

INNOVATIVE METHODS FOR LEVERAGING A 3D PRODUCT MODEL

M Waldie, D Larkins, D Morais SSI, Canada
N Danese, NDAR, France

SUMMARY

By utilizing a 3D product model as a single source of truth, both for subsequent design phases but also for interdepartmental communication, organizations can reduce errors and cost by maintaining information. The information preserved is not only the obvious geometric and attribute data, but also the design intent that is incrementally built into the product model. If neutral formats and platformization are used, a company can further derive the benefits of becoming what is known as a Model Based Enterprise. This paper will show the advantages gained by various companies that have utilized this approach by harnessing the Marine Information Model from SSI's ShipConstructor software which sits on top of the popular Autodesk platform.

NOMENCLATURE

<i>BOM</i>	Bill of Materials
<i>CAD</i>	Computer Assisted Design
<i>CAM</i>	Computer Assisted Manufacturing
<i>DWF</i>	Autodesk Design Web Format
<i>MIM</i>	Marine Information Model
<i>MBD</i>	Model Based Definition
<i>MBE</i>	Model Based Enterprise
<i>SSI:</i>	ShipConstructor Software Inc.

1. INTRODUCTION

At one time, ship design and engineering were more linear processes with work proceeding in a step by step fashion through various stages. Different workers with different skillsets performed isolated activities using specialized tools. However, in recent years due to time and cost pressures along with advancements in software capabilities, there has been growing usage of concurrent work methods and an increasing recognition that designers, naval architects and engineers along with associated sub-disciplines should work together to achieve optimum results.

But despite this growing overlap, there is still much separation between individuals, departments and tools. There are many products and have been many papers that espouse the need for a continuation of the product model between each phase of design. However for activities such as visualization, engineering review, owner / operator review, analysis and more within those phases, the direct exploitation of a 3D product model is still disjointed and fragmented. The problem is often related to how information is shared and utilized.

Even if there is a single source of truth for all data (along with its context), in order to harness the efficiency and quality gains that should logically flow, the details regarding communication of information from/to a 3D product model are important. Without a smooth method of communication, in reality, information will become

out of sync and inaccurate. Quality will suffer and work will be inefficient.

2. HOLISTIC APPROACH

These problems become particularly noticeable when one examines the work methods that the most sophisticated naval architects and shipyards are adopting today.

An example of this trend is the naval architecture and engineering firm Vripack from the Netherlands. When describing its processes, it talks about adopting what it calls a "holistic approach". For instance, in a recent paper for the 23rd International HISWA Symposium on Yacht Design and Construction, the company pointed out the critical interrelationship between design, naval architecture and engineering.[1] One of the key slogans of the paper was an almost word for word echo of a prominent point of another recent paper delivered at ICCAS by British shipbuilder Mustang Marine (now Mainstay Marine Solutions) that was related to the overlap of production and engineering.[2] Both papers said to adopt a "right the first time" or "first time right" approach since the wrong decisions at earlier parts of the process ripple through subsequent stages and are much more costly and time consuming to fix later on.

The fact that this holistic approach is the optimal methodology can be seen even at the very beginning of a project. Starting from the first few weeks of Concept Design, decisions are made regarding main dimensions, building materials, location of the engine room, propulsion concept, shape of the hull, and internal volume versus the length etc. Each of these decisions affects cost and performance and it is a delicate balance to make the right trade-offs. Thus, during the process of making these decisions it is important to have accurate information to check feasibility of certain approaches so various software tools are used to perform calculations and model various ideas. This back and forth interplay between different shipbuilding disciplines ideally continues throughout the entire project so that all stakeholders can give input to each other and work together for optimum results.

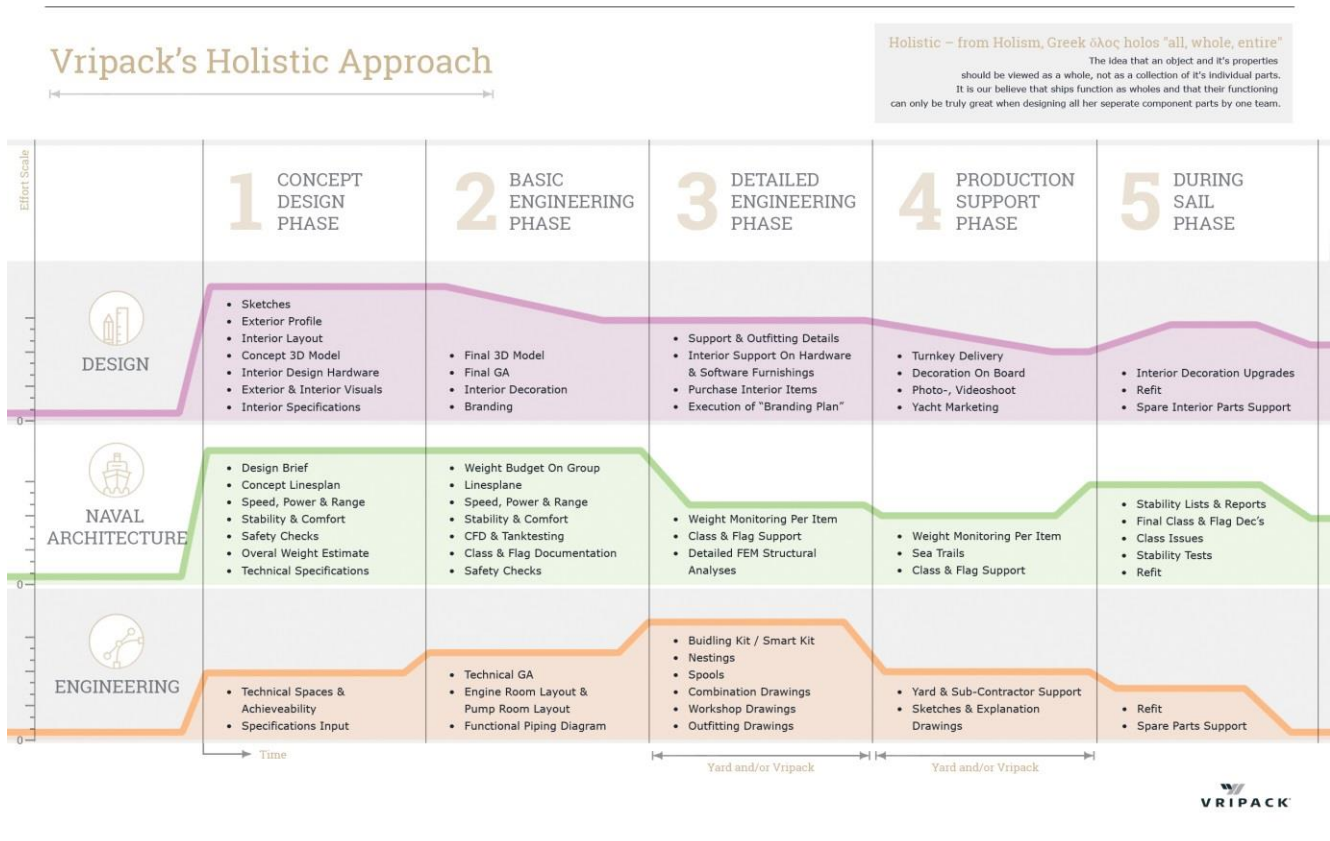


Fig. 1, Concurrent Engineering

For instance, at project commencement, pure concept designers may be mainly concerned with the overall looks. However, very early on they should be getting input from the naval engineer in regards to factors such as weight and centre of gravity. Of course, you also have to consider engineering factors such as technical specifications and not long after that, as concept design fades into the basic design/engineering phase, you should also start thinking about more engineering factors such as where some primary systems might go.

The overlapping relationship between each of these disciplines has been conveniently highlighted in an infographic from Vripack that is displayed in Fig. 1.

The point of the graphic is to show how different disciplines work together concurrently and thus need to communicate information with each other. Indeed, if anything, the chart simplifies things because to create a true view of the actual interactions between departments, processes, people and tools, both within and between each of the traditional phases described, might blur the lines so much that there might not even be distinguishable phases anymore. There is so much information sharing that is needed.

3. TYPICAL COMMUNICATION METHODS

If we look at how these transfers of data are accomplished, you will find that often in organizations, inefficient methods are used.

3.1 INEFFICIENT METHOD: DRAWINGS

The traditional method of choice has always been some kind of drawing.

But these days, really, what is a drawing? Too often organizations act as if a drawing is a source of truth. This is wrong. Not only is a drawing not a source of truth, it is not truly a source at all. For anyone using a product model (and these days, at a certain point, for any sizeable project, a vessel *will* be put into a product model), a drawing is actually just a representation of a collection of information regarding a specific portion of the product model, usually for a specific purpose. For instance, an assembly drawing brings together standards, libraries, product hierarchies, part, spool or assembly attribute data relationships and other details. This provides enough information for production workers to perform certain tasks. Other drawings bring together other collections of information about the underlying product model for other purposes. However, note that no matter how much information a drawing contains, it only contains a tiny

fraction of all the data contained in the vessel's product model.

This point has practical consequences. Drawings are not going anywhere; they are great for many tasks, but they are not the right representation for many others. They are usually only ideal for the primary tasks for which they were originally created, not for the various other purposes that drawing-centric organizations use them for. The information on many drawings is either insufficient or not enough.

One might ask why the shipbuilding industry uses drawings so much and one of the answers has to do with interoperability challenges when dealing with different software used for different purposes or by different companies or organizations. Now sometimes this is a valid point and until there is a greater amount of standardization, drawings will be a natural method of communication with Class Societies and other organizations. However, a less significant, though perhaps more important reason in reality is that for many companies, drawings are simply what they are used to. They know how to create, use, read, transmit and interact with drawings and do not believe it worth the efficiency and quality gains to do anything otherwise.

3.1 (a) Loss of Information during Copying

These organizations should consider more carefully the downsides of this approach. Every time you have to transfer information from one format to another, it takes more time and also inevitably leads to errors during the transmission process. When anything changes, someone has to remember to correctly update all the drawings and identify exactly what has been altered. With the thousands upon thousands of drawings generated during the ship design and building process, this is an extremely difficult undertaking and the source of an enormous amount of errors.

3.1 (b) Loss of Design Intent

That may be obvious but a further reflection upon the issue shows an even deeper concern. When you transfer information to a static drawing, often the design intent is lost, thus increasing the chance of later errors yet again.

A non-shipbuilding example, may perhaps make this point more clear. Consider Microsoft Word and the usage of various Style types, e.g. Heading 1, Heading 2, Heading 3 and Normal. The usage of these styles indicates the intent of the author, i.e. certain words do not just randomly change appearance; they are headings to group information and they are organized in a hierarchical fashion.

Now consider the case where Word is used to create a software manual. At the stage where the manual is to be provided to another department for the creation of help

files, a PDF file is saved and sent. This secondary team has enough information to create the help file but if they wish to convert, modify or otherwise reuse the information for anything other than a direct copy they need to infer the intent of a particular piece of writing from the visual presentation of that text. The intent of the original author has been lost in translation.

On the other hand, if the help team was exploiting the Microsoft Word document itself, you would be able to simply look at the Navigation pane and go to the relevant section with full knowledge of how everything fit into the hierarchical outline of the manual.

The key point is that the source of the information incorporates relationships that are easily discoverable by the user and can be leveraged to provide other functionality (e.g. in this case, things such as an auto-generated table of contents if one desired.)

That is a simple illustration using a simple program with little in the way of relationships. But now consider shipbuilding which is one of the most complex construction fields that exist, with part counts and interrelationships that dwarf even aircraft production. There are massive amounts of complicated relationships that are found in a product model. Hopefully a drawing makes the relevant relationships clear to a particular user but real world experience at shipyards shows that this is by no means always a warranted assumption. Inevitably there are errors and inefficiencies incurred.

3.2 INEFFICIENT METHOD: EXCEL

Another inefficient method of communication is overly relying on Microsoft Excel. Excel is a great spreadsheet tool that has excellent data manipulation capabilities for analysis but if these tables are not associatively linked in a bi-directional manner with an underlying product model, there will be a disconnection which leads to unnecessary duplication and errors.

3.3 INEFFICIENT METHOD: SUPPLEMENTARY 3D VIEWERS

Another problem with overly relying on Excel is that tables full of text are not always intuitive. Ship design and ship building are spatial by nature so visualizations are important for more intuitive understanding. Often organizations use supplementary 3D viewers for this purpose but once again, unfortunately, not enough information is shared and often creating these 3D views is quite cumbersome.

4. MODEL BASED ENTERPRISE

More and more, ship designers and builders are realising that the ideal method of communication is to work as much as possible by directly leveraging a unified 3D product model with effective methods of communicating

information. Similar to Building Information Modelling (BIM) in the architecture, engineering and construction industry, SSI calls this approach Marine Information Modelling (MIM) but it has been called other names in other contexts. The US Department of Defense, via the National Institute of Standards and Technology has been working for quite some time on a concept that they call creating a Model Based Environment (MBE). The focus is on sharing a common 3D product definition throughout the enterprise and life of the product.

SSI strongly endorses this concept, but to be clear, a few caveats are in order. First of all, this paper is not proposing that all tools within and across phases of the ship design and construction process come from a single vendor. Nevertheless, SSI feels strongly that information in the product model (or more specifically in the source of truth for that info) should be leveraged directly without conversion, or translation whenever feasible.

Secondly, this paper is also not arguing that a single monolithic data store should be the source of truth for all information. What this paper is proposing is that there should only be one source of truth for any particular piece of data.

4.1 WAYS TO USE A PRODUCT MODEL EFFECTIVELY

With those caveats out of the way, we can describe what is necessary to effectively leverage the power of a product model. But before doing that, it should be noted that this approach cannot be implemented with any and every product modelling software. The primary requirement of any product model to be used in this type of approach is that all information is available (in context) to other applications and processes as required. In general, this requirement can be satisfied in different ways but two ways in particular are worth mentioning: neutral standards and platformization.

4.1 (a) Neutral Standards

Looking at neutral standards first, it should be noted that it is not sufficient to simply export to a suitable standard as this disconnects the information from the product model and can lead to the challenges described earlier in this paper. You may be communicating information but in a disjointed, non-associative way that will hinder your ability to manage changes.

A way to get around this is to ensure that the native formats used by all applications communicating with the product model are de facto standards themselves.

In the case of SSI's ShipConstructor application, this is the case because ShipConstructor is based on Autodesk DWG and Microsoft SQL. It may be argued that officially, DWG and SQL are not 'neutral' standards, but for all practical purposes, they have become ubiquitous

enough to satisfy this requirement for a standard fairly well in the real world.

4.1 (a) Platformization

As a side note, if we move a step beyond the use of standards used by products, we can also talk about the development of platforms. This trend, inelegantly referred to as platformization, opens the door for the type of direct use of product models being proposed earlier in this paper.

But unfortunately, this is not a trend that is as common in the shipbuilding industry at the moment as it is in other industries. SSI would like it to be which is why SSI has developed a product called SSI EnterprisePlatform in order to platformize the ShipConstructor Marine Information Model. This paper will not cover the details of the EnterprisePlatform as it has been well documented in an earlier paper.[3] We will instead focus on the first way to use a product model effectively, standardization.

5. CASE STUDIES USING DE FACTO STANDARDS

Let us look at some examples of de facto standardization in practice.

5.1 PRODUCTION SUPPORT

Let us first look at how using the de facto Autodesk standard facilitates communications. In both Detail Engineering and Production Engineering, organizations can use a program called Autodesk Navisworks as a virtual reality collaboration tool. Navisworks is an Autodesk product, and therefore, part of SSI's overall Autodesk based shipbuilding software solution. It is part of the solution because SSI's ShipConstructor software itself is built on top of an Autodesk platform and an AutoCAD foundation.

Navisworks is an ideal tool for interference checking. It is used for walkthroughs and analysis of design for production. In an SSI solution it is also typically the primary tool for collaboration between naval architects, shipyards and other subcontractors because it allows everyone to see what is going on.

All of these strengths are delivered directly from the ShipConstructor Marine Information Model. While a Navisworks model can be disconnected from the ShipConstructor product model, it can also be (and is typically) a real time dynamic view of the product model, complete with attributes and intelligence.

Navisworks is a common integrator of model information from other sources as well, including other computer programs, and even point clouds and as-built scans. You can also process data in Autodesk ReCap and then use

Navisworks to do the overlay between point cloud and model. The key to making all this communication work is the de facto Autodesk standard.

5.2 COMMUNICATION WITH OWNERS

Another example further illuminates this concept. Navisworks may be a visualization tool for virtual reality but if one wants photo realistic renders and even animations, the tool that SSI's clients typically use is Autodesk 3D Studio Max, which, being a related Autodesk based product, SSI treats as part of its scalable software solution. As part of the integrated solution, it seamlessly leverages ShipConstructor's product model to create movie quality images. Indeed, 3ds Max, as it is known, is the tool of choice for renderings in numerous Hollywood blockbusters such as the Harry Potter and X-Men series.

When dealing with buyers of super yachts at any stage of the project, one can understand why the presentation of photo-realistic images is beneficial in the luxury market. However, SSI has also been informed by clients such as Gibbs & Cox that the same is true for a number of its US Naval projects as well. The usage of Autodesk 3ds Max to efficiently produce these images by taking information from the ShipConstructor Marine Information Model is another example of how de facto standards (in this case, Autodesk) make this application of a Model Based Enterprise environment possible in reality

6. MODEL BASED DEFINITION

But even if Autodesk is a de facto standard, it is still technically not neutral because the end consumer of the information may not have purchased an Autodesk product. That means that we need to look at an even better way to implement the MBE concept.

A key piece of any MBE approach is something called an MBD or Model Based Definition. In essence, an MBD is a single neutral format file complete with the metadata and annotations and all other information required to manufacture a product. It should contain all information required for the product and it should be able to be used by manufacturing, procurement, planning, and anyone else who needs information about the product. If it is a truly neutral format and you combine that with free viewers, there should be few barriers to adoption or use.

In the generic CAD world, 3D PDF is emerging as a standard for many implementations. For example, SOLIDWORKS has recently come out with an MBD product for manufacturing that delivers 3D PDF based MBD files. Other vendors are also looking at similar solutions.

Unfortunately, when we look at how such an approach might apply to shipbuilding, we seem some potential challenges. Some are cultural. Even though the

shortcomings of drawings were noted earlier in this paper and CAD companies (such as SSI) are frequently talking about the benefits of 3D fly-throughs, for the foreseeable future, it is difficult to envision many people, either in engineering or down at the waterfront, actually giving up drawings. And even if we get to a point where we are paperless, will we ever be drawing-less?

Other challenges are more technical. The scale of a ship product model is so much greater than that of any manufactured component which means we cannot create an MBD deliverable for the entire ship. Therefore, we have to think about chunking it up by construction block, subassembly, panel, or something else.

And other challenges are just intrinsic to shipbuilding. The shipyard environment is (comparatively) more chaotic, hazardous and destructive than any manufacturing floor. One wonders whether that type of environment will ever be paper-less, much less drawing-less?

7. AUTODESK DESIGN WEB FORMAT

Thus, if in practice we are not going to do away with drawings, we need to take a hybrid approach. One option is the Autodesk Design Web Format DWF.

The application of DWF for the creation of an MBD would appear to be ideal if a user was already using SSI's ShipConstructor. This is because it seamlessly works with ShipConstructor without a lot of changes to existing tools, processes and workflows.

7.1 NON-DISRUPTIVE TO ENGINEERING

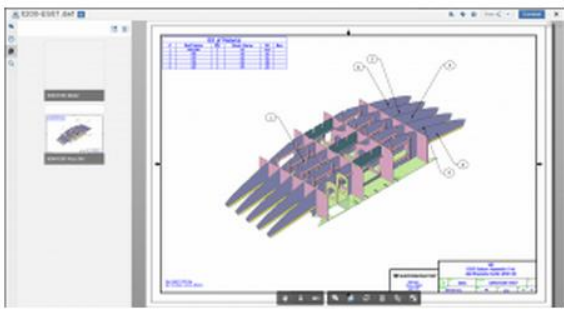
Here is how it works. ShipConstructor drawings (like any AutoCAD drawings) contain both a layout with the 3D model, *and* layouts for each deliverable drawing. That means that they can be effortlessly turned into DWF files that contain both the 3D model *and* those drawings.

When the drawing is plotted (whether for a PDM/PLM system, a paper work package or simply to a file folder), the PUBLISH command can be run to create the DWF as well.

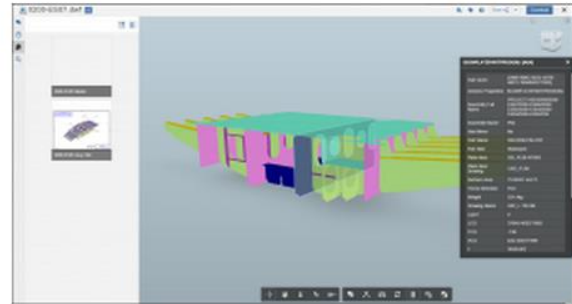
7.2 DRAWINGS PLUS MORE

Note that because the process would be created from drawings, and drawings would be a key portion of the deliverable in the package, individuals who currently consume PDFs or other representations of the drawings could now consume the DWF file instead (or as well.)

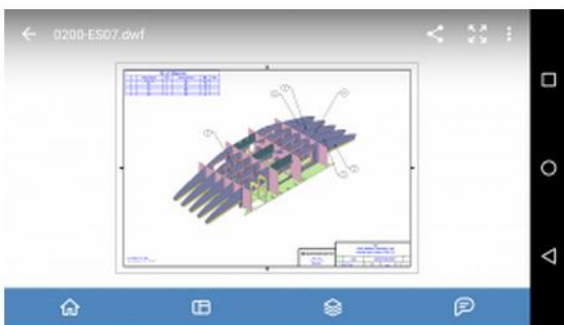
And since this process would be initiated from ShipConstructor/AutoCAD, the 3D model contained in the DWF would include all of the product model information included in the ShipConstructor model and drawings. That is a lot of useful information.



Drawing layout in Autodesk A360 (cloud based)



Intelligent 3D model in Autodesk A360 (cloud based)



Drawing layout in Autodesk A360 (mobile app)



Intelligent 3D model in Autodesk A360 (mobile app)

Fig. 2, Viewing a DWF (either drawing or 3D model)

7.3 DE FACTO NEUTRALITY + VIEWERS

Now, it must be admitted that DWG still would not technically be a neutral format because it is not an officially recognized standard. But, in reality, it does approximate one, both because it is an Autodesk format (due to Autodesk's position in the CAD market space you will find add-ins for other CAD products to export DWF etc...), and, because of the multitude of free and simple viewers for DWF. In addition, both mobile and web (cloud) based viewers are readily available.

7.4 DWF CREATION

Creating a DWF from ShipConstructor is simple. You just use the PUBLISH command within any ShipConstructor drawing. Other than ensuring that the 3D DWF option is selected for the Model layout, there are no additional steps required here.

Of course this is for the simplest possible case where a single ShipConstructor drawing contains the entire 'product' you want to capture in your MBD package and that might cover a decent number of use cases. However, the real power would come from adding additional layouts and models from other drawings to the package.

Here are some possible scenarios:

- A pipe arrangement, system model, and all spool drawings for that system.
- A model of a structural block and all class approval drawings for the block as a class package.
- A model of a structural block and all assembly drawings for the block.

During the PUBLISH command, layouts from other drawings could also be added.

Therefore, because of their simplicity of creation and the ease with which information can be shared and used in a real-world practical shipbuilding workflow, DWFs

would seem to fit the criteria for a Model Based Definition.

8. CONCLUSIONS

To sum this all up, having workers in multiple disciplines collaborate and work concurrently increases quality and reduces costs. To make that possible, a single source of truth found in the product model should be used. However, the key to making this possible is communication between people and programs. Ways to make this happen include standard formats and possibly platformization. Because ShipConstructor is built on top of AutoCAD, it works seamlessly with other Autodesk products. This enables concurrent engineering to become a reality. However, Autodesk's DWF format allows an even stronger implementation of a Model Based Enterprise environment. This is because DWF is easily created and free viewers are available that show a wealth of product model information in both 3D as well as in traditional drawing format.

9. REFERENCES

1. MARKOV, A.; ABMA, A., Design Optimization, *HISWA Symposium on Yacht Design and Yacht Construction, Amsterdam, 2014.*
2. PAINE, A.; RANSING, R.; GETHIN, E.; SIMS, G.; RICHLEY, J.; BOISSEVAIN, L.; LEWIS, M. Challenges Faced by a Small Shipyard in Integrating Computer Aided Design and Production Procedures- a Real Life Case Study, *International Conference on Computer Applications in Shipbuilding, 2013.*
3. MORAIS, D.; WALDIE, M.; LARKINS, D. (2013), Empowered Engineering: Availability of Engineering Data throughout the Shipyard, *International Conference on Computer Applications in Shipbuilding, 2013.*

10. AUTHORS' BIOGRAPHY

Darren Larkins is the CEO of SSI. For more than 14 years Darren has met with shipbuilders around the world, developing an in-depth understanding of industry challenges and global best practices. Darren played a lead role in the US National Shipbuilding Research Program (NSRP) - Second Tier Shipyard Design Enhancement Project (STSDEP) and projects focused on Design for Production (DFP).

Mark Waldie is the PR Coordinator for SSI where he is responsible for promoting SSI's innovative software solutions and success stories worldwide via various forms of media. He is an award-winning author of various technical papers and has more than 15 years' experience

marketing advanced technology for use by the world's leading naval forces.

Nick Danese is the founder and General Manager of NDAR and is the Senior Partner for SSI EMEA. He is responsible for overseeing SSI's network of sub-dealers in the EMEA region. He has worked in the CAD and engineering business since 1983. Danese has implemented software solutions at various leading shipbuilding, naval architecture and marine engineering firms and has presented technical papers at numerous international conferences. A Naval Architect by training, Danese also has extensive hands-on experience utilizing ShipConstructor and associated software for the design of various marine projects.

Denis Morais is Chief Technology Officer at SSI. He manages all aspects related to the development of SSI's product portfolio with a focus on determining technical solutions to business problems by bridging the gap between technology focused software developers and results oriented business executives. Denis has been internationally recognized for his published papers and continues to give presentations on innovative solutions to the current challenges of the marine industries.