Delivering Subsea Solutions Using a Systems Engineering Approach

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SYSTEMS AND ENGINEERING TECHNOLOGY
Agenda

1. Frazer-Nash Consultancy Overview
   i. Systems Engineering
2. Using a Systems Engineering Approach to Deliver Subsea Solutions
   i. Case study 1 – Asset Integrity Management Case Study (Defence Sector)
   ii. Case study 2 – Riser Concept Selection for a New Development (Oil & Gas)
3. Conclusions
4. Questions
Frazer-Nash Consultancy Overview

- Frazer-Nash Consultancy is a leading systems and engineering technology company.
- 750 employees (UK and Australia).
- Our consultants apply their expertise and know-how to develop, enhance and protect our clients' critical assets, systems and processes.
- Cross-sector: aerospace, transport, nuclear, marine, defence, and the power and energy sectors.
- Subsea: renewables (wind, wave and tidal), defence, oil and gas, and marine.
- Our Systems Approach helps us respond to your challenges.
Systems Engineering

1. Define – project end goal and develop effective solutions
2. Understand – assess and improve behaviour of equipment and systems
3. Integrate – integrated solutions across the full project lifecycle
4. Assure – support critical decisions on safety, the environment and business risk

- Assisting the subsea sector using a Systems Approach:
  - Increased availability with reduced through-life costs
  - Increased reliability
- This is illustrated in the following 2 case studies.
Improving Safety and Availability of the UK Royal Navy Submarine Fleet: An Innovative and Collaborative Asset Integrity Management (AIM) Solution
Case Study 1: Improving Safety and Availability of the UK Royal Navy Submarine Fleet: An Innovative and Collaborative Asset Integrity Management (AIM) Solution
Case Study 1 Background

- Greatest constraint on AIM strategy for a submarine fleet is **dry-docking**.
- Carry out essential maintenance to ensure safety
  - Every 3-5 years.
  - Significant time (reducing submarine availability).
  - Significant cost.
- One Key Driver that dictates dry docking frequency and duration is replacement of the **Submarine Tailshaft**.
Case Study 1 Background

- The tailshaft connects the “engine” inside the submarine to the propeller outside the submarine.
- Large hollow steel shaft, about twice the length and twice the diameter of a telegraph pole.
- Tailshafts are at risk of corrosion-fatigue cracking, caused by seawater contact with the shaft outer surface due to protective bandage failure.
- Subjected to rotating bending fatigue under its own weight as the tailshaft rotates, this gives a large number of low stress cycles.
- Historical maintenance was to replace a tailshaft every 7 years irrespective of its condition. It was not known whether this was too often or not often enough.
- Aim: To develop an inspection system to evaluate the condition of the tailshafts in-situ in order to enable informed decisions on operational and replacement schedules. The key is to understand the tailshaft condition, how it deteriorates with time and relate this to a safe operational risk profile.
Case Study 1 Background
Case Study 1 Background

Detection of water ingress provides little benefit.

Defect detection here maintains safety but also informs through-life decision-making, providing maximum flexibility.

Defect detection here allows safety to be just maintained if the defect can be found quick enough.

Detection of water ingress provides little benefit.
Case Study 1 Approach

- How to carry out a high-fidelity NDT inspection 20m away, through a hole only 4” diameter?

- Collaboration between parties with the right expertise:
  - The Ministry of Defence – Requirements and will (££££)
  - Frazer-Nash – Programme and technical leads, life calculations.
  - Babcock International – Dockside facilities, infrastructure.
  - TUV Rheinland Sonovation – High technology NDT expertise.
  - Imes International – Mechanical scanner design.

- Brought together in an environment of co-operation to do what it takes to solve the problem.

- Broke the problem down into small manageable streams of work that came together to deliver the solution.
Case Study 1 Approach
Case Study 1 Approach
Case Study 1 Approach

Inspect so understand condition and risk

Acceptable Risk level
Benefits to the Client

- Understand and can monitor key risks that were unknown.
- Optimise maintenance and replacement strategy.
- Collect data to increase knowledge base.
- Inform design improvements.
  - Address the root cause.
  - Design for ease of inspection / maintenance.
  - Apply to other related components.
Riser Concept Selection for a New Development (Oil & Gas)
Case Study 2

- Case study 2: Riser Concept Selection for a New Deepwater Development (Oil & Gas)
Case Study 1 Background

- Riser concept selection must consider multiple factors.

- Two new field developments involving conceptual riser system assessments are presented:
  - A deep-water production facility offshore Norway, in the northern Norwegian Sea
  - A production facility offshore the Falkland Islands, in the South Atlantic

- Both of these examples required optimisation of existing technology for new and challenging applications
System Functional Requirements

- Outlining of functional requirements for the system are defined upfront
  - Requirements capture
  - At this stage, various riser configurations could be optimised through engineering to meet the design requirements
    - If cost and time are not restricted then a concept may be demonstrated to be feasible through engineering and innovation
    - Objective is to maximise value by performing the minimum amount of early engineering required to confirm suitability of a particular concept

- Anticipated production requirements
  - To define an approximate riser arrangement:
    - Number of wells
    - Quantity of risers, including duties and diameters
    - Flow assurance requirements
    - Predicted pressure and temperature ranges
System Functional Requirements

- Local environment
  - To define the necessary structural response of the riser to various loading scenarios
    - Static loading – significant self-weight of pipe
    - Normal operating, extreme and survival events
    - Current, wave and wind vary with location and season
      - Complex dynamic loading
      - Estimate extreme stresses and fatigue damage rates
      - Available weather window for installation
      - Interface with vessel mooring design
Various constraints can influence the design selection:

- Fabrication requirements
  - Limited number of specialist suppliers who have the requisite skills / technologies. Examples include:
    - Fabricator location and availability
    - Maximum diameter of structures such as foundation piles and buoyancy tanks – limiting load capacity
    - Some specialist applications (such as direct heating) have bespoke solutions developed by individual manufacturers
  - Requirement for local content
Construction, Transportation and Installation

Transportation logistics
- Remoteness of field location
- Assessment of potential impact to project schedule – and associated risk
- Potential fatigue damage incurred during transportation (prior to installation)

Installation challenges
- Limited choice of installation contractors depending on riser type and system weight – can increase project cost
- Local environmental conditions can affect the weather window in which it is safe to install the riser system
Riser Concept Selection for Norwegian Sea

- Water depth ~ 1300m with significant dynamic loading
  - Floating solution required
- Type proposed: Hybrid riser
  - Attractive solution due to dynamic decoupling of the risers from the vessel, and ease of optimising the subsea field layout
- Results of high level analysis found the hybrid riser selection largely unsuitable:
  - Component utilisations exceeded acceptable values under extreme loading (e.g. flex joint, bend stiffener)
  - The environment was particularly severe in comparison with other examples of hybrid risers that have been considered for operations in more dynamic environments (e.g. Brazil, Gulf of Mexico), with large wave heights predicted
  - Hence, significant engineering effort would be required through analysis to define suitable riser configurations – may not be optimal solution
  - Limited weather window for installation
Other commercial and technical factors

The hybrid riser configuration:
  - Requires complex fabrication and installation requirements
  - High cost

A combination of the technical and commercial factors formed the basis of a reasoned argument against proceeding with this concept at an early stage
Riser Concept Selection for South Atlantic

- Water depth < 500m with significant dynamic loading along a small length of riser
  - Floating solution required
- Type proposed: Hybrid Riser
  - Flexible risers had already been considered but had some drawbacks
  - Client required benchmarking against alternative concepts
  - Various hybrid riser concepts were compared
- Results of the high level analysis found all hybrid riser concepts to be largely unsuitable:
  - Severe dynamic environment in a comparatively low water depth:
    - Hybrid risers have not been used previously in this water depth
    - Increased depth required to accommodate the harsh environmental loading
  - Significant engineering effort required to define optimum riser configurations
A number of additional challenges were identified:

- Lack of local infrastructure
  - Components would need to be fabricated remotely – in other parts of the world
  - Transportation required to the well site
- Political sensitivity in the region
- Environmental challenges
  - Seasonal variation is not significant – weather can be severe all year
  - Limited weather window for installation

Various alternative riser configurations were assessed and considered to be more suitable when multiple criteria were taken into account.

A combination of the technical and commercial factors formed the basis of a reasoned argument against proceeding with this concept at an early stage.
Case Study 2 Conclusions

A complex multi-disciplinary approach is required to select the most appropriate riser concept for a new field development

- Many factors affect the suitability of the proposed riser concept
- The ability of the riser type to integrate effectively with the EPCI requirements of other parts of the field development must also be considered in detail

There are often multiple potential solutions which could be demonstrated to be feasible if sufficient effort is applied

- It is crucial to identify at an early stage if the concept justifies the additional effort to develop an appropriate solution

Comparing these factors at an early stage in the concept select stage helps to inform the project and enable efficient progress to be made, with appropriate rationale to support decision-making
Conclusions
Summary

- Systems Engineering Approach delivered the following benefits in the 2 case studies discussed:
  - Reduced costs by technically informed maintenance
  - Increased availability – asset is ‘in the field’
  - Increased system reliability: increasing revenue, reducing costs and improving company reputation
  - Detailed requirements capture supplemented by analysis to identify at an early stage if a concept justifies the additional engineering effort to develop it as a solution.
Summary

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Questions

Frazer-Nash Consultancy:
- Successful completion of traditional and novel engineering projects
- A growing company with over 700 engineers enabling collaboration with academia, research institutes and industrial partners