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Leveraging Single-Fault Tolerance to Support Business Objectives

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Stena Evolution – Single Fault Tolerance Journey

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Stena Evolution – Achieving Single Fault Tolerance: A Technical Journey

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Abstract

This paper details the technical journey undertaken by Stena Drilling to upgrade the Stena Evolution for single fault tolerance and closed bus operations, in preparation for deployment in the Gulf of Mexico. The project encompassed significant system upgrades, a change of classification society, and rigorous testing and validation, all underpinned by a collaborative, multi-stakeholder approach. Lessons learned and recommendations for future projects are presented, with a focus on technical challenges, regulatory compliance, and operational efficiency.

1. Introduction

In January 2022, Stena Drilling acquired the Stena Evolution, a dynamically positioned (DP) drillship previously left as a distressed asset at the SHI shipyard in Korea. Although the vessel was completed and approved for DP operations to ABS DPS-3 class and was 'closed bus ready', it required substantial upgrades to meet the operational and regulatory requirements of its intended deployment for Shell in the Gulf of Mexico (GoM).

The primary objective was to upgrade the vessel's protection systems to enable reliable closed bus operation and full single fault tolerance, in accordance with both DNV Dynpos Autro CB-T notation, ABS EHS-E notation and Shell's DP DEP engineering specification. This paper outlines the project's approach, technical challenges, solutions implemented, and key lessons learned.

2. Project Scope and Objectives

The scope of the project included:

- Upgrading the ABB Enhanced Power Plant Protection System (EPPS), formerly known as the Diesel Generator Management System (DGMS).
- Comprehensive review and revision of the DP Failure Modes and Effects Analysis (FMEA) and associated documentation.
- Changing classification from ABS to DNV to align with fleet standards.
- Achieving full approval for DNV Dynpos Autro CB-T notation and Shell's DP DEP engineering specification.
- Ensuring the vessel could operate in closed bus configuration to maximise fuel efficiency.

The overarching aim was for Stena Evolution to commence operations in the GoM in Q1 2023, operating in the most fuel-efficient manner possible.

3. Regulatory and Standards Framework

The project was guided by a robust framework of rules and standards, including:

- ABS and DNV class rules
- MTS TechOps guidance
- IMCA and OCIMF guidelines
- Client-specific practices (Shell DP DEP)

This comprehensive regulatory approach ensured that all design and testing activities met or exceeded industry best practices.

4. Stakeholder Engagement and Project Management

A key factor in the project's success was early and continuous engagement with all stakeholders:

- DNV RA (responsible for FMEA and documentation)
- ABB (EPPS upgrade)
- DNV Class
- KM (Power Management and DP Systems)
- SHI (shipyard)
- Shell (client)

Workshops and interface meetings were conducted in person, despite the challenges posed by extensive travel. Importantly, vessel approvers (Class and Client) were involved from the outset, ensuring alignment on expectations, deliverables, and timelines. This proactive approach minimised late changes and fostered a collaborative environment.

A quality plan was developed, detailing:

- Applicable rules and regulations
- Key deliverables (FMEA, FDS, test documents, etc.)
- Responsibilities and timelines for both vendors and approvers
- Hold points and witness points

The plan emphasised the importance of timely feedback from approvers including Class, Client and Stena Drilling. It was acknowledged that late feedback from approvers could significantly delay the project. Furthermore, Stena Drilling coordinated and consolidated all comments ensuring they were clear and aligned to avoid conflicting feedback and delays.

5. Technical Challenges and Solutions

5.1 Cross Connections

The detailed FMEA review identified 62 potential cross connections in the vessel's design, despite prior approval for DP operations. Nearly all were eliminated by removing the unnecessary connections, prioritising safety over redundancy. The remaining connections, primarily redundant 24Vdc supplies in safety cabinets, were deemed acceptable based on robust design and protection. No cross connections were left to be managed procedurally, thereby minimising the risk of human error.

5.2 UPS Redundancy

The vessel's forward Integrated Automation System (IAS) UPS arrangement was found to be inadequate, with only two UPS units from two redundancy groups supplying three thrusters from three separate redundancy groups. This posed a risk of a single event (e.g., fire or flood) affecting multiple redundancy groups. The solution involved utilising a dedicated Thruster Drive UPS in each thruster space, supplied from the correct redundancy group, ensuring proper isolation and redundancy. Similar issues have been identified and corrected on Stena's existing drillships, and it is suspected that this is an industry-wide concern.

5.3 System Testing and Validation

Comprehensive system testing, including DP FMEA proving trials and CB-T live short circuit testing, was completed in December 2022. The testing process was collaborative and largely uneventful—a positive outcome for such critical safety tests.

A notable challenge was meeting blackout recovery requirements for closed bus operations. ABS and DNV rules stipulate recovery times of 60s and 45s, respectively. Achieving these targets required fine-tuning of the blackout recovery sequence, with all vendors collaborating to optimise system response. While the targets were met, the complexity introduced to save a few seconds raised concerns about long-term reliability. It is recommended that the industry reconsider these time limits to balance recovery speed with system robustness.

6. Model-Based Testing

Early stakeholder engagement revealed an expectation for model-based testing (MBT) and DNV CB-S approval. Although this was not achievable within the initial project timeline, a parallel effort was initiated. MBT is relatively new in DP operations, with limited guidance beyond DNV-RP-0591 which itself is quite vague on the subject. The project adopted a similar collaborative approach, developing a test plan with defined methodology, acceptance criteria, and milestones.

The lack of built-in-test equipment which enables verification of the protective functions within the equipment poses challenges and is something that the industry should consider for future builds and projects.

A total of 160 case studies were selected, with 104 tested in ABB's laboratory and 56 planned for onboard testing. Although 56 onboard tests may seem excessive, analysis of the vessel FMEA and failure modes justifies each test as necessary. It is also Stena's opinion that without built in test equipment getting the

correct persons onboard and the testing setup time is the longest factor. Once the people and equipment are in place performing 50 as opposed to 30 tests does not excessively increase the schedule.

Due to the need for an operational window to complete the onboard testing, this has not yet been completed; however, it is intended to be completed in 2026.

Signs so far indicate that this will be extremely beneficial in achieving single fault tolerance and represents the next step for the industry in comprehensive verification and validation. It is anticipated that this testing will soon become standard practice.

7. Operational Results and Efficiency Gains

Since commencing operations in the GoM, the Stena Evolution has operated in closed bus configuration for top hole sections. Stena Drilling records detailed vessel data, enabling direct comparison of fuel consumption and operational efficiency between closed and open bus configurations. Preliminary analysis indicates a significant improvement in efficiency with closed bus operation, supporting both cost savings and environmental objectives.

8. Conclusions and Recommendations

The Stena Evolution project demonstrates the importance of early stakeholder engagement, rigorous technical review, and disciplined project management in achieving single fault tolerance and regulatory compliance. Key recommendations include:

- Involve all approvers from project inception to ensure alignment and avoid late changes.
- Prioritise elimination of cross connections through design rather than procedural controls.
- Ensure UPS and redundancy arrangements are robust and aligned with redundancy groups.
- Consider the trade-off between recovery speed and system complexity in blackout recovery requirements.
- Adopt model-based testing as a standard practice for comprehensive system validation.

The vessel’s successful deployment and operational efficiency gains validate the project’s approach and provide a model for future upgrades in the offshore drilling industry.