94.6%	z1	zi1	→



Results provide operational KPI which are convertible to actions





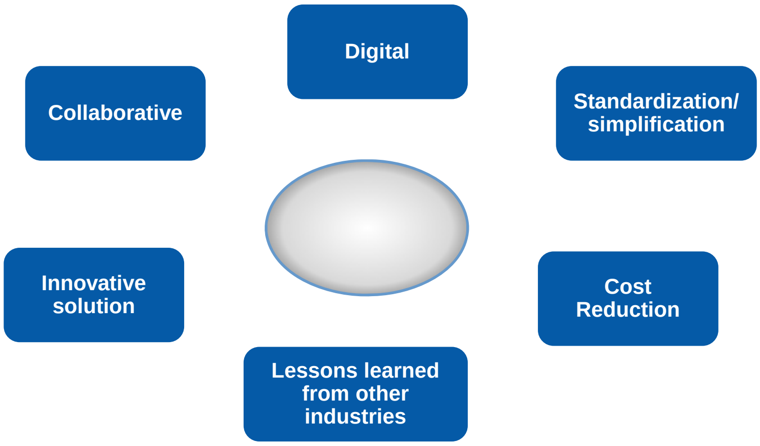
Case Study 2 | Benefits

BENEFITS:

- Location and quantity of spares parts **optimisation** (same availability but at lower cost for instance)
- Strategy optimisation using specific KPI:
  - Operational Availability, MDT (Mean Down Time), MUT (Mean UpTime)
  - PNRS (Probability of Non Running out of Stock...)
- Level of repair economically optimal
- **Cost saving :** using such approach on a fleet of assets, Apsys conducted a study and proposed to reduced by 75% the cost of stock inventory

Concluding remarks

- Solutions embracing the key and challenging aspects pointed by the O&G industry



Concluding remarks

- Should we be talking about maintenance or availability?
- RCM & CBM strategies offer cost saving opportunities when based on properly executing reliability engineering approach
- Digital technology brings new opportunities for CBM and AIMS
- Offshore vessel industry is already familiar with RAMS studies: FMECA are conducted at equipment level
- Need to better understand interconnections between the systems, including the supply chain :
  - During design phase, to optimise the intrinsic availability of a vessel
  - During operations, to reduce cost of ownership
- Other industries as Aerospace, Automotive and Defense have developed proven approaches and tools to face similar situations
- These technics could be explored to inspire the OSV industry to face the cost efficiency challenge

Move Forward with Confidence