SOFTWARE

Structure Integrity Management for Fixed Structures

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Cangbo Zheng  Head of Section - Fixed Structure Offshore Engineering

October 31, 2016
The Situation: 3000+ Fixed Offshore Platforms in GOM

More than 50% of the platforms have exceeded the design lives

The Situation: Oil Price

Industry focus on Cost Cutting (OPEX & CAPEX)
How DNVGL can help with data-smart SIM solutions

**OPEX related**

- Keep Control of your assets with reduced staff
  - Efficient Data Management
- Lower data hand-over costs
  - Contractor <-> Operator
- Lower data integration costs
  - In between SIM related applications
- Optimize the SIM Program
  - Moving from time based to Risk based planning
  - Smarter Structural Assessments

**CAPEX related**

- Asset Life Extension vs. New Field Development
SOFTWARE

Synergi Structure
DNV GL’s Structural Integrity Management System
### DNV GL - Software

<table>
<thead>
<tr>
<th>Area</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and engineering</td>
<td><img src="image" alt="Design and engineering" /></td>
</tr>
<tr>
<td>Asset simulation and optimisation</td>
<td><img src="image" alt="Asset simulation and optimisation" /></td>
</tr>
<tr>
<td>Process Safety, risk and reliability</td>
<td><img src="image" alt="Process Safety, risk and reliability" /></td>
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<tr>
<td>QHSE and enterprise risk</td>
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<td>Ship management and class</td>
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<tr>
<td>Asset integrity and performance</td>
<td><img src="image" alt="Asset integrity and performance" /></td>
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DNV GL is the world-leading provider of software for a safer, smarter and greener future in the oil and gas, energy, maritime and process industries.
**DNV GL integrity management software packages**

### SYNERGI STRUCTURE
- Structure data and model
- Structure RBI
- Inspection planning and recording
- 3D viewer
- KPI, traffic light, and report
- Integration interface

### SYNERGI PLANT
- Facility management
- RBI and RCM
- Inspection and maintenance plan
- Work packaging and execution
- Integrity assessment and anomaly
- KPI, traffic light, and report
- Integration interface

### SYNERGI PIPELINE
- Pipeline data management
- Pipeline risk assessment
- Inspection data management
- Integrity and anomaly
- GIS and spatial
- KPI, traffic light, and report
- Integration interface

### SYNERGI DASHBOARD
- Management overview
- Risk summary and trend
- Geographical risk view
- Integration and drilldown
Synergi Structure Applications as of 2016

DNV GL Offshore Class

IIP In-service Inspection Program for Mobile Offshore Units

Shared Web solution DNV GL – Client

300+ Units: Semi-Subs, Jack-up, FPSO,++
Synergi Structure Applications as of 2016

Configurations for fixed & floating structures
Module for RBI for fixed platforms
Integration with Sesam Analysis Models
Why SIM?

NORSOK N-005

ISO 19902 / 19904

API- RP-2SIM

“SIM is a process for ensuring the fitness for purpose of an offshore structure from installation through to decommissioning.

The process is a rational means for understanding the effects of degradation, damage, changes in loading, accidental overloading, changes in use, life extension, and the evolution of offshore design practice.

SIM provides a framework for the damage evaluation, fitness-for-purpose assessment, inspection planning, maintenance, and repair of a platform or group of platforms.”

Ensuring fitness for purpose of offshore structure(s) throughout the lifetime
**Structural Integrity Management Process**

- **DATA**: Managed system for the archival and retrieval of SIM data and other pertinent records.

- **EVALUATION**: Evaluation of structural integrity and fitness-for-purpose; development of remedial actions.

- **STRATEGY**: Overall inspection philosophy and strategy and criteria for in-service inspection.

- **PROGRAM**: Detailed work scopes for inspection activities and offshore execution to obtain quality data.
Managed system for the archival and retrieval of SIM data and other pertinent records.
Synergi Structure Asset Condition Tracker Models

Visualisation Models in Synergi Structure:

- From FEA Sesam (Entire Structure or substructure) reusing Sesam names
- Sesam Models mapped to a hierarchical breakdown
- Hybrid Model (Sesam + CAD components) mapped to a hierarchical breakdown
Synergi Structure Asset Condition Tracker Models

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SIM Process in Synergi Structure

Evaluation of structural integrity and fitness-for-purpose; development of remedial actions
Structural RBUI: Risk Evaluation

Consequence of Failure (COF)
- Consequence band derived from Company Risk Matrix. (Configurable 5x5 Matrix)
  COF defined as the most severe of:
  - Health and safety
  - Environmental
  - Business
  - Reputation

Probability of Failure (POF)
- Probability (likelihood) of failure can be categorized by either
  - Qualitative (rule based) method
  - RSR semi-quantitative method
  - Refined quantitative methods

Platform Risk = COF x POF
- Inspection interval is determined from interval matrix. (3-15 years)
Rules have been developed to produce a score that defines the relative probability of failure of the platform based on:

- Baseline platform Design (characteristic) data
- Present condition of the structure
- Load susceptibility rules

To capture the relative importance of each rule, a weighting system is used.

The summation of the product of the weight and score for each rule gives the overall probability of failure score for each platform.

\[ S_{\text{Total}} = \sum_i W_i S_i \]

- \( S_{\text{Total}} \) = Total score for Probability of failure
- \( W_i \) = Weighting attributed to rule i
- \( S_i \) = Score attributed to rule i

The resulting Probability severity level (1-5) is determined based on a calibrated score range band for each severity level.
Utilising Reserve Strength Ratio (RSR)

- **RSR: Measure of Platform Robustness**
- Ratio of the base shear at ultimate capacity to the base shear from the ULS 100-year load
- Derived from Non-linear progressive collapse “Pushover” analysis by e.g. Sesam Usfos

> Important that analysis models truly reflect the current condition
(Ref. Analysis Portal)
RBUI Assessment in Synergi Structure

![RBUI Assessment in Synergi Structure](image)

**Probability of Failure Details**

1. Platform Vibration
2. Platform Towing
3. Structural Failure
4. Weathering
5. Mechanical Damage
6. Disarrangement
7. Flawed Number
8. Joint Damage
9. Degradation of Apparatus
10. Fatigue
11. Wake in Tank
12. Deck Loading
13. Additional Apparatus
14. Drilling
15. Dynamics of Shifting Load
16. Solar Depth

<table>
<thead>
<tr>
<th>Probability Details</th>
<th>Platform Score</th>
<th>Inspection Score</th>
<th>Total Score</th>
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<tr>
<td>Platform Vibration</td>
<td>2</td>
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<tr>
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<td>Weathering</td>
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<tr>
<td>Disarrangement</td>
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<td>2</td>
</tr>
<tr>
<td>Flawed Number</td>
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<td>2</td>
<td>4</td>
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<tr>
<td>Joint Damage</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Degradation of Apparatus</td>
<td>5</td>
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<td>10</td>
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<tr>
<td>Fatigue</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Wake in Tank</td>
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<td>2</td>
<td>4</td>
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<tr>
<td>Deck Loading</td>
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<tr>
<td>Additional Apparatus</td>
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<td>0</td>
</tr>
<tr>
<td>Drilling</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Dynamics of Shifting Load</td>
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<td>1</td>
<td>2</td>
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<tr>
<td>Solar Depth</td>
<td>70</td>
<td>70</td>
<td>140</td>
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</table>

**Total Score:** 214.5
## PoF Scorecard Calculation Drilldown

### 1. Platform Rating
- **Design date:** 30/11/1995
- **Score:** 2
- **Weighting:** 1

### 2. Platform Framing
- **Number of legs:** 4
- **Bracing type:** XH
- **Score:** 4
- **Weighting:** 10

### 3. Grouted Piles
- **Piling type:** Skirt Piles and Pile in Li
- **Leg to pile annulus grouted?** Yes
- **Design date:** 30/11/1995
- **Score:** 0
- **Weighting:** 2

### 4. Inspection History
- **Last inspection date:** 18/09/2003
- **Inspection gap:** 11.9 Years
- **Score:** 10
- **Score (robustness adjusted):** 4
- **Weighting:** 10
## RBI in Synergi Structure: PoF Calc. with RSR Override

### Probability of Failure Details

<table>
<thead>
<tr>
<th>Probability of Failure</th>
<th>RSR Over.</th>
<th>Platform weighted score</th>
<th>Inspection weighted score</th>
<th>Missing Information</th>
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<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Platform Framing</td>
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<tr>
<td>Grouted Plies</td>
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<tr>
<td>Inspection History</td>
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<tr>
<td>Mechanical Damage</td>
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<td></td>
</tr>
<tr>
<td>Corrosion</td>
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<tr>
<td>Flooded Members</td>
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<td></td>
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<tr>
<td>Marine Growth</td>
<td></td>
<td></td>
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<tr>
<td>Unprotected Appurtenances</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave In Deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck Loading</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Additional Appurtenances</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Seismic</td>
<td></td>
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</tr>
<tr>
<td>Distance to Shipping Lane</td>
<td></td>
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<tr>
<td>Scour Depth</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**RSR Override Score:**

|             | 75  | 75  |

**Total score:**

| Score       | 195.5 | 192.5 |
Portfolio Risk Overview

![SYNERGI STRUCTURE](image)

**Field:** All  
**Assessment type:** API RP 2SIM

<table>
<thead>
<tr>
<th>CoF</th>
<th>PoF</th>
<th>VeryLow</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>VeryLow</td>
<td>VeryLow</td>
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<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Yellow" /></td>
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<td>Low</td>
<td>Low</td>
<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Yellow" /></td>
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<td><img src="image" alt="Yellow" /></td>
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<tr>
<td>Medium</td>
<td>Medium</td>
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<td><img src="image" alt="Red" /></td>
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<tr>
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<tr>
<td>Catastrophic</td>
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</table>
SIM Process in Synergi Structure

Evaluation of structural integrity and fitness-for-purpose; development of remedial actions

DATA → EVALUATION → STRATEGY → PROGRAM

Evaluation of structural integrity and fitness-for-purpose; development of remedial actions

DATA

EVALUATION

STRATEGY

PROGRAM
**SIM Assessment Process**

1. **Data** → **Evaluation**
2. **Initiator Triggered?**
   - No → **Strategy** → **Program**
   - Yes → **Assessment**

**Triggers**
- Modifications
- Metocean Criteria
- Weight Change
- Damage/Deterioration
- Regulatory Compliance

**Structural Analyses**

Analysis Portal: Managing Change for As-Is Analysis Models
Structural Analysis As-Is Models

As-is = As-built + CHANGES

- Modifications
- Metocean Criteria
- New Codes/Regulations
- Air-Gap/ WiD
- Damage/Accidental Events
- Deterioration
- Exceedance of design life
- Foundation (Scour)
Analysis Portal – Analysis Model Tracker

- Showing compliance status, which Analysis models are required, and the status, whether the present as-is models are in compliance with all changes
- As-Is Model register for all Structural Analysis Models
- Safe controlled storage of Model data including geometry, loads & execution scripts + all design basis documents
- Full version history with historical models
- Tracking Changes for As-Is Models
  - Change Register with audit trail
  - Overview of all affected models
  - Holds all pertaining documents
  - Workflow with email notifications
Overall inspection philosophy and strategy and criteria for in-service inspection

**SIM Process in Synergi Structure**

**DATA** → **EVALUATION** → **STRATEGY** → **PROGRAM**

- **DATA**
  - Inspection
  - Long Term Inspection Plan
  - Report

- **EVALUATION**
  - Risk Overview
  - Portfolio RBI Plan
  - System Asset

- **STRATEGY**
  - Field: Fixed Structure
  - From: 2008

- **PROGRAM**
  - Table: Area, Item, Method, Access, Affiliation, Dwr.
Alternatively, Long Term Plan based on quantitative RBI
## Condition Monitoring – Inspection Management Supported

<table>
<thead>
<tr>
<th>Type</th>
<th>Methodology</th>
<th>Description</th>
<th>Applicability</th>
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<tbody>
<tr>
<td>DNVGL Offshore Class In-service Inspection program</td>
<td>DNVGL-RU-OU-0101</td>
<td>Component Based</td>
<td>Mobile Offshore Units</td>
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<tr>
<td></td>
<td></td>
<td>Periodic Inspection</td>
<td>(All vessels in DNVGL Offshore Class)</td>
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<tr>
<td></td>
<td></td>
<td>5 year renewal cycle</td>
<td>(All vessels in DNVGL Offshore Class)</td>
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<td>Scope pending on type, age, Class Notation</td>
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<td>In accordance with API RP 2SIM</td>
<td>System based</td>
<td>Fixed Structures</td>
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<td>Risk Rule Based</td>
<td>Fixed Structures</td>
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<td>Risk RSR Override</td>
<td>Fixed Structures</td>
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<td>API RP 2SIM Default</td>
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<td>Monopods</td>
<td>Fixed Structures</td>
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<td>Quantitative RBI</td>
<td>DNVGL-RP-C210</td>
<td>Component based</td>
<td>Fixed &amp; Floating Offshore Structures w/fatigue exposure</td>
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<tr>
<td></td>
<td></td>
<td>Calc. of PoF &amp; CoF based on fatigue</td>
<td>Fixed &amp; Floating Offshore Structures w/fatigue exposure</td>
</tr>
</tbody>
</table>
Utilizing Qualitative & Quantitative RBI

Data Gathering
(A selected or a fleet of structures)

Risk Ranking & Initial Assessment
(Fleet of structures)

Perform RBI Analysis
- Risk Screening
- Refined Fatigue Analysis
(Selected structures)

Prepare IMR Program
(Selected structures(s))

Import Framework Inspection Plan into Synergi Structure
Quantitative RBI: Based on DNVGL RP-C210
The Fatigue Analysis and RBI vs. Synergi Structure

Fatigue Analyses
Member Importance Analyses
Inspection Planning (RBI)

Data
Models
Inspection history
RBI Inspection Plan

Inspection Program
Integrity status

Evaluation of findings
Inspection Results

Where to inspect?
When to inspect?
What inspection method?
How to organize information?
SIM Process in Synergi Structure

Detailed work scopes for inspection activities and offshore execution to obtain quality data

Inspection Workflow:
**Inspection Workflow**

- Creating Inspections
  - Scheduled
  - Unscheduled – Special
  - Historic
- Selecting Scope from LTIP
- Creating Work-Packs
- Recording wizard or Excel Templates
- Finally import of Inspection results into Asset Condition Tracker
Inspection Workflow – Asset Condition Tracker

- 3D View from Sesam Model
  - (alt. import from Sacs)
  - (alt generated from CAD)
- Multiple Viewing features
- Filtering on all attributes
- Trending of Inspection Data
- Assignment of Mitigations
- Follow-up until closure
Synergi Dashboard
# Synergi Risk Dashboard: Demonstrate you are in control

## Risk Profile

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<tr>
<th>Location</th>
<th>High</th>
<th>Medium</th>
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<tbody>
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10 Top New DNV GL Appointments Strengthen Global Leadership; DNV GL Appoints Maritime Regional Manager for A
Configurable Risk Maps – Offshore Field 1

Offshore Field 1

- Pipeline
- Well Head Tower
- Super Complex Platform
- Flare
- Bridge

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
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</tbody>
</table>
Risk Map – Drill Down to Structure Dashboard

Offshore Field 1

Click

Click

Pipeline
Well Head Tower
Super Complex Platform
Flare
Bridge

Offshore Production Platform 1

Structures
Offshore Production... Passport Assessment Integrity Viewer Mitigation Actions

Wells
No well found in this location

Critical Safety Systems
6.1 Safety Instrument System
Safety Instrument Sys.

PASSPORT

Structure Information

My Activities

Unassigned Activities
Summing up

Synergi Structure provides:

- One central data management system holding all SIM data readily available
- Instant overall KPI overview with easy drill down
- Efficient tool for planning & executing Risk Based Inspections
- Anomaly Management including 3D-View visualisation models
- Analysis Portal – Change Management of Analysis models
The world-leading provider of software for a safer, smarter and greener future

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SAFER, SMARTER, GREENER