Modernizing Ship Maintenance Through Use of Digital Measurement and Displays

Final Report

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National Center for Manufacturing Sciences
3025 Boardwalk
Ann Arbor, Michigan 48108

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Acronyms and Abbreviations

Term	Definition
ALARA	As Low as Reasonably Achievable
cSv	centiSievert (unit of measure)
CTMA	Commercial Technologies for Maintenance Activities
DOD	Department of Defense
DOE	Department of Energy
NCMS	National Center for Manufacturing Sciences
ODASD-MR	Office of the Deputy Assistant Secretary of Defense, Materiel Readiness
PSNS	Puget Sound Naval Shipyard
U.S.	United States

1. Executive Summary

Traditionally, radiation safety groups at U.S. Navy shipyards have lagged their commercial nuclear power and Department of Energy (DOE) counterparts in implementing newer technology. To modernize shipyard activities, the Code 105 team at Puget Sound Naval Shipyard (PSNS) implemented a digital measurement wireless data communication system called the Link2 Display Controller RDX-PRO in 2022. This system would allow certain human-labor centric shipyard activities to be automated, resulting in increased production, fewer human errors, reduced exposure to radiation to create a safer work environment. However, PSNS quickly realized this commercial off-the-shelf product would require modifications to meet the unique demands of a Navy shipyard and its specific operational requirements. The information required by the Navy shipyards for its electronic status board was highly technical and had to be molded to meet existing reporting requirements and protocols specific to the to the Navy shipyards.

PSNS identified six key customization points to the RDX-PRO interface that would allow the system to better meet their needs:

- RadEye low battery warning indicator
- Change widget position by dragging using the mouse
- Configuration of widget and text colors
- Add device serial number as a property that can be easily viewed
- Size sliders to show percentage as the slider is adjusted
- Multi-image views using pages with click-through navigation

Advetage Solutions brought these needs to the attention of the manufacturer of the RDX-PRO, Charthouse Data Management, to develop a solution that achieved the requested modifications. It was quickly realized that changes to the software source code that drives the RDX-PRO were needed to incorporate all the customization points identified by PSNS. The project began as a collaborative effort between Advetage Solutions, Charthouse Data Management, PSNS and NCMS.

The Advetage Solutions team and Charthouse Data Management software developers created a plan to utilize a Waterfall-Agile hybrid methodology for the solution development. This allowed developers to maximize efficiencies on a set time schedule while allowing for user feedback and thus ensuring the desired product solution. As each custom feature was developed, the feature was presented to the shipyard team. This was followed by a software update submitted to the shipyard allowing for an internal evaluation of their existing system to ensure no bugs were detected and that the update worked properly in the field. While that evaluation was being performed, the developers worked on the next customization to present to the shipyard and took any feedback on the previous update that required correction or fine tuning. This process was repeated until all customization requests were completed and the final product was ensured to operate as requested.

Funding was secured for the collaborative initiative through the National Center for Manufacturing Sciences (NCMS) Commercial Technologies for Maintenance Activities (CTMA) Program and the Office of the Deputy Assistant Secretary of Defense, Materiel Readiness (ODASD-MR).

1.1 Results

PSNS received a completed software update in November 2023 and confirmed their ability to implement the finished product as part of their electronic status board project that allows workers to see real-time radiological conditions

remotely, saving time, reducing dose exposure and creating a safer work environment. PSNS will review their work practices using the electronic status board over the next year and present it to other Navy shipyards for evaluation allowing the opportunity to realize the same benefits.

1.2 Benefits

The development of modifications to the RDX-PRO produced a viable product for Navy shipyard's radiation safety needs, benefiting both the general public and Navy. Using the RDX-PRO as the electronic status board increases operational efficiencies in one of the most challenging and restrictive aspects of maintenance, radiological work. The reduction in maintenance turnaround times not only creates direct cost savings for the Navy but allows ships to return to sea sooner and defend America's interests around the world.

Implementing the RDX-PRO in monitoring of radioactive environments remotely without necessitating the physical presence of personnel in the area helps reduce unnecessary exposure to radiation. This dose savings creates a safer work environment and reduces risk for potential adverse effects in the future from radiation exposure. The enhanced safety for personnel equates to significant cost savings for the Navy and public taxpayers.

Another benefit of the RDX-PRO is that it can help mitigate the potential of a radiological accident that results in the inadvertent release of radiation to the environment or the public. In any accident scenario, time is of the essence. The more time personnel have to assess a situation, confirm results and take action, the greater the chance to avoid catastrophic consequences. The RDX-PRO constantly monitors work areas for elevated levels of radiation, allowing shipyard personnel to remotely detect abnormal conditions in real-time and take immediate actions quicker.

1.3 Technology Transition

The technology was implemented into existing Navy systems, which means technology transition was completed and available for use at the end of this project.

1.4 Invention Disclosure

☐ Yes Inventions ☒ No Inventions
DD882 Invention Report sent to NCMS ☒

1.5 Project Partners

- Puget Sound Naval Shipyard Code 105
- Advetage Solutions LLC
- Charthouse Data Management LLC
- National Center for Manufacturing Sciences (NCMS)

2. Introduction

2.1 Background

Navy analysis has shown that the average age of shipyard capital equipment now exceeds its expected useful life. Due in part to their poor condition, ship repair facilities are not fully meeting the Navy's operational needs, leading to maintenance delays and net negative operational readiness. There have been hundreds of innovative technologies identified that would improve productivity and increase operational efficiency. America's Navy shipyards have been left behind in the global transition to more efficient, digital practices. These technologies, utilizing digital measurement, wireless data communication, and electronic displays provide real-time monitoring of remote areas, allowing human-labor centric shipyard activities to be transitioned to commercial industries which can increase production, minimize human errors, and create a safer work environment for the maintainers and the surrounding communities. This is achieved by integrating a novel yet extremely innovative maintenance technology, the electronic status board, to demonstrate significant cost savings and increased throughput.

The RDX-PRO, manufactured by Charthouse Data Management (Charthouse) is currently being used by PSNS as the hardware and software solution to create an electronic status board. This provides standalone monitoring application displaying telemetry data received from instruments in the field.

In order to better meet the specific needs of PSNS and maximize the use of the RDX-PRO, the shipyard has asked for customized enhancements to the RDX-PRO.

The RDX-PRO has been in use by civilians in the nuclear industry for the past five years. This includes government agencies, hospitals, and commercial nuclear power plants.

Customization of the controller was necessary to take a commercial off-the-shelf product and have it meet the unique needs of the Navy and Navy shipyards. The information required by the Navy shipyards for its electronic status board is highly technical and specific to the Navy shipyards.

2.2 Purpose

The customization of the RDX-PRO involved taking a commercial off-the-shelf product, traditionally used in the private sector, and transitioning its originally intended purpose to meet the unique needs of the military, specifically the Navy and Navy shipyards. This customization would help shipyard workers get the information they need, in the necessary format, while also allowing configurability that makes data easier to interpret and streamline routine tasks. These customizations enhance worker efficiency and increase their ability to maintain a safe working environment for personnel, the public and environment.

2.3 Scope/Approach

The software enhancements to the RDX-PRO were completed by Advetage Solutions in collaboration with the RDX-Pro manufacturer, Charthouse. Developers located in Alpharetta, Georgia developed six unique software solutions to fulfill the customization needs identified by the Navy shipyard team. Figure 1 and Figure 2 show the basic user interface from the old software. Note the simplistic Summary and Tabular formats that don't show location of the personnel and area sensors.

Figure 1. Old Software Interface –Summary

Figure 2. Old Software Interface – Tabular

Six key customization points:

- **RadEye low battery warning indicator:** Battery Low status indicator will be added for device types that support it. The status will be shown on the device widget when active. This will allow a Radeye to show a "Low Battery" status when the battery is running low.
- **Change widget position by dragging using the mouse:** Allow the user to position a widget by clicking and dragging with the mouse. Once a widget has been created it can be accurately positioned by clicking a handle at the opt of the widget and dragged into position by using the mouse.
- **Configuration of widget and text colors:** Allow the color of text to be configured independently of the widget alarm colors e.g., text can be configured as black while the widget has a red/blue/white color pattern to indicate the alarm state (instead of the default red/yellow/green).
- **Add device serial number as a property that can be easily viewed:** Allow the user to click on a sensor to show the serial number of the device. This will allow sensors to be identified independently of how it has been named.
- **Size sliders to show percentage as the slider is adjusted**: Properties that have sliders, such as widget size, will show a percentage to accurately indicate the value of the setting. This will allow widget sizes to be made consistent across the application.
- **Multi-image views using pages with click-through navigation:** Allow multiple images to be added to represent different locations and different levels of detail. Master page can be used to define an overall area with additional images to define further areas or additional levels of detail:
  - Allow images to be on multiple pages in a tabbed view. Navigate between images by selecting tabs or by clicking on a "Hotspot" defined on one image to move to the view on another image presenting more detail (e.g., master view can show a building with detailed views showing individual rooms).
  - Each image should have its own display configuration so that widget positions and size can be configured independently for each image. Default configurations and other properties, such as units, will be common across all images.
  - Images can be added and deleted as required.

3. Project Narrative

The project kicked off February 1, 2023, with a meeting between all the stakeholders to discuss the time frame of the project, the roles and responsibilities of all parties and a review of the needs identified by the Navy shipyard team and fully understand their expectations. After that meeting, the Advetage and Charthouse teams worked to create a resource and allocation plan to meet the project milestones.

A project plan was then developed that prioritized the order of which customizations needed to be completed, based on the complexity, and need for foundational elements between each individual set of code. It was agreed between the Advetage and Charthouse teams that a Waterfall-Agile hybrid project management plan would be the best course of action to develop the custom software components within the project milestone timelines, while at the same time incorporating user feedback. This plan would help to minimize downtime and ensure the best possible product outcome.

Developers would work on one customization at a time and then present and submit to the Navy shipyard team a working demo once it was completed and tested. As the shipyard was performing their own evaluation, the developers would begin development on the next customization based on the priority order established. As soon as the Navy shipyard completed their evaluation, any bugs, errors or requested improvements they found would be submitted to Advetage-Charthouse and the developers would work to resolve that in tandem with the next customization design (Figure 3).

This process was repeated and the order of completion of each task was as follows.

1. Size sliders to show percentage as the slider is adjusted.
2. Multi-image views using pages with click-through navigation.
3. RadEye low battery warning indicator.
4. Add device serial number as a property that can be easily viewed.
5. Change widget position by dragging using the mouse.
6. Change widget position by dragging using the mouse.

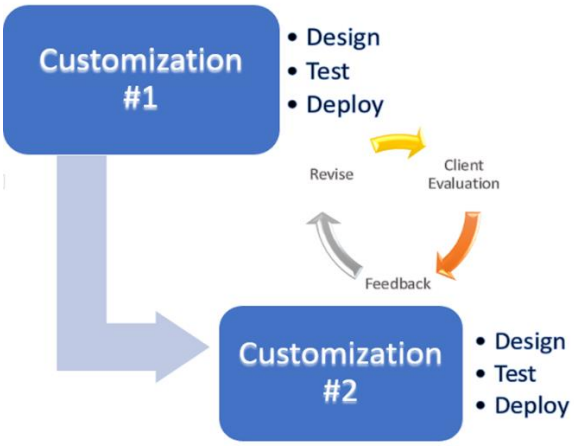

Figure 3. Project Plan Cycle

There were several challenges encountered after initial deployment that required additional attention by the Charthouse developers. The first was related to Item #6 (above), that required a refinement to the code which allows for better accuracy of the widget placement and smoothing, caused by latency during the drag. The software upgrade in general, was running slower than expected. and led to a discovery of an issue in the source code.

The additional customizations created a cascading effect of lag and delays with the addition of each new feature. Charthouse developers performed an audit and discovered the original source code would need to be rewritten to properly accommodate for all the additional customizations. After the source code was rewritten and the performance of the software was optimized, there were several minor tweaks requested by the Navy shipyard to

enhance the customizations implemented by the Charthouse developers.

These tweaks included renaming the Hotspots feature to “Zones” to prevent confusion relating to current terminology already in use. Other requested changes included enhancements to allow for a more accurate positioning of the widgets and also resizing of the widgets.

Once these enhancements were completed the final version of the software was submitted to PSNS and the team performed final acceptance testing. Figure 4 shows the areas as a map with full customizations for other display functionality.

The final acceptance testing was completed to the satisfaction of the PSNS team with no additional comments or requests.

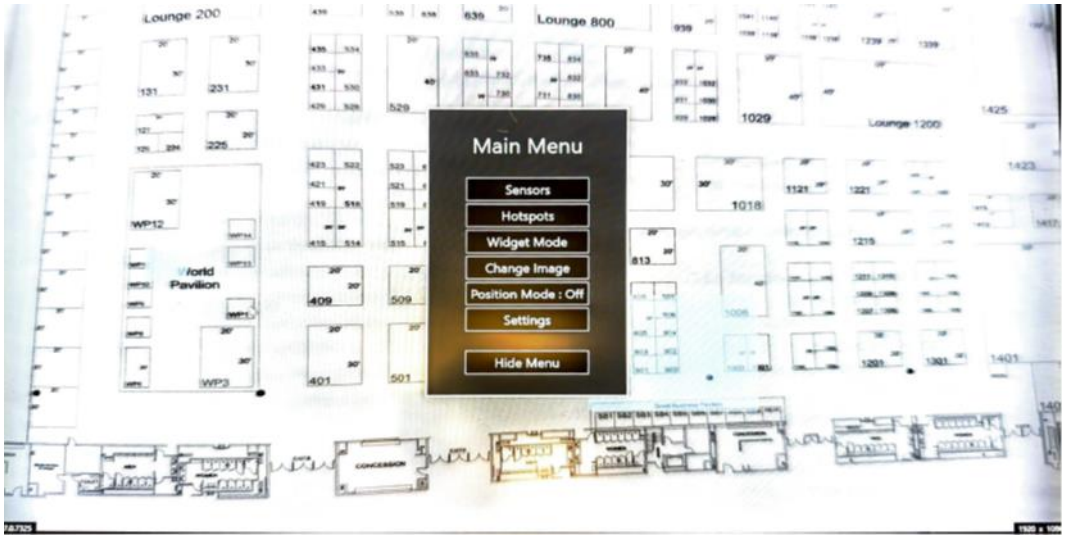

Figure 4. New Software Interface

4. Conclusions

The Code 105 team at PSNS has since implemented the RDX-PRO with the enhancements to utilize in day-to-day operations. They are satisfied with how it works, and the additional benefits provided. So much so that they've presented the RDX-PRO's capabilities and benefits to several other shipyards.

PSNS will continue to use the RDX-PRO and record their findings over the next year to accurately quantify their time, dose and cost savings. They will then formally present their findings to other shipyards for fleetwide implantation.

Additionally, PSNS has begun looking into expanding their use of the RDX-PRO system to integrate with digital survey record keeping and record results for more in-depth trend analysis and utilizing that data to further improve operational efficiencies and work practices. They are also looking into expanding the wireless remote monitoring technology from the RDX-PRO ecosystem to other operations in their purview such as environmental monitoring and emergency planning. This empowers the shipyard to share data with local, state, and federal agencies, enabling increased efficiency and coordinated responses that better protect the environment and public in wake of a nuclear accident or release event.

The costs and hazards associated with unintended radiation exposure has proven to be costly, especially in the case of nuclear accidents that result in the unintended release of radioactivity into the environment or public. Utilizing all available resources to enhance risk mitigation of these hazards is imperative for all entities working with radioactive materials, including the Department of Defense (DOD). The current use of the RDX-PRO system is proving to be very beneficial for PSNS in its current iteration and is looking like it can further be used to provide additional benefits to the Navy and the public for years to come.

5. Project Benefits

5.1 Benefits for the General Public

The primary benefits the RDX-PRO provides to the public represents savings to the taxpayer as a result of increased safety to workers and enhanced efficiencies in maintenance activities. Radiological work is inherently dangerous and involves a robust list of mandated regulatory safety protocols. The primary goal of the RDX-PRO is to provide remote real-time data and assist radiation safety personnel. It removes the past need for a physical presence in affected areas that would risk unnecessary radiation exposure. This leads to reduced overall exposure to those personnel and a safer working environment. Reduced exposure consequently reduces the risk of future genetic effects and non-fatal cancers. The United States Nuclear Regulatory Commission assesses dose avoidance a value at $750-$1,500 per person, per cSv in a white paper titled *Value of Public Health and Safety Actions and Radiation Dose Avoided*, published in 1994[1]. Real-time data also helps to reduce time needed to survey areas and gather the data to plan work. The reduced time to plan and implement work packages results in overall less time to do the same work and saves taxpayers more money.

Additionally, the RDX-PRO can enhance safety to the public in areas surrounding the shipyard by reducing the risk of potential inadvertent release of radioactive materials to the environment. The RDX-PRO can provide shipyard workers early warning of potential rises in radiation levels, indicative of a radiological accident and begin taking immediate actions sooner. Additionally, the RDX-PRO provides shipyard workers the ability to coordinate with emergency response agencies much quicker in the event of an unexpected release, by providing real-time data on conditions without having to send personnel in harm's way. Another benefit to the public in the event of a radiological accident is that real-time data from the RDX-PRO can't be manipulated. This helps to provide transparency in actual levels and increase the public trust in what actual radiation levels are being reported.

Last and most importantly, reducing maintenance times in the shipyard allows ships to return to sea earlier and pursue the Navy's mission to protect America at sea, defend freedom, preserve economic prosperity, and keep the seas open and free.

5.2 Benefits for DOD

The guiding principle in radiation safety is an acronym called ALARA (As Low As Reasonably Achievable). The goal in ALARA is to minimize exposure to ionizing radiation as much as possible, no matter how small the dose. Implementing the RDX-PRO to monitor radioactive environments remotely without the need of personnel being in the area, helps to achieve ALARA and enhance the safety for personnel working in the shipyard. By moving people away from the area, the three protective measures for achieving ALARA are being adhered to: Time, Distance and Shielding. By moving workers who would normally monitor the area away, they reduce their time being exposed, increase their distance from the source of radiation and put multiple objects in the path of the radioactive source to increase shielding.

The RDX-PRO also helps to increase the readiness of Navy ships by reducing maintenance times in the shipyard. Radiological work is one of the most restrictive aspects of shipyard maintenance. The RDX-PRO helps to improve the efficiency of radiological work by providing

[1] NURREG/CR-6212, BNL-NUREG-52413. *Value of Public Health and Safety Actions and Radiation Dose Avoided* Date Published: April 1994 Prepared by: J.W. Baum, Brookhaven National Laboratory, Upton, NY 11973-5000.

real-time radiological data to workers before they go into the work area, allowing them to be more prepared for the tasks at hand while also allowing radiation protection technicians to monitor multiple areas at once from a safe location. This leads to time and cost savings for the Navy and taxpayer as less time is required to prepare for work and safety can be adhered to more efficiently.

The RDX-PRO can also help provide advanced warning of radiological accidents by monitoring radioactive systems unmanned, 24 hours a day, seven days a week. Utilizing the preset limits and thresholds features of the RDX-PRO can alert personnel of a rise in radiation levels indicative of an accident. By having immediate indications of unexpected rising radiation levels, shipyard personnel can assess the situation much sooner and take immediate actions if needed to reduce the possibility of an inadvertent release of radioactivity to the environment or public.

The modular nature of the RDX-PRO allows integration with other technologies to further improve on maintenance activities beyond radiation detection, increasing efficiencies throughout the shipyard. The RDX-PRO could be integrated with other types monitoring instruments to provide real-time data, via wireless telemetry on pump speeds, vibration, valve positions, ambient noise, heat stress conditions or any other vital components that need to be measured.