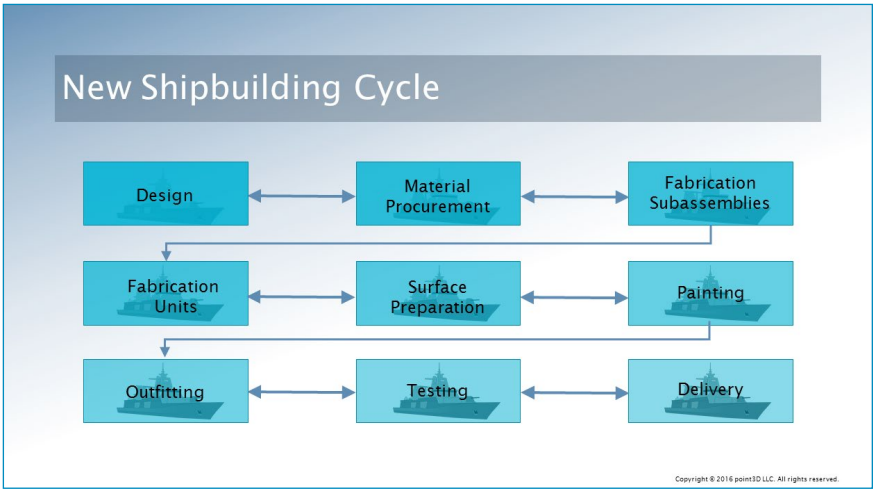
The Digital Thread from Concept to Lifecycle Support in Shipbuilding

The shipbuilding industry in the US is undergoing what some might characterize as a slow digital transformation. Shipbuilding begins with concept design and progresses through functional and detailed design, and on through manufacturing and final commissioning. There is a digital thread of information that begins with the concept models, and in a perfect world, seamlessly carries information forward and back through all stages of manufacturing and lifecycle.

The design and manufacturing environment in shipbuilding today is not fully integrated as the entire shipbuilding process is concerned. This applies both vertically to entities involved in the overall chain (owner, design house, shipyard) and horizontally to the project phases, from early design to delivery.

There are factors somewhat unique to shipbuilding that have worked against the idea of a seamless digital thread, factors such as long program life. The early decisions about which CAD and product lifecycle management (PLM) tool to employ affect manufacturing perhaps 10 years down the road, and lifecycle management programs perhaps 20 years down the road.



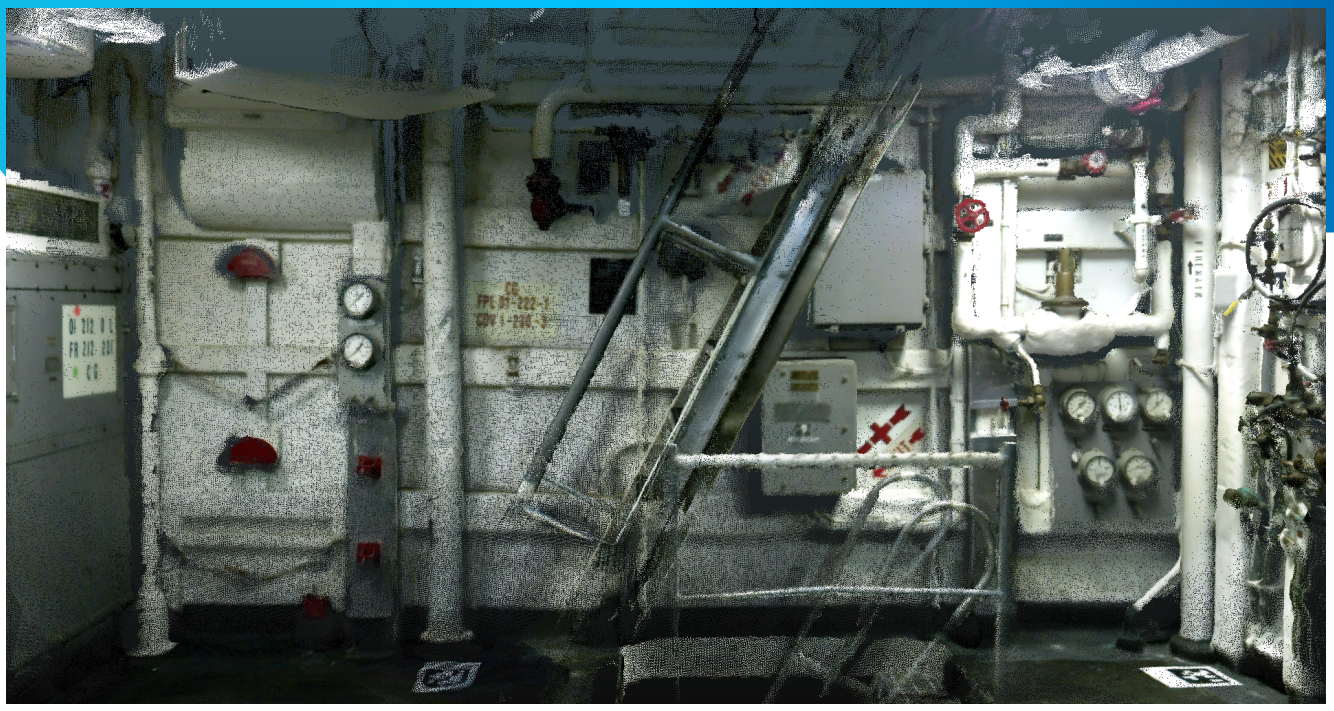
The image above reflects a typical ship building cycle from design through delivery

BY GREGORY B. LAWES

The USS Arleigh Burke (DDG-51), named for Admiral Arleigh A. Burke, USN (1901–1996), and the lead ship of the Arleigh Burke-class guided missile destroyers, is a good example of this timeframe. The ship was originally ordered in April of 1985, laid down by the Bath Iron Works company in December 1988, and launched in September of 1989. Some 27 years later the Navy announced yet another Arleigh Burke-class destroyer, DDG 126, which would be named Louis H. Wilson Jr. in honor of the 26th commandant of the Marine Corps who was also a Medal of Honor recipient.

Much has changed in the information technology world in that 27-year time span, from CAD and PLM systems to 3D capture technologies and 360-imaging. Laser scanning technology was born during this period, and now today we have hand-held capture devices like the DotProduct DPI-8, 3D mapping the spaces of ships designed in the early history of the program.

The Navy and shipbuilding industry, through groups such as NSRP (National



The image above is from a DotProduct DP file captured aboard the USS Samuel B. Roberts (FFG-58) as part of a NAVSEA technology review. The Roberts was also built at BIW during a similar time period.

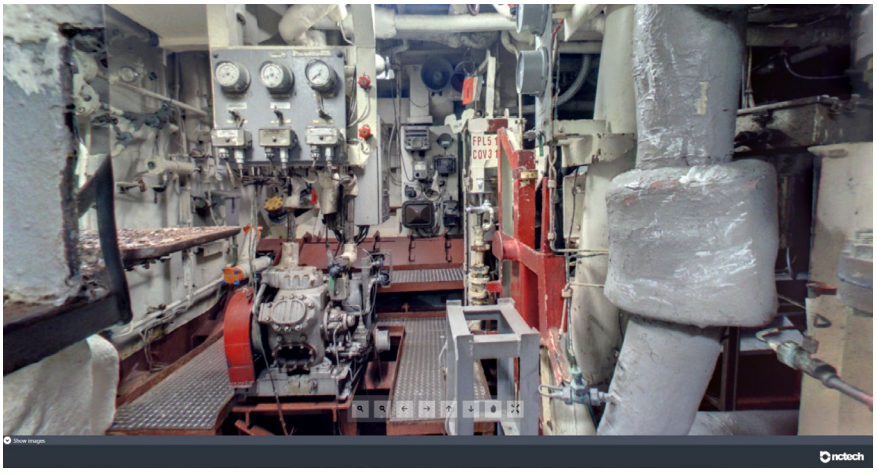
Shipbuilding Research Program) have been evaluating 3D capture technologies for almost as long as the Arleigh Burke-class destroyer program has been delivering ships. The NSRP project "Ship Check Data Capture (2005-380)" had a stated objective to "Develop a process to capture ship check data in digital format, process the digital data, and create and/or validate 3D CAD models for that data cost effectively."

The project objective was to automate the process of capturing ship check data and incorporating the results into the ship's CAD documentation. The team findings on laser scanning technology mirror what other industries were seeing, that laser scanning to collect as-built data has the potential to provide time and cost savings. For the shipbuilding industry, the application was ship checks for retrofit or modification projects. There was promise too, for validation of as-built to the design CAD model. The technology also promised to eliminate frequent visits to the yard to obtain measurements, and capture once what may have taken many trips and personnel resources using traditional ship check methods with tape measures.

> "The scan is the new model, and the image is the new asset."

Ten years have passed since the inception of that NSRP Ship Check Data Capture project, and this industry is seeing a resurgence in 3D capture technology interest. Shipyards are independently, or through NSRP, evaluating and cautiously implementing laser scanning and 360-imaging technology programs. Technology changes in those ten years will help fulfill the promises of yesterday, today.

What has changed is an evolution of both 3D capture and 360-imaging hardware and software. One example is the Z+F IMAGER® 5010X laser scanner which introduced a unique positioning system that works both outdoors and indoors. The system records the current position and orientation of the scanner to support automation in the registration process, driving down the cost of capture and turn-around time.



The image above is a NCTech iSTAR 360-Image camera captured aboard the USS Samuel B. Roberts (FFG-58) in one of the aux engine room spaces also part of a NAVSEA technology review.

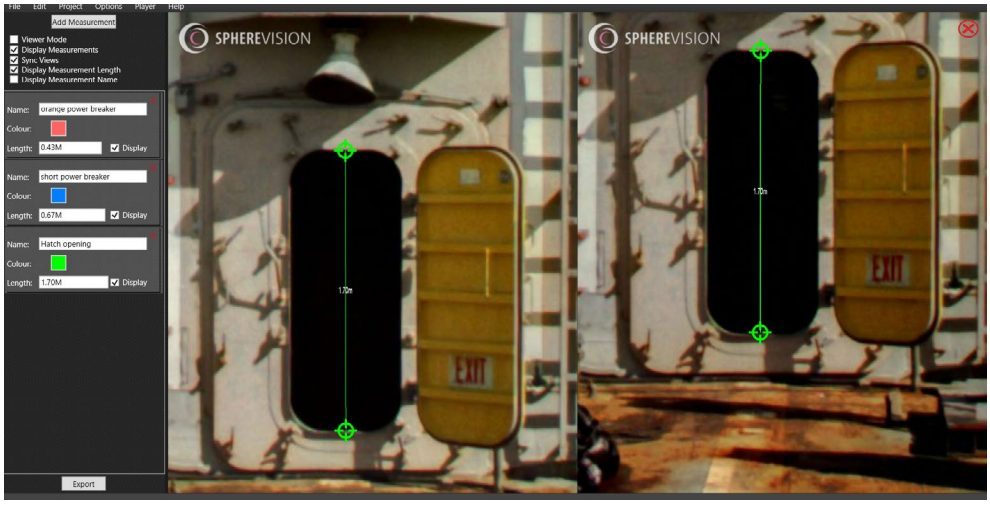
Another example is the DotProduct DPI-8, a hand-held self-contained 3D scanner based on the Android tablet platform. Real-time camera/sensor tracking and instant colored 3D point cloud creation allow a ship-check technician to capture for instance, an engine room compartment space on a ship at port in Pearl Harbor, and email results back to the office for real-time evaluation.

The NCTech iSTAR camera illustrates advances in the 360-imaging world for shipbuilding. With its plug-and-play HDR capture and postprocessing capabilities, a shipyard technician can easily document compartment completion during manufacturing for lifecycle applications, or supplement ship-check work with both 360-visial and measurement capabilities.

Software applications for managing and utilizing laser scan and 360-image data too, have greatly matured. One major challenge working with laser scans is data size, raw files are large, and capturing a complete ship results in enormous datasets. LFM Software's Server application, a mainstay of the industrial and offshore project market, can efficiently handle projects with 10 to 10,000 scans. LFM NetView extends the same data into lifecycle manage applications with easy linking of 3D models and meta-data to the photo realistic laser scan bubbleview data. Other laser scanning tools are allowing scan data to be streamed on tablet and phone devices. Assemble Systems of the BIM domain is integrating the scan model streaming capability with data extraction and management for real-time collaboration and answers. To the ship technician who needs quick answers on board during outfitting, data at the finger tips can be invaluable.

The collective thinking in the ship building world needs to be shaken up with respect to the 3D data capture and 360-imaging applications. Early 3D capture development programs and projects focused on laser scanning to collect as-built data much in the way it was being used in the industrial world. While there are opportunities for as-built collection and model development, much greater potential is possible when employed early in manufacturing in support of quality programs in real-time. Work has begun to show how the complete compartment inspection process, traditionally done with industrial survey tools, can be reduced from days to hours using automated laser scan data collection and automated inspection processes. If a scan based QA program is implemented, the shipyard could be developing a complete digital point cloud model alongside the physical ship. The scan model which

The image is a LFM NetView bubbleview of a ballast compartment, and reflects a lifecycle use.



The two images show 360-imaging capture. The first is an NCTech iSTAR camera in action, and the second features measurement extraction using the SphereVision application.

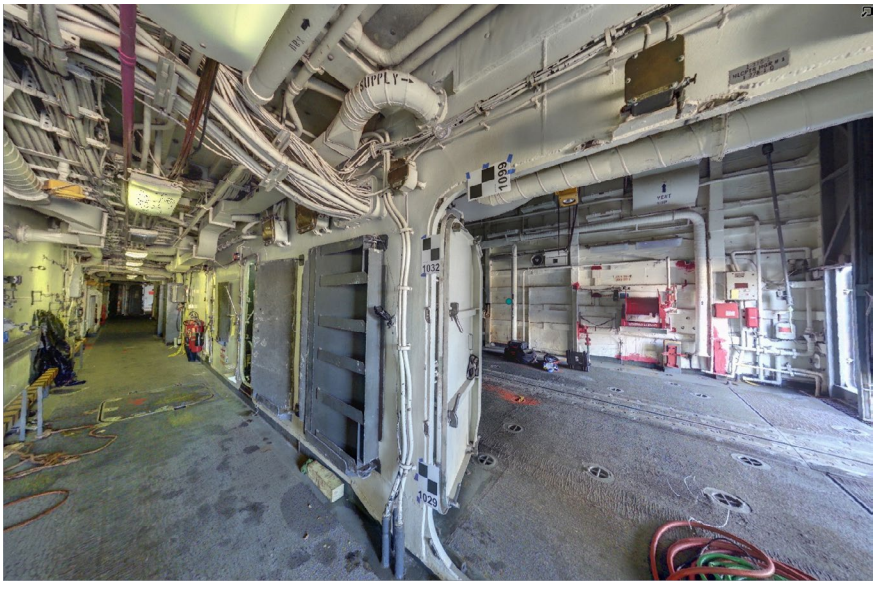
is a by-product of the QA effort, would be immensely valuable for uses such as lifecycle management or program development of future program upgrades.

With the same 3D capture/360-imaging tools, ship check data collection that is accomplished with large teams of people utilizing drawings, tape measurement and digital photos, can be reduced to a small team capturing far more data in a fraction of the time. The AVEVA E3D application for marine, which integrates outfitting and hull information with scan data, can bring hand-held scans directly into the model to begin retrofit with ease.

Accompanying the technology change, there must also be a rethinking of how 3D capture and 360-imaging information fit into the digital thread. The stated objective of NSRP project, "In Service Ship Re-Documentation & Configuration Management (2015-408)", is to *"Build and test a digital process that will provide cost effective Product Life Cycle Support for in-service ships. This digital process will replace existing manual processes currently performed during ship checks and provide an as-configured 3D Product Model for ship in-service maintenance."* The intent was to collect scan data for the purpose of building an as-configured 3D product model. Scan data in this instance, is just a tool to develop the as-built model.

Remodeling is a process that has been first implemented in the industrial market, and somewhat abandoned in favor of a work process that utilizes the point clouds directly. The point cloud provides existing data reference for spatial purposes. Linking to point clouds also provides the tie to meta-data and balance of digital project information. Working with point clouds directly is favored as it provides huge cost saving over remodeling and provides faster access to data. Data from a ship check in Pearl Harbor can be on a designer's desktop in the home office for immediate use, rather than waiting for days for re-modeled information.

Central to the new thinking is the scan is the new model, and the image is the new asset. The product model must be viewed as a hybrid of information of

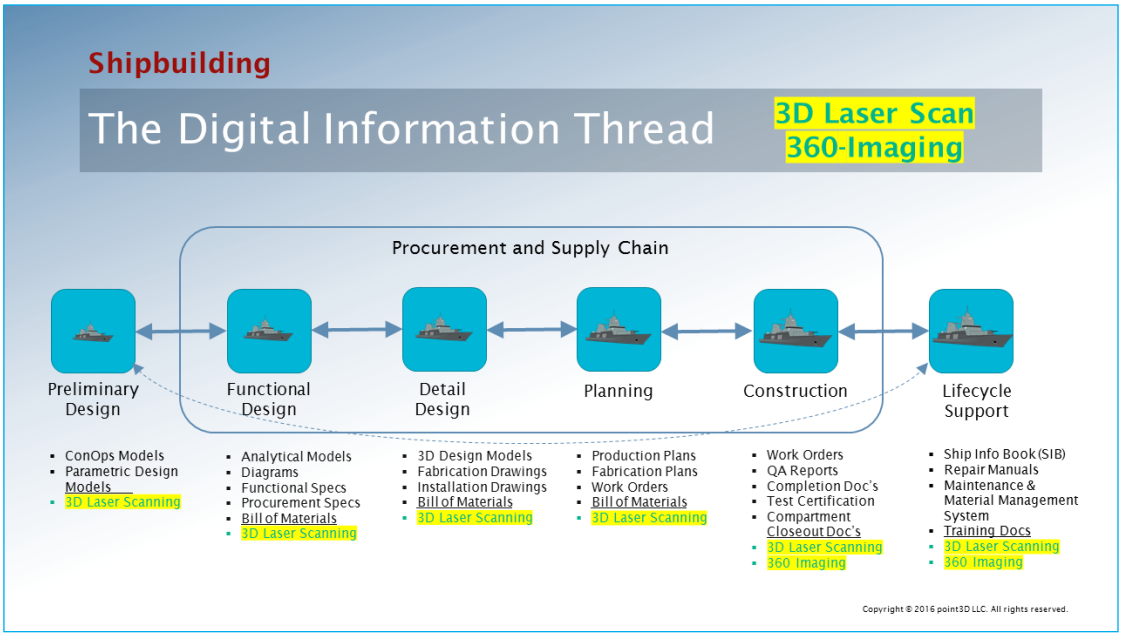


The last image is a bubbleview of USS Samuel B. Roberts (FFG-58) Hanger deck, captured and processed with a Z+F scanner using automation assisted processing. It is ready to support ship lifecycle applications.

different types and possible sources. The 3D model, historically developed for a *single* purpose, can be extended to support additional purposes from design to manufacturing production to lifecycle use. The overall product model can now be viewed as a composite of 3D geometry model and meta data, layered with the scan point model. In this new digital thread, the asset (the ship) can be delivered with an accompanying hybrid model comprised of 3D CAD, scan, image and digital data. This hybrid model set can be groomed to extract from design and manufacturing data, a new fit-for-purpose model for lifecycle. As changes and retrofits occur, new scans and design models are layered on to the lifecycle model already in place. Digital completely replaces paper.

Point3D is working with several ship builders who are adopting this new thinking. A wholesale change mid-stream is not feasible, but incremental changes and improvement are allowing these customers to build on small successes now to effect greater changes in the future. ■

Gregory B. Lawes spent 20+ years with an international, multi-discipline engineering and construction firm where he had a pioneering role in the laser scanning and 3D data capture fields. He owns point3D, a technology firm providing 3D data capture and 360 imaging solutions from industry leaders AVEVA/LFM Software, Z+F, Dot Product, NCTech Imaging, Arithmetica, and now Assemble Systems.



This image reflects the digital thread in the ship building cycle with 3D capture and 360-imaging activities shown where use is appropriate.