DASSAULT SYSTEMES

MARINE & OFFSHORE

MODERNIZING SHIP PRODUCTION PLANNING TO SURVIVE

Whitepaper

EXECUTIVE SUMMARY

The shipbuilding sector has always been tumultuous. More than ever, success in all of shipbuilding is survival of the fittest.

From initial design through fully built ships, technology has changed the face, and build, of marine vessels for the past 30 years and is a key driver in shipbuilding optimization. The far-reaching impact of ship design and construction software on the marine industry cannot be overstated, especially in an era of increasing regulation, bigger, more complex ships, and razor-thin margins. Shipbuilding used to start and end with oceans of paper, millions of paper drawings and huge pattern sheets laid out on the floors of enormous lofting rooms. In the 70s came calculations run on expensive mainframes, just as the industry was transitioning from slide rulers to calculators. The 80s brought the PC revolution and affordable computer-aided design (CAD) to the desktop. Naval architecture hasn't been the same since. Nor, actually, has the collection of related processes involved in the design and construction of ships – from the selection of materials and parts, to the supply chain, to purchasing, scheduling, and every stage of manufacturing.

Today, shipyards are in a literal fight to survive, as it is generally agreed that shipbuilding capacity must be pruned to ensure the long-term health of the industry as a whole. While trimming shipbuilding capacity is a political conundrum in some regions, the basic market force of supply and demand has a habit of making these decisions. Bottom line: shipbuilding companies intent on a long healthy future need to invest now in efficient production planning, the very foundation for efficient construction, as well as new products and automation systems that will produce efficiency gains for the coming generation.

Key ways to improve manufacturing efficiency include:

- **Increased automation in shipyard activities**
- **Design for manufacturing to more closely wed the two processes for truly optimized manufacturing**
- **Implementation of lean manufacturing concepts, relying not simply on machines rather using the collective knowledge of the shipyard team to incrementally improve shipyard efficiency.**

SETTING THE STAGE

As a manufacturing sector, global shipbuilding historically is difficult to pigeonhole as the practice of designing and manufacturing ships is as diverse as the products it produces. Yet, one of the greatest challenges to shipbuilders is the below-cost shipbuilding contracts due to overcapacity in shipbuilding, a huge order back log, speculative orders and defaults. This puts great pressure on shipbuilders and sub-suppliers alike, with resultant influence on quality and service.

Ship orders by tonnage is the holy grail of industry health, and a quick look at statistics from 2002 to 2014 reveal a raucous market with wild swings. In looking at new orders for ships in the 100 gross tonnage (GT) and over sector, new orders worldwide were 28.8 million GT in 2002, spiking to 169.9 million GT in 2007, plummeting back to 33.6 million GT in 2009 and rebounding to 82.5 million GT in 2014[1]. General sentiment for the near-term is predominately negative as depressed global energy prices coupled with weak growth in China means that fewer raw materials and fewer finished products will be transported.

[(1)] IHS World Shipbuilding Statistics

That said the very nature of shipping and shipbuilding is a conundrum; built equal parts on market reality, market speculation and politics. In looking at the ship construction order book and ship delivery statistics over the past three decades, it is a rollercoaster ride of sharp peaks and valleys. But when examining the evolution of World Seaborne Trade from 1986 through 2015 it is a picture of slow, steady and continual growth[2].

Part of the disconnect from traditional supply and demand models is simply explained: as a general rule commercial ships are becoming progressively larger and increasingly complex structural behemoths. While the quantity of goods transported steadily increases, the number of ships grows progressively smaller. Nowhere is this more evident than the containership sector. The industry is scheduled to welcome in 2018 its first 20,000 TEU (twenty foot equivalent unit) ship – a leviathan so big that few ports in the world can service it. For container shippers, the motivation for bigger ships is a simple question of economics. The cost of moving a box from Hong Kong to New York in 1973 was about US$5,800 per box, today it is about US$2,500 per box[3].

The precipitous increase in size and ever-increasing layers of strict new international environmental regulations – new rules mandating drastic reductions in ship emissions, and a ship's overall impact on the environment – are challenging those who design, production plan and produce ships like never before.

WHAT IS SHIPBUIDING OPTIMIZATION

Shipbuilding optimization is a broad topic, involving every aspect of the process of building ships – design, material procurement, production planning and workforce management, production facility design, all the way through the work in the shops and on the waterfront to testing, delivery and trials. True optimization requires ensuring that not only is each of those elements as efficient as possible, but just as importantly, that the interfaces among the elements is carefully managed to ensure that the end-to-end shipbuilding process is as efficient as possible. It is developing a design that best optimizes the performance of the vessel with the cost of construction. That typically involves integrating design for production elements into the design from the on-set. The greatest complication in this is identifying the production elements that truly drive cost and optimizing those parameters.

While shipbuilding is an ancient industry, modern shipbuilding design and construction is still somewhat in its formative years, as the most recent step changes over the past three decades have been driven by computerization, the constant evolution of software solutions, and, increasingly, the availability and mobility of mass amounts of data and information. It is an industry still rife with small- and medium-sized operations, but there is a decided trend toward fewer and bigger: fewer and bigger shipyards, particularly in the Far East which has come to dominate the commercial shipbuilding sector. Today's ships and platforms— in both commercial and military sectors – are becoming larger and more sophisticated, with millions of parts, multiple disciplines, hundreds of workers, numerous partners and suppliers, multiple sites. The time from initial plan to ship delivery is measured in years, during which technology can change, sometimes dramatically. Today, more than ever, the ability for shipyards to optimize operations, from design to production planning to manufacturing, will determine not only a shipyard's profitability, but its survival.

To be fair, many shipbuilders do a good job of optimizing their in-yard production within the limitations of their facilities, infrastructure and workforce.

Other than additional capital investment, the best way for shipbuilders to improve their production processes is to more closely integrate production planning and fabrication practices with the design process beginning with initial concept work and continuing through production engineering and detail design.

[2] Clarksons Research Shipping Review and Outlook

[3] The Shipping Survival Guide in Compass #8 2015 http://compassmag.3ds.com/8#/8/Industry/THE-SHIPPING-SURVIVAL-GUIDE

This is difficult for many yards because their customers define major elements of the design before they select a shipbuilder. In some cases, the shipbuilder may lack the in-house engineering resources to support the entire design cycle from concept to production. Critical is finding a partner to help work through the entire design process from concept development to working drawings, helping the shipyard to bridge those gaps.

Current solutions enable the designer to efficiently generate products that optimize production to shipyard production practices and facilities. They are useful, but less effective in the early stages of design where cost, capabilities and requirements have to be balanced. This is where man and machine work hand-in-hand, as critical to the process is the experience of the design team, its understanding of individual shipyard practices and its experience with carrying design definition through the full production cycle. As anyone involved in the ship design and production value chain will attest, real cost control and savings comes at the outset of each project, with production planning solutions, the very foundation to efficient project management and completion.

CHALLENGES ABOUND

Unlike manufacturing operations in other sectors, the global shipbuilding market faces a number of unique challenges to establishing and maintaining design, production planning, and production practices that are commonly associated with efficient, modern manufacturing, namely high levels of automation, repeatability of design and construction, and long-term stability of markets to foster long-term planning and growth strategies. The assets that it produces can range widely in price, from tens of millions for a simple bulk carrier to many billions of dollars for advanced naval ships and offshore floating production systems. Prices for the exact same ship, particularly in the commercial shipbuilding market, can vary wildly in price pending prevailing market and world economic conditions. Fluctuating demand levels in both commercial and military markets makes major investments in existing optimization processes difficult. Looking ahead, here are some challenges the shipbuilding industry faces in its quest to deliver a more optimized, efficient and cost effective process:

- Scale & Volume

The most notable challenges to making the shipbuilding process a more optimized, automated manufacturing endeavor relate economies of scale and the deployment of capital. Road, rail and aviation manufacturing most often involve dozens of units built to a single design, subject to repetitive manufacturing processes. This situation more easily lends to the deployment of capital to automation improvements, and the recoupment can be calculated over a sustained sales volume. Though shipbuilding does possess more work content per unit, a contract will be for a small number of vessels, or just one. Each vessel will typically have a unique customer with unique design attributes. Furthermore, each shipyard will build different types of ships on the same production lines, requiring unique set up and processing procedures for each vessel. That said, smaller ship builders have learned to create markets for repeatable designs, and modular design offers an opportunity to adopt unique customer requirements around a common set of configurations.

- Big Data

Advances in the management of information cuts both ways, in that it provides both optimization opportunities and challenges. "Big Data" is a buzzword in maritime these days, a buzzword usually used in regards to how ships and ship managers send, receive and manage increasing amounts of data from ship to shore in the name of increasingly efficient, cost-effective operations. But "Big Data" certainly has ramifications to the ship design and production sector as well, as increasingly major shipbuilding projects can includes hundreds if not thousands of participants scattered globally, with increasing demand to share information seamlessly, efficiently, in real-time.

As one major shipbuilder explained, the ability to process data has become both the greatest tool and the biggest challenge, explaining this complexity simply. 'Decades ago, if we wanted to have a system on a ship to fight a fire, we would have a pump and a hose and a sailor. Today, we still have the pump, but instead of a hose we'll have sprinklers. Instead of the sailor we have 2000 electrical signals coming in from around the ship to a processor to let a computer know whether or not to turn on the fire suppression system'[4]. Increased information onboard the ship is an opportunity to enhance that asset's life-long operations, but it creates challenges for ship designer and builder in integrating that type of system.

[4] Mike PETTERS, President and CEO, Huntington Ingalls Industries, in Maritime Reporter & Engineering News, November 2015

- Workforce

The employment base of the traditional shipbuilder is best described as aging, and it is easy to argue that 'attracting and retaining a quality workforce' is a top challenge to every CEO in the sector. Today many shipbuilders are faced with a bulk of its manpower and a wealth of shipbuilding knowledge that has been generations in the making sailing toward retirement, and there is no clear line of succession. The on-line, unplugged millennial generation is much more geared toward a life in Silicon Valley than one in a hardhat fitting a pipe or welding steel. From the shipbuilder's perspective, it takes many years and hundreds of thousands of dollars to train someone proficient in the shipbuilding craft. When this cyclical market inevitably turns south, reduction in headcount is often the first and surest means to weather the fiscal storm, but lost with the lay-offs are a collective group of manufacturing talent that is displaced, needing to find a means to pay rent, buy food and support family. More often than not workers lost find new jobs in other industrial sectors, never to return.

Shipbuilders that are progressive in optimizing their operations are seeking means to capture existing knowledge in a form and function that can be updated, enhanced and reused for a generation to come. They are melding not only generations of accrued experience, but company process and procedure that can be melded across its entire design and production planning structure, giving a leg-up on competition that opts to 'start from scratch' out the outset of each project.

Increased knowledge accrual and sharing across a diverse, multi-site operation is a decided advantage in bringing projects from conception to fruition more quickly and cost-effectively.

- Changes in Requirements

As the shipbuilding process often takes years, step changes in technology, and changes in markets themselves can make changes in vessel design necessary. In any manufacturing process, the later the changes come in the design process, the more costly. That said, the magnitude of cost to change a ship design is completely dependent on the project, the players, the shipyard and the involved scope of change, so generalities would be misleading. Several measures are commonly used to discuss the cost of change based on the relative maturity of the construction effort itself. For every hour it takes to perform off hull work, it may take 3-4 hours to do the same effort after float off, and 8-10 hours once the ship has been delivered. This varies by shipyard and project, but is indicative of the positive influence advanced planning and reduced design/build concurrency has on production. With design changes being a huge cost driver in ship construction programs, the ability of a solution to incorporate changes, maintain configuration control of the changes and optimize the impacted areas is an area of anticipated improvement over the next 5-10 years.

That planning includes the ability to automate the manufacturing assembly definition, work preparation and process planning. Full integration between design and manufacturing provides the ability to start the manufacturing process very early in ship design.

It includes the generation of the digital information and directly interfacing with machines and robots to drive nesting and cutting. It also allows planners to easily identify and propagate changes between design and manufacturing.

WHAT'S NEXT

As the technology improves, ship designers and builders alike have been better able to support optimized shipyard processes. There has been a marked transition in the last 20 years where design, simulation, production planning, and manufacturing solutions are better able to present data directly out of 3D models in formats that support a production line type approach. Early in that transition, CAD tools were used to more efficiently generate drawings that were in the format of legacy 2D products previously drawn by hand using light tables and other means to generate an interference free design. Today, for clear market sector leaders, the process is evolving from stand alone operations into a comprehensive and integrated approach on a single collaborative business platform which seamlessly melds operations and business function for a project, cradle to grave.

3D Modeling applications eliminated the need for overlaying 2D drawings to check for interferences, but construction drawings were still using the old formats and shipyards were breaking these drawings down after extraction from the models to develop construction work packages to be used on the shop floor. The industry has arrived at a point where manufacturing needs and manufacturability are driving the design and the seamless integration between 3D Modeling and production planning applications now makes it possible for production workers to use the work instructions directly generated from the design information without additional work.

For many shipbuilders, teaming arrangements with established optimization partners have helped to advance the process, and ship design, production planning and manufacturing processes have become more integrated. Specifically, the flow of information between the processes has improved significantly over the past 10 years, including ship design integration with production team member input, ship design model information integration with ship planning systems, and ship design model information integration with steel cutting and welding machines.

While the process of shipbuilding optimization has come a long way, there are more efficiencies to be gained. There have been major improvements in automated optimization of hull forms, ship hull structure, and system routing. Optimization tools allow the exploration of thousands of permutations of variables to find an optimized design. Optimizing hull lines to achieve the best performance over an operational profile using Computational Fluid Dynamics (CFD) Codes is a mature capability. Integrating that optimization to the hull structural design is also achievable and can consider the production costs associated with the manufacturing of that hull structure. The Holy Grail is to optimize multiple design elements concurrently at a construction / production driven cost level while still meeting engineering, regulatory body and client requirements.

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