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Enhancing the DP Operator Experience

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Abstract

Dynamic positioning systems have become increasingly complex, typically evolving based on available technologies and expectations of what operators might need rather than a holistic look at their experiences. Furthermore, the overall look-and-feel has been largely left up to engineers as opposed to user experience (UX) experts. The result is operators being more preoccupied with managing the computer versus the primary task of controlling the ship.

Rather than follow an engineering-centred redesign approach, the Power Conversion team partnered with UX experts from GE's Design & Experience Center of Excellence and Connected Experience Labs to implement a user-centred approach to supporting true seamanship. Leveraging 40+ years of engineering experience and 800+ system installations, design best practices, user research with 60+ participants and analyses of operators' HMI activity logs from different types of vessels, the new DP HMI and console improves situational awareness, promotes better decision-making and increases operator efficiency and safety. Visual and auditory alarm presentation minimizes operator irritation.

Every piece of information that the operator needs and every action he or she performs has been reviewed and optimised. At the same time, needs of secondary users (e.g., captain, chief engineer or fleet supervisor) are supported by allowing user-specific features to be selected. Enhancements extend beyond the console and HMI to the underlying control algorithms. For example, an *energy efficient DP* mode is integrated to enable greater operator efficiency and reduced emissions, power consumption and thruster/machinery wear and tear in rough and calm seas.

DP lessons learnt are being integrated into a common experience across our offerings so that we can continue to power, propel and position the marine industry with the most mariner-friendly and cutting-edge solutions possible.

Keywords

Dynamic positioning, DP, human-machine interface, HMI, user experience, UX, human factors, ergonomics, user-centred design, energy efficiency, energy efficient DP, DP operators, alarm management, alarm sound design, semantic profiling.

Introduction

Since being introduced over 50 years ago, dynamic positioning systems have become increasingly complex in their configuration and operation. DP operators are more preoccupied with managing the computer rather than on the primary task of controlling the ship. Furthermore, despite system advances, human error is still the biggest single cause of incidents [2, 7].

Leveraging 40+ years of experience and 800+ system installations worldwide, GE Power Conversion embarked upon a journey to re-imagine our DP offerings—HMI, console and algorithms—with the goal of reducing the burden of the technology on the DP operators. By allowing the mariner to focus on his real job, controlling the ship, and not be distracted by the task of manipulating and controlling a complex computer system, we have taken control out of the engineering world and given it back to the operator. Our new system enables true seamanship and departs radically from our existing solution ([FIGURE 1](#)).

Rather than following an engineering-centred redesign approach, the Power Conversion team partnered with user experience (UX) experts from GE's Design & Experience Center of Excellence (CoE) as well as the Connected Experience Labs (both part of GE Global Research in San Ramon, CA) to implement a user-centred approach to the redesign. The approach begins with a deep understanding of users' goals and

activities and the contexts in which they work. The experience is designed to satisfy those needs, and the design evolves based on user feedback and testing.



Figure 1 Existing C Series console and HMI compared to the new system.

To deliver the new system, we leveraged HMI best practices [3]; followed a user-centred design approach [5]; and engaged an international, multidisciplinary team of collaborators from UX experts to control engineers, software engineers, salespeople and subject matter experts. Most importantly, we gathered input and feedback from 60+ participants throughout the redesign process, mostly DPOs along with trainers, masters, consultants, ship yard representatives and owners.

Designed to be intuitive, innovative and mariner-focused, the new system improves situational awareness, promotes better decision-making and increases operator efficiency and safety through key design aspects:

- Unprecedented flexibility and operational features to put the operator in control;
- New look-and-feel HMI and ergonomic console to minimize eye fatigue, cognitive load and operator strain;
- 1- or 2-click access to all HMI functionality and data entry error prevention to promote accurate operation;
- A 26-inch touchscreen (16:10) that accommodates operators of different heights;
- Improved warning and alert handling to maximize safe operation and minimize irritation; and
- An energy efficient nautical system to maximize fuel, emissions and maintenance savings.

The new system can produce improvements in total vessel efficiencies of up to 30 percent, and user research suggests that a 10-minute familiarization time is sufficient for operators to get used to the radically different design. These factors, plus a very clean and uncluttered control panel with very few

control devices, are attractive to DP stakeholders: Their responses have been overwhelmingly positive since we debuted and began taking our first orders at OTC 2013.

Work is underway to leverage the DP lessons learnt to rollout a common user experience and tight integration across our Automation, Insight, Visor, Drives and other offerings. Better integrated offerings will allow us to continue to power, propel and position the marine industry with the most mariner-friendly and innovative solutions possible.

User Experience Principles

At the start of the design process, we identified three UX principles (FIGURE 2) to guide our redesign efforts: *intuitive*, *innovative* and *mariner-focused*. These principles, and a focus on good HMI design practices [1, 3, 6], enabled us to consider and incorporate yesterday's lessons, today's mariners and tomorrow's technology into a solution that works well. Inexperienced users are able to complete their workflows with ease and speed. Mariners are delighted with a system that is not only on par with or ahead of the industry's best solutions, but also aligned with how they are trained to think and their environment.

In addition to these product-focused principles, we aligned with the Design & Experience CoE's principles of delivering *clear*, *connected*, *intelligent* and *transformative* experiences. Such experiences perform well and are reliable, accurate and attuned to users' needs. They integrate data from many sources and analytics into a common environment to provide greater intelligence and efficiency. Most importantly, they change the experience benchmarks for our users.



Figure 2 Guiding user experience principles.

Design Process

Using these UX principles to guide our redesign efforts, we employed an iterative, user-centred design process advocated by the Design & Experience CoE (FIGURE 3). In the discovery phase, before designing or developing a solution, we engaged with SMEs to create initial personas, scenarios and a sketch of our UX concept. We then conducted user and design research at training schools, within our training simulator and through in-person interviews. Contextual observations of operators enabled us to better understand their tasks and workflows as well as factors that have a negative impact on their performance.

In addition to observing and interviewing 13 participants (operators, captains, trainers and a field engineer), we analysed log files from actual vessels to understand operators' use of mimics, conducted a competitive audit of existing DP solutions and explored design alternatives. We established a UX baseline for our existing solutions by asking participants to evaluate them with our UX scorecard.

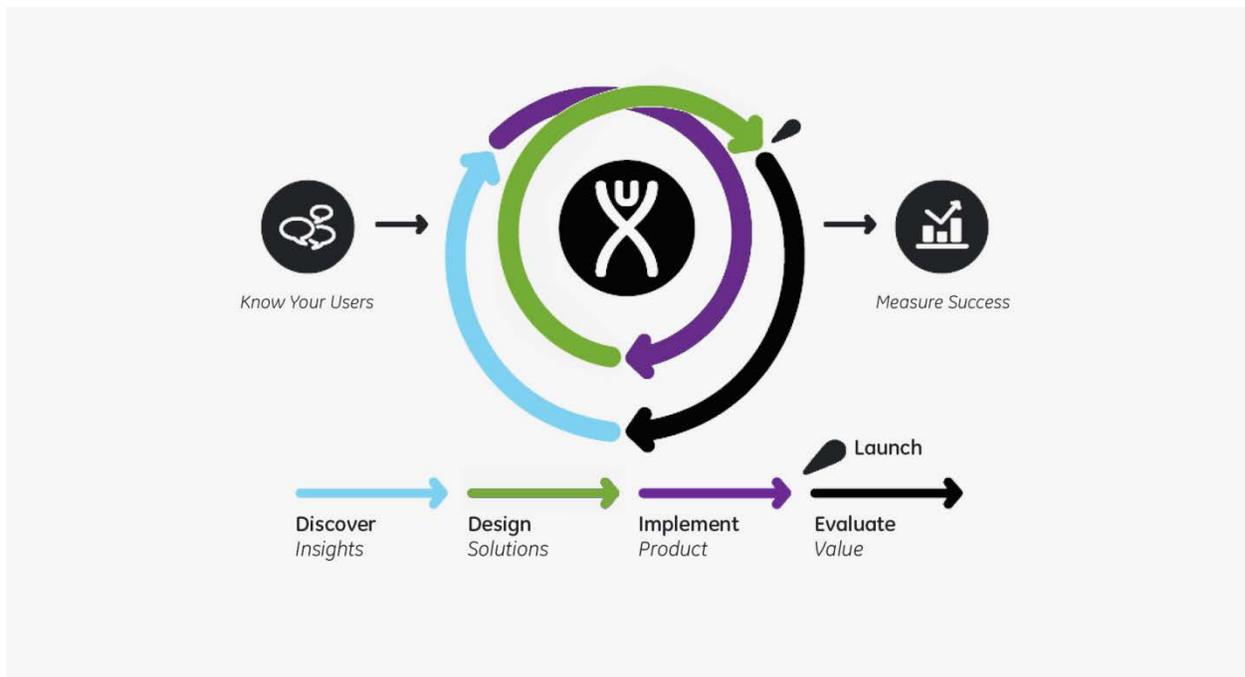


Figure 3 GE Design & Experience CoE's UX process.

Research findings validated our personas, scenarios and UX concept. Studies also helped us to adjust design artefacts and identify specific software, hardware and UX requirements, such as the need for easy DP setup by vessel and operation, streamlined data entry and confirmation, intelligent alarming and a robust touchscreen to accommodate wet or messy operator fingers.

We revisited these findings repeatedly throughout the Design phase to create a prototype HMI and console for evaluation. That evaluation in turn informed the final design during the Implement phase. We will conduct additional human factors evaluation before launching the solution and carry out continuous UX measurement using our UX scorecard after the system's launch in the Evaluate phase.

Personas and Scenarios

Personas or user profiles are essential artefacts to humanize end users. They help designers, developers, researchers and other collaborators to understand the needs, pain points and contexts in which users operate a vessel. Personas also informed our decisions about the new HMI and console.

Given that DP operators were our primary focus, we developed three personas based on the type of vessel and corresponding operations completed (e.g., supply or drill ship). [FIGURE 4](#) shows an excerpt from our supply ship operator persona. We constructed similar personas for other key captains, engineers, fleet managers and owners.

Scenarios or stories about system use, typically involve more than task (e.g., unloading a supply ship). They are also essential to help the UX team and developers to understand users' goals, ideal system interactions and factors affecting interactions, for instance being in the midst of an incident or dealing with rough seas. We developed several scenarios to inform our design decisions.

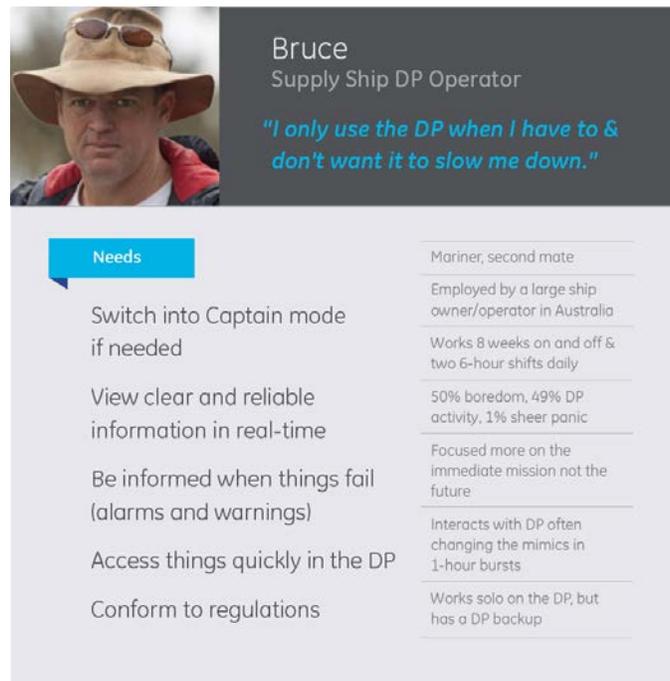


Figure 4 Excerpt from an example persona.

UX Redesign

We leveraged research and our UX principles to deliver console and HMI designs that are aligned with the “Industrial Internet” Design System, and an effort to create a repository of common design patterns for HMIs across GE. We evolved our design sketch into a full HMI and console prototype, evaluated it with operators and other stakeholders (discussed later) and used the feedback to produce the final designs depicted in [FIGURE 5](#).

In our new, ergonomically designed system, the control panel is very clean and uncluttered with very few control devices. The 26-inch touchscreen adjusts to each operator's preference while also accommodating operators of different heights via a tilt mechanism. In addition, it is a robust and anti-reflective multi-touch display. The console provides quick access to DP alerting features and uses lighting to provide visual cues about HMI activity. To help bridge the gap between ‘conventional’ and ‘modern’ operators who differ in their levels of technology adoption, the system comes with an alternative input device for controlling the HMI.

The HMI is divided into dedicated regions: key persistent information within the header, status of all elements along the left side, alarm banner above the viewing regions, three viewing regions for mimics and controls along the right side. Our progressive presentation of information, from the status views on the left to the small mimics and the full-size mimics, conforms to HMI best practices and speeds up DP setup, checklist completion, operation and diagnostics.

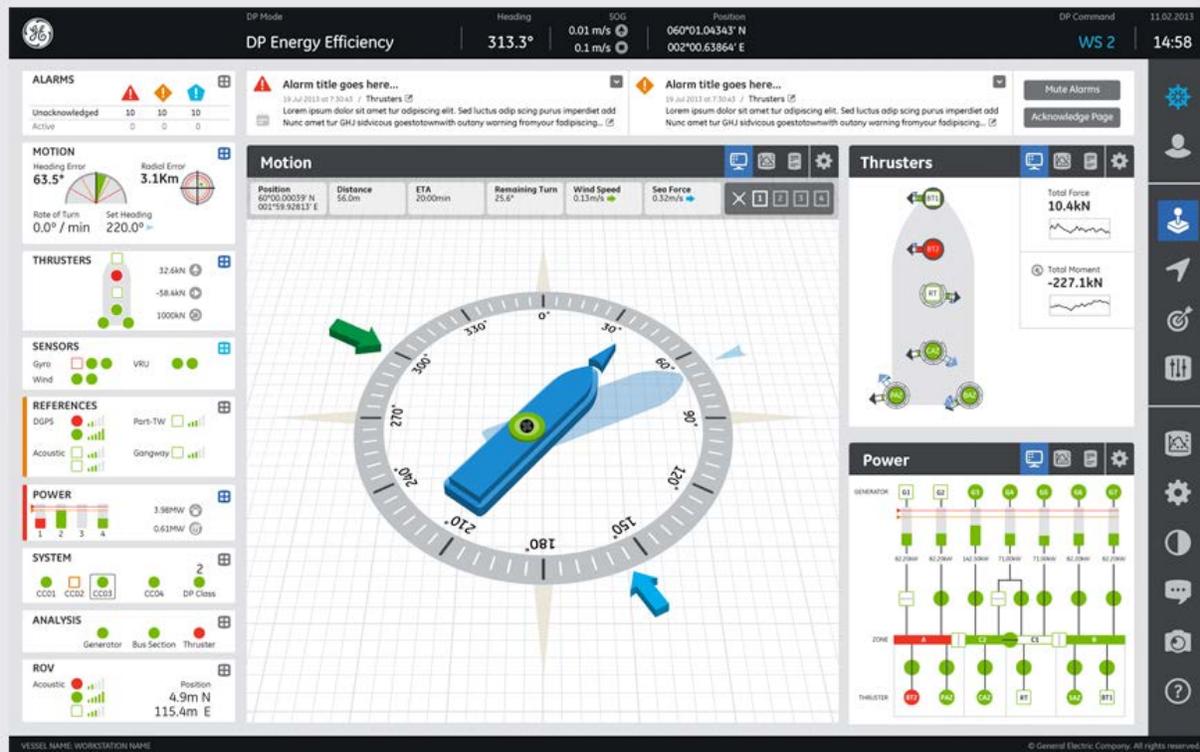


Figure 5 Research-based console and HMI designs.

We employed a simple confirmation scheme to enhance safety in the HMI and the console's independent DP alerting functionality. Mechanisms to minimize data entry errors and operator inefficiencies (e.g., popup windows appearing outside of the context of actions) are incorporated throughout the system. Equally visible across a wide range of lighting conditions, the screen displays come in a selectable range of languages that allow the operator to access all system functionality in his or her mother tongue. Operators can create and load profiles to quickly setup the DP according to their unit, language and mimic preferences.

The HMI provides 1- or 2-click access to all functionality, vessel-specific status information and touch-friendly controls for large fingers and multiple-monitor support. It includes a multi-touch-enabled 3D motion mimic that supports operators who have good depth perception and want a more realistic “feel.”

Alarm System Redesign

We paid considerable attention to the redesign of our alarm system, not only for the DP, but also for all of our offerings. The new system uses visuals and sounds to convey meaning, aggregates related alarms to help determine root causes, provides actionable information and enables operators to act on alarms without navigating elsewhere within the HMI. Relevant information and actions for the two most recent alarms (or events if there are no alarms) are displayed within a persistent alarm banner. Sounds are designed to be unique from other sounds on the bridge, yet more harmonious [4]. They convey urgency when appropriate without irritating operators.

Controls Redesign

The user’s perspective must also be considered during the design of control algorithms. As far as possible, the interaction between the algorithms and the user must be straightforward and understandable. If control algorithms are complex and confusing, the HMI is unlikely to be able to rectify this issue. We used research findings and customer requests to inform adjustments and additions to our control algorithms to enhance operator efficiency.

One example is the addition of a new mode, *energy efficient DP*. This feature was conceived from requests for reduced thruster activity and fuel consumption during periods when a vessel could be allowed to move around. When a supply vessel is alongside a rig, high-accuracy positioning is most important. The same supply vessel, standing by at a significant distance off the rig, can employ the *energy efficient DP* mode, resulting in a greater degree of tolerance on the position accuracy with substantially reduced fuel consumption. In the latter case, fuel savings of 10 percent or more and a corresponding 20 percent reduction in NO_x are possible ([FIGURE 7](#)).

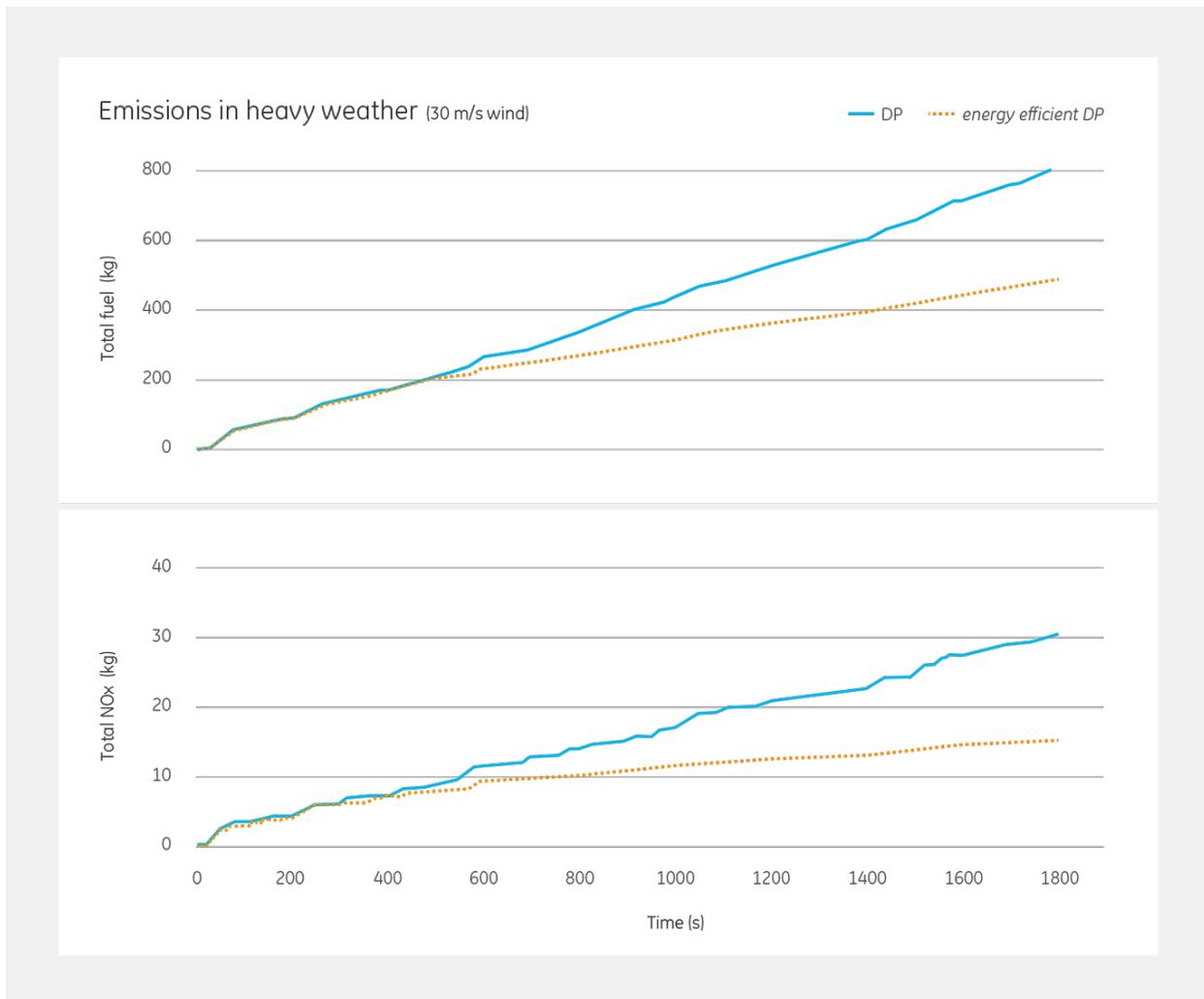


Figure 6 Example fuel and NOx simulation results for conventional DP and *energy efficient DP* modes.

The new system employs predictive software to anticipate position variation and to limit thrust changes if the vessel is predicted to remain within the operating window. If the vessel is predicted to move outside its operating window, the system develops optimum thrust to remain within that window.

In addition to greater operator efficiency, these advanced algorithms reduce power consumption and limit thruster/machinery wear and tear in rough and calm seas. Efficiencies created by predicting future activity, optimizing thrust usage and minimizing environmental forces by adjusting the vessel heading—taking into account all variables—could save a typical supply vessel as much as \$300,000 annually in fuel costs and even more in emissions and maintenance savings.

Design Validation

Using a prototype of the new HMI and console elements, including the *energy efficient DP* mode, we conducted design and market research through booths at the OTC and European DP 2013 conferences, five-hour deep dives with field engineers and two-hour customer visits with 2–10 representatives. One customer visit took place aboard a vessel with DP operators.

Each research venue provided a different mix of participants from current operators to trainers and owners. Participants represented a range of organizations from training schools to vessel owners, ship yards, consultants, etc.

Our research methodology entailed providing a brief demonstration of the system, enabling participants to explore the system, observing system interactions and interviewing participants. It enabled us to collect behavioural and interview data as well as analyse observations, comments and interview responses from 50+ participants who represented a broad set of stakeholders (operators, owners, trainers, consultants, masters, etc.). Some participants represented more than one role, and there were four repeat participants from our Discover phase research.

The extensive data we collected helped us to gauge market acceptance, identify user experience issues and inform system enhancements. Based on research observations and the 157 comments collected, we found that operators, owners, masters, trainers, consultants and others considered our new system to be “approachable,” “engaging,” “desirable,” “intuitive,” “innovative,” “mariner-focused” and “modern.” They viewed the system as being on par with the industry UX leader and better than other competitors. Furthermore, they likened the new system to Apple’s design quality. [FIGURE 8](#) depicts example comments from participants.

Conclusion

GE’s experience in DP stretches back to the 1970’s. In the time that has elapsed since then, we have commissioned more than 800 systems, from joystick manoeuvring and “simple” DP to multi-redundant DP and Thruster Assisted Mooring Systems (TAMS) on all vessel types and sizes. We understand the role of the DP control system relative to the entire vessel’s operations, in particular its integrated role in a network involving power generation and distribution equipment, propulsion and manoeuvring machinery, digital controllers, electrical systems and more.

Our new DP offering builds upon our deep experience with DP and acknowledges the unique skill sets of the mariners operating the system, allowing them to focus on ship handling rather than becoming distracted by DP system management. By partnering with UX experts in the Design & Experience CoE and the Connected Experience Labs, we designed a system that enhances situational awareness and improves operator comfort, safety and efficiency.

The system is also designed with an eye towards energy efficiency and sustainability, including a new *energy efficient DP* mode, which improves operator efficiency as well. Consistent with its focus on fuel economy, emissions and machinery wear and maintenance (time/cost), operational costs are reduced and overall system up-time/availability increased. Stakeholders’ responses to this new mode and UX have been overwhelmingly positive since we debuted and began taking our first orders at OTC 2013.

“I like it. It's not intimidating to me. That's important to me as an operator.”

“Minimalist approach is good.”

“Very user friendly, ergonomic and comfortable.”

“Looks fairly simple more so than competitor's systems.”

“User interface works well. It's clean, and you can see info.”

“It's an improvement to what you had. I'm looking forward to seeing it on a ship.”

Figure 7 Example HMI and console comments from research participants.

Validating our system with users helped us to solidify interaction design patterns and visual presentation. Work is currently underway to integrate lessons learnt and roll out a common experience across our Automation, Insight, Visor, Drives HMI and other offerings. Better integrated, mariner-focused and innovative offerings will allow us to continue to power, propel and position the marine industry with the best solutions possible.

Acknowledgements

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