Marine & Offshore Electrical Power & Automation Engineering

mjr Power & Automation

ELSYS MARINE AUTOMATION

CASE STUDY

AHTS UT 722L Battery Hybrid Conversion



Main Switchboard Rebuild, Power Management System Replacement, Vessel Automation & Machinery Operating System (VAMOS) Replacement, Battery & Converter Integration

Delivered in 2004, Mr Chafic is a classic Ulstein (Rolls Royce) UT 722 Anchor Handling Tug Supply Vessel fitted with a conventional diesel mechanical propulsion system. In addition to its 2 main engine driven controllable pitch propellers, 2 x 2400 kW main engine driven shaft generators provide electrical power to the vessel and its 4 electrically driven thrusters for normal dynamic positioning operations. In order to reduce fuel consumption during standby operations, the vessel was converted to hybrid operation by installing 2 x 375kWh containerized battery systems with a peak power delivery capacity of 2 x 1.2MW. This upgrade required the existing main switchboard to be re designed and rebuilt to be able to integrate the battery systems and their converters, and a replacement power and energy management system to control the new hybrid architecture, together with a replacement integrated automation & machinery control system.

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MJR's scope of work was to provide the turnkey design, approval, build, supply, installation and commissioning package including: Main Switchboard rebuilding for hybrid conversion; replacement Integrated Automation & Machinery Control System & Power Management system; and upgrade from DNV DPS-1 to DPS-2/Battery (Safety) notation.

With the assistance of the Shipyard (Navship, Brazil), in late 2024 MJR and partner ELSYS carried out the installation and commissioning of the MJR supplied system including:

- **2 x 4000A Shaft Generator Isolation Air Circuit Breakers**
- **2 x 2500A Battery Energy Storage Air Circuit Breakers**
- **Modification of 450VAC Main Switchboard Control Circuits & Instrumentation**
- **Hybrid Power Management System**
- **Integrated Automation & Machinery Control System**
- **New Extension Alarm System**
- **New Dead Man Alarm System**
- **New Tank Gauging & Valve Control Systems**
- **Interface to DP System & Stability/Loading Computer**

At the heart of the system upgrade was the ELSYS VAMOS Vessel Automation & Machinery Operating System that was installed together with an advanced Power Management System to automate the Ship's new hybrid electrical power generation architecture. The photograph below shows the replacement Operator Station on the Bridge DP Console.



Bridge Console complete with replacement VAMOS 21" Colour LED Operator Stations

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Throughout 2024 MJR carried out the basic and detailed design of the upgrade, with manufacturing of the electrical hardware carried out at MJR Teesside, UK facilities and manufacturing of the automation system at ELSYS facilities in Vigo, Spain.

Design & Engineering:

- Single Line Diagram
- General Arrangement Drawings & Layouts
- Main Switchboard Electrical Schematics
- Short Circuit Calculations
- Protection Study
- Load Balance
- Harmonic Analysis
- I/O List
- Alarm List
- IAS Mimic Screen Design
- PMS System Design
- Tank Gauging System Design

Class Approval:

MJR were responsible for DNV approval of the full electrical power and automation design with FAT of the Integrated Automation & Machinery Control System and Power Management System carried out at our sister company ELSYS in Vigo.



ECR Console complete with replacement VAMOS 21" Colour LED Operator Stations

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CASE STUDY



VAMOS Bridge Navigation Console Extension Alarm System (EAS) Panel



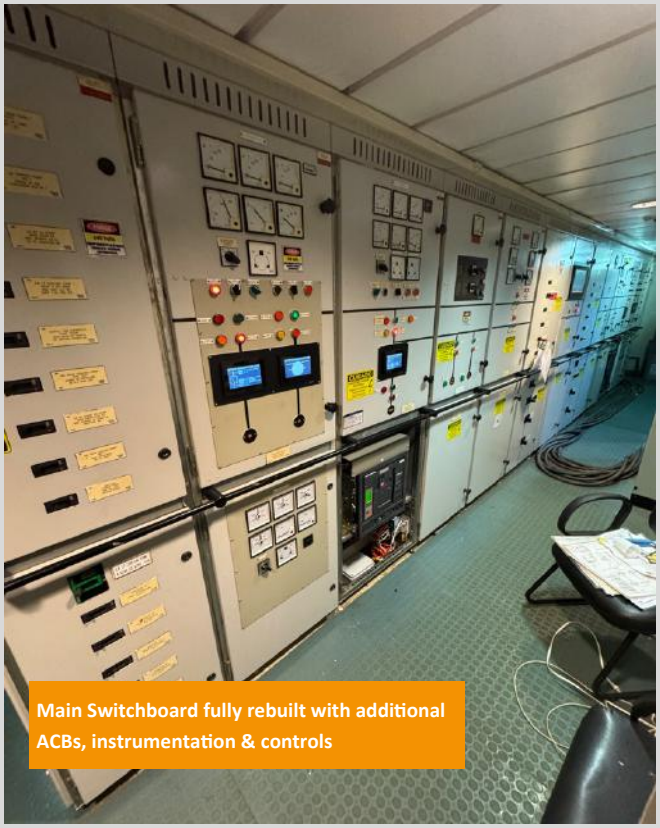
VAMOS Extension Alarm System (EAS) Panel in Crew Mess Room

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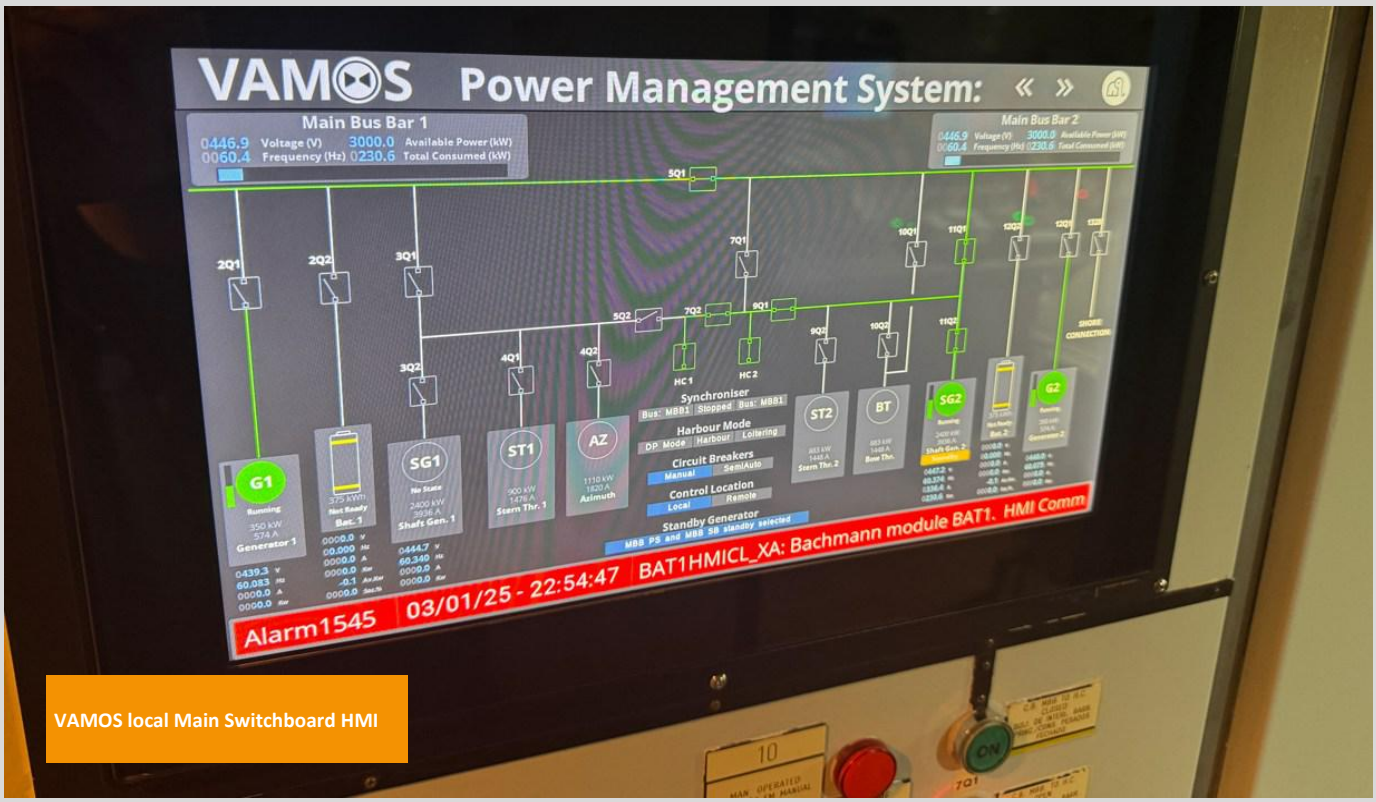
CASE STUDY



Main Switchboard fully rebuilt with additional ACBs, instrumentation & controls



VAMOS software synchroscope HMIs fitted to each generator



VAMOS local Main Switchboard HMI

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CASE STUDY



Containerised Battery Energy Storage System & Converters

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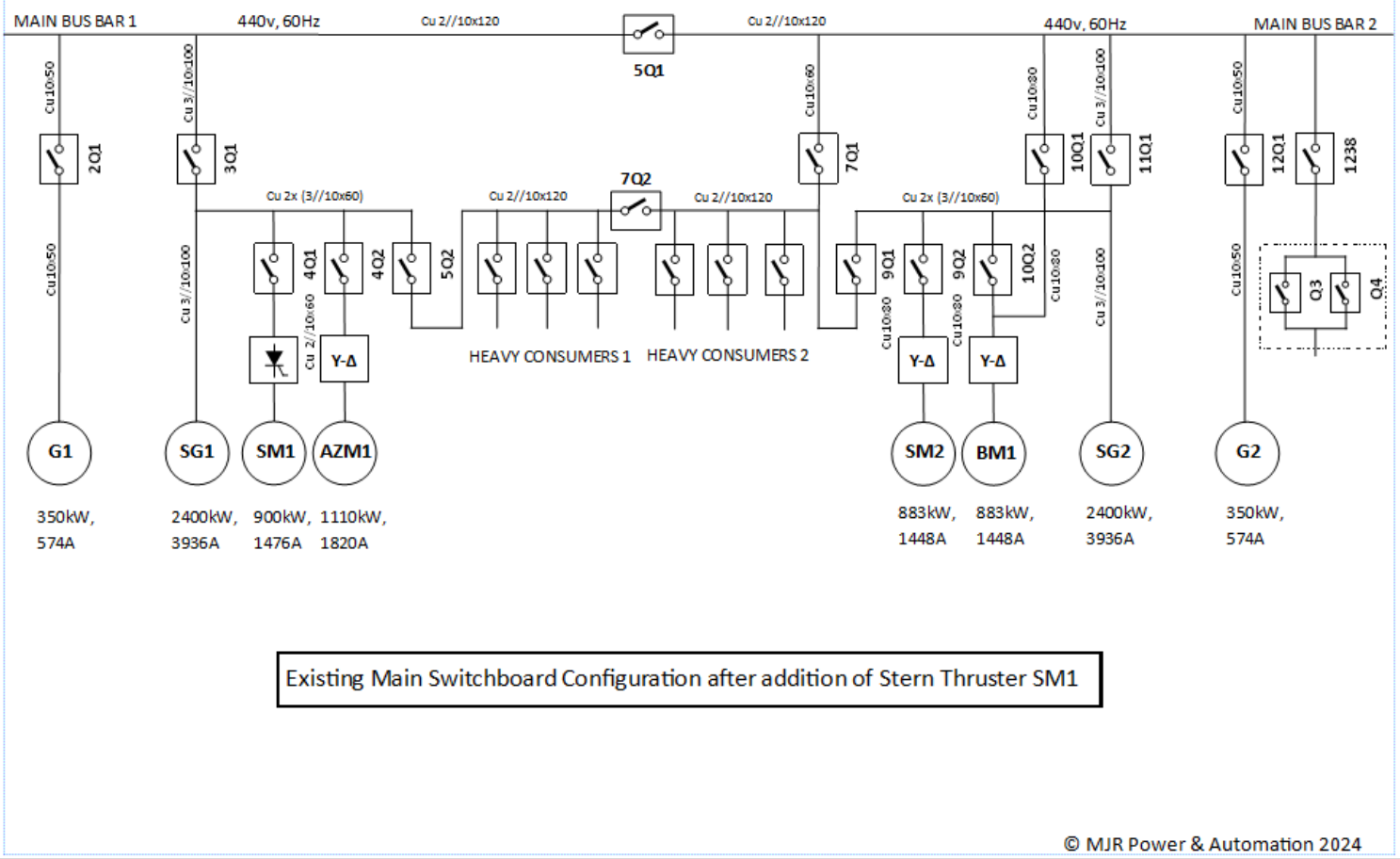
CASE STUDY

Main Switchboard & Power Management System Upgrade

The existing main 450V AC Main Switchboard was a conventional design, controlled by a simple single PLC. In order to integrate the Battery Energy Storage Systems (BESS), intelligently manage the new hybrid power configuration, and achieve DNV DPS-2/ Battery (Safety) notation, extensive modifications were required.

The original (unmodified) simplified single line diagram for the power plant is shown in Figure 1 below.

Fig 1: Mr Chafic Single Line Diagram - Existing Configuration



Existing Main Switchboard Configuration after addition of Stern Thruster SM1

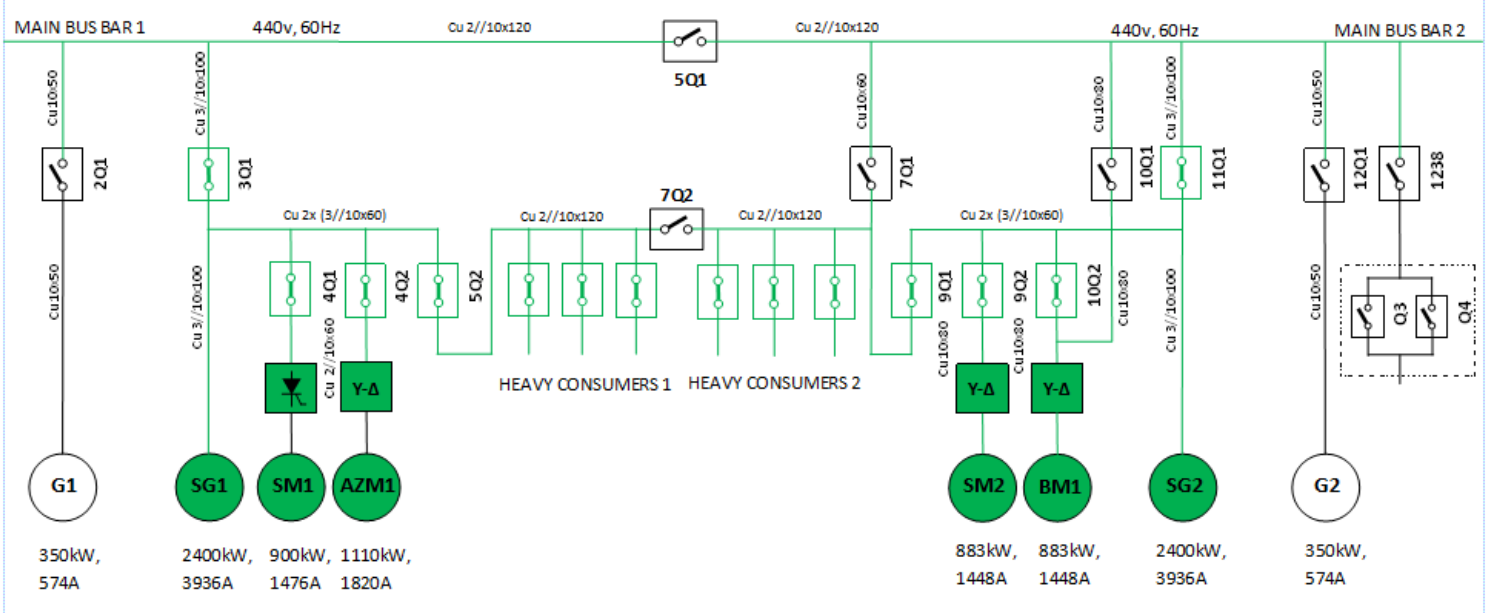
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There are a number of different operating modes available, however Figure 2 depicts the most common configuration when operating in DP, with Shaft Generators supplying both the thrusters and the main busbar in open bus configuration.

Original DP Operating Mode

Fig 2: Mr Chafic Single Line Diagram - Existing Configuration: **Normal DP Mode (M/E Constant Speed)**



1. Main Engines/Propulsion Plant in Constant Speed Mode
2. Main Bus Tie open (5Q1)
3. Heavy Consumer Bus Tie open (7Q2)
4. SG1 feeds port side - Main Busbar 1 + SM1 + AZM1 + Heavy Consumer Bus 1 (HC1)
5. SG2 feeds starboard side- Main Busbar 2 + BM1 + SM2 + Heavy Consumer Bus 2 (HC2)

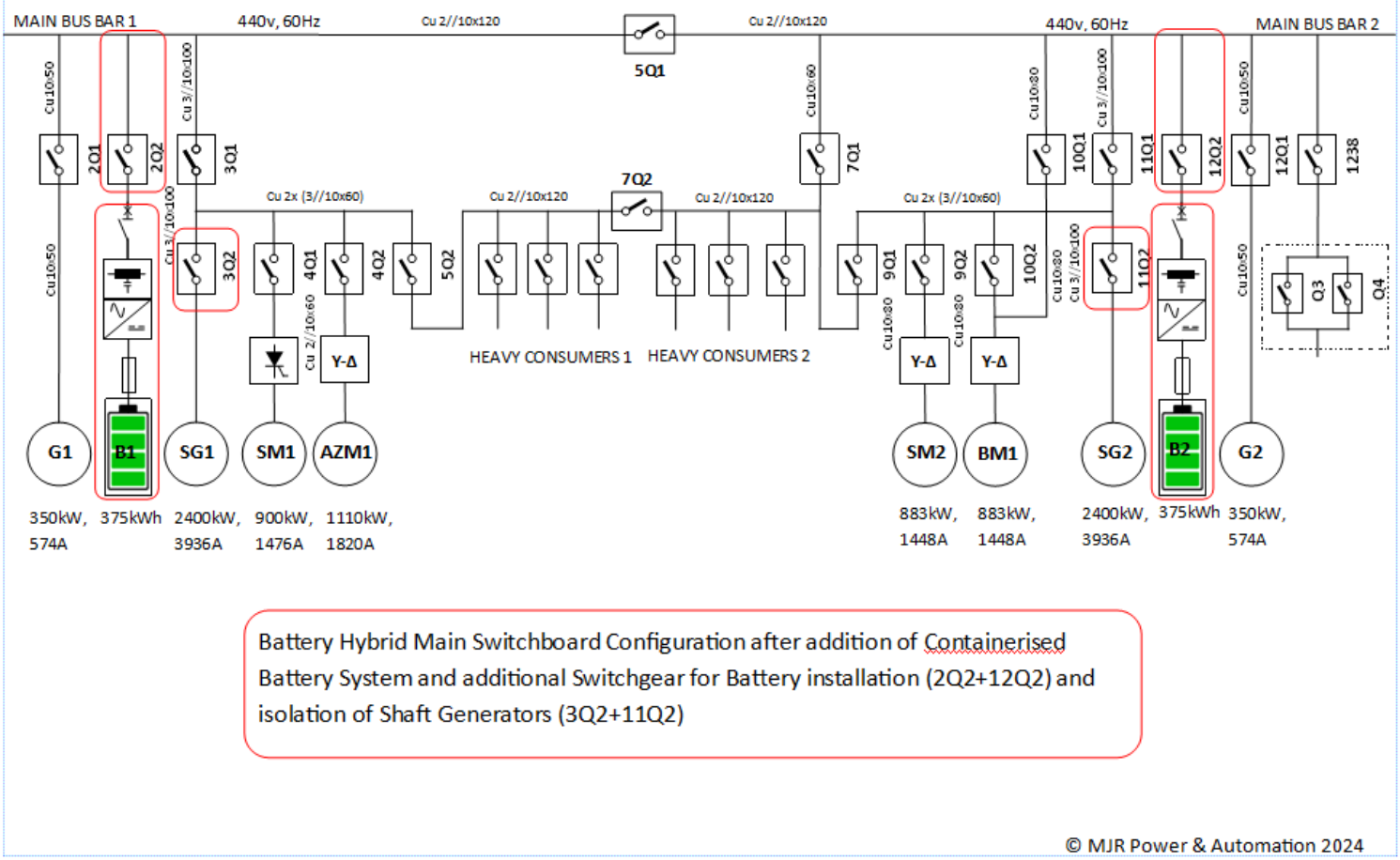
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Additional air circuit breakers were required to isolate the shaft generators from the Heavy Consumer busbars in order to be able to supply thrusters from auxiliary generators and batteries in a low power loitering mode when main engines were stopped.

Also the containerised battery energy storage systems required additional air circuit breakers to be installed into the main switchboard. With very limited spare space available in the existing main switchboard and no space in the compartment to extend it, this proved extremely challenging.

The modified simplified single line diagram for the power plant is shown in Figure 2 below. The additional switchgear and battery energy storage systems are show inside the red boxes.

Fig 3: Mr Chafic Single Line Diagram - Battery Hybrid Configuration



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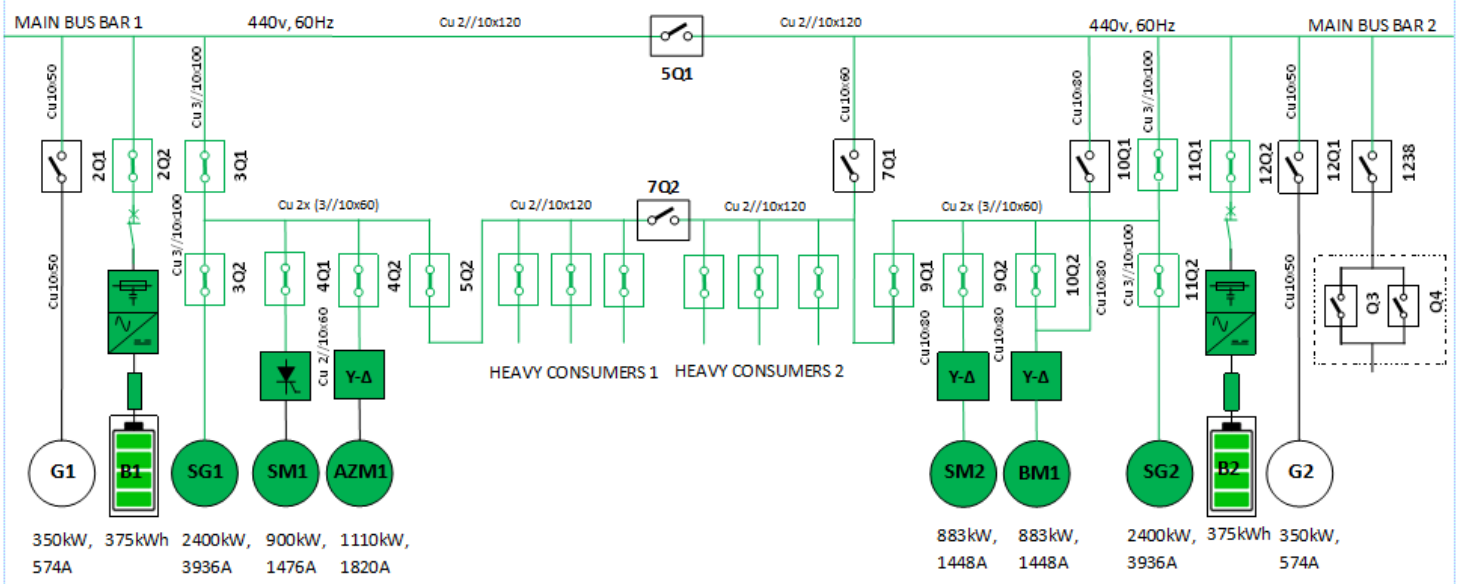
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Normal DP mode as in the original configuration shown in Figure 2 remains the main DP operating mode, but the addition of the Battery Energy Storage Systems means that the batteries can be used for peak shaving and spinning reserve. Thus saving significant amounts of energy and improving vessel safety in case of a shaft generator or main engine failure.

DP Operating Mode + Battery

Fig 4: Mr Chafic Single Line Diagram - Battery Hybrid Configuration: **Normal DP Mode + Battery**



1. Main Engines/Propulsion Plant in Constant Speed Mode
2. Main Bus Tie open (5Q1)
3. Heavy Consumer Bus Tie open (7Q2)
4. SG1 feeds port side = Main Busbar 1 + SM1 + AZM1 + Heavy Consumer Bus 1 (HC1)
5. SG2 feeds starboard side— Main Busbar 2 + BM1 + SM2 + Heavy Consumer Bus 2 (HC2)
6. B1 connected to Busbar 1, B2 connected to Busbar 2, both in standby

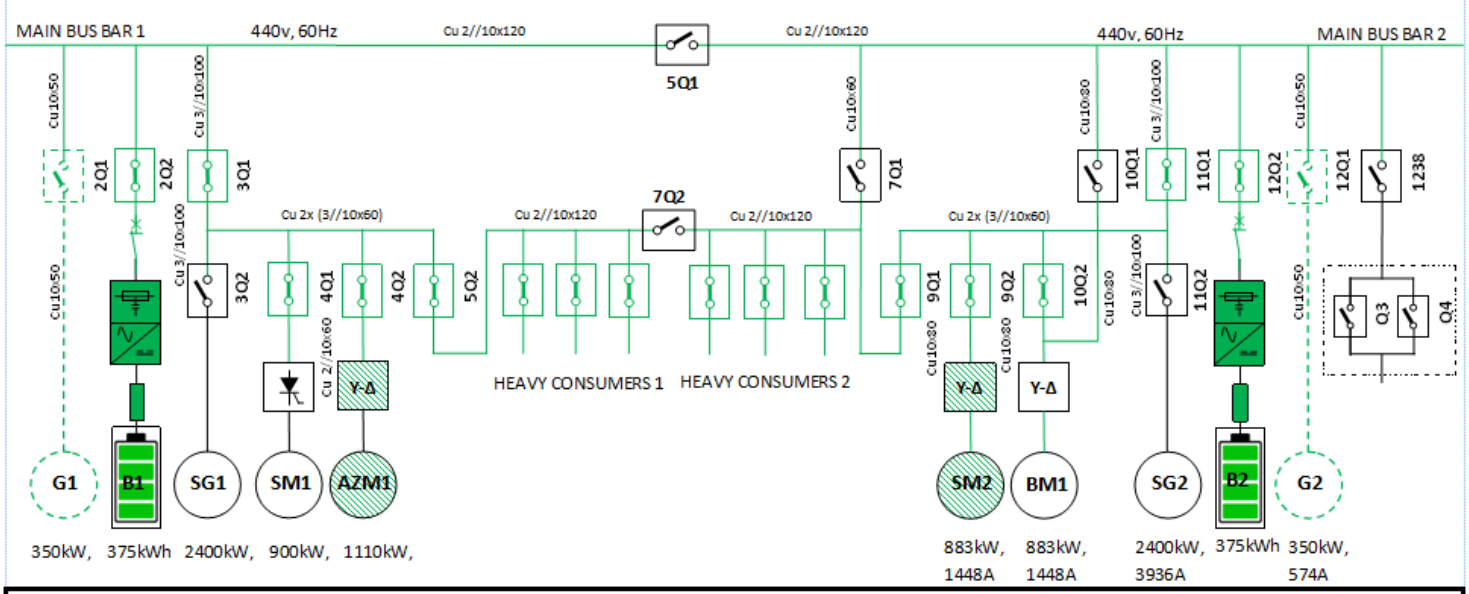
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However the largest savings can be made when the vessel is standing by outside the 500m safety zone, whereby in the new hybrid configuration, the main engines can be stopped and two thrusters can be operated at low power from the batteries and auxiliary generators.

Figure 5 depicts this configuration.

Low Power Loitering Mode

Fig 5: Mr Chafic Single Line Diagram - Battery Hybrid Configuration: : **Low Power Standby Mode (Loitering)**



1. AZM1 and SM2 started from SGs (or already running from SGs) and running (in low load limit) → B1/B2 connected → SGs then disconnected and isolated by opening 3Q2 & 11Q2 → ME1/ME2 stopped
2. Main Busbar 1 supplied from G1//B1, Main Busbar 2 supplied from G2//B2. 5Q1 can be open or closed
3. Heavy Consumers supplied from Main Busbars via 3Q1 & 11Q1
4. AZM1 and SM2 provide low power position keeping. Alternative thrusters can be used but no more than 2 (TBC)
5. G1/G2 operate continuously in parallel with B1/B2 or automatically in B1/B2 SoC dependent start/stop mode to charge batteries; where start = 30% SoC and stop = 90% SoC

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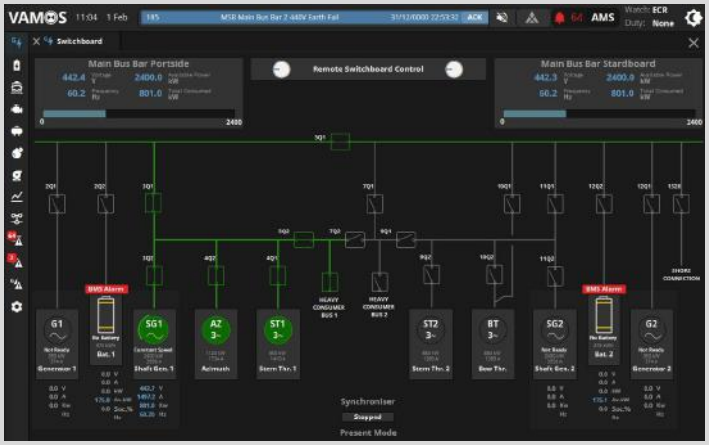
By adding circuit breakers 3Q2 and 11Q2, the main engines (shaft generators) can be stopped whilst the heavy consumer bus is supplied from batteries and auxiliary generators. This enables one thruster on each side of the bus to operate at low power to provide a low power loitering mode. Other modes are available, for example battery only operation in port, with auxiliary generators periodically starting to recharge them.

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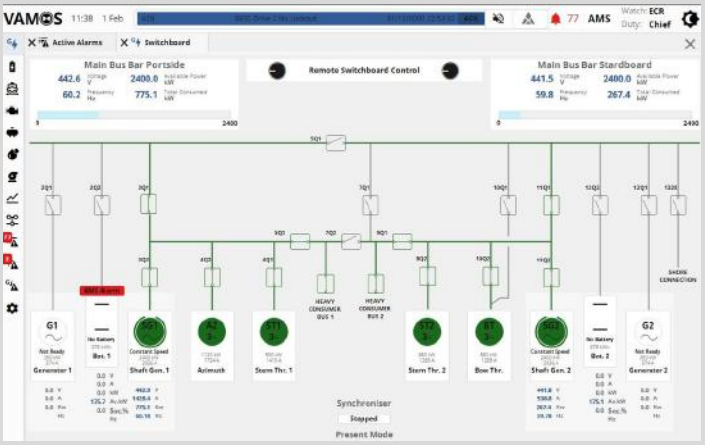
CASE STUDY

VESSEL AUTOMATION & MACHINERY OPERATING SYSTEM

At the heart of the upgrade is the ELSYS (an MJR partner company) proprietary Marine Automation Platform, VAMOS, developed over a number of years and already deployed successfully on a number of retrofit marine and offshore projects.



Power Management - dark theme



Power Management - light theme



Vessel Performance Overview



Overall Propulsion

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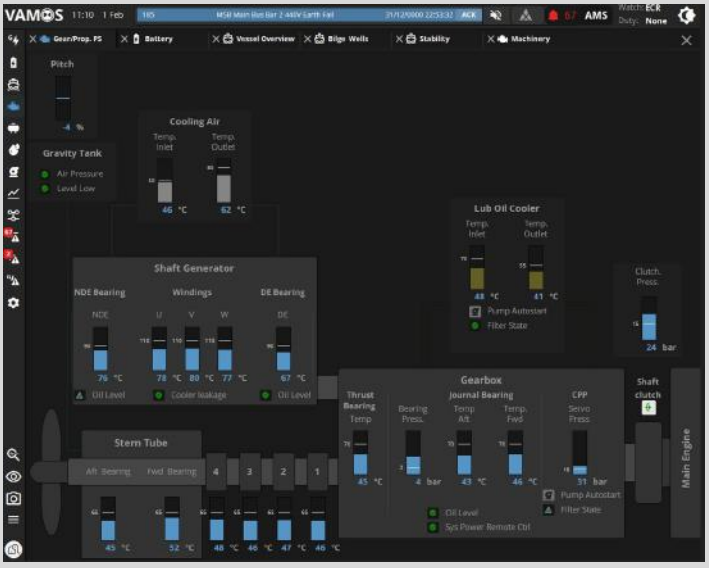
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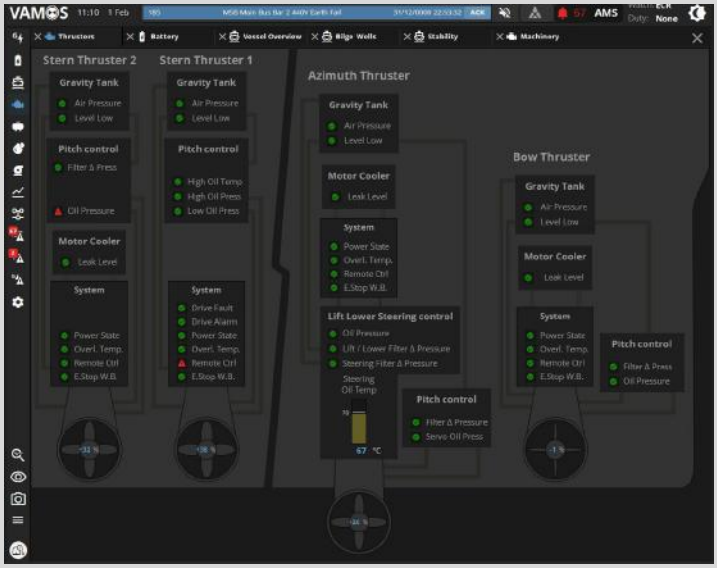
CASE STUDY



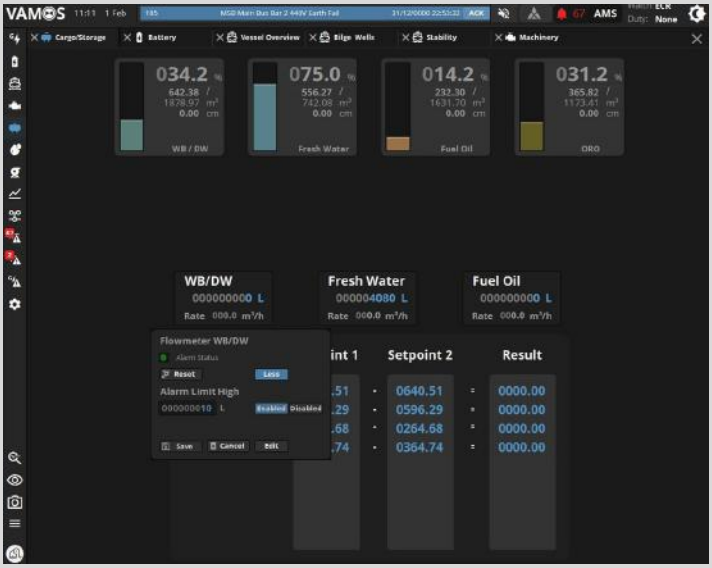
Main Engine



Gear/Propulsion



Thrusters



Cargo Storage & Transfer

- **PC based, with true hardware independent architecture — can be deployed on any commercial off the shelf marine type approved I/O and PLC hardware**
- **Modular and scalable—cost effective for small (a few hundred I/O) to large (tens of thousands) of I/O and data points**

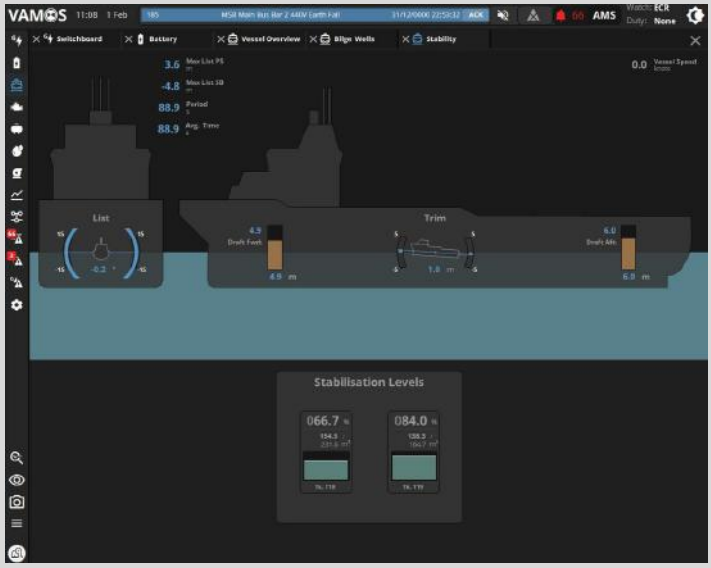
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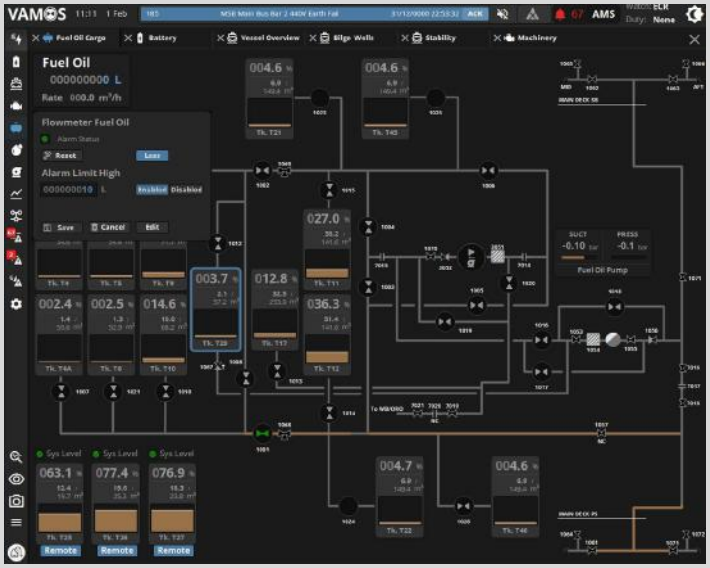
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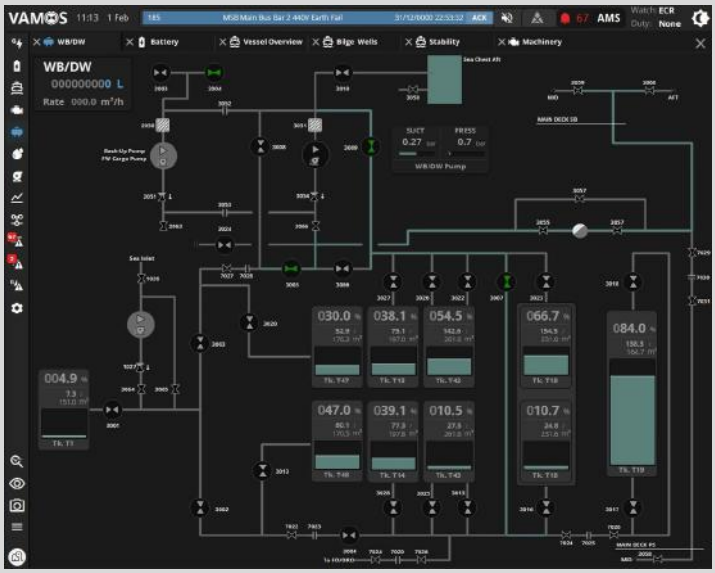
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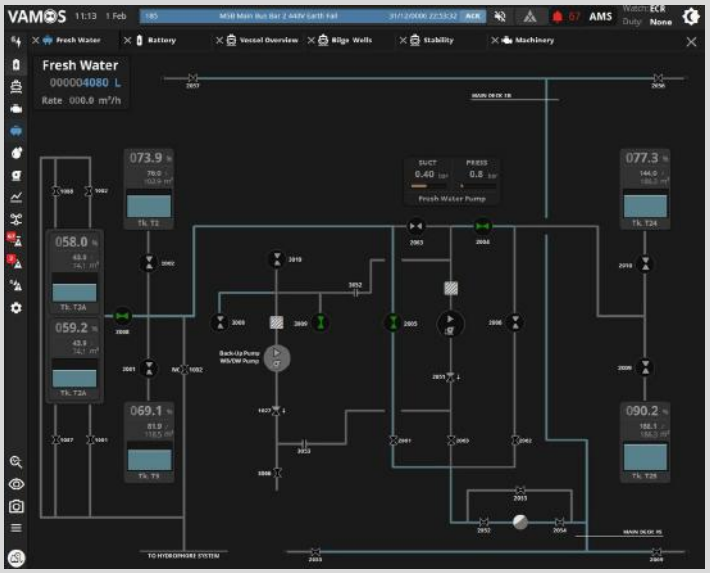
Trim & Stability Overview



Fuel Oil Cargo Control



WB/DW



Fresh Water

- **Suitable for all vessel types, from harbour tugs to complex and specialist dynamically positioned offshore construction vessels**
- **Power & Energy Management System (optional) specifically designed to integrate the latest energy storage technologies, alternative fuel and hybrid/fully electric power and propulsion plant**

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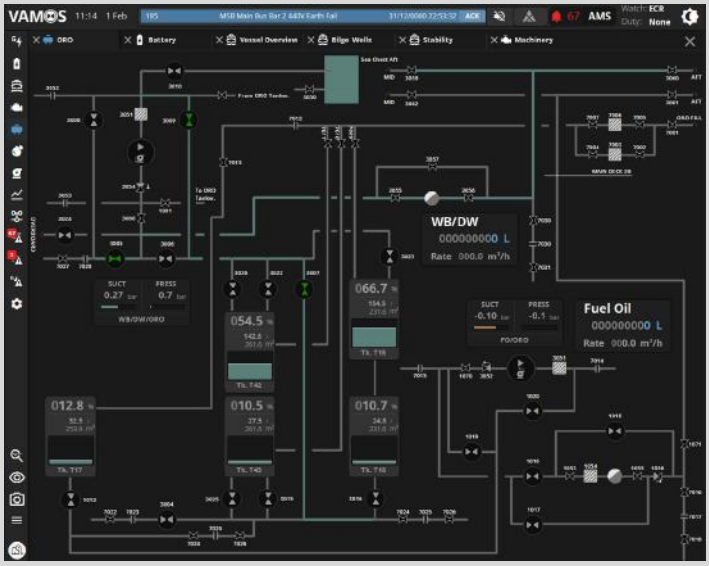
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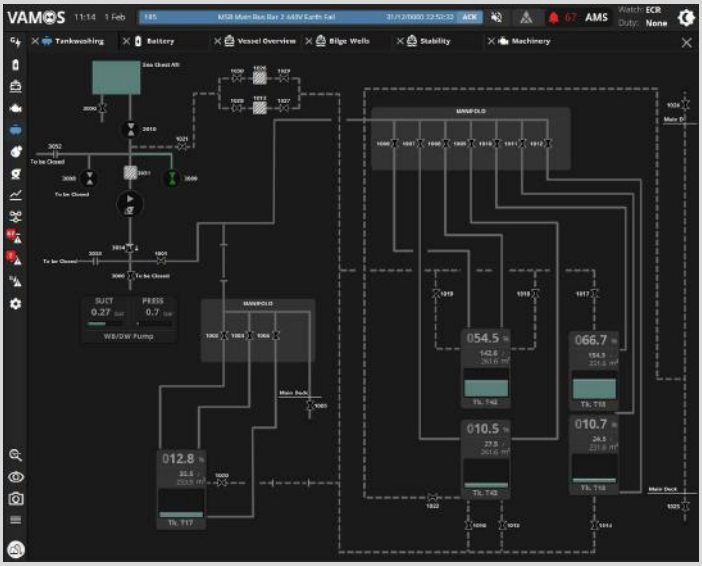
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CASE STUDY



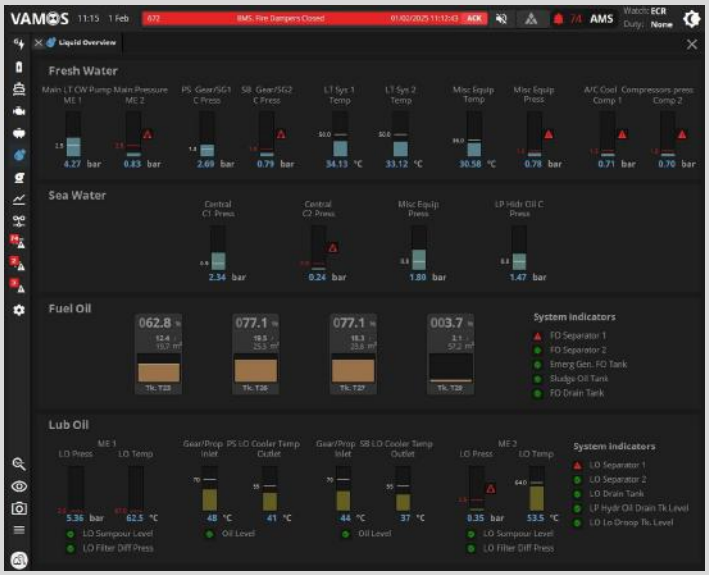
Oil Recovery Operations



Tank Washing



Tank Sounding



Liquids Overview

- **Virtually unlimited data interfaces for integration with external third party systems such as Main and Auxiliary Engines, Power Generation & Propulsion Plant, HVAC, Tank Sounding, Pump & Valve Control, Integrated Bridge, Voyage Data Recorder, Stability & Loading Computer, Customer Shore Based Data Acquisition & Management Portal**

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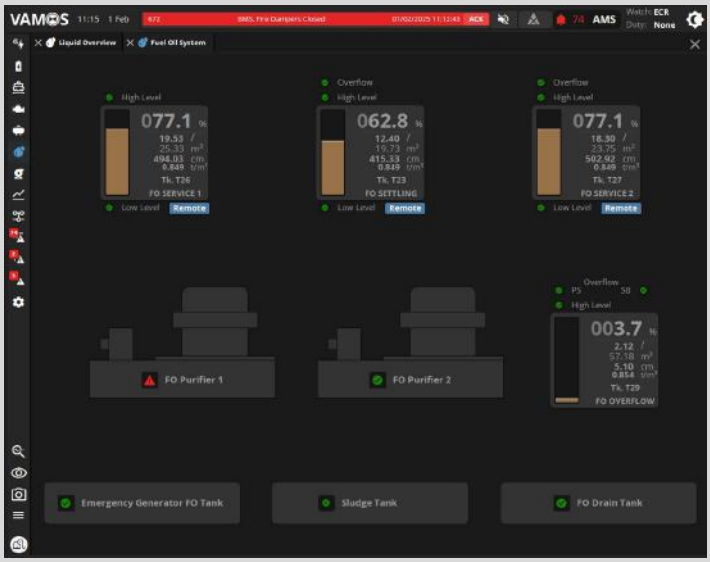
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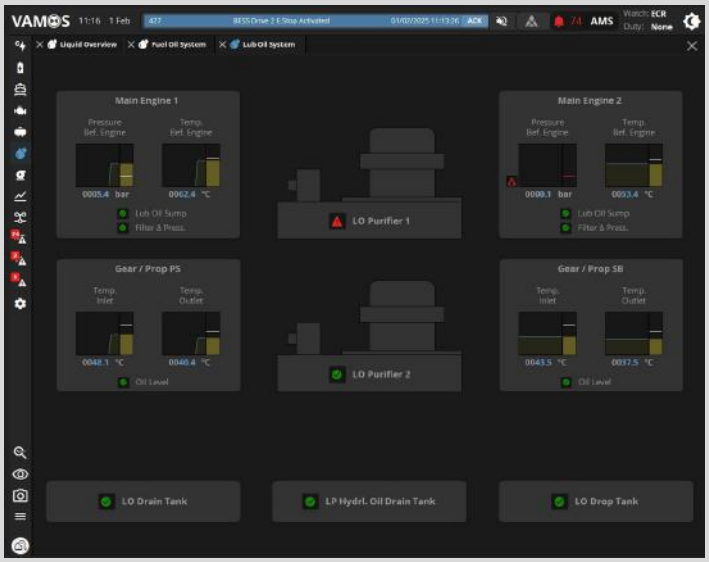
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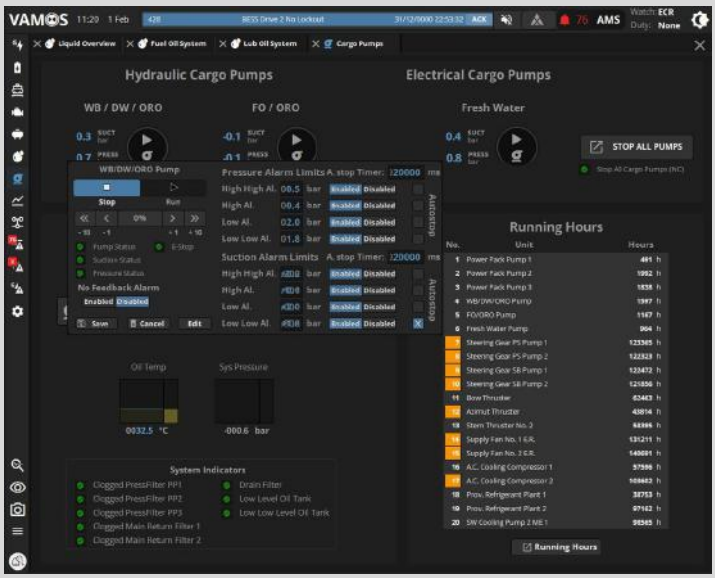
CASE STUDY



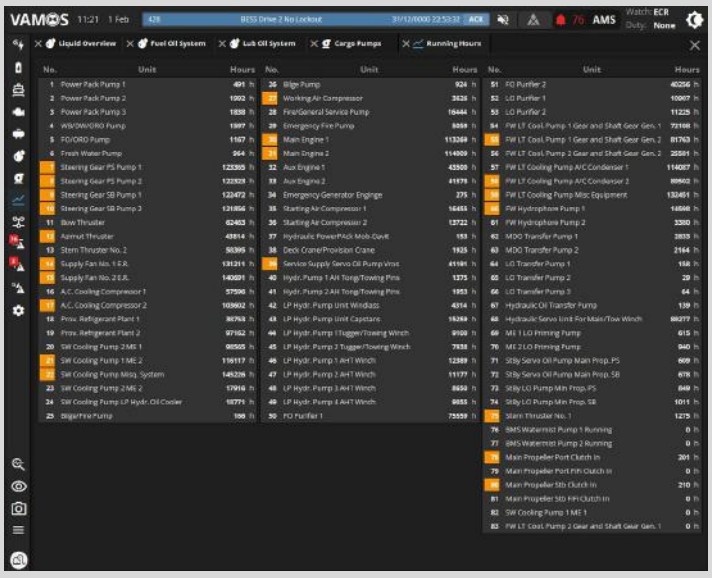
Fuel Oil System



Lub Oil System



HPU & Cargo Pumps



Running Hours

- **Can be supplied with additional control modules for direct control and monitoring of all main and ancillary equipment including (but not limited to): Propulsion, Pumps & Valves, Fresh Water & Ballast Water, Fuel & Lub Oil, Cooling Systems, HVAC, Tank Sounding, Auto Heeling & Stability, Deck Machinery & Mission Equipment, Reefer & Cargo Control & Monitoring**

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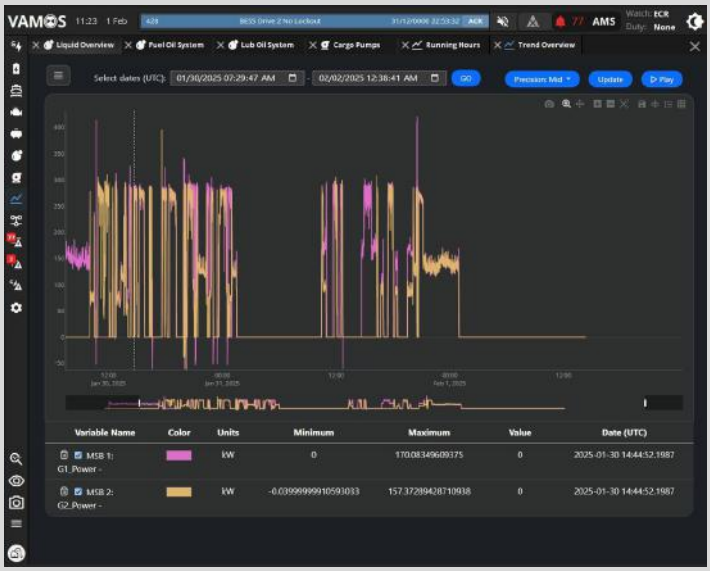
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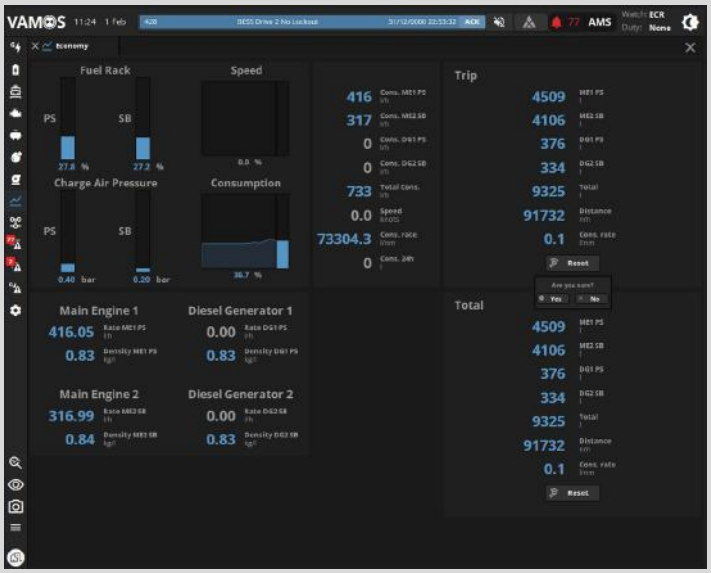
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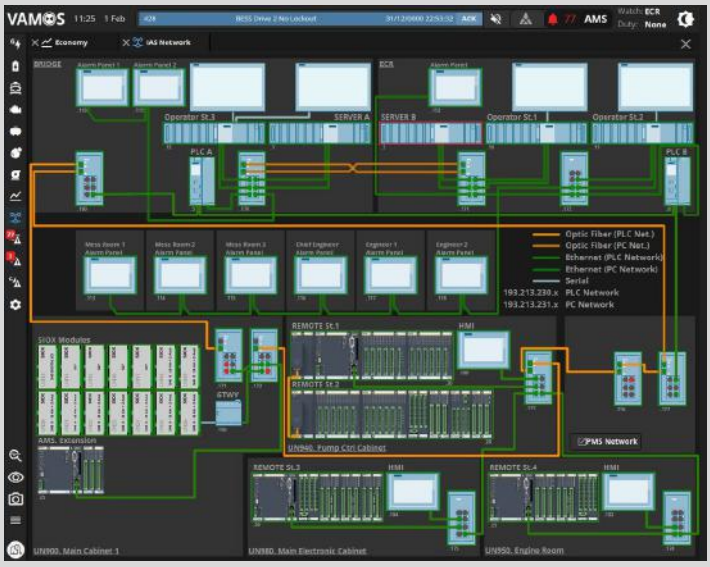
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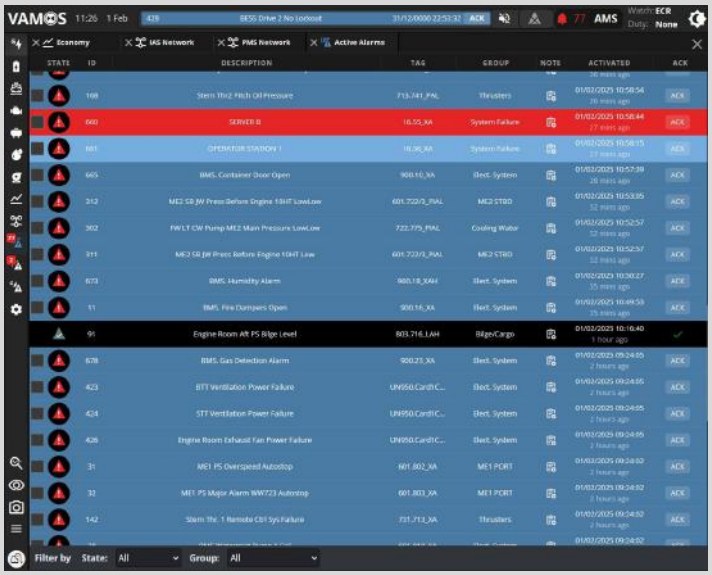
Trending, Historian & Data Analysis



Economy



Network & Diagnostics



Active Alarms

- **Fast and powerful user interface with intuitive navigation to minimize requirements for training and enhance usability in difficult and stressful situations**
- **Sophisticated and powerful system diagnostics, data recording and analysis tools to assist with complex problem solving and performance analysis**

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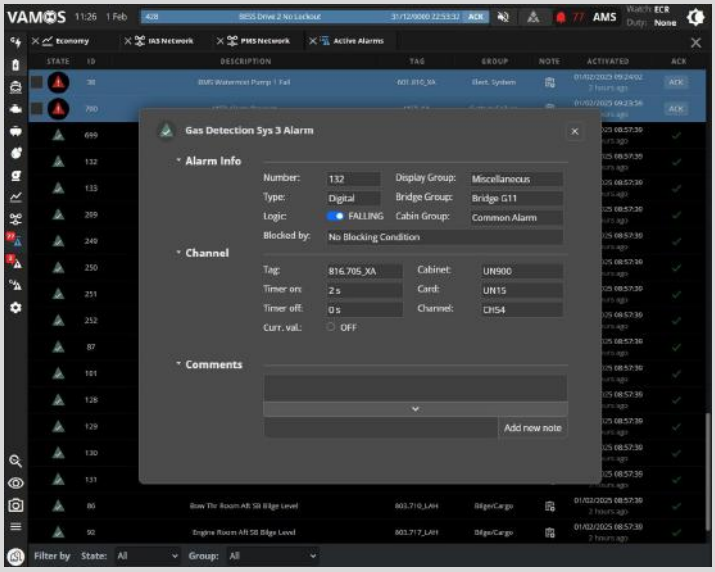
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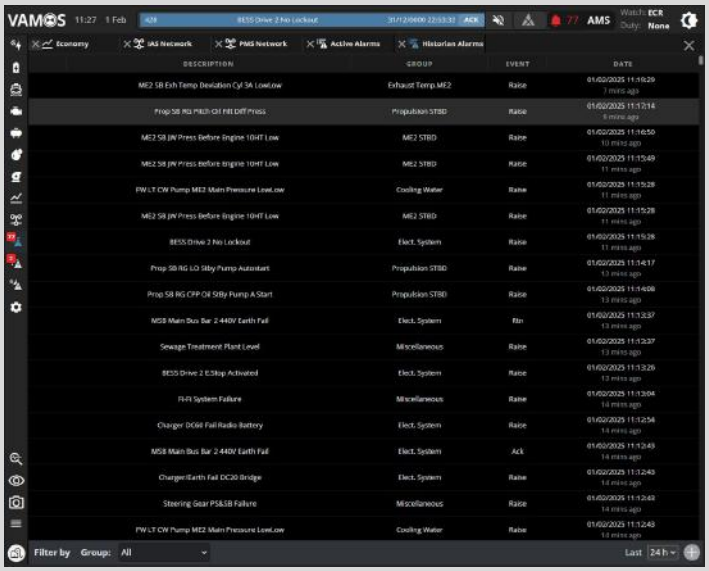
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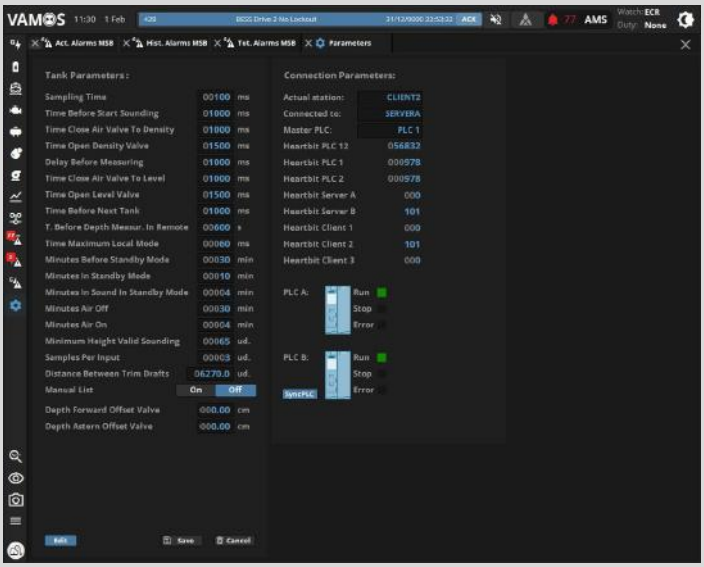
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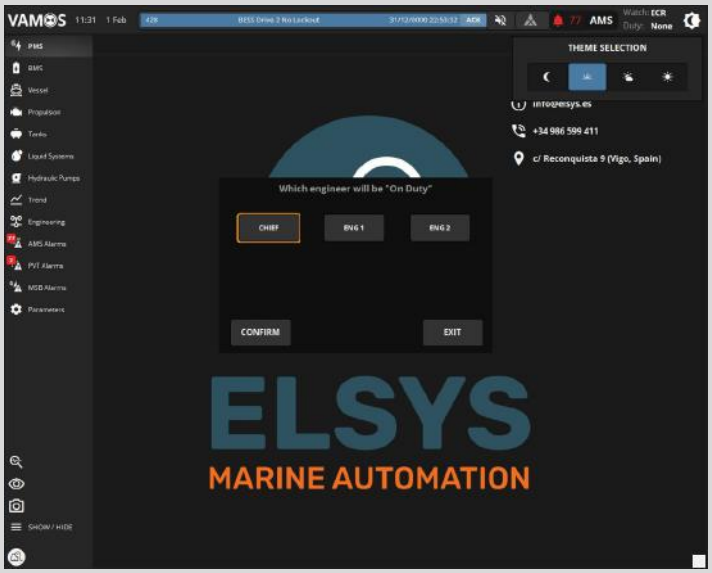
User Configuration of Alarm Channels



Alarms Historian, Event Log & Audit Trail



Continuous System Performance Monitoring



Unattended Operation—Duty Engineer Selection

- **User configurable but with comprehensive audit trail functions to keep track of changes made, crew interaction with the system and real time events**
- **Full remote access for service and integration with ELSYS (& Customer if available) shore based data acquisition and monitoring platform - compliant with class rules for Cyber Security**

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