Diesel Electric Propulsion Systems and Controls - African Traction Systems

SAIMENA - The South African Institute of Marine Engineers & Naval Architects

Presented by Wicus du Preez – African Traction Systems

History of ATS

African Traction Systems is a privately owned company.

The lineage of ATS dates back to 1968 with the inception of Saftronics by Mr. Bonne Posma in Johannesburg, South Africa.

1968

Saftronics founded in South Africa

(still in operation)

1976

Saftronics opens in Ontario

(now SAF Drives)

1986

Saftronics opens in New York

(moved to Fort Myers, Florida in 1987 - purchased by Emerson in 2005)

1992

Saminco opens in Florida

(still in operation, opened China office in 2009 South African office in 2011)

2008

ATS opens in Florida

2012

African Traction Systems opens in South Africa

ATS Milestones

2008

64 Dual 90kW DC Propulsion Systems
New Orleans Streetcars

2008

Dual 300kW AC Propulsion Hybrid System
the Alcatraz Hybrid

2009

1.5MW DC Propulsion systems
Brookville Co-Gen Locomotives

2009

550kW AC Traction System
Venturi Buckeye Bullet 2
487km/h Hydrogen Fuel Cell Electric Vehicle

2010

1.5MW DC Propulsion Systems
Loram RG400 series MoW Grinder

Milestones

2010 500kW DC Propulsion Battery System
Norfolk Southern 999 Locomotive

2011 Dual 700kW AC Propulsion Hybrid System
Statue Cruises

2012 Dual 350kW Permanent Magnet Hybrid System
TARDEC Ultra Light Vehicle

2012 Dual 700kW AC Propulsion Hybrid System
Alcatraz Clipper

Milestones

2012

1.5MW DC Propulsion Hybrid System
AMPS Hybrid Locomotive

2012

Dual 700kW AC Propulsion Hybrid System
Alcatraz Flyer

2012

Dual 385kW Permanent Magnet System
Venturi Buckeye Bullet 2.5
514km/h Battery powered EV

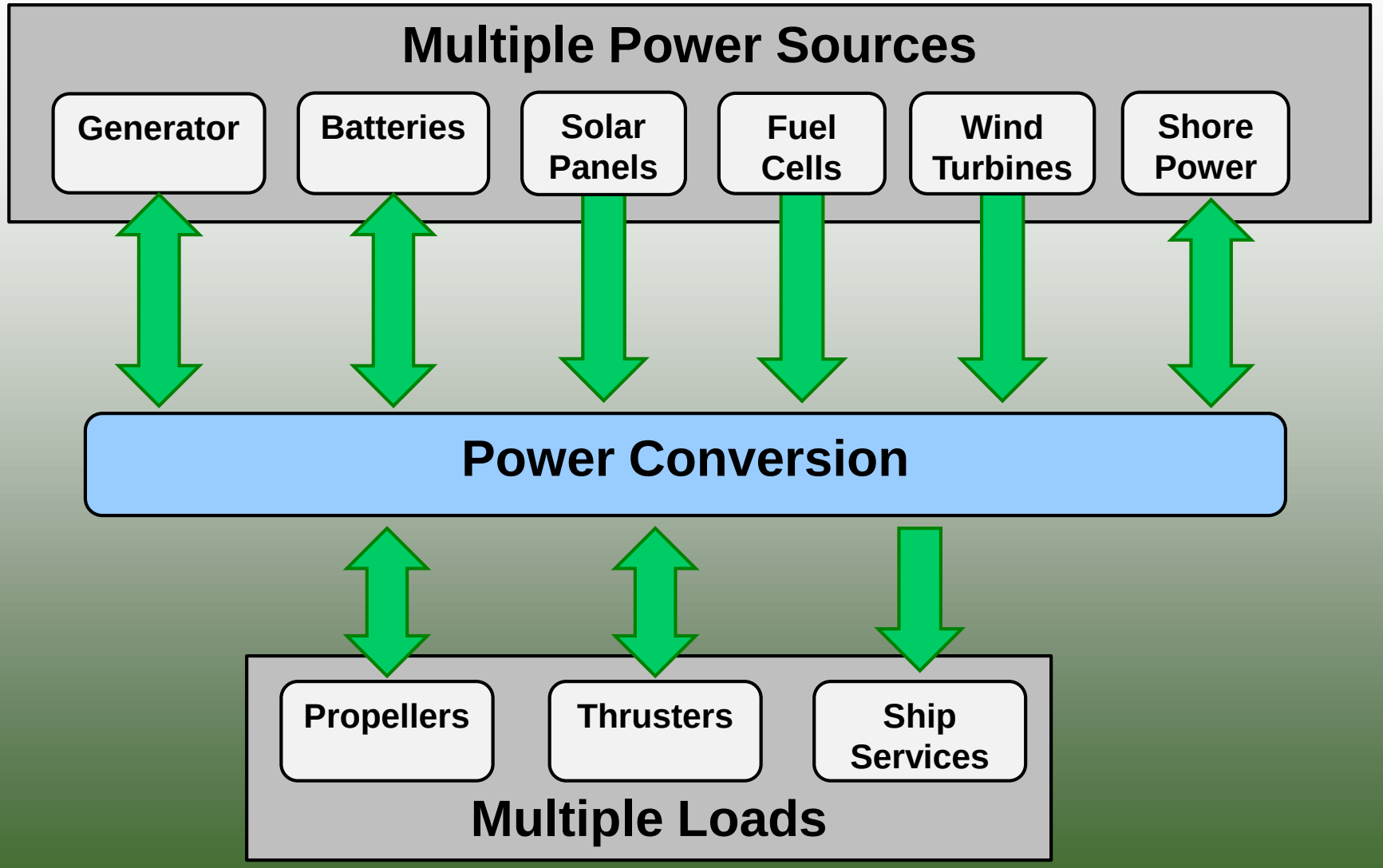
2013

Dual 3MW DC Propulsion System
USNS Waters

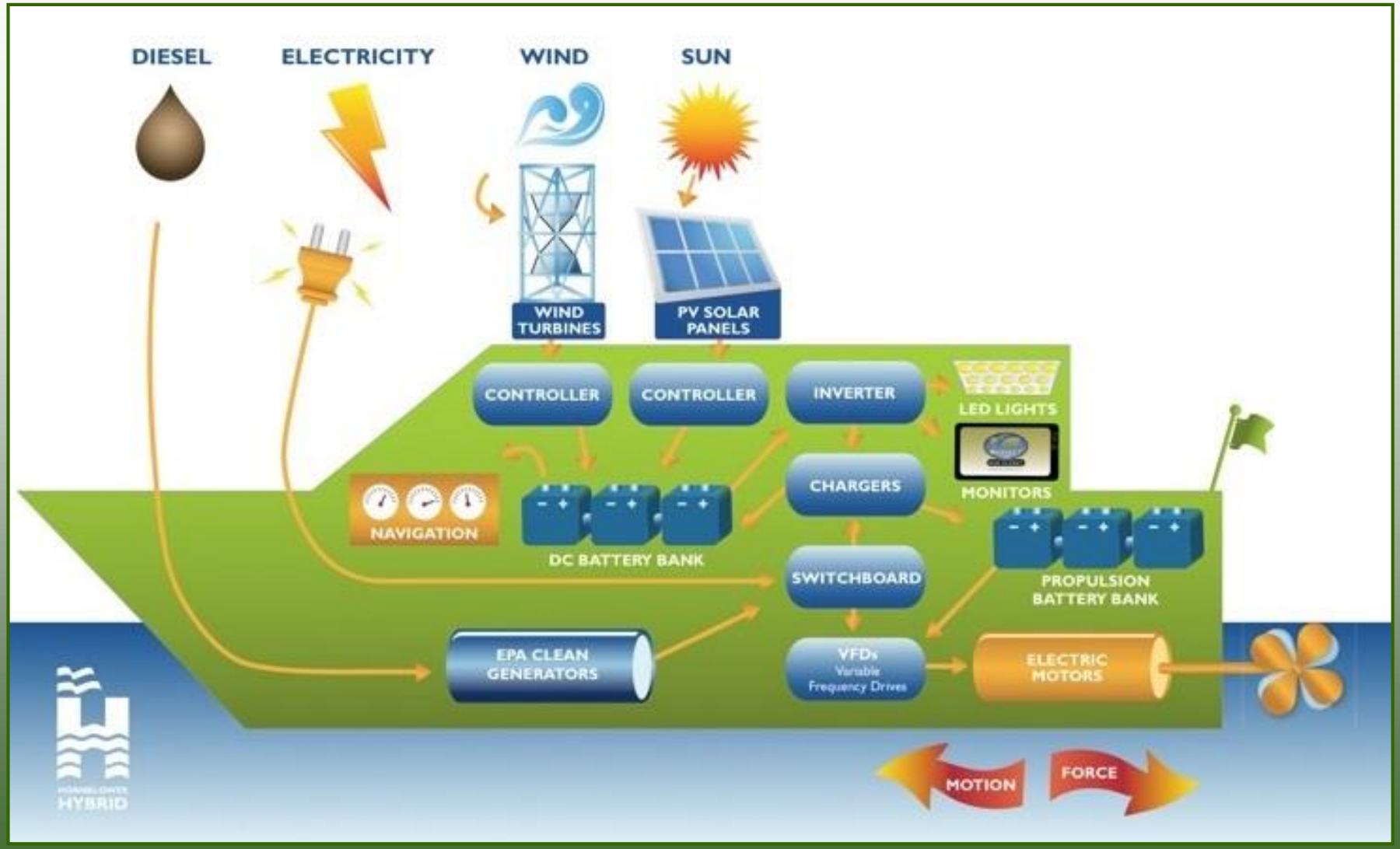
2014

1.5MW DC Propulsion Systems
RRL Grindrod

What is a Diesel Electric Hybrid Propulsion System



The Alcatraz Hybrid – 20 meter dual 300kW Propulsion



Hybrid Propulsion Systems

The only US Coast Guard approved diesel-electric-hybrid passenger ferries operating in US waters

- **The Alcatraz Hybrid**
- **The Horn blower Hybrid**
- **The Alcatraz Flyer**
- **The Alcatraz Clipper**

All powered by ATS propulsion systems

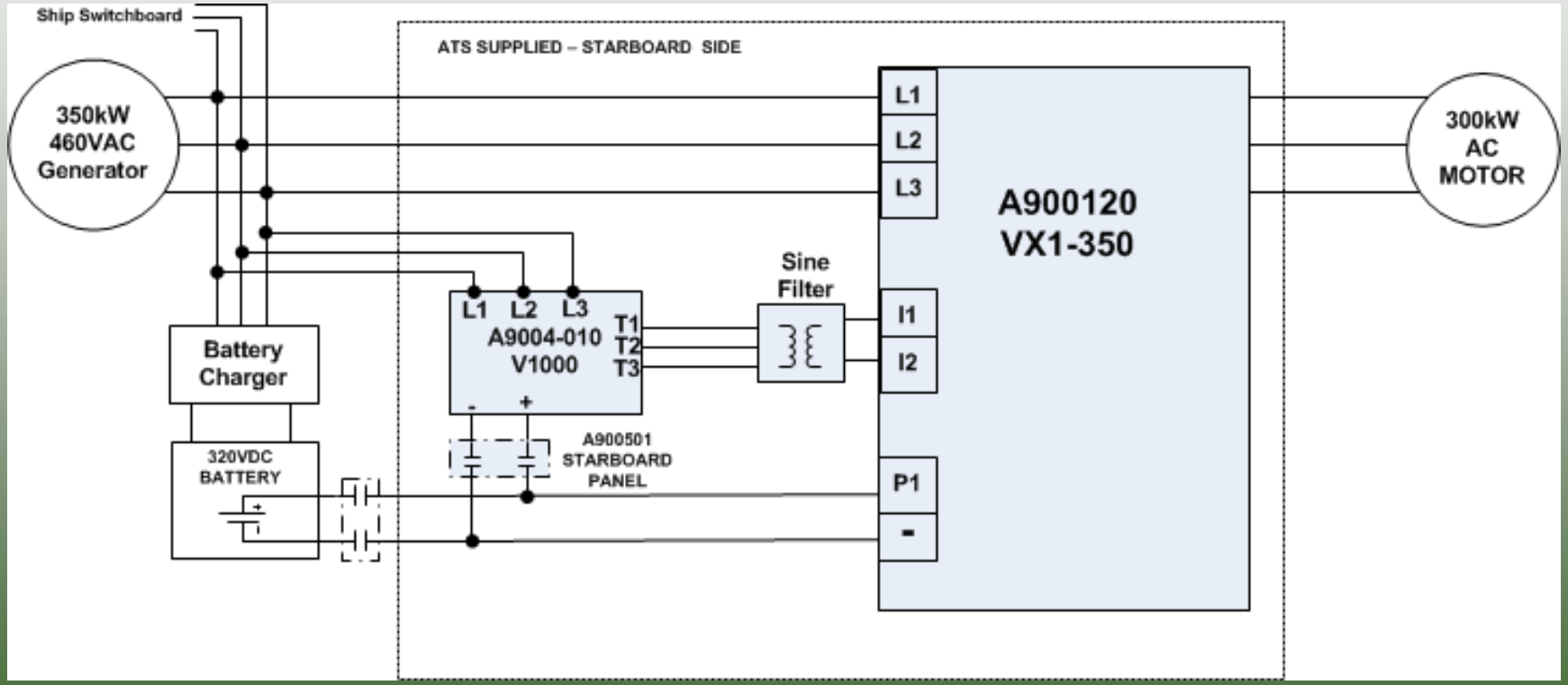
The Alcatraz Hybrid – 20m dual 300kW Propulsion

Commissioned in 2008, The Horn blower Hybrid was the first hybrid passenger ferry in the United States. The vessel utilizes battery power when moored at the pier, reducing fuel consumption and eliminating the noise and fumes associated with diesel engines while passengers are boarding.

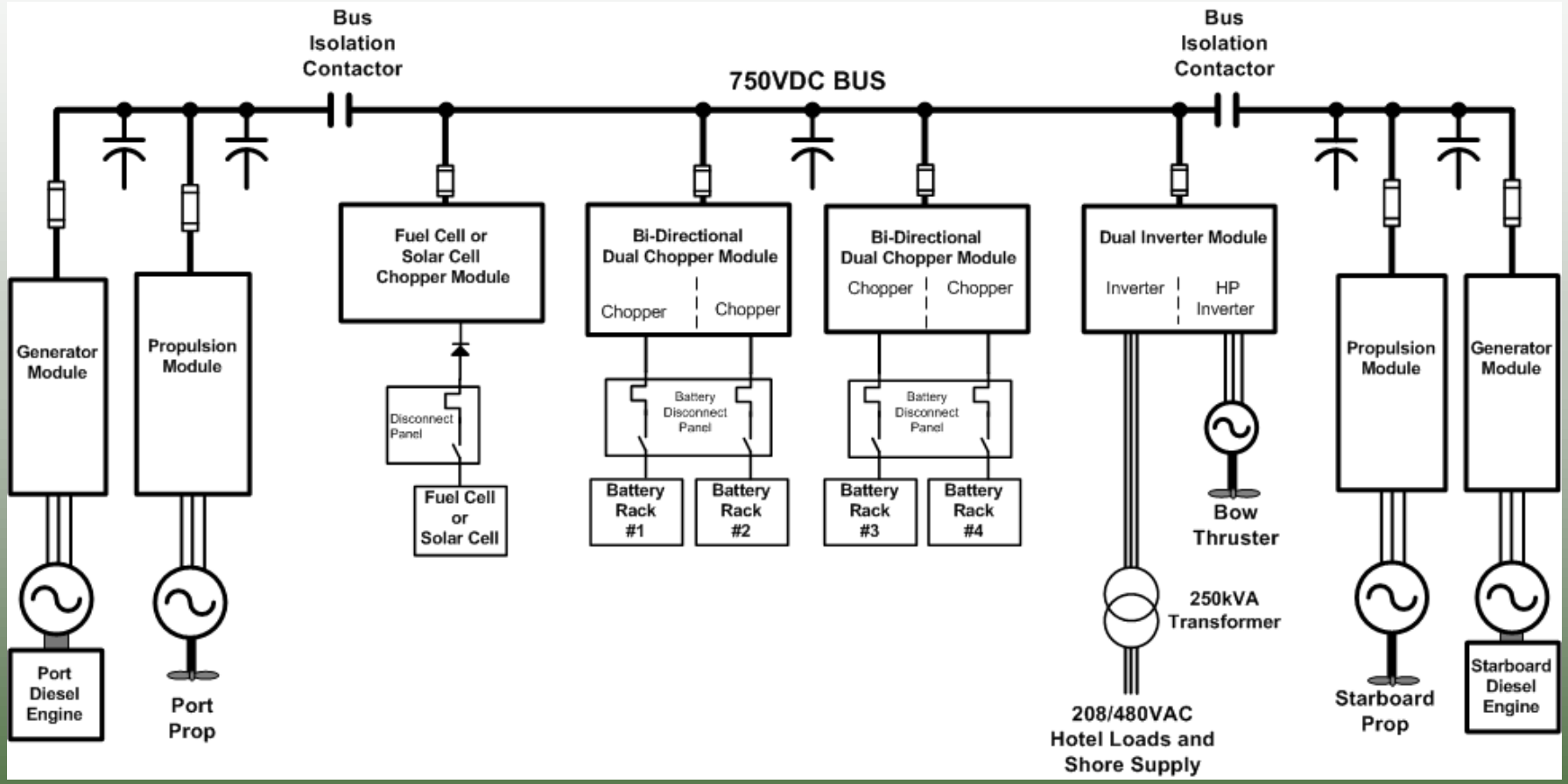
The Tier II diesel generators come on-line as necessary while underway, depending upon the vessel load requirements.
Solar panels and wind turbines also augment the power from the generators.

The Alcatraz Hybrid – 20 meter Dual 300kW Propulsion

ATS adapted our standard 350HP Variable Frequency Drive (VFD) to accept either 460VAC 3-phase 60Hz from the generator *or* 320VDC from the battery packs. The ATS control algorithm allows the VFD to seamlessly transition from generator or battery input allowing the vessel to change power sources while underway.



Typical ATS Hybrid Marine Propulsion System



Typical ATS Hybrid Marine Propulsion System

Vessel Engine Room

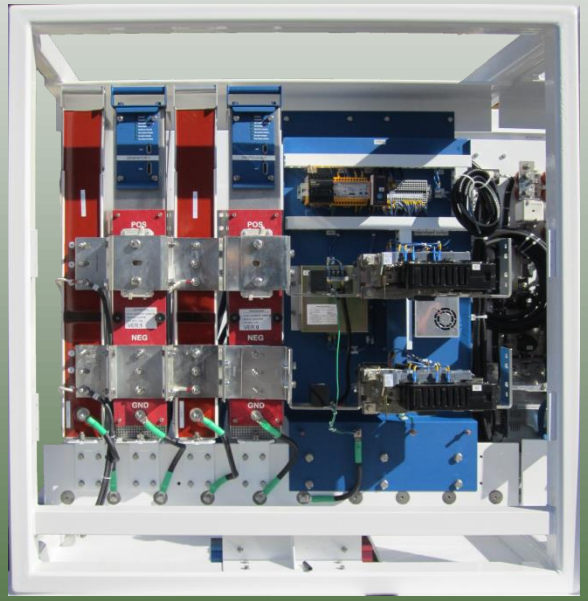
ATS Vessel Propulsion System

Typical ATS Hybrid Marine Propulsion System

The typical ATS system is divided into three high-voltage rack assemblies.

Two generator and propulsion control assemblies (with DC bus isolation contactor) and one power conversion/distribution rack in the center.

Each assembly measures 1200mm deep x 1200mm wide x 1270mm tall.



Port Propulsion

Power Conversion/Distribution

Starboard Propulsion

ATS IGBT Power Modules

The ATS power conversion equipment is based upon a set of compact liquid-cooled Insulated Gate Bipolar Transistor (IGBT) modules operating from a common DC bus. At 130mm wide x 860mm tall x 380mm deep the propulsion system can fit into extremely tight quarters. Over 400 modules are in daily operation in Marine, Locomotive, Off-road and Military applications.

The same power module is used for DC to DC Choppers or DC to AC Inverters. The function of the power module is determined by the application-specific control module installed into the power module.

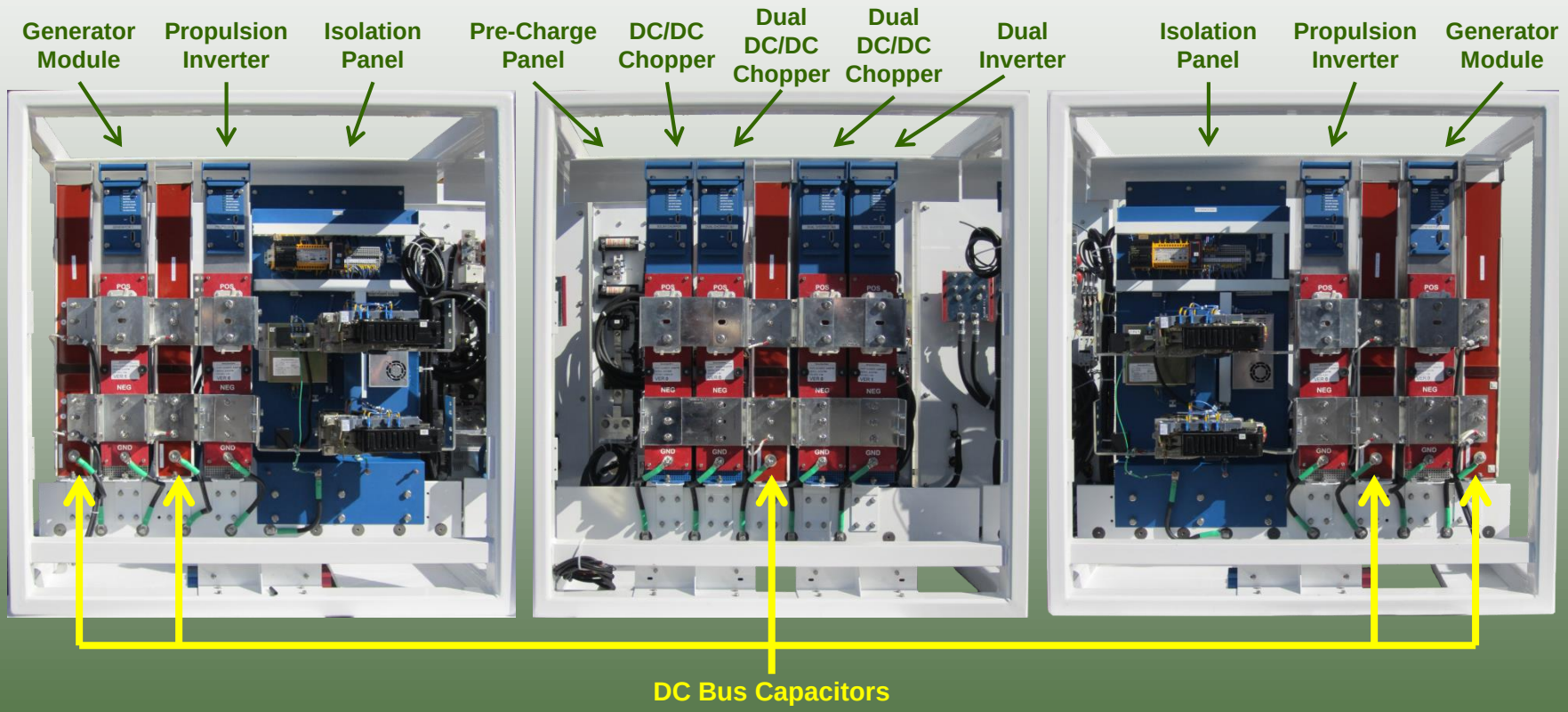
All configurations are bi-directional. They can absorb power from or deliver power to the DC bus.

ATS Power Module

ATS Control Module

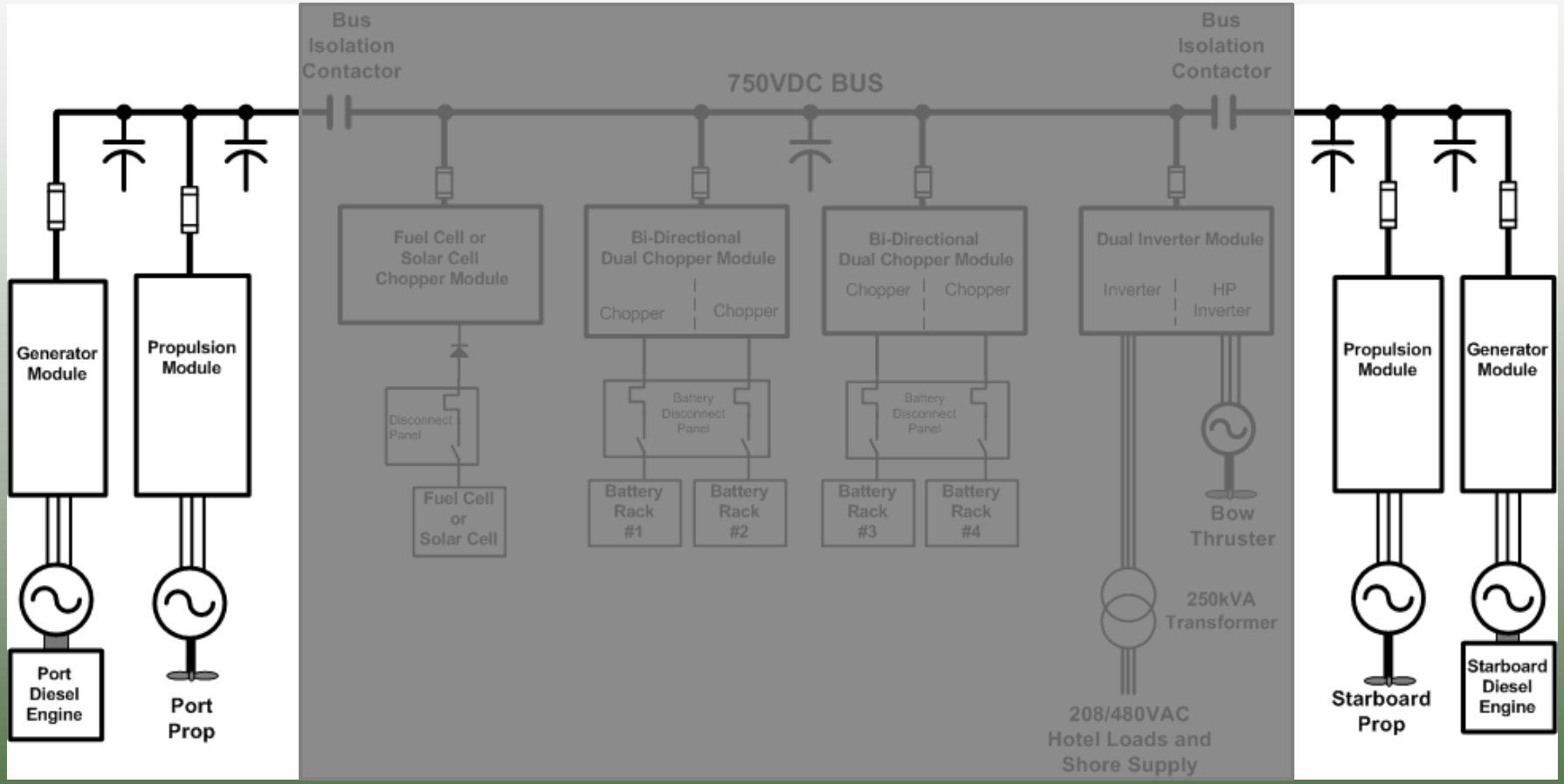
ATS Dual Module

Typical ATS Hybrid Marine Propulsion System



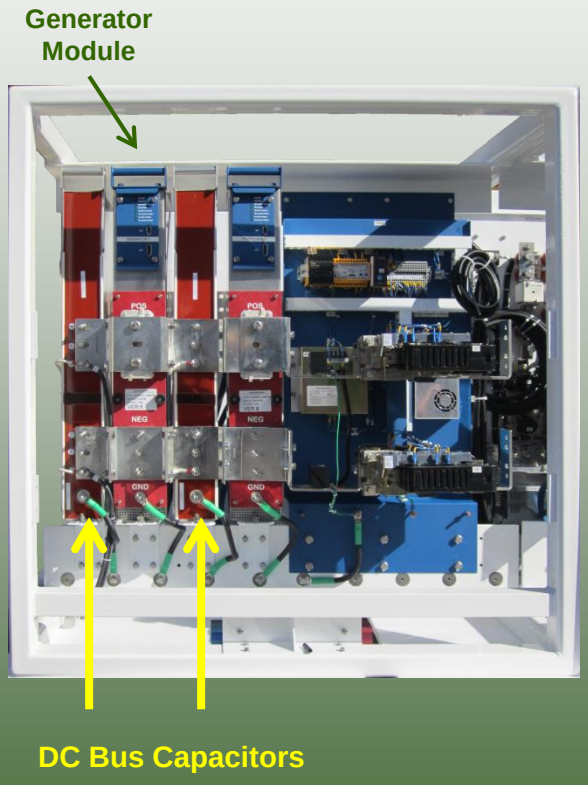
Typical ATS Hybrid Marine Propulsion System

Generator and Propulsion Rack Assembly

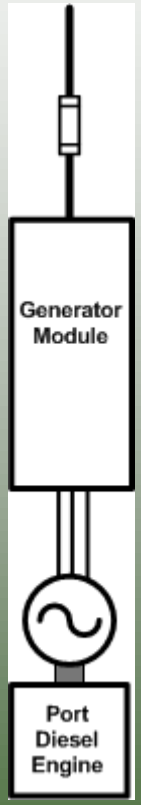


Generator and Propulsion Rack Assembly

The generator and propulsion section of the system consists of one generator and one propulsion module, two DC bus capacitors and a DC bus isolation contactor panel.



Port Propulsion Rack



Induction Generator

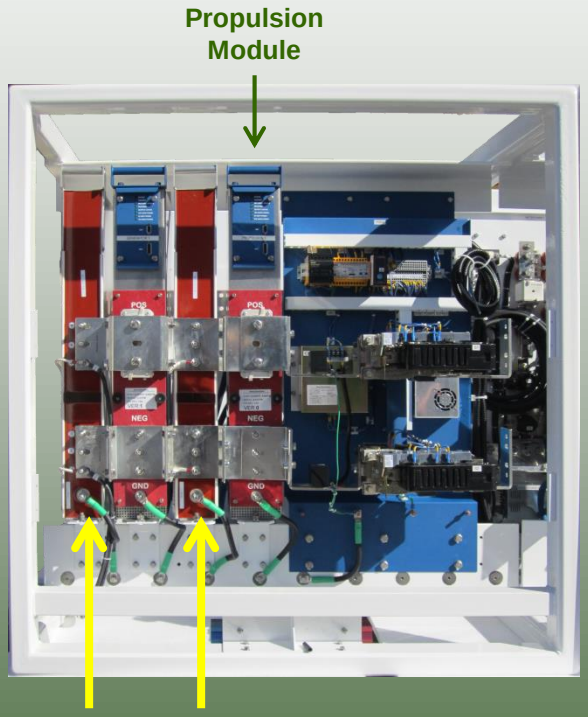
Power is supplied to the common DC bus from diesel-driven induction generators. Each diesel engine is coupled to an induction motor of matching power capability.

Induction generator converters regulate the electrical output to the 750V DC bus by operating at negative slip in order to absorb power from the diesel engine. Operation of the generator is possible over a speed range of 600 rpm to 1800 rpm.

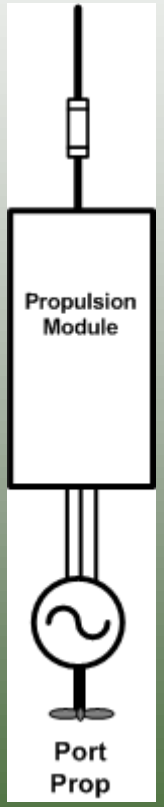
The induction generator converters are capable of bi-direction power flow. They are used to crank the engine to a speed slightly above idle in order to achieve a smoke-free start. The normal starter motors are used only if the propulsion batteries are discharged or if shore power is not available.

They also operate as engine brakes if a crash-stop reversal of the propulsion motors is necessary.

Generator and Propulsion Rack Assembly



Port Propulsion Rack



AC Propulsion

The AC Induction propulsion motors operate at a speed commanded by the control head located at the bridge.

The propulsion inverter converts power provided by the 750V DC bus to AC power of suitable voltage and frequency to achieve the required propeller speed.

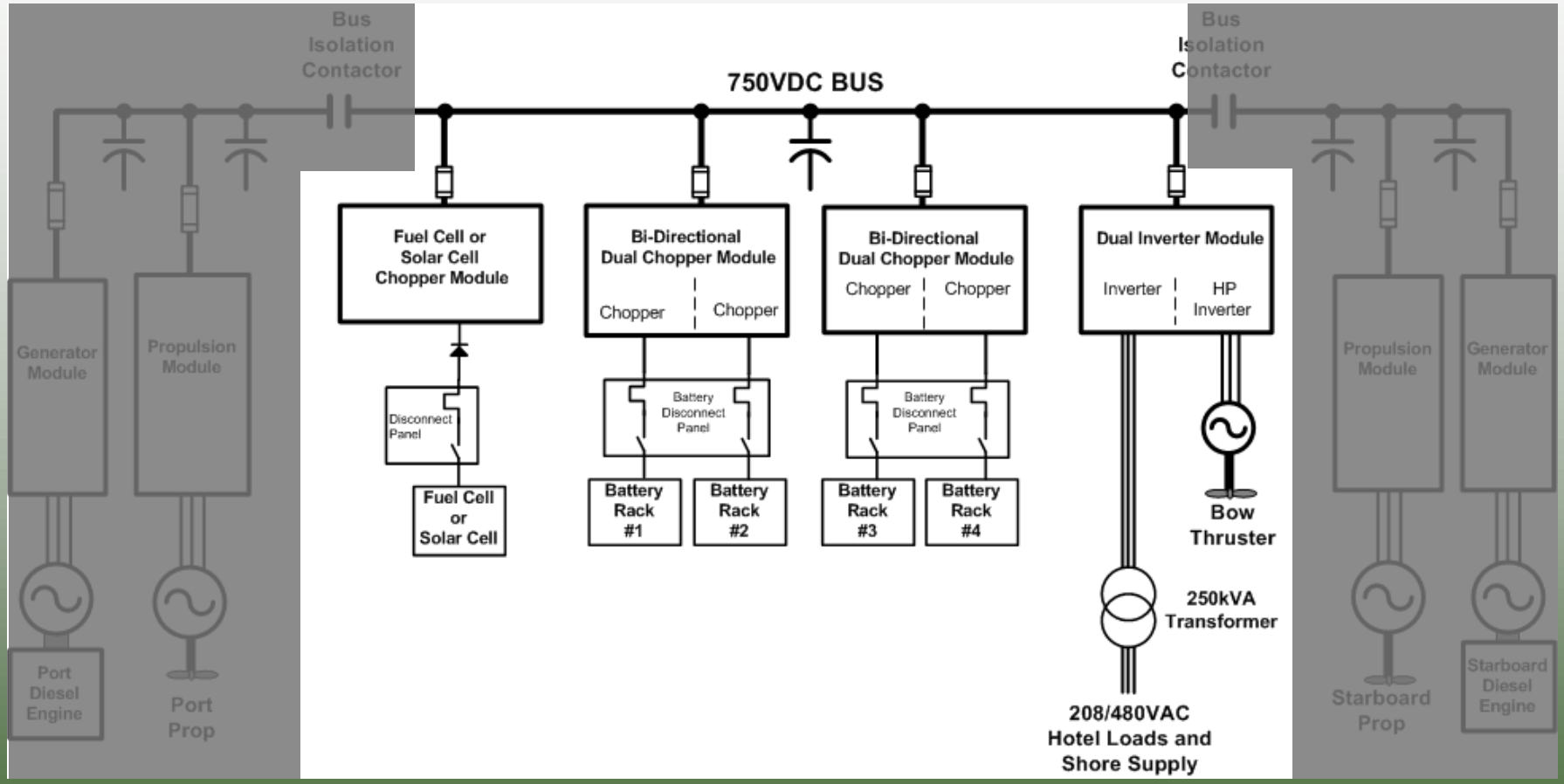
The propulsion system continually monitors the load requirements to assure the total capacity of all power sources is not exceeded.

If the maximum power limit of all of the sources is reached, the commands from the control head are modified proportionally to remain within the system limits .

When moored in a strong current, it is possible for the propulsion inverters to absorb power from the rotation of the propellers and deliver electrical power to the DC bus.

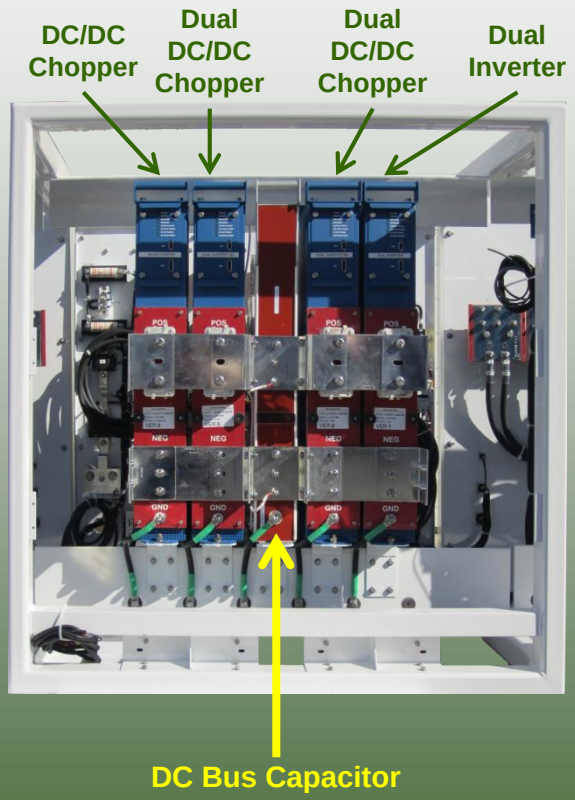
Typical ATS Marine Propulsion System

Power Conversion Rack Assembly

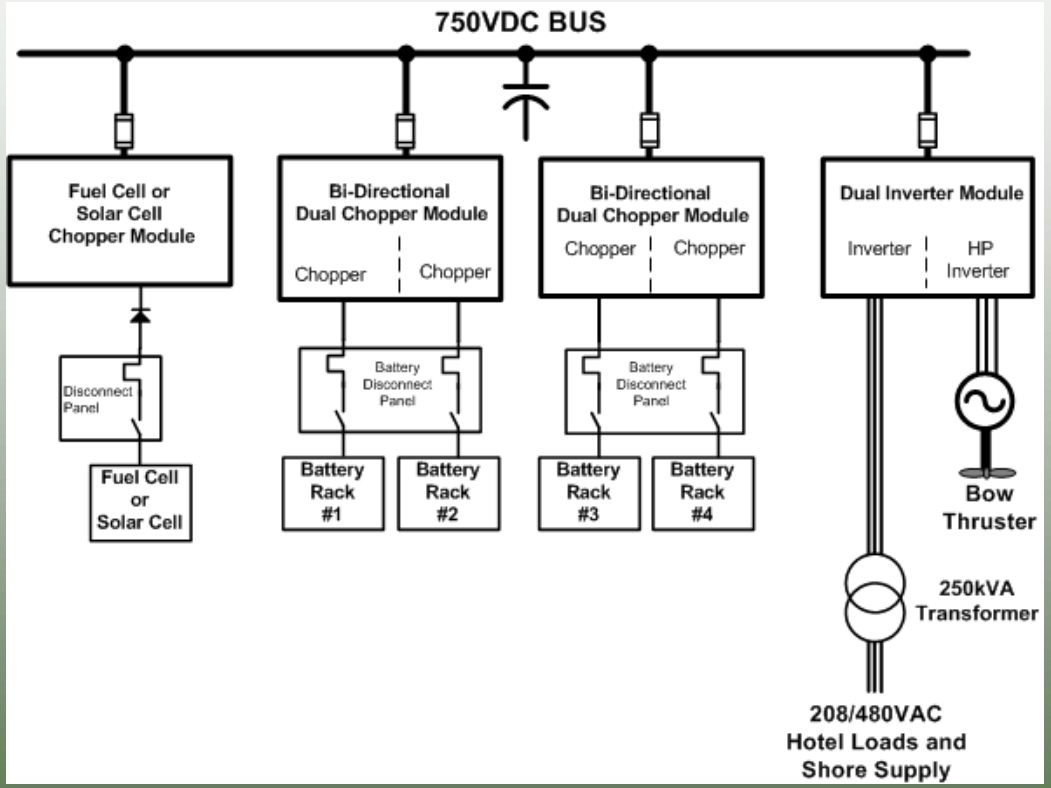


Power Conversion Assembly

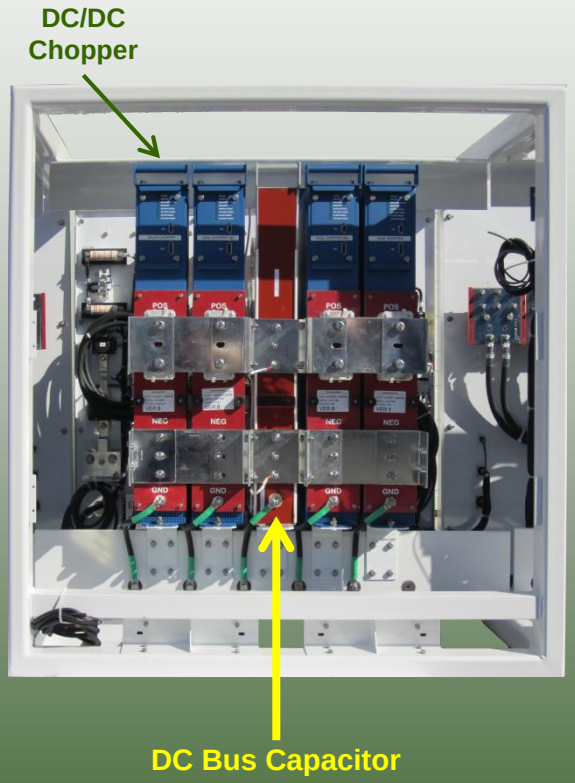
The Power Conversion section of the system consists of one DC to DC chopper, one DC bus capacitor, two dual DC to DC Choppers, one dual inverter and a pre-charge contactor panel.



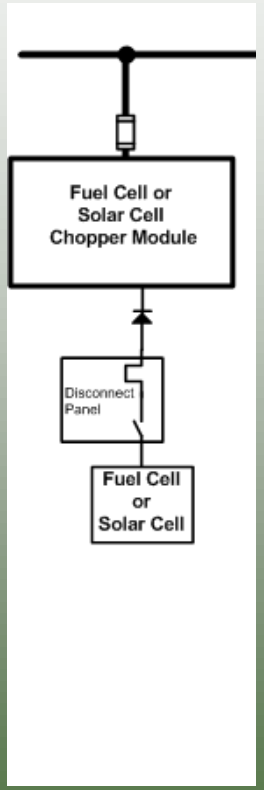
Power Distribution Rack



Power Conversion Assembly



Power Distribution Rack



DC-to-DC Chopper

The DC to DC Chopper is used to interface fuel or solar cells to the 750V DC bus. The operating voltage of the fuel/solar cell is chosen so that it is always lower than 750V allowing total control of the current that is drawn from the source.

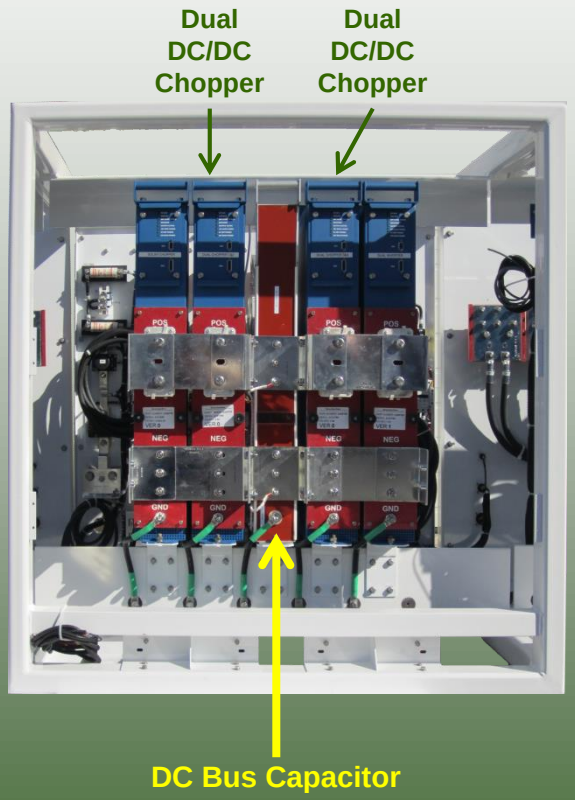
If the vessel is equipped with solar panels, the power management system assigns the highest priority to this source.

The converter connected to the fuel/solar cells is limited only to operation in the discharge direction.

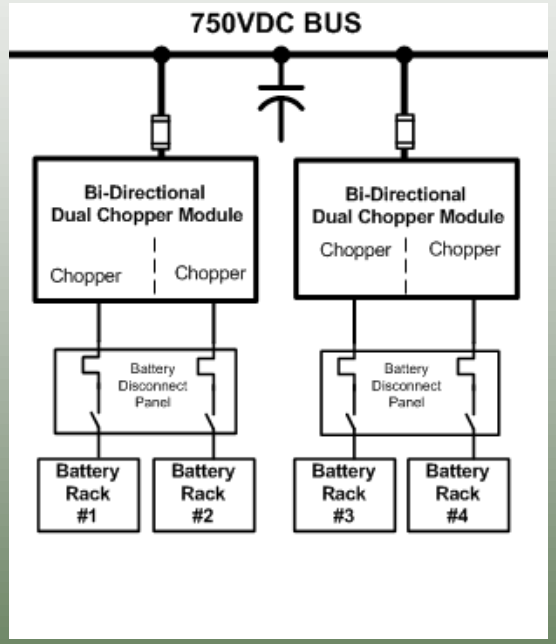
Each DC to DC Chopper is connected to its power source by three inductors and a soft-charge circuit.

The inductors smooth the current flow in the source and the soft-charge circuit prevents the large inrush of current during initial charging of the 750V bus capacitors.

Power Conversion Assembly



Power Distribution Rack



Dual DC-to-DC Choppers

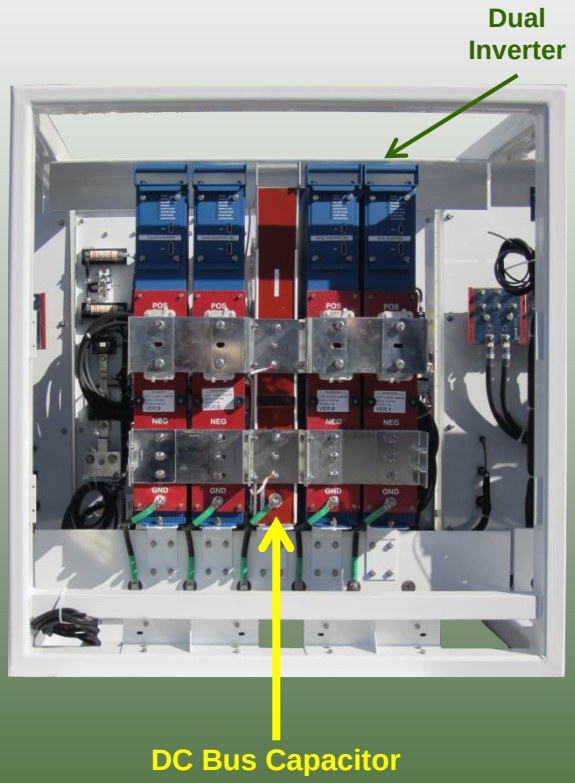
The Dual DC to DC Choppers are used to interface 600V energy storage batteries to the 750V DC bus.

The DC to DC Choppers have bi-directional current capability up to 400A.

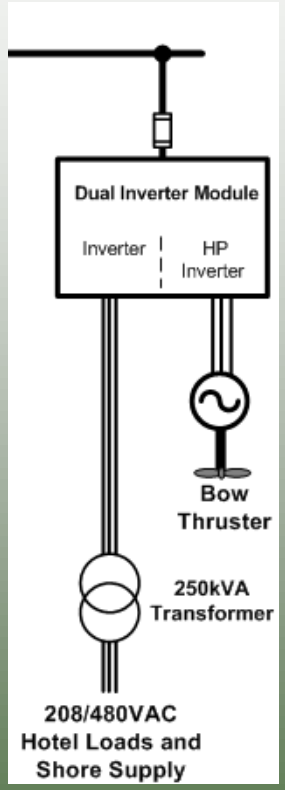
The converters are able to transition smoothly from discharge to charge according to the needs of the power management system.

The dual DC to DC Choppers are connected to battery disconnect panels and a soft charge contactor.

Power Conversion Assembly



Power Distribution Rack



Dual Inverter

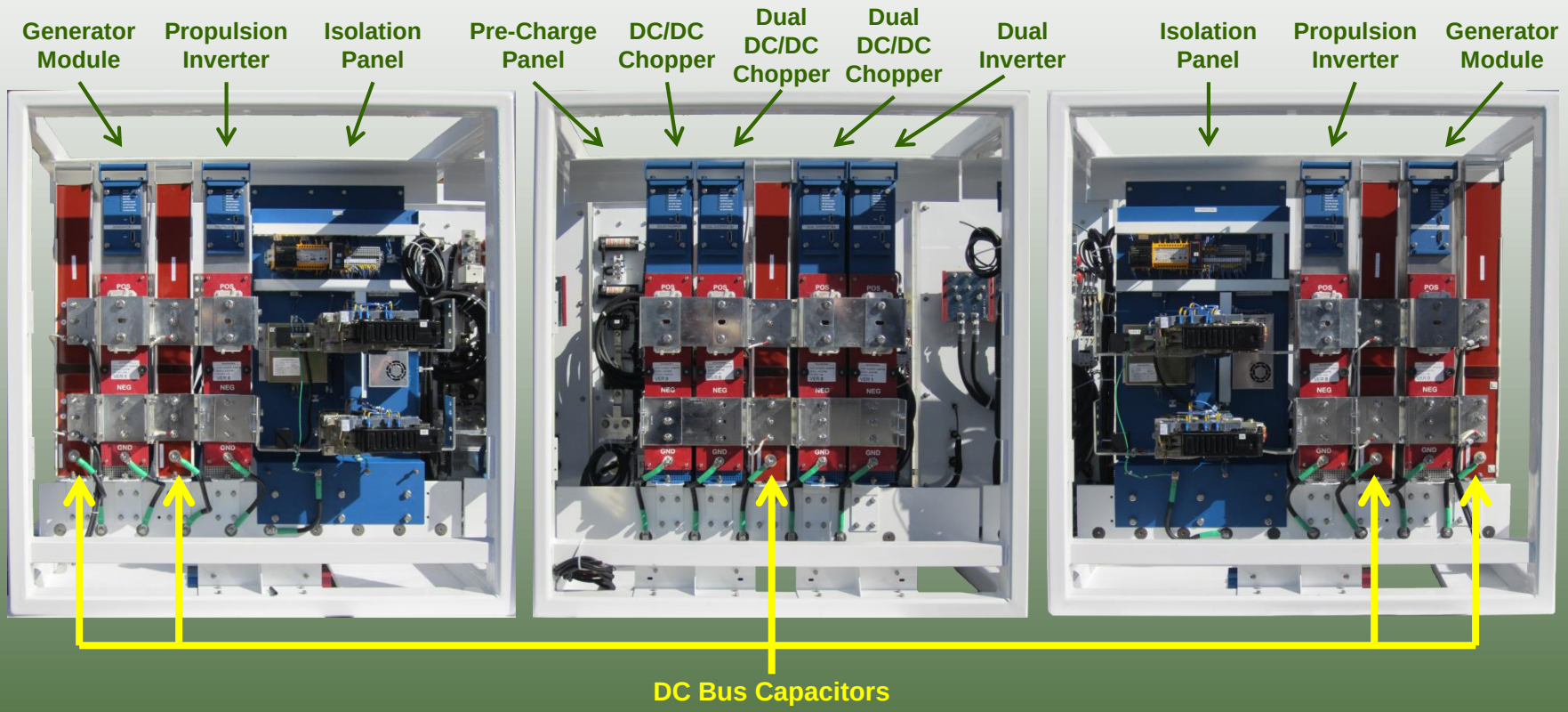
A module consisting of two inverters, each having a capacity of 250kVA, is used to provide on-board utility power at 60Hz and also to control a 100kW bow thruster motor.

The inverter used for utility power can also be back-fed through a 480V shore supply connection.

In this arrangement, the inverter output is not active but the diodes of the IGBT modules function as a passive rectifier supplying up to 150kW to the DC bus for battery charging and auxiliary loads.

The cost of energy supplied through the shore power connection is typically only 25% of the cost of energy supplied by diesel engines.

Typical ATS Hybrid Marine Propulsion System



Hybrid Ferry Operational Review

Alcatraz Island, San Francisco CA is only serviced by the Hybrid fleet.

During the summer holiday season, 5,200 passengers per day are transported to the island; the nine month off-season sees 2,000 passengers per day making the trip.

The two at Alcatraz ships make twelve round trips each per day, 363 days a year

Over 1 million people per year have been utilizing the hybrid ships to visit this national park.

Reductions of 15% (average) fuel consumption has been measured resulting in a reduction of emissions and particulate matter.

10% lower decibel output than conventional ships

Zero diesel fuel consumption, exhaust fumes and reduced vibration during passenger boarding

Features and Benefits of the ATS Diesel-Electric Propulsion System

The system allows one diesel generator set to operate two large propellers. The second generator provides redundancy and extra power when needed. This eliminates light load or "wet stacking" conditions detrimental to diesel engines. Engine operating time is reduced and engine life is extended.

System can have multiple control stations.

Electronic motor thermal overload protection and short circuit protection

Better fuel economy by decoupling the engine speed from the propeller speed allowing operation at the most efficient load point over a wide speed range.

Minimized pollution due to highly efficient operation of the diesel engine.

The engine is not overloaded when accelerating the vessel during departure.

Features and Benefits of the ATS Diesel-Electric Propulsion System

Longer maintenance intervals because only one engine is operating under normal cruise conditions.

Engine run time is automatically balanced between generators.

Redundancy of engine availability enhances safety.

Elimination of the 60Hz auxiliary power generator and its control and cooling system.

Elimination of direct coupling between the engine and the propeller. This eliminates the tedious task of aligning the engine, gearbox and propeller shaft and allows the engine to mounted in any convenient location with complete vibration isolation from the hull.

Elimination of mechanical shifting between forward and reverse. Instead, forward and reverse is quietly and gently performed by reversing the rotational direction of the electric propulsion motor.

Hybrid Propulsion System - Review

The ATS Hybrid Propulsion System is compatible with all modern subsystems for the vessel's propulsion control and monitoring

- ABS ACCU certifiable propulsion control and monitoring system
- Dynamic Positioning System (DPS) integration
- Generator load management systems
- Power conversion and drive components
- Propulsion motors (direct drive or azimuth)
- Thruster motors (direct drive or azimuth)
- Main electrical switchboards
- Main propulsion generators
- Aux generators (optional)
- Batteries (optional)

Hybrid Propulsion System - Review

Propulsion Control and Monitoring system

- Utilizes redundant programmable automation controllers
- Incorporates touch screen displays to provide metering, control and indications, in multiple locations for user convenience
- Allows for open integration with future control and monitoring system changes.

Load management system

- Utilizes redundant programmable automation controllers
- Adjustable power limiting set points (password protected)
- Incorporates Human Machine Interface (HMI) screens on Propulsion control touchscreens
- Prevents overloading of propulsion systems when one main generator is online

Power conversion and drive components

- Insulated Gate Bi-polar Transistor “IGBT” drive system for propulsion and thruster motor
- Speed and power control
- Generator converter
- House power inverter
- Bi-directional battery converter
- Shore power converter, allows any voltage or frequency of shore power to be utilized
- Complete inverter rack assembly

Hybrid Propulsion System - Review

Motors

- Inverter Duty rated
- Motors cooling systems are included and mounted on motor housings
- The same AC Induction motors can be used for generators or propulsion

Main Electrical switchboard

- Custom made free standing switchboard/s designed to fit in the allowable space at the engine rooms
- All main breakers for incoming and outgoing power to distribution panels
- Digital metering that interfaces with the vessel's monitoring and control system
- Integration and proper interlocking of shore power, house inverter and generator power sources
- Switchboard is fully controlled and monitored from the vessel's touchscreens.

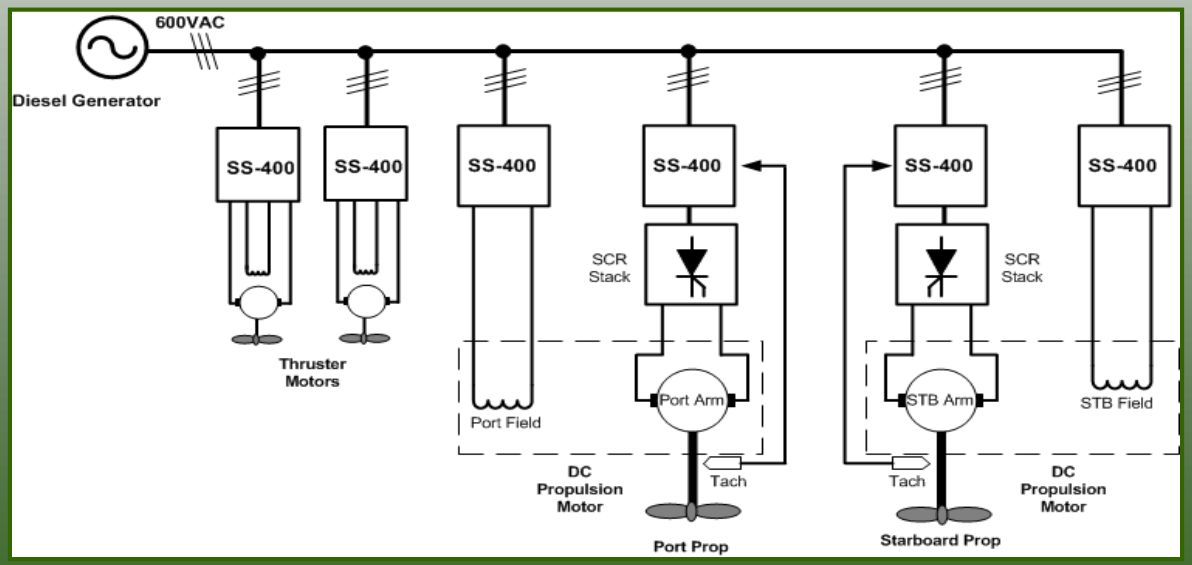
Large Vessel Projects

- **USNS Waters Replacement of Ross-Hill Propulsion and Thruster SCR Drives**
- **Encso plc/Ensco 7500 Overhaul**
- **SBX Life Cycle Engineering**
- **Throttle Control System Upgrades for Cruise Ship**
- **Automated Control Systems for Propulsion & Auxiliary System for 2 Offshore Platform Supply Vessels**
- **M/V Aker Dove – Provided all monitoring and control systems.**

USNS Waters

- ABS Approved SCR Drive System
- Two 2950 kW Propulsion Drives
- Four 850 kW Thrusters

140 m - 12,250t Displacement - Dual 2950kW Propulsion

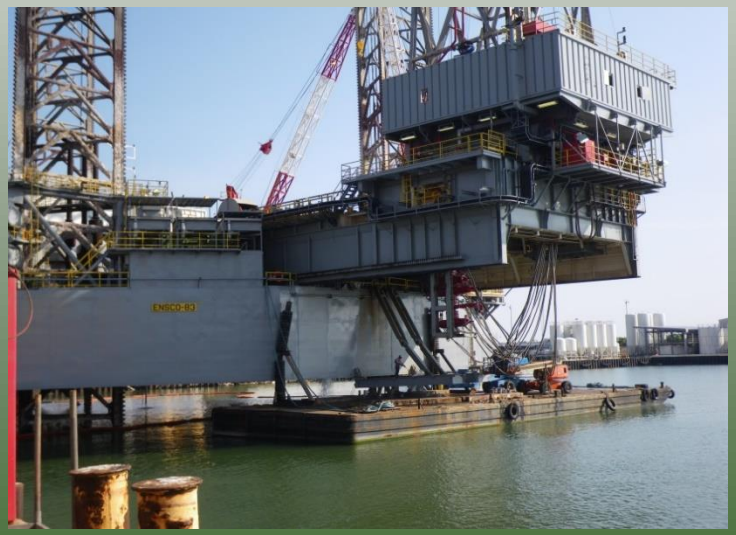


USNS Waters Replacement of Ross-Hill Propulsion and Thruster SCR Drives

- Design and validation ship check
- Detailed design for the following systems: power limiting system, generator controls, SCR bridges and electronics, field exciters, automation system interfaces and switchboard controls.
- Conducted Failure Mode Effects Analysis (FMEA) and Design Verification Test Procedure (DVTP) to identify system/equipment functional failure points
- ABS and USCG approvals of equipment and system upgrades
- Prototyping and on-board ship test of the SCR drives
- Fabrication of the system and factory acceptance testing
- Development of all drawings and technical manuals to meet Military Sealift Fleet Command (MSC) standards
- Installation, dockside and sea trials

Encso PLC/Ensco 7500 Overhaul - January 2010

- **Complete project development and oversight of the $100M refurbishment and upgrade package to the Ensco 7500**
- **Installed Dynamically Positioned Level 2 (DP2) classed semi-submersible mobile offshore drilling unit (MODU).**
- **Project required overhauls and upgrades to most major vessel equipment including main propulsion thrusters (9000 kW) and its control system**
- **Once system engineering was completed, we developed the proper shipyard work scope to install the system and integrate each control unit with the system overall and the total Vessel Management System.**



Sea Based X-Band (SBX) radar platform
(Life Cycle support to Boeing)

- Provided marine engineering management and Life Cycle support to Boeing for the Sea Based X-Band (SBX) radar platform.
- Our engineers and project managers assisted with construction and marine engineering management, support for extended SBX shipyard periods, program and business management activities, SBX System Modification support, and shipyard selection support.
- The SBX Platform Development and Lifecycle project involved the conversion of a Moss CS-50 bare deck semi-submersible rig to a self-propelled offshore vessel ready to accept the 8,000-ton load radar that was constructed at a separate facility in Corpus Christi.

Throttle Control System Upgrades for Cruise Ship

- Provided and installed a Kobelt electronic multi-station throttle control system on the vessel.
- The control system encompassed the vessel's AC VFD powered bow thruster.
- All USCG drawings, compliance and sea trial testing was done by our personnel.
- Main console and bridge wing consoles were fabricated and supplied.
- A touchscreen based vessel central monitoring system and HVAC management system were also installed.
- All system were Opto22 based.

Automated Control Systems for Propulsion & Auxiliary System for 2 Offshore Platform Supply Vessels

- We provided and installed complete monitoring and control systems and consoles for the M/V Highland Guide and M/V Highland Scout.
- Automated touchscreen controls for central vessel propulsion and auxiliary systems monitoring.
- All documentation, drawings, as well as all ABS and USCG review were provided.
- Designed included the integration of Nautronix' joystick propulsion control systems
- All systems utilized Opto22 I/O hardware and processors.
- Electronic charting, central vessel propulsion and auxiliary systems monitoring.

M/V Aker Dove – Provided all monitoring and control.

- As part of a new construction vessel built at Halter Marine 1999
- Our personnel designed and installed new monitoring and control systems.
- The vessel has a 12 000 kW SCR diesel electric propulsion system.
- The project scope was to provide complete integration with SCR drive systems, power management and generator controls.
- All documentation and drawings, as well as all ABS and USCG review was provided as part of the project.

Questions