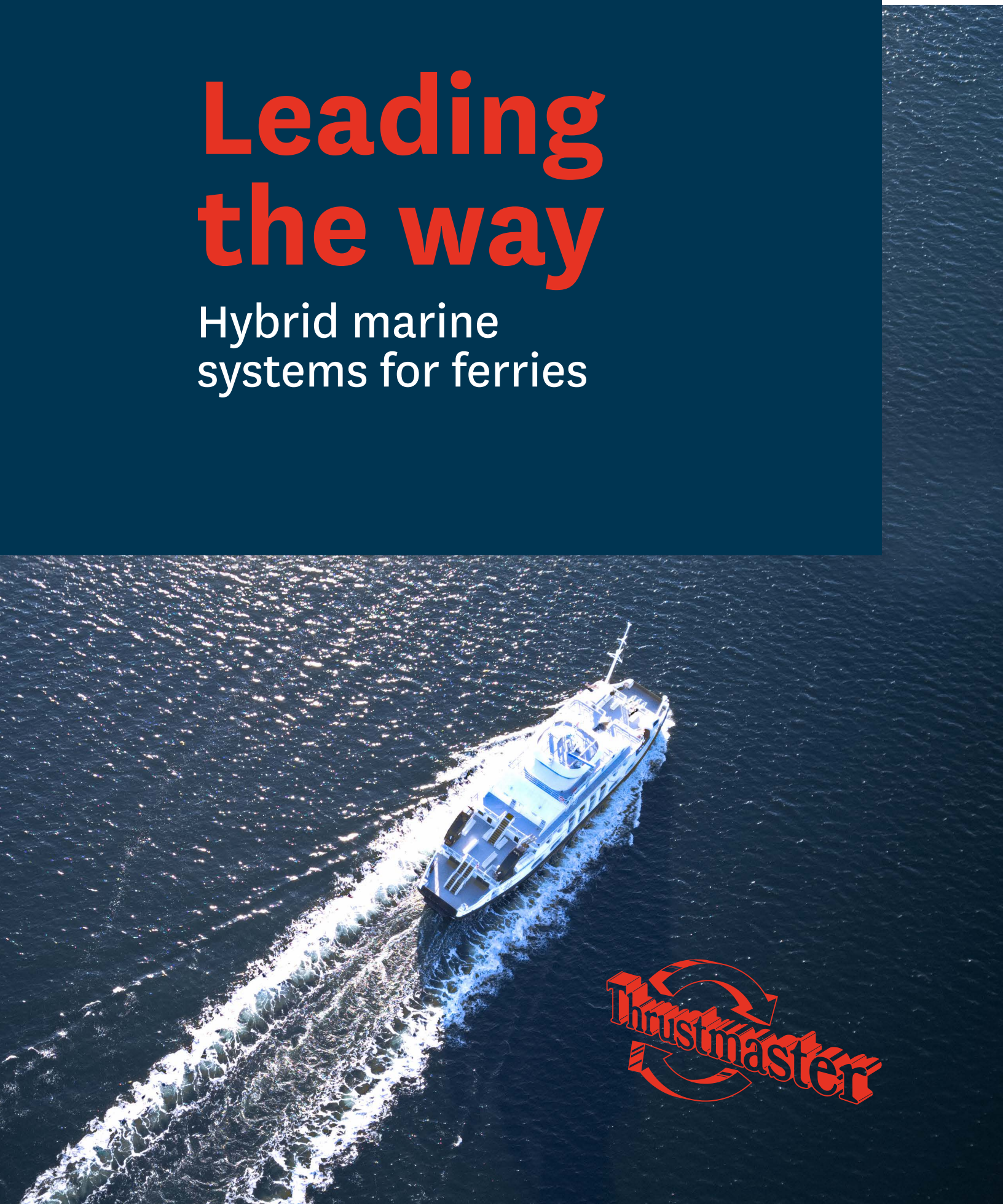
Leading the way

Hybrid marine systems for ferries




We build innovative and fully integrated propulsion packages made up of robust and durable components using advanced engineering technologies.

Contents

Thrustmaster leads the way

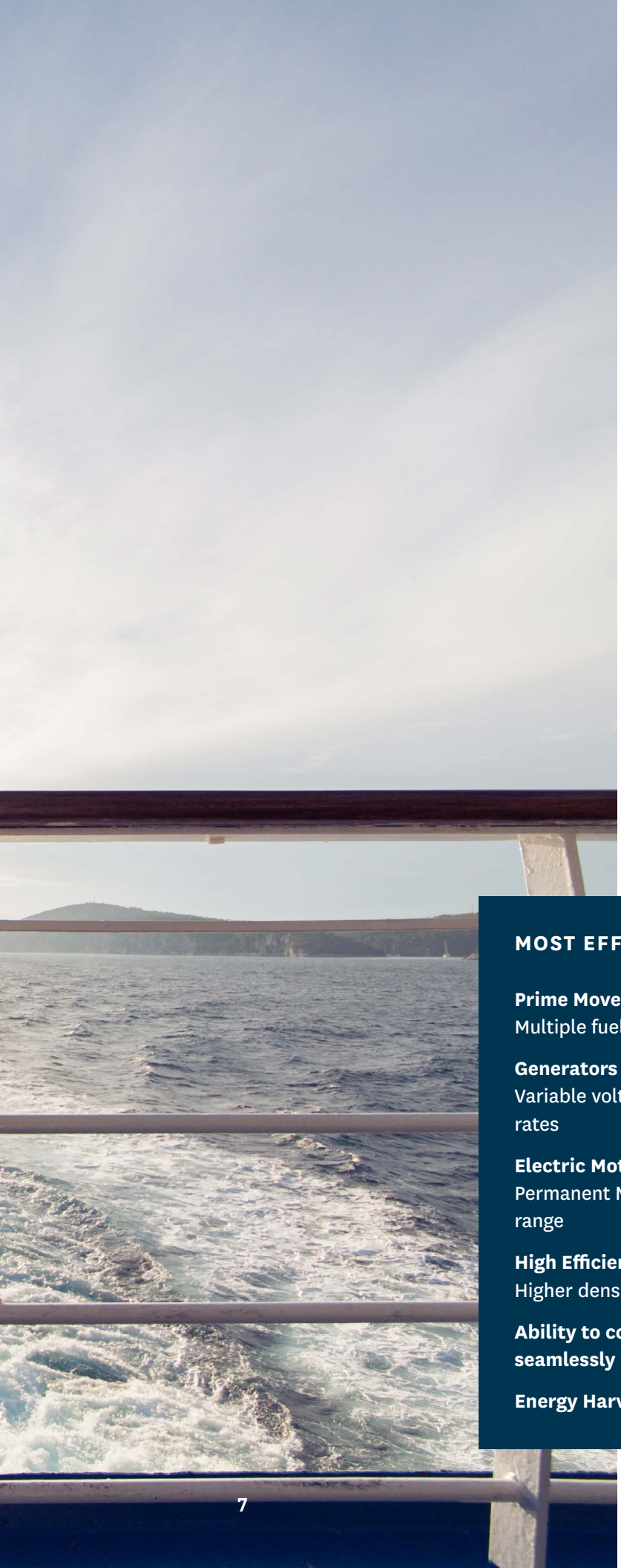
Innovative products with lifelong support

For more than 35 years, Thrustmaster of Texas, Inc. has been designing and manufacturing high quality marine propulsion equipment for vessels of all types.

We have grown into a leading supplier of thrusters ranging from 75 kW to 8 MW, serving customers all over the world. Our headquarters in Houston, Texas has the largest thruster factory in the world, with complete fabrication, machining, assembly and testing carried out at the facility. Our products are designed in-house by a complete engineering department for mechanical, hydraulic, electrical and electronic design.

Hybrid: Lower costs, better results

Reduce fuel consumption and vessel emissions while automatically drawing power from the most efficient source



What do we mean by hybrid? Strictly taken, hybrid means a solution somewhere in the middle. In our context, this would suggest that with a hybrid solution a ferry can operate on electric power, diesel engine power, or a combination of both.

In the context of marine propulsion ‘hybrid’ is a collective noun for all sorts of propulsion solutions other than conventional diesel engine driven propellers, whether this is diesel electric or full electric.

In a hybrid solution, a ferry propulsion system operates with two separate sources of power, using either all electric, all diesel engines, or a combination of both.

MOST EFFICIENT EQUIPMENT AVAILABLE

Prime Movers
Multiple fuel options

Generators
Variable voltage/frequency/rpm control optimized output rates

Electric Motors & Generators
Permanent Magnet, improved efficiency over operating range

High Efficiency Inverters and Battery Storage
Higher density power sources available

Ability to control and select multiple power sources seamlessly

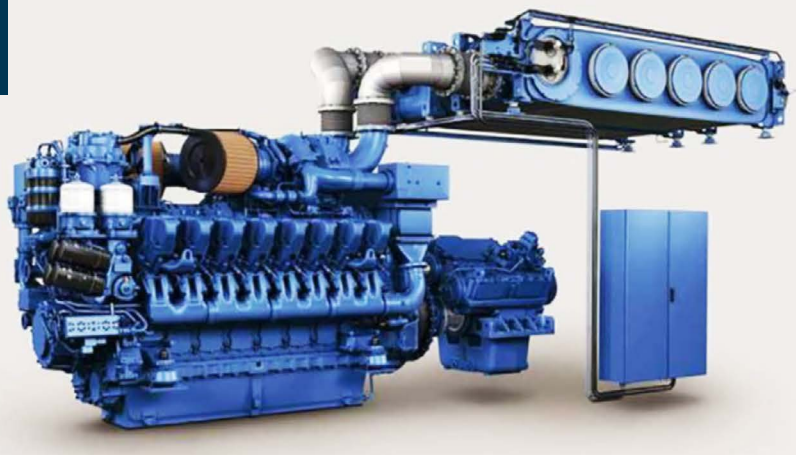
Energy Harvesting Software

US EPA STANDARDS REQUIRE TIER 4 COMPLIANCE ABOVE 600KW/805HP

Selective Catalytic Reduction technology required

Significant weight and volume increases

Cost increase



Smart use of multiple low power engines

Installing three or four Tier 3 engines instead of two higher horsepower Tier 4 engines allows operation with only one or two of these smaller engines running during loitering and periods of reduced power demand. The engines are running at relatively high load, efficiently and clean, rather than slugging way below their design load at low fuel efficiency while expelling carbon deposits and half burnt diesel fuel. The battery bank supplements power for peak loads and allows for the time needed to bring other engines on line.

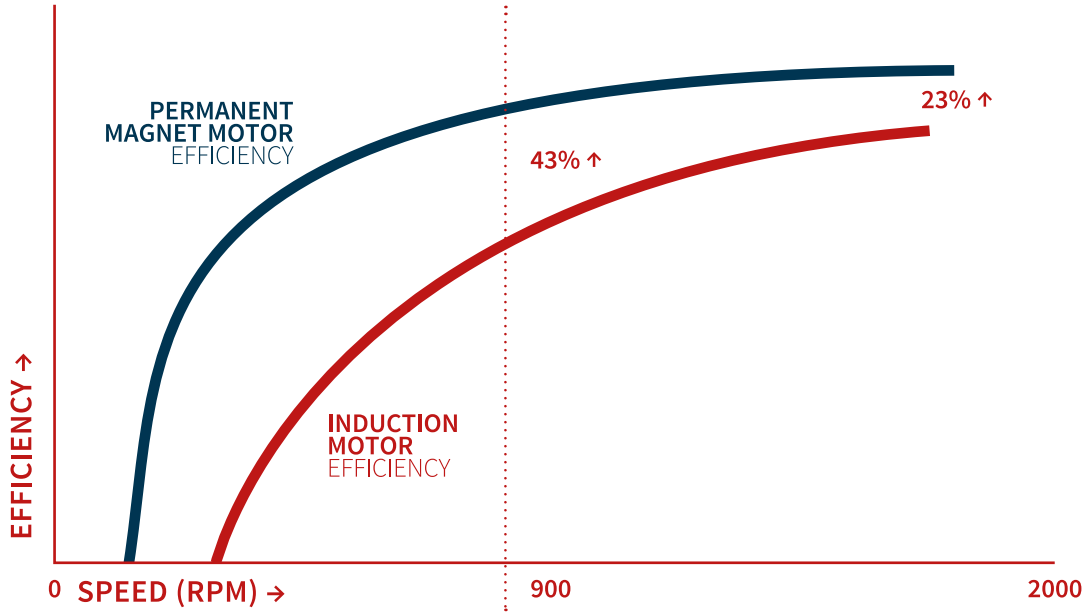
The reduced running hours and more efficient and cleaner operation of the engines results in reduced maintenance and longer times between overhauls. This translates into much longer engine life and significant reduction in fuel cost and maintenance expense.

The smaller Tier 3 engines save weight and space when compared to the large Tier 4 engines with their SCR's and urea tanks.

And they cost less.

Permanent Magnet Technology ensures higher efficiency

Compact designed e-motors and generators that are more efficient at all motor speeds



PM technology consumes less fuel. Is lighter weight, lower volume and higher efficiency.

The advantage of variable speed generator sets

Efficient, optimal sized and quiet engines with low maintenance frequency

BENEFITS OF THRUSTMASTER'S HYBRID SYSTEMS

Average fuel savings of up to 30%

Reduced emissions as fuel is burned more cleanly

Reduced noise and vibration ›6dB

Decreased engine wear
Time to overhaul can be doubled

Optimum engine sizing
Engines sized according to average load requirement, with peak load requirements supplemented by electrical storage system

ENERGY STORAGE SYSTEM TESTING (LOADED CONDITIONS)

Over 6,833 Full Charge/ Discharge Cycles

Bi-Directional Regen on to Power Lines Fully Tested

Smooth sailing

Optimized and extensively tested Energy Storage Systems (ESS)

Our hybrid control system is equipped with ESS Overload Protection and makes use of smart technology:

- Bi-directional control
- Rapid Charge Ability
- Charge Rates and Battery Life Cycle Prediction

Several measurements are made to be in full control of safety:

- Temperature Monitoring of each Bank
- Energy Harvesting Amplitudes
- Prediction Software developed
- Battery Cell Voltage Managers built-in
- Class Society Approved

Hybrid propulsion and the ferry market

A match made in heaven

We offer a power and propulsion system that continuously chooses the most efficient energy source and delivers it to the required load.

WHY APPLY HYBRID PROPULSION ON NEW BUILD/ UPGRADED FERRIES?

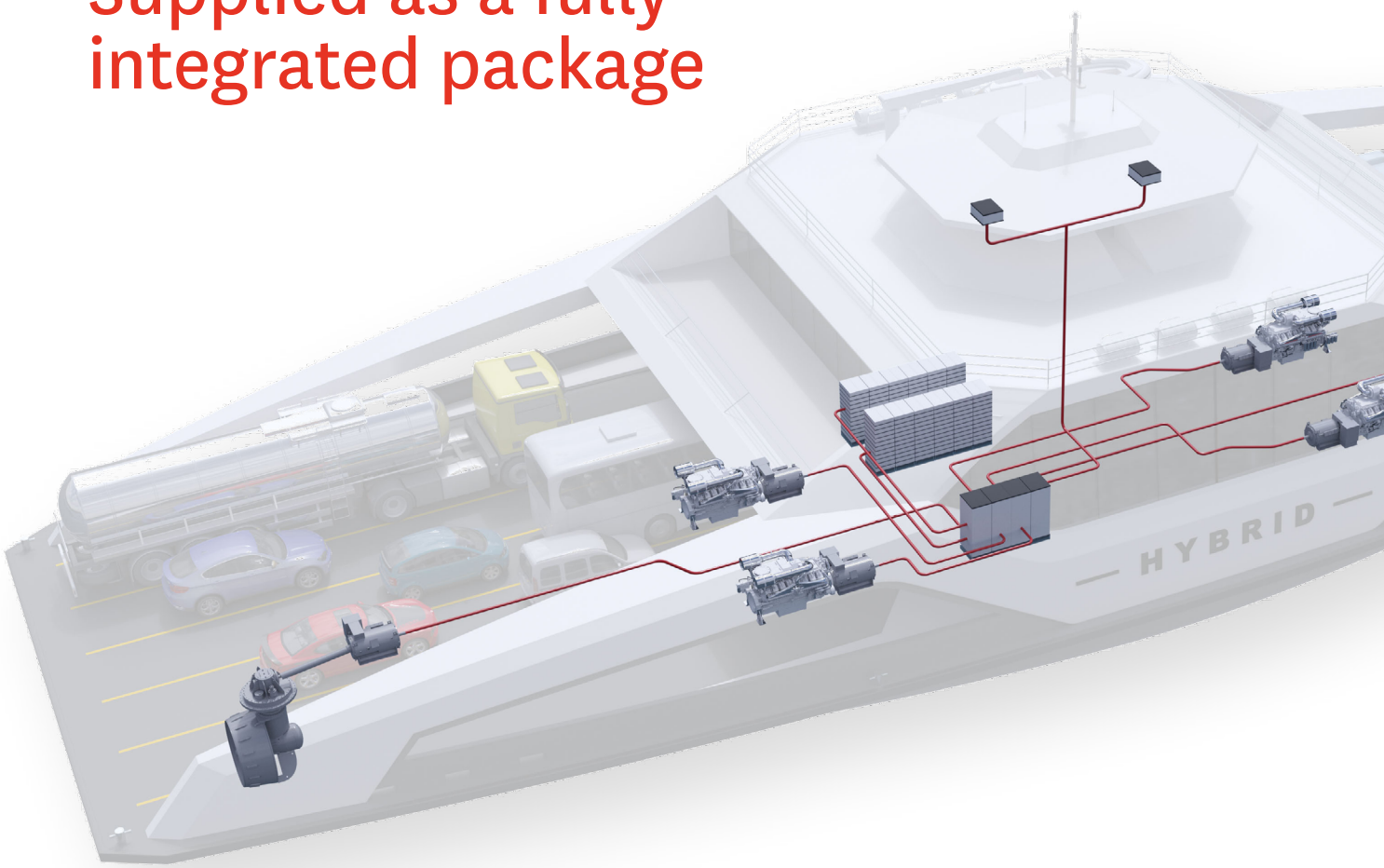
Enhanced performance
Vessel performance can now be significantly enhanced with proven integrated mechanical / electrical systems

Efficiency improvements
Fuel consumption
Emission gases

Improved customer experience
Lower structureborne and airborne noise
Lower structural vibration

Marine hybrid propulsion system

Supplied as a fully integrated package



Thrustmaster supplies all the components of a marine hybrid propulsion system for the customer as a fully integrated package.

We will integrate the equipment and components and provide a power management system which is seamless to the operator over the total range of power sources.

Our system integration capabilities provide a one-stop-shop for the customer and reduce management oversight costs.

We invest in knowledge and innovation

Utilizing patented and proven technologies to ensure an efficient power control system

Innovation comes in a pod

Emphasis on environmental sustainability

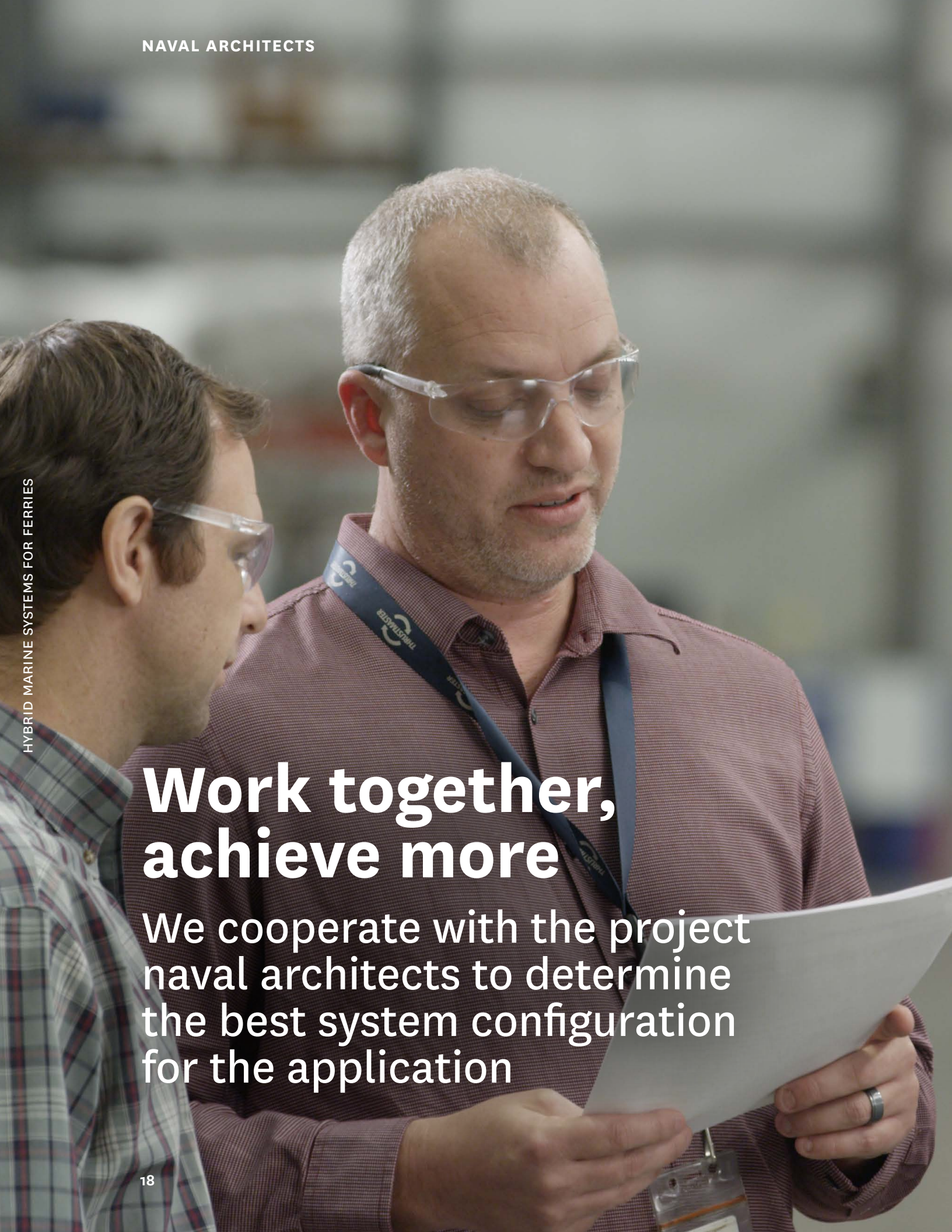
REVOLUTIONARY COMPACT POD DESIGN WITH INTEGRATED PM E-MOTOR

Our patented compact pod uses an efficient permanent magnet motor installed in the lower pod, directly driving the propeller shaft. This eliminates the need for spiral bevel gears and all of their associated shafts and bearings. The motor is cooled by the surrounding seawater or river water. The units are available in fully azimuthing configuration with multi-conductor slipring assembly as shown, or as fixed non-steerable pods for use in conjunction with rudders, or with +/- 90° steering.

The podded thruster is available in a range from 90kW to 2.5MW either with an open propeller or in a high thrust nozzle.

The T-Pod[1] is the latest environmentally friendly thruster from Thrustmaster. The highly efficient Permanent Magnet Motor, with no requirement for an external cooling system, no lubrication pump(s) combined with stored energy supply system results in a highly energy efficient and environmentally friendly thruster.

[1] Thrustmaster of Texas-Pod



Work together, achieve more

We cooperate with the project naval architects to determine the best system configuration for the application

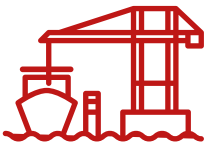
Distance, speed, turnaround time, payload capacity

Analysis of the required vessel operations is of paramount importance to select the right propulsion system design and configuration

REQUIRED INFORMATION TO DETERMINE OPTIMUM SYSTEM CONFIGURATION

Drag resistance of the vessel as a function of vessel speed at various load conditions

General arrangement and machinery space(s) layouts



Turnaround time schedule of the ferry at point A and B. (Unload, Reload, Ready-to-Depart)

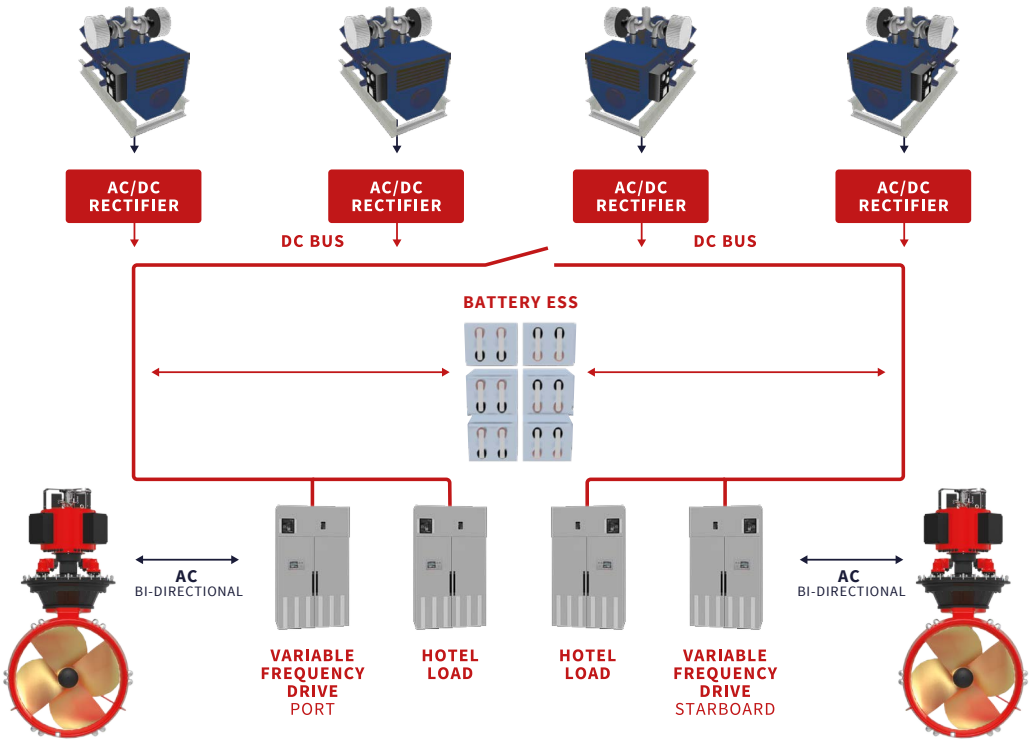
Operating profile of thrust and vessel speed requirements as function of total time

Power cost in kWH from power company at points A and B

Knowledge of the owner's emergency planning procedures

Examples – Flexible configurations to your needs

Concept #1



SPECIFICATIONS DIESEL ELECTRIC PROPULSION SYSTEM

Generator sets/Permanent Magnet Generators **4x**

Battery Energy Storage Systems **1x**

Permanent Magnet Motor T-Pod Thruster **2x**

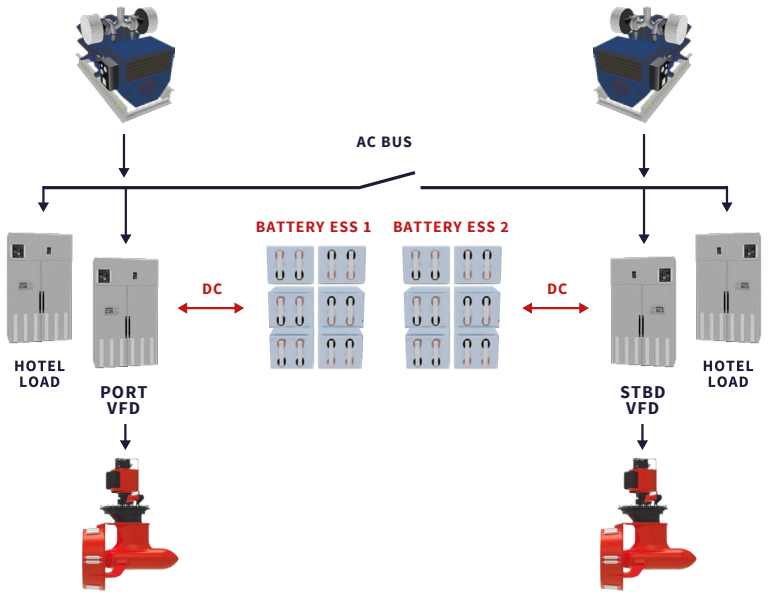
Rectifiers

Inverters

Variable Frequency Drives

Power Management System

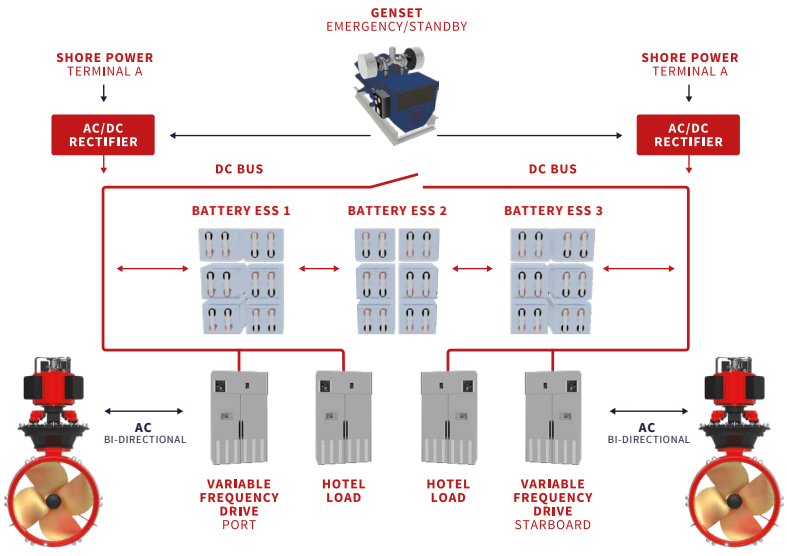
Concept #2



SPECIFICATIONS DIESEL ELECTRIC PROPULSION SYSTEM

- Generator Sets/Permanent Magnet Generators **2X**
- Battery Energy Storage System **2X**
- Permanent Magnet Motor T-Pod Thruster **2X**
- Variable Frequency Drives
- Power Management System

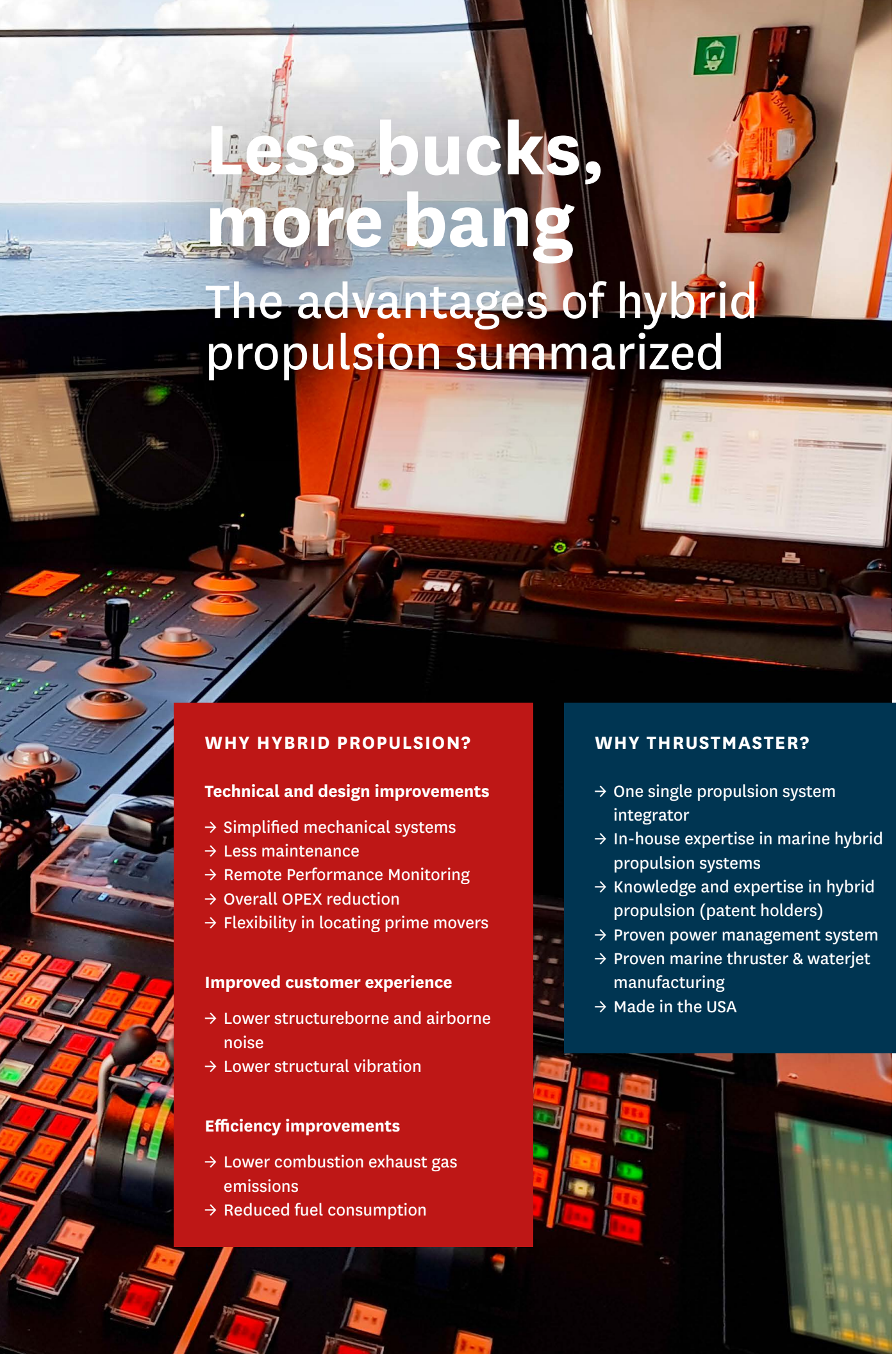
Concept #3



SPECIFICATIONS ALL- ELECTRIC PROPULSION SYSTEM

- Emergency Generator Set
- Battery Energy Storage Systems **3X**
- Permanent Magnet Motor T-Pod Thruster **2X**
- Rectifiers
- Inverters
- Variable Frequency Drives
- Power Management System

Take control with our advanced power management system



Less bucks, more bang

The advantages of hybrid propulsion summarized

WHY HYBRID PROPULSION?

Technical and design improvements

→ Simplified mechanical systems
→ Less maintenance
→ Remote Performance Monitoring
→ Overall OPEX reduction
→ Flexibility in locating prime movers

Improved customer experience

→ Lower structureborne and airborne noise
→ Lower structural vibration

Efficiency improvements

→ Lower combustion exhaust gas emissions
→ Reduced fuel consumption

WHY THRUSTMASTER?

→ One single propulsion system integrator
→ In-house expertise in marine hybrid propulsion systems
→ Knowledge and expertise in hybrid propulsion (patent holders)
→ Proven power management system
→ Proven marine thruster & waterjet manufacturing
→ Made in the USA

Thrustmaster Hybrid Systems

For a cleaner environment,
an enhanced passenger experience,
a happier crew,
and a better world.

CONTACT US

Thrustmaster of Texas, Inc.

6900 Thrustmaster Drive
Houston, TX 77041
USA

Phone **713-937-6295**
Fax **713-937-7962**
Email **sales@thrustmastertexas.com**

www.thrustmaster.net

ABS Quality Evaluations

Certificate Of Conformance

This is to certify that the Quality Management System of:

Thrustmaster of Texas, Inc.
6900 Thrustmaster Drive
Houston, TX 77041
U.S.A.

has been assessed by ABS Quality Evaluations, Inc. and found to be in conformance with the requirements set forth by:

ISO 9001:2015

The Quality Management System is applicable to:

DESIGN AND MANUFACTURE OF MARINE PROPULSION EQUIPMENT

This certificate may be found on the ABS QE Website (www.abs-qe.com). For certificates issued in the People's Republic of China information may also be verified on the CNCA website (www.cnca.gov.cn).

Certificate No: 35756
Certification Date: 19 April 2011
Effective Date: 11 May 2018
Expiration Date: 28 March 2020
Issue Date: 11 May 2018

Alex Weissberg, President

Validity of this certificate is based on the successful completion of the periodic surveillance audits of the management system defined by the above scope and is contingent upon prompt written notification to ABS Quality Evaluations, Inc. of significant changes to the management system or components thereof.

ABS Quality Evaluations, Inc. 16855 Northchase Drive, Houston, TX 77060, U.S.A.
Validity of this certificate may be confirmed at www.abs-qe.com/cert_validation.