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Virginia Digital Shipbuilding Program (VDSP): Building an Agile Modern Workforce to Improve Performance in the Shipbuilding and Ship Repair Industry

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Virginia Digital Shipbuilding Program (VDSP) – Building an agile modern workforce to improve performance in the shipbuilding and ship repair industry

Mr. Joseph Peter Kosteczko, Old Dominion University

Joseph Kosteczko received his Bachelor of Science and USCG Merchant Marine License from the US Merchant Marine Academy in 1998 and a Master's of Science in OPM from Southern New Hampshire University in 2015. Mr. Kosteczko currently is serving as the Program Manager for the Virginia Digital Shipbuilding Program (VDSP) at ODU's Virginia Modeling Analysis and Simulation Center (VMASC). Prior to joining ODU in 2018, Mr. Kosteczko spent over 10 years working in the shipbuilding, ship repair, and maritime industry as a Project, Contract, and Program Manager. He also spent over 8 years on active duty as a US Navy Surface Warfare Officer and 3 years in the reserves. At ODU, Mr. Kosteczko supports the Director of Digital Shipbuilding Enterprise in developing programs and strategies to develop Industry 4.0 curriculum, upscale industry workforce and develop a center of excellence in shipbuilding and ship repair. Mr. Kosteczko's research interest include topics concerning marine transportation and marine engineering, shipbuilding and ship repair, advanced manufacturing, workforce development, veteran transitions, and maritime industry.

Ms. Katherine Smith, Old Dominion University

Katherine Smith received B.S. degrees in applied mathematics and mechanical engineering from Old Dominion University and an M.S. in Applied and Computational Mathematics from Old Dominion University. Ms. Smith is a Research Associate at ODU's Virginia Modeling, Analysis & Simulation Center under Digital Shipbuilding. She was previously a senior lecturer in the Department of Mathematics and Statistics at Old Dominion University and is pursuing a PhD in Modeling and Simulation. Her research interests include data analytics and machine learning, augmented and virtual reality, scientific and information visualization, and serious games for STEM education. Prior to teaching at ODU, she worked as an Aerospace Engineer at NASA Langley Research Center.

Mrs. Jessica Johnson

Dr. Rafael Diaz

Dr. Rafael Diaz is Research Associate Professor at VMASC. Previously, he has been an Affiliate Researcher at the MIT Center for Transportation and Logistics and a Professor of Supply Chain Management at the MIT-Zaragoza International Logistics Program. He has a Ph.D. degree in the field of Modeling and Simulation Analytics focused on Operations and Supply Chains Management and an M.B.A degree in financial analysis and information technology from Old Dominion University. He holds a B.S. in Industrial Engineering from Jose Maria Vargas University. Prof. Diaz's research is in the area of shipbuilding supply chain management, data analytics, logistics, production planning, lean manufacturing systems, and the intersection between operations management and information and technology. More specifically, his research seeks to innovate and improve operational performance using data analytics and IoT technology at manufacturing and supply chain levels. He is also particularly interested in supply chain resiliency, coordination issues, and real-time analytics-based decision making. Prior to his academic career, Dr. Diaz worked for seven years as a process engineer and management consultant in the international consulting arena.

Virginia Digital Shipbuilding Program (VDSP) – Building an agile modern workforce to improve performance in the shipbuilding and ship repair industry

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Abstract

Industry 4.0 is the latest stage in the Industrial Revolution and is reflected in the digital transformation and use of emergent technologies including the Internet of Things, Big Data, Robotic automation of processes, 3D printing and additive manufacturing, drones and Artificial Intelligence (AI) in the manufacturing industry [15]. The implementation of these technologies in the Shipbuilding and Ship Repair Industry is currently in a nascent stage. Considering this, there is huge potential to produce cost savings, decrease production timelines, and drive down inefficiencies in the lifecycle management of ships. However, the implementation of these Industry 4.0 technologies is hindered by a noticeable gap in workforce capability and capacity. The shipbuilding and ship repair industry is projected to lose approximately 33% of its skilled workforce and 48% of management by 2028 [9]. With an aging workforce and an incoming digital generation that excels in tech savviness, flexibility, global thinking, and multi-tasking, it is crucial to be innovative in workforce development. The Virginia Digital Shipbuilding Program (VDSP) responds to this need by providing a process and platform to address education, training, and adoption of innovative new technology as well as the ability to provide real-time solutions to current and future industry problems. This paper will focus on the three pillars of Digital Shipbuilding – Career Pathway Mapping and Curriculum Development, Outreach and Workforce Development, and Research and Development. Additionally, this paper will address how the team is ensuring that stackable, transferable education and certification processes are implemented between military and industry to facilitate the transition of veterans to the civilian workforce.

Section 1: Introduction and Background

With the creation of the world-wide web and ever-increasing computer power, the world economy has entered the 4th Industrial Revolution or what has been coined by the German Government as Industry 4.0. This fourth revolution is marked by the adoption of a range of new technologies that combine physical and digital worlds in unique and evolutionary ways. Impacts of these new technologies are felt across all disciplines, economies, and industries and have created new challenges in how we socialize, work, shop, travel, and even how we entertain ourselves. It has completely changed our lives [16].

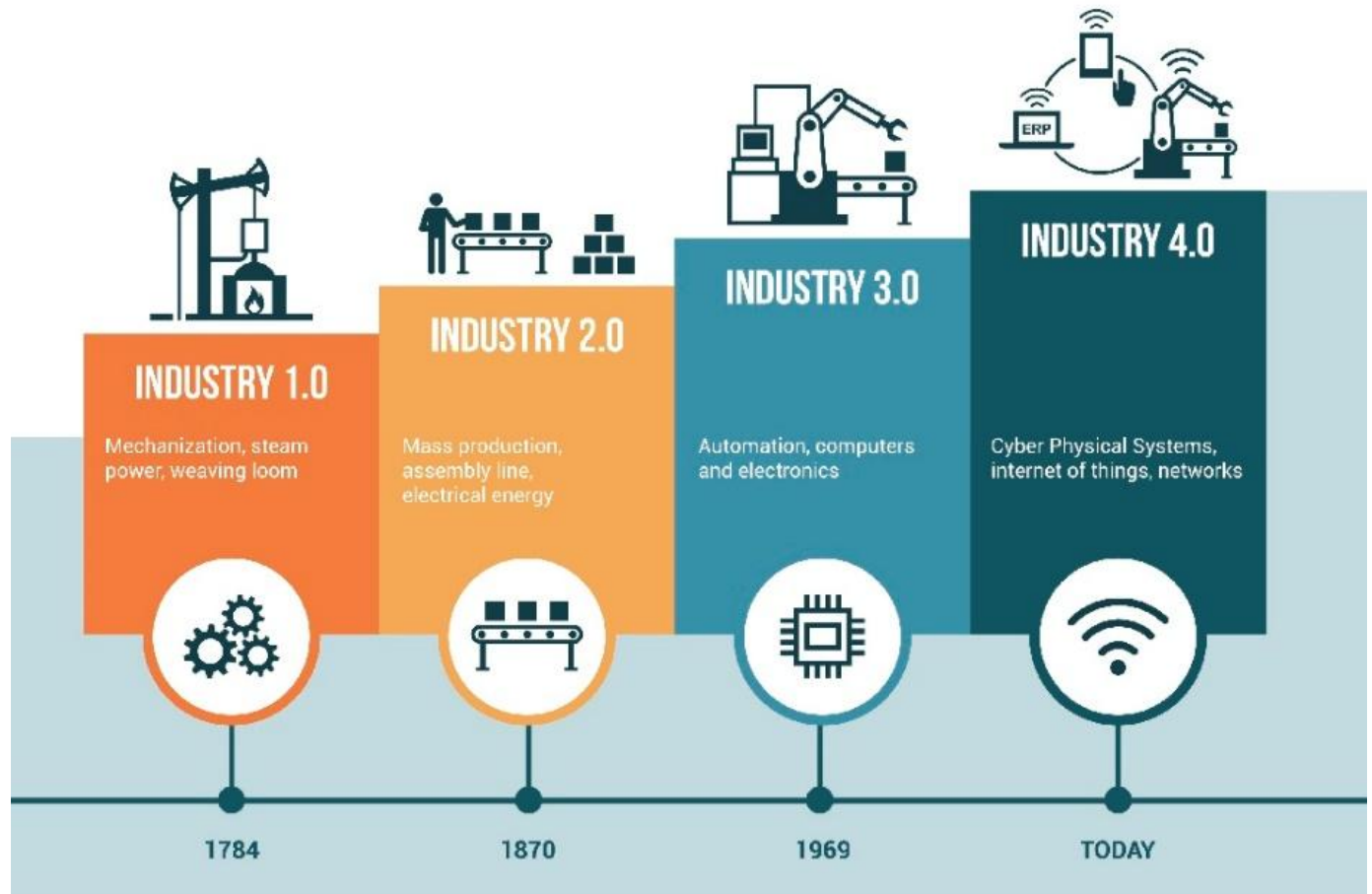


Figure 1: The 4 Industrial Revolutions [15]

Industry 4.0 or Digital Transformation is marked by the integration of many new technologies such as use of Internet of Things, Big Data, automation of processes with Robots, 3D printing, drones & Artificial Intelligence (AI).

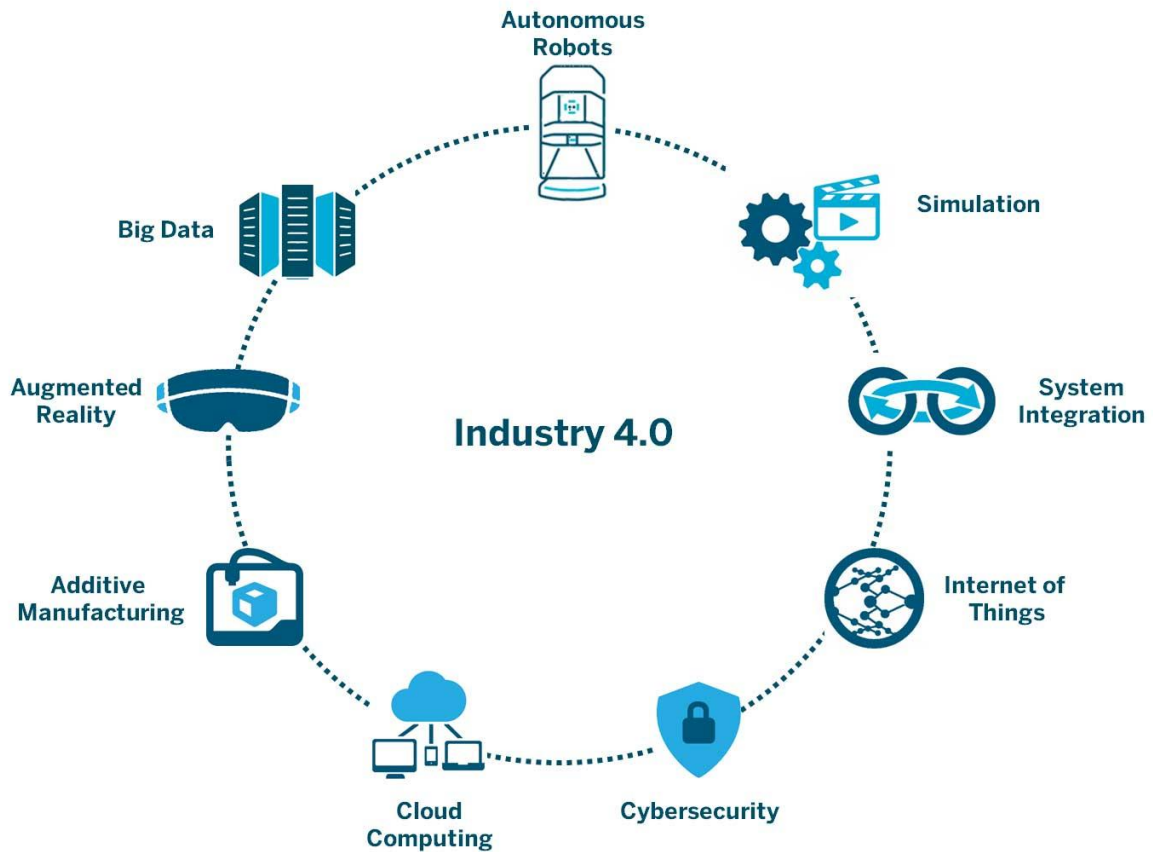


Figure 2: Digital Transformation [15]

The future of Industry involves the interoperability of machines, devices, sensors and people that connect and communicate with one another. In the Internet of Things, sensors with the ability to collect real-time data can be used by manufacturers, producers, supply chain, and consumers. The advancements in big data and powerful analytics means that systems can process huge quantities of data and rapidly produce actionable insights. This results in information transparency and leverages a virtual copy of the physical world produced from sensor data in order to contextualize information. These new technologies allow systems to support humans in decision making and assist in tasks that might be hazardous or cumbersome for humans. There is a drive for autonomy to reduce cost and improve performance [7].

Digital Shipbuilding and Repair is the application of Industry 4.0 to the shipbuilding and ship repair industry. It encompasses but not limited to the following digital technologies and processes:

- Fully annotated 3D Design of vessels, systems, and subsystems
- Laser Scanning, Point Clouds, “Digital Twin”

- 3D Printing and Additive Manufacturing
- Digital Thread, Digital Lifecycle Management and leveraging real-time data on the digital thread
- Augmented Reality, Virtual Reality, and Mixed Reality
- Developing an agile culture – Empowering Innovation - “Learn by Doing”
- Craftsman and foremen focused solutions
- Faster time-to-talent for complex work

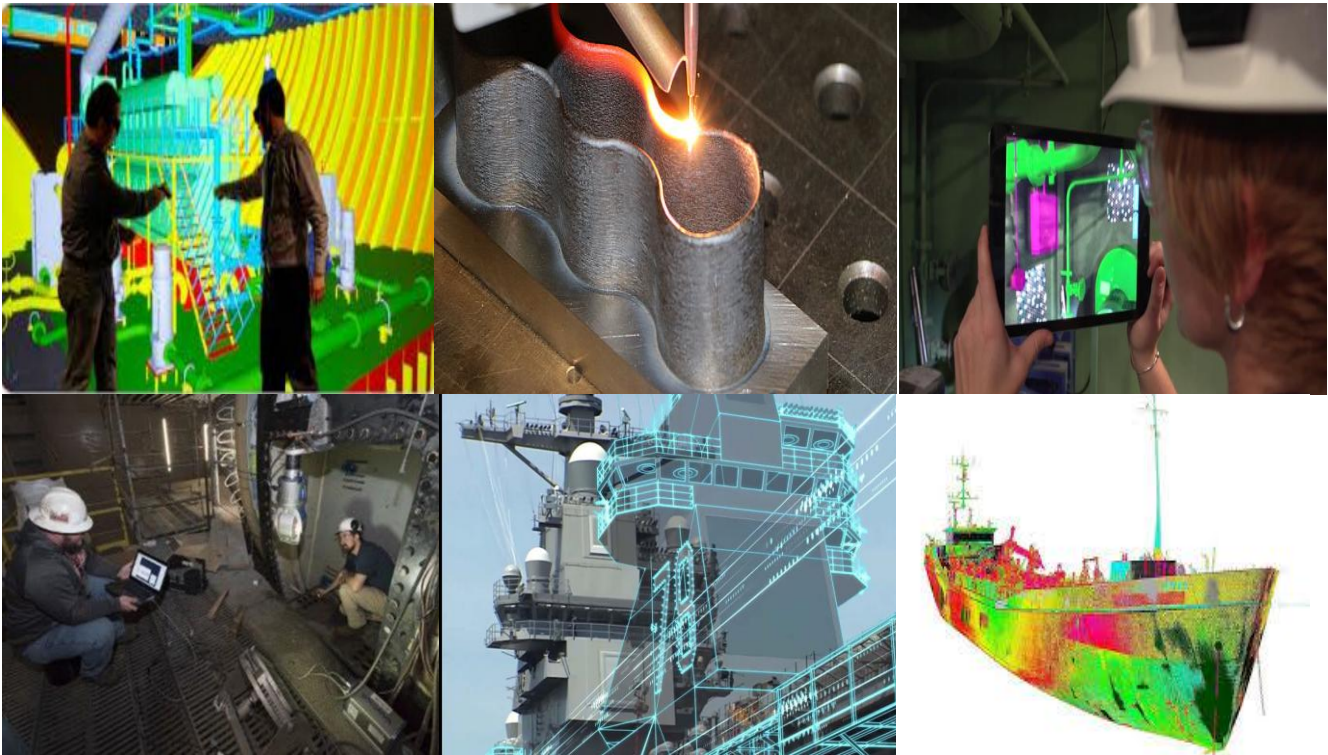


Figure 3: Digital Shipbuilding in Action

Section 2: Why Digital Shipbuilding?

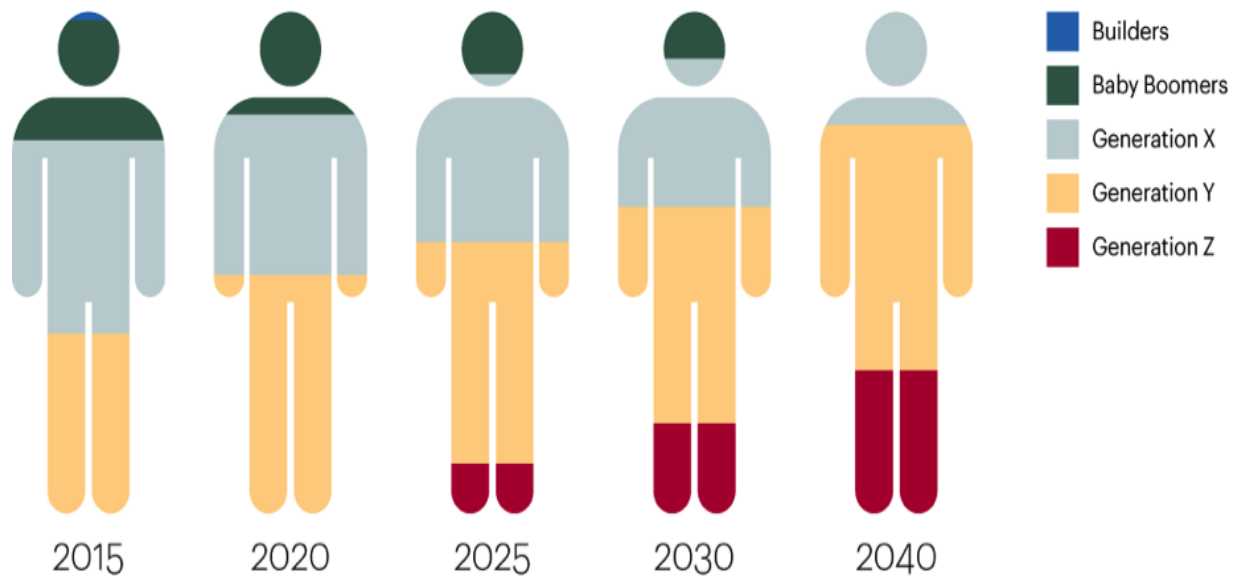
The United States is a maritime nation. In 2016, the US maritime transportation system carried \$1.5 trillion of cargo through US seaports to and from our international trading partners [11]. The Ocean Economy, which includes six economic sectors, contributes more than \$350 billion to the GDP and supports over 3 million jobs [11]. While the number of ocean-going US built and US Flag vessels has declined over the years, there continues to be a demand for the domestic and inland waterway vessels. There are tens of thousands of suppliers and vendors in almost all 50 states that support shipyards and ship repair facilities all over the nation. The

Maritime Administration estimates there are over 120 shipyards in the nation spread across 26 states that contributes over \$37 billion to the national GDP [4].

Virginia has been a center for shipyards and vessel repair on the east coast with one US government owned public yard, eight private yards, and numerous other repair and modernization facilities. There are over 63,000 shipbuilding, ship and vessel repair related jobs in the state resulting in about \$5.5 billion of work performed a year [14]. Hampton Roads, or Coastal Virginia, also has the only shipyard in the nation that builds US Navy nuclear power aircraft carriers, one of three that repairs aircraft carriers, and one of two that builds and repairs submarines. With government vessels from five different agencies, including approximately 75 US Navy ships, calling the Norfolk area homeport a robust infrastructure is required. In addition, the area is a hub of maritime activity that has resulted in the recommendation of widening the Hampton Roads Channel to 55 ft depth and 1400 ft width [8]. An estimated 79 million metric tons of cargo per year flows through the Port of Virginia and continues up the Chesapeake Bay [12]. All this inland waterway traffic requires support from local shipbuilding, ship repair, and manufacturing industry.

As you can see that shipbuilding and ship repair plays a large role in the US and Virginian economy. However, this industry is increasingly outdated and often out of sync with modern manufacturing techniques. The industry has not adopted technologies that are common in aerospace and automobile manufacturing. Some of this is due to the reliance on true and proven processes that have been passed consistently from one generation to the next in a methodical way. However, the shipbuilding and ship repair industry is at a crucial moment in time with a rapidly aging workforce that does not have time to replace talent quickly. The average age of a person working in the shipbuilding and ship repair industry is 55 years old [6]. Newport News Shipyard estimates by 2028 that the shipbuilding and ship repair industry will lose approximately 33% of skilled workforce and 48% of managers due to upcoming retirements [9]. Generation X, which is substantially smaller than Baby Boomers and at mid-career, were not encouraged to join the industry because the slumps in economy and impression of shipbuilding and ship repair were “dead end” jobs that have no stability with multiple layoffs. In addition, overall the Digital Generations such as Gen Y (Millennials) / Gen Z will make up over 50% of the workforce by 2025 [13].

Millennials will comprise the majority of the workforce by 2025



Source: U.S. Census Bureau

Figure 4: Workforce Projection [13]

This new generation workforce is completely different than the one it is replacing. They are tech savvy, flexible, desire meaningful work, resourceful, global thinkers, and multi-taskers. They grew-up with technology easily at their fingertips and unlike all previous generations they have an innate desire to embrace new technologies rather than older technologies [3].

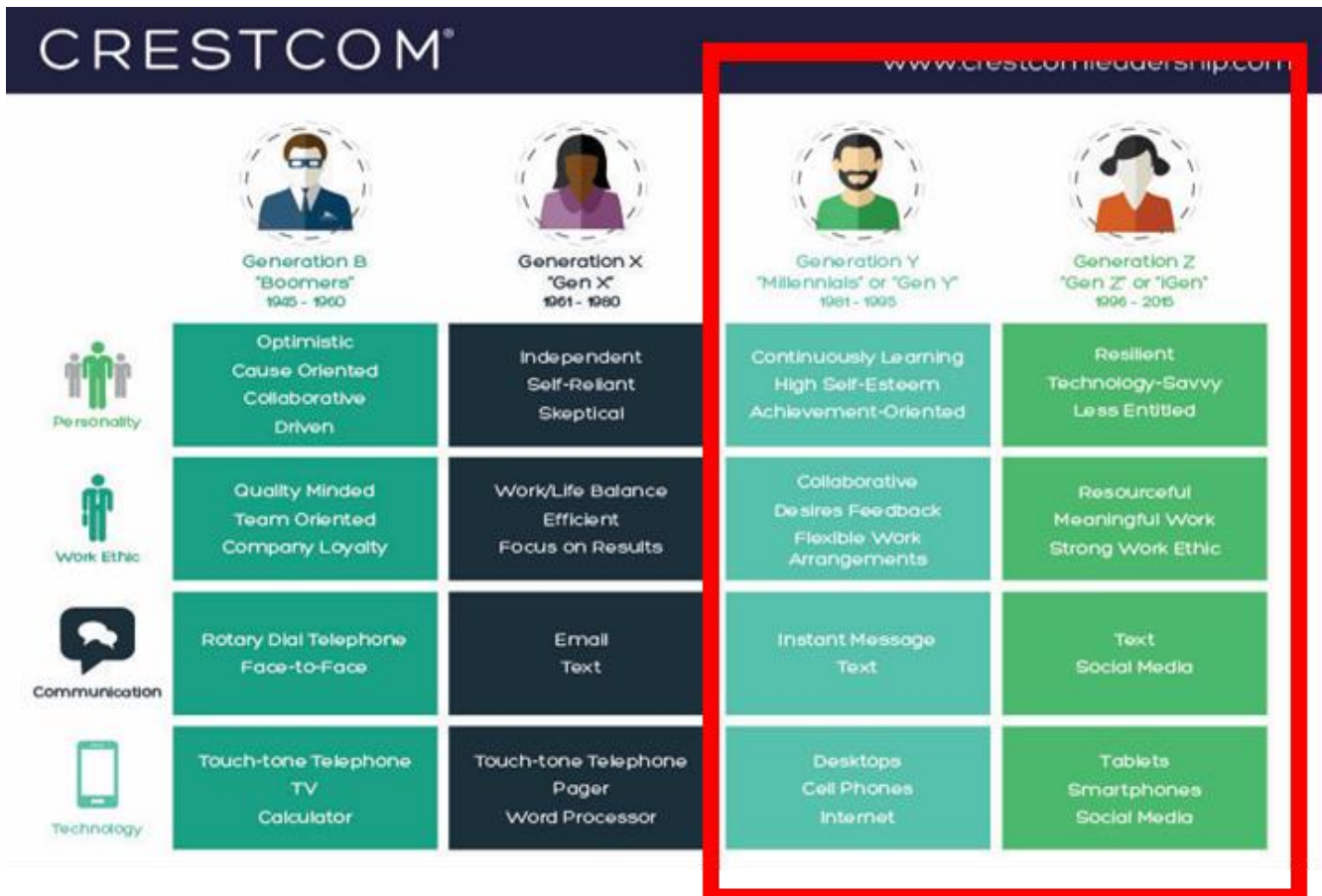


Figure 5: Differences in Workforce Priorities [13]

Additional pressure is being applied to the industry with a drive for an increased US Navy Fleet and modernization of other services such as US Coast Guard and US Army watercraft. The FY 2020 US Navy 30-Year Shipbuilding Plan highlights increasing the battle force from approximately 270 ships to 355 ships by FY2034 with a major increase to 314 ships by FY2024 [2]. Besides just sheer numbers, the US Navy and other services are facing a demand for readiness and enhanced capabilities of their assets. Additionally, with tightening budgets the increase in size, capability and readiness of the US Navy puts a large demand on the industry to reduce timelines and drive down costs of not only building but also maintenance of vessels over their lifetime.

The unemployment rate in the United States as of December 2019 was 3.5 percent. This marks the lowest rate since 1969 and marks a point that the rate is below the "natural rate of unemployment" [1]. With a workforce near full employment and businesses in general cannot find enough workers to keep operating at full capacity, there is little room to address the changing workforce in the shipbuilding and ship repair industry. In order to maintain and grow there must be a force multiplier. The answer is adopting the industry ready 4.0 technology to

improve supply chain, decrease production timelines, increase productivity of current workforce and create a resilient system of systems.

Section 3: Virginia Digital Shipbuilding Program (VDSP)

The Virginia Digital Shipbuilding Program is a project that was funded in February 2018 with “seed money” by the Virginia Growth and Opportunity Board (GoVA) as part of the Go Virginia Grant Program and is now sustained by baseline funding from the Virginia State Assembly. The initiative is led by Old Dominion University’s (ODU) Virginia Modeling, Analysis and Simulation Center (VMASC) with partnerships from industry, education, local and federal government, and community partners throughout Hampton Roads and Virginia. VDSP has three distinct pillars which are: Career Pathway Mapping and Curriculum Development; Outreach and Workforce Development; Research and Development.

With collaboration of stakeholders across the ecosystem, VMASC started with an end-to-end analysis of education and training at all levels to include K-12, higher education, trade schools, military and government, and workforce development centers. We conducted this analysis through a series of workshops and other events pulling into the conversation organizations such as the Virginia Ship Repair Association, industry leaders like Newport News Shipyard, Hampton Roads Public Schools and Community Colleges and community outreach groups. This has identified gaps in workforce education and training. Some of the gaps included little or no awareness of opportunities, lack of base technical and math skills, curriculum not aligned to industry needs, and shortfalls in “soft-skills”. When surveying stakeholders not directly working with the shipyards we found that many including educators, workforce development groups and general public had an impression that shipyard work was “dirty”, “dead-end”, “low-paying”, “not technical”, and “not dependable”. However, the reality is that the shipyard jobs are growing, the technical skills are in a demand and there is a backlog of work creating long term stable jobs. The lack of awareness has driven many students and working adults away from technical fields and professions that would be useful for the shipyard. We have also found gaps in technical skill levels. Many education institutions have abandoned the hands-on learning due to crunch in budgets and push for standardized testing. With the digital age it was found that the basic “soft skills” such as problem solving, communication, using measurements, and team work has been lost. VDSP has taken these results and is applying them to improve current and develop new curriculum to upscale the current workforce and prepare the future digital natives as they enter the workforce. As of January 1, 2020, four new courses and workshops have been integrated at the K-12, community college, and bachelor’s level. A higher education course that is open to undergraduates as well as non-degree seekers has been taught for three semesters. VDSP has also developed curriculum for two workshops called “Up Against the Wall” and “Build a Boat” centered on outreach, development of softs-skills, and applying digital shipbuilding skills. The “Up Against the Wall” has been offered 22 times in the last year with over 1350 participants ranging from 8th graders to freshman in college. This course

provides participants some history of shipbuilding and ship repair, introduces them to current practices and skillsets needed, and most importantly exposes them to a project-based learning engineering exercise relevant to today's shipyard using 4.0 technologies. The "Build a Boat" workshop has been offered 4 times in the last year with over 100 participants who are mostly high school, community college or freshman in 4-year institutions. Just like the other workshop this is centered on project-based learning objectives that introduce 3D modeling and digital design. A 9-12th grade curriculum has been developed and pilot recently starting in September 2019. Currently there are 45 students enrolled and this is expected to grow to 85 by next fall as the greater maritime career curriculum is expanded. This course work project based and is centered on 3D modeling and use of digital tools in the marine environment. In addition, digital shipbuilding curriculum fundamentals have been integrated into many existing courses from K-16. Some of this integration includes capstone projects in high school level physics courses, 8-12th grade drafting and technology elective courses, shipyard and industry pre-hire programs, Apprentice School technology programs, and afterschool National Parent Teacher Association sponsored programs. Spring of 2020 curriculum development includes implementation of a professional development series tailored towards K-12 teachers, development of a digital certificate program that can be offered to undergraduates, industry professionals, and veterans, and expansion of the existing curriculum and projects to multiple institutions. VDSP is building a multi-track curriculum architecture that leads to industry recognized credentials that have coherent linkages across education partners' programs and clear paths with multiple entrance and exit points with stackable and transferable certificates, degrees, and credentials for high-wage careers in shipbuilding, ship repair, and advanced manufacturing. As indicated above the current focus is skilled trades, design, engineering, IT, and cyber, but as the curriculum development continues it is intended to cross all disciplines through the industry to include business, logistics etc.

Over 50% of the shipbuilding and ship repair that is accomplished in the Hampton Roads, i.e. Coastal Virginia, area is related to the government or the military. In this complex industry, it makes sense that the workforce requires clearances and specialized training. Finding or developing these qualifications in the commercial labor pool takes an investment of time and funding. The military has a need for similar set of qualifications and invests substantial time and tax dollars training their force. It is logical that the military, specifically the US Navy, should be a partner in upscaling the workforce. Besides aligning K-12 curriculum to support the digital workforce, the unique Navy training can transfer to the industry. Veterans are an underused human resource for the shipbuilding, ship repair and advanced manufacturing industry. The biggest issue is that the training they receive while in the service does not transfer well to civilian certifications. This is where VDSP is bridging the gap. By involving government training and education programs in the end-to-end analysis allows synergy to be developed across the ecosystem. To be truly stackable and transferable the education and training needs to align across all stakeholders. So far, VDSP has been working with the US Navy and industry partners

on a common comprehensive diesel maintenance, education, and training tool. Other initiatives involve integrating various digital shipbuilding curriculum within various service rates and military operational specialty training pipelines. Most recently, VDSP has been teaming with a local contractor on developing a platform to launch an integrated ship maintenance university where common and stackable qualifications for in-service and civilian shipbuilding and maintainers can be achieved. The intention of this program is to standardize some of the common core skill sets building synergy and aiding in transitioning veterans. With the development of the certificate program as noted above, we are hoping to attract veterans into the shipbuilding and ship repair field. Currently the veteran aspect of the program is at the infant stage and there is a lot more work to be done but VDSP is providing an avenue to facilitate the process. Going forward the next initiatives are to work with USN and USCG in incorporating curriculum into rate training. VDSP has also open the conversation with Military Sealift Command and USN on upscaling Port Engineering training which is planned for Fall of 2020.

Just adopting new technologies and upscaling education and training does not mean the gaps in human resources are automatically filled. A major goal of VDSP is getting the word out and promoting the industry through outreach. Branding, awareness and inspiration through workshops, trade shows, and other events are crucial. As of January 1, 2020, VDSP has engaged over 300 businesses, 25 government and academic partners, conducted over 10 workshops at various levels, and have engaged almost 10,000 people through career fairs, expos etc.

Leveraging VMASC track record for research and development, an analysis of shipbuilding and ship repair programs, systems, infrastructure, workforce and supply chain is underway. VDSP is working in collaboration with industry partners to find real-time solutions for integrative innovation and adoption of Industry 4.0 technologies and new workforce practices to improve efficiency. Current work involves use of big data analysis to improve internal and external supply chain processes. VDSP research team is also working on practical uses of laser scanning and digital twin to improve performance of ship repairs.

In support of the three pillars, VDSP established three separate laboratories. Establishment of a Digital Shipbuilding Lab at VMASC (Figure 6) is tailored to hands-on engagement and project-based learning of Digital Shipbuilding skills. This lab is opened to stakeholders in early 2019 throughout the region and state for training, technology development and research, and outreach efforts including conferences, workshops, recruiting/job fairs, and STEM events. In August of 2019, VDSP partnering with the City of Newport News and Newport News Shipyard, opened the Brooks Crossing Innovation Lab (BCiLab). This lab is a first of its kind in Virginia fabrication facility co-located with a new workforce development center and Newport News Shipyard engineering and development offices. The lab is designed to be a STEM center open to the public that through project-based learning, teaches skills and technology utilization to students, parents, teachers, industry and Hampton Roads citizens. The final lab established is

the Marine Electrical Propulsion Simulation Lab located in Newport News. This is a partnership between VMASC, Ockerman Automation, and Lavle to conduct high-impact research and professional training in hybrid and electric propulsion, power system architectures, energy storage technologies, and autonomous systems for future naval and commercial usages.



Figure 6. Digital Shipbuilding Lab at VMASC.

With any program the metrics are proof of success. VDSP is in the infant stages but some early successes have been noted. As part of the GoVA grant the tracking of various milestones were required. As of 29 February 2020 which is the conclusion of the grant the following metrics have been recorded:

Metric	Totals As of Feb 2020	Benchmark
# Businesses Engaged	315	300
# Organizations Engaged	45	25
# Local Governments Engaged	14	5
# School Districts Engaged	26	10
# Community Colleges Engaged	9	3
# 4-year Higher Ed Institutions Engaged	5	2
# Advertisers on Website	16	10
# Institutions Adopting VDSP Curriculum / Course Outlines	4	2
# Digital Shipbuilding employees hired	449	500
# VDSP Co-Lab Demonstrations and Experiments Conducted	2	2
# Conferences and events attended and conducted	37	10
# of Iterns and Ambassadors Participating	225	200

VDSP has met or exceeded the original tasking. The real story is that VDSP has reached over 10,000 students, parents, educators, and members of the public in 2019. This outreach has generated new found interest in shipbuilding and ship repair. The High School Course has led to several graduates pursuing a career in shipbuilding and ship repair with at least two students being accepted into the Newport News Shipyard Apprentice School. VDSP is continuing to track and develop new metrics to measure success as part of the long-term strategy.

Section 4: Way-forward for the Virginia Digital Shipbuilding Program (VDSP)

The long-term strategy of VDSP is to establish Virginia, particularly Hampton Roads, i.e. Coastal Virginia and recently called "757", as the Digital Shipbuilding hub with VMASC as a Center of Excellence for research, technology development, services, education and training with the following goals:

- Adoption of the Virginia Digital Shipbuilding Program (VDSP) curriculum by all regional school districts, and community colleges across Hampton Roads.
- Adoption of the VDSP curriculum by 4-year engineering and IT programs throughout Virginia and expanding nationwide.
- Deployment of the VDSP curriculum to K-12 school districts, community colleges, and regional higher education centers within Virginia's rural Appalachian region.

- Assist Maritime Industrial Base Ecosystem (MIBE) in promoting and strengthening the Hampton Roads Naval and Commercial Maritime Ecosystem
- Conduct meaningful innovative research to develop real-time solutions to industry problems in shipbuilding, ship repair, advanced manufacturing, supply chain management, and education / training.

In order to establish this ecosystem, VDSP has developed a long-term strategic plan building on the results and current successes of the GoVA grant. To achieve the goals as indicated above, a curriculum and a research strategy have been established with specific building blocks and milestones.

It has been determined that the sustainability and expansion of the shipbuilding, ship repair and advanced manufacturing industry requires a robust and resilient multi-track workforce pipeline that has on and off ramps at various stages of career progression. In support of this the way ahead the VDSP Curriculum Strategy has embraced the following four principles:

- Stackable / Transferable Industry Recognized Credentials
- Multi-Track Curriculum architecture
- Upscales Workforce to meet demands
- Industry Feedback for continuous improvement

The strategy has and will tackle development at all the levels of education and training. As indicated by Figure 7, you will see that going forth there has been implementation and planned implementation K-16. This graph just represents the start and as the program matures with feedback from customers to include but not limited to industry, workforce, and government the curriculum catalog will expand. In addition, VDSP is evaluating metrics to be added at the various stages to capture the successes of the architecture.

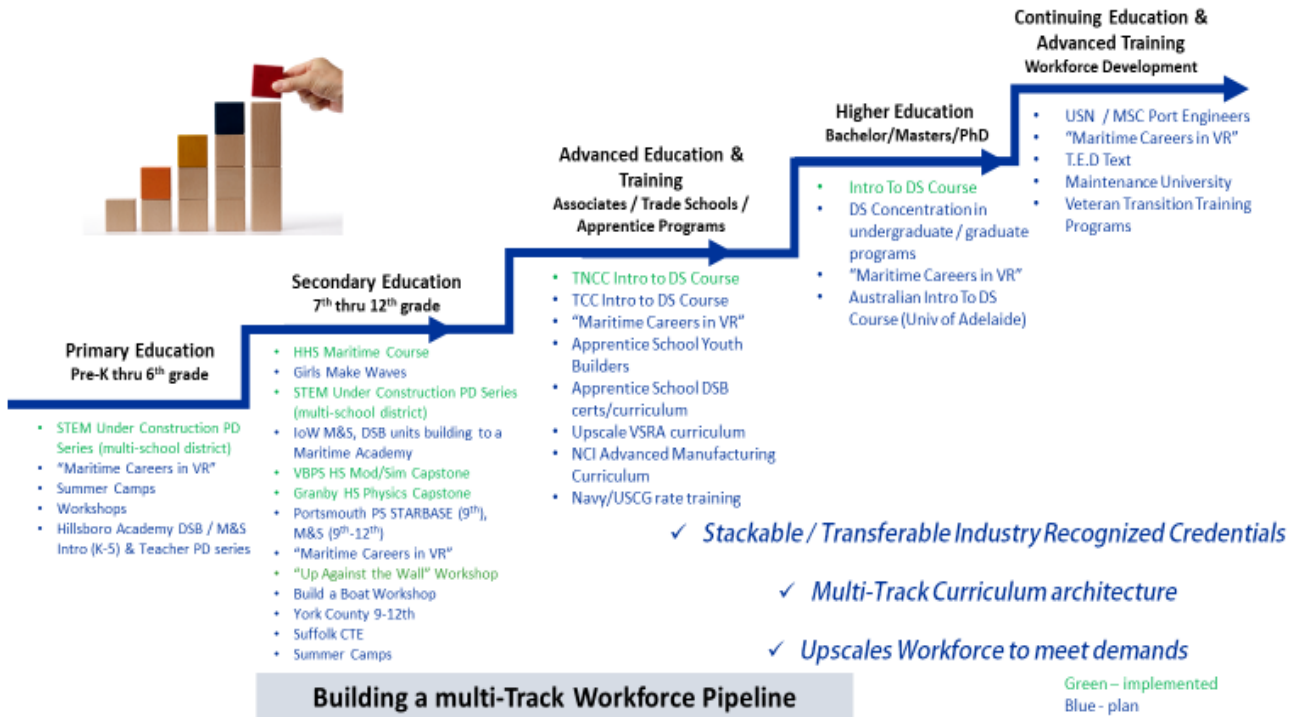


Figure 7. Digital Shipbuilding Curriculum Strategy.

Research and development creates innovation which strengthens systems. The research strategy is in an infancy stage and just emerging. VDSP has taken on a few projects across the shipbuilding, ship repair and advanced manufacturing domain. We hope to expand this to address issues found through-out the life-cycle management of ships, vessels and watercraft. In addition, we hope to expand research into related areas in the maritime domain such as port operations, wind energy, logistics, and etc to take advantage of the common problems in training, education, operations and engineering. In many cases the workforce, equipment, supply chain and other resources are shared between shipbuilding, ship repair and other industries. The opportunity for synergy is apparent.

The following (Figure 8.) represents the four basic tenants of the Maritime Domain and the research strategy moving forward. This graph just represents the start and as the program matures with feedback from customers to include but not limited to industry, workforce, and government the research catalog will expand.

Digital Shipbuilding Research Strategy

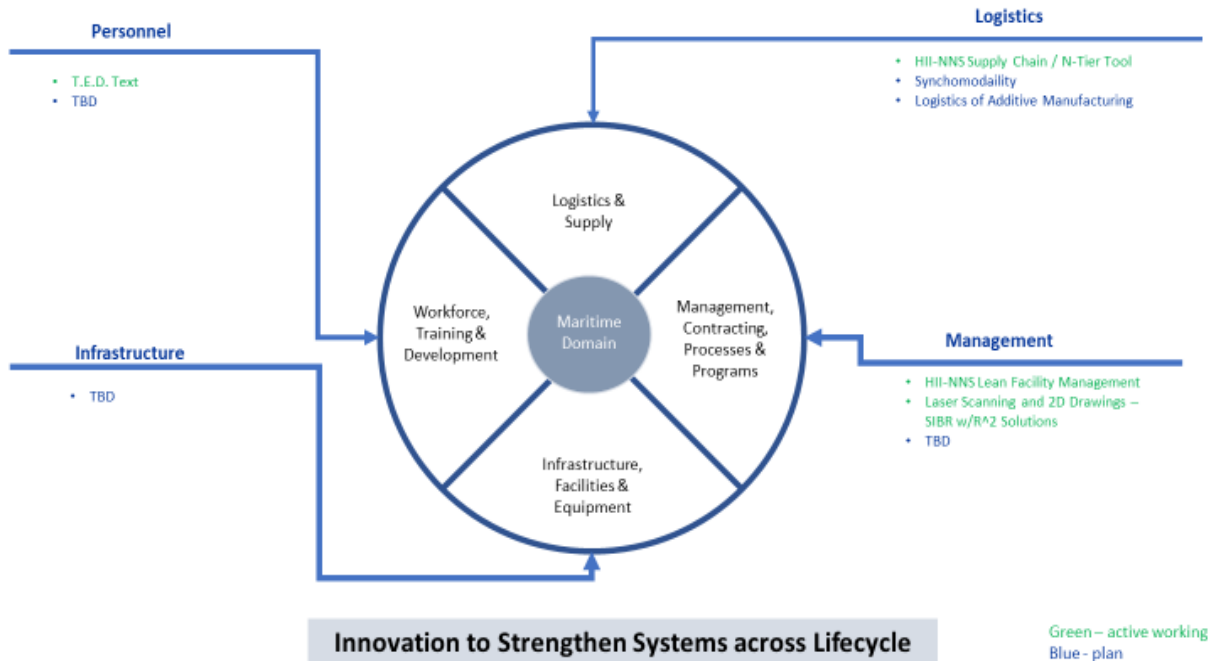


Figure 8. Digital Shipbuilding Research Strategy.

For CY 2020, VDSP has a robust plan that includes outreach, conferences, papers/publications, research and expansion of curriculum. In conclusion, VDSP is just getting started in reinvigorating the industry in preparation of Industry 4.0 Revolution and beyond.

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