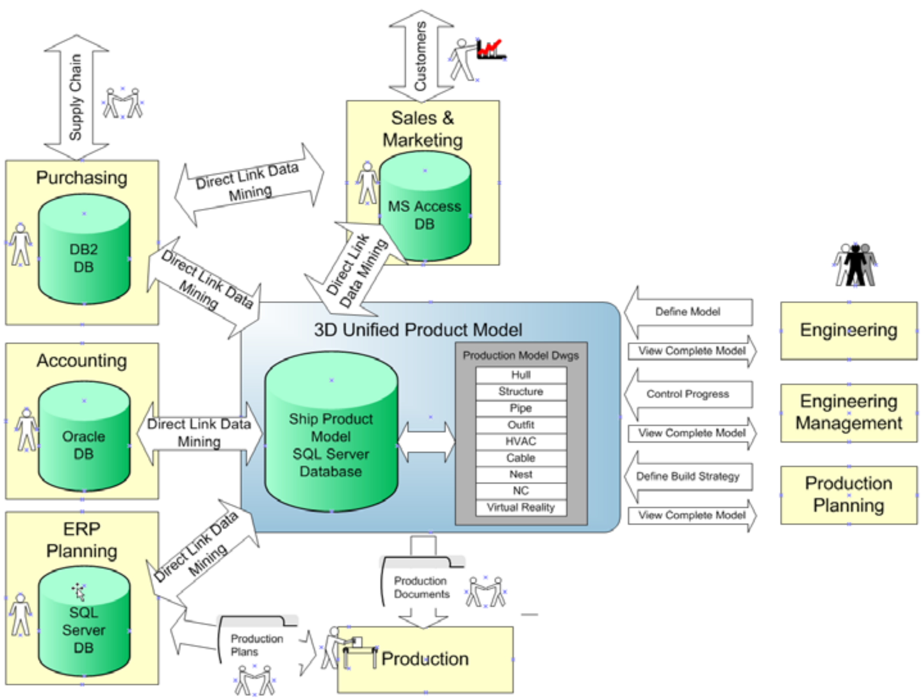
SHIPYARD USA
Washington Marriott Hotel, Washington DC
June 15 & 16, 2004
Presented By:
Marine Log, 345 Hudson Street, New York NY 10014
And the
U.S. Maritime Administration

LINKING THE SUPPLY CHAIN INTO THE PRODUCT MODEL

Rolf Oetter, Dipl. Ing.
Christopher D. Barry, P.E.



ABSTRACT

The Integrated Product Model provides significant benefits to shipbuilders. Though the role of the Product Model in construction is well established, using the Internet, both the Internet itself and the conceptual model of multiple databases with multiple links, we can go on to the next step: By linking the Product Model to vendors we can implement Lean supply chain principles, improve manufacturing, production engineering, procurement and even maintenance and operation of the ship throughout its lifecycle.

*Information technology is … an **essential enabler** … permits companies to reengineer business processes*
Hammer & Champy (1993)

INTRODUCTION

The computer based ship Product Model has been widely accepted as the best way to approach the problem of defining geometry and similar aspects of design, but the flexibility of CAD systems and linked databases allows extending it in many ways to improve productivity, quality, reliability and maintainability.

Defining geometry in electronic format affords the opportunity to automatically transfer part definition data to computer-controlled machinery. Manufacturing data, especially group technology data and scheduling and management data, can be coded into structural, piping or other fabricated part data and this information can also greatly enhance shipyard productivity (Oetter *et al* 2003).

The next step is linking supplied component interface data to objects representing outfit items. This data goes beyond geometry as well. Technical interface data such as flow or electrical connection information is obvious, but so is procurement and data such as pricing, delivery date, and testing requirements. The Product Model can be used as a navigation tool to locate procured item information in these databases. The procurement and interface data can be used, and enhanced, to provide long term logistics support information, and aids for training and emergency response.

The authors would also like to note that their experience is in the AutoCAD and SQL database environment using the Ship Constructor system (which includes ShipCAM as a primary hull definition tool). This paper discusses some specific techniques in terms of this software and its nomenclature as an example, but the authors recognize that other packages have similar features and capabilities.

WHAT IS A PRODUCT MODEL?

A Product Model is a database or set of linked databases that defines the ship to the extent desired by the users and developers of the model. Prior to the invention of orthographic drafting, the Admiralty model was a physical scale model that was used as a key contract "document" to define ships to be constructed, generally actually using the same materials that the ship was to use, but at a greatly reduced scale.

Conventional paper drawings then took over the main role of defining the geometry and other features of ships to be built, but much of the capability to readily envision and understand the final product was lost, since drawings have to be interpreted.

Conventional paper drawings were then produced using Computer Aided Drafting (CAD). This is not a true Product Model, but even then, the use of data linked into the drawing had begun. AutoCAD offered "attributes", arbitrary text or numeric data linked to blocks representing components. The archetype for this was examples of phone numbers linked to symbols of telephones in an office arrangement drawing.

This use of extended databases has revolutionized the use of CAD and databases, especially in the area Geographic Information Systems, which links CAD maps, databases of features such as property definitions, tax payments or any other geographically identifiable data. Similar drawing/database hybrids are used to manage shopping centers, linking tenant business information and drawings. It has even been said that more existing oil refineries are being redrawn in CAD to build management databases than are being originally drawn for new construction.

In the marine field, the ready availability of three-dimensional CAD, combined with the needs of Computer Aided Lofting/ Numerically Controlled Cutting fostered the development of three-dimensional models, especially structural models. The requirement to manage the piece parts resulting from these models, and the need to automate the routine but tedious processes of extracting information for numeric code development fostered development of automated tools to build the model, to extract data from the model in various formats and to link data both to databases from the model and in reverse. Jolley (1992) gives an early example of automatic drawing editing from a database. He developed a system to automatically draw stiffeners in an AutoCAD R10 drawing from a DBaseIII stiffener list that was originally derived from the AutoCAD drawing. Any changes in the database due to design development were fed back into the drawing automatically. End cuts and similar features were also automatically derived. Mercier (1997) illustrates a hybrid 2-D 3-D system that automatically derives and inserts structural weights in an internal database.

Each of these steps (and many more) has brought us back in a circle to a true, three-dimensional model, though now in virtual reality rather than small scale. The model also has substantial non-graphic, or non-geometric information either internal to the CAD file or dynamically linked to it.

There are substantial advantages to the 3D Product Model compared to paper drawings or even CAD drawings. First, of course, the geometry of the model is exact, inherent and three-dimensional, so measurements are reliable and unambiguous. Also, since there is only a single depiction of any given system or component in the files that make up the Product Model, there is no possibility of conflicts between drawings. Finally, the inclusion of non-graphic data increases the richness of the data included in the model.

It is important to note, as a practical matter, that it must be easy, even automatic, to be able to develop any type of drawing from the Product Model, just by taking a view of the model. In actual production, such views are taken to illustrate particular work packages (or "pallets"), and the use of these views is one of the most powerful improvements in productivity. Otherwise, the Product Model is too cumbersome to be useful in actual detailed construction. In the same way, views must be able to be derived for training or maintenance.

These elements are the minimum features distinguishing a 3D Product Model system, from a collection of CAD drawings, or even 3D CAD models, and it is important to understand this distinction before moving on: Though a Product Model may provide more or less conventional drawings, the drawings are views of the Product Model, (usually automatically derived). They are not themselves the Product Model. Such models can be either a single massive file, or a series of linked CAD files, but as long as they are set up so that each component is uniquely defined once and once only, and that it is possible to interrogate and view any component or combination of components through their linkage, the essential advantages of a basic Product Model are obtained: the product geometry is fully and unambiguously defined and readily accessible.

This definition may leave an initial impression that massive files are somehow superior to linked small files, but this not the case. The concept of linked files, especially in the context of an open system, is actually considerably more powerful, because it allows endless opportunities for extensions.

Once the basic geometric model is achieved, the next steps in improvement are to go beyond simple geometry and add linked data, and here the extensibility afforded by an open system is optimal: Linked databases in an open system allow connecting, accessing, and using data in a wide variety of unexpected ways throughout the vessel construction and subsequent lifecycle. In addition, the capability to link arbitrary databases allows the model to be extended long after the initial design of the core databases, in ways the initial database designers would not have anticipated. This is not possible with a definitive system massive file system, as demonstrated by the Internet.

The Internet is the next key to increasing the richness of the Product Model, though not just the Internet itself, but the concept and model of the Internet as well. Once a Product Model has the capability of linking to non-graphic attributes, such an attribute can be an HTML tag to another file, either on the actual Internet or on some other intranet. AutoCAD has offered this capability for some years, and the basic technique is fundamental to every website and simple: A thirteen year old's "Mary-Kate and Ashley" fan club website uses exactly the same techniques to link arbitrary files to graphic objects. This example is even more instructive: Though the "Mary-Kate" website author might not anticipate it, it is likely that another teenager will be eventually be able to able to find 'N Synch or Hello Kitty material through links accessed via the initial seemingly unrelated graphic. This is the whole point of the Internet, that links can provide means of accessing data in a completely unanticipated, serendipitous fashion. Likewise, the capability to use Net tools in a web architecture means that future users of the Product Model can easily link to data that the original author had no way of anticipating.

THE BUSINESS CASE

How many psychiatrists does it take to change a light bulb? Only one, but the bulb has to want to change.

A move to a vast, linked, and possibly somewhat uncontrolled database of internal and external files is a big paradigm shift in ship design, especially if we are linking data that crosses functional boundaries between engineering, production, procurement and even plant safety and environmental compliance. Is there enough payoff to this to make it worth the effort?

The most obvious advantage is in design. Some sources suggest that a general industry designer spends as much as 80% of his time researching component features, mainly for minor details such as connection information and weight, not product features. Weight estimates are tedious enough without having to scour catalogs and make phone calls all over the country. One of the authors has spent an hour actually driving to a local vendor's warehouse to measure the stem on a ¼" valve. This meant the valve cost more than doubled. A downloadable interface model, with links to the vendor's website, would save countless design hours, especially when the valve needs to be replaced, and the operator modified, ten years from now.

Again though, a part's quality is more than its technical features. Price, delivery time, and even packaging impact the shipyard. Let's take a real case and see just what might have been possible:

A containership was under construction recently. The engine lathe was late when the deckhouse module had to be installed to make schedule. The shipyard decided reluctantly to land the deckhouse. Naturally when the lathe arrived, there was substantial rework required to install it. The unfortunate part of this, though, is that the lathe had arrived on time and was in storage at the shipyard all along. If there had been a Product Model with links out to the rest of the system, and the lathe receipt and storage location had been entered in a similar system, even without an explicit, anticipated link, (who could anticipate losing a lathe?) it is likely that a few minutes of mouse clicking would have found the lathe. At least, it could have linked to the supplier's site and the trucker's site to show that the lathe at least had been delivered – both FedEx and the US Postal service do this now. The cost of the rework involved in this single incident would probably have paid for the whole Product Model.

The whole notion of Lean Manufacturing and "just in time", and all of their proven benefits in productivity, rests on rapid, efficient exchange of data between primary producers and their suppliers, Suzaki, (1987). An automobile plant may be able to use less integrated systems because the product is highly standardized and built in huge numbers, however ships are built in low volumes with a highly mixed variation of features from one product to another, whether a "product" is considered a whole ship or modules – it is the ultimate challenge in "High-Mix Low Volume Manufacturing" (Mahoney, 1997). This requires a more flexible approach that only a live Product Model will provide.

LIFE CYCLE SUPPORT

A ship almost certainly costs much more to maintain through its lifecycle than it does to build. Anyone who has to deal with an existing fleet knows the frustration associated with inadequate initial design information, the maintenance of drawings, shipchecks of existing vessels and as-builts that aren't. Bills of material are always organized the way the shipyard needs to procure the parts, not the way a maintainer needs to get them, especially when the maintainer is handling multiple classes of vessels. The new drive to consider disposal also makes the model useful. The model by its nature contains an inventory of any materials which might be hazardous (now or later) and the amount, location, and purpose.

If the Product Model is available to the maintainer, he can use the model and the database to maintain configuration control throughout the life of the vessel and the databases can be interrogated, sifted and sorted as required. A shipboard engineer can interrogate a drawing developed from the database by clicking on a component and get the linked information needed to obtain parts or even to go to a manual. The derived drawings can also be used for emergency response.

In the long term, the need for an open database becomes even more acute. Young (1998) has noted that Product Models are useless to maintainers who might not have the funds to buy a piece of software specialized for a given proprietary database format, or the trained personnel to use it. Product models must use at least "de facto" industry standards, and the vendors should provide proxies and similar features to allow the model to be used and maintained subsequent to ship delivery.

If we consider lifecycle support, then both intranet and Internet capability adds enormous value. If a part has a link to a website, future maintainers can find service bulletins, updated Material Safety Data Sheets, and possibly even obsolete parts. (Maybe a vendor can link to Ebay when he sells off parts for an old product so future maintainers can try to find them). One of the largest previously unanticipated cost of ships is now disposing of them, and even here, a Product Model could help identify where hazardous materials are or are not. In the latter case, considerable savings are possible if unknown materials can be readily identified as benign.

The business case for vendors is even more powerful. As both examples illustrate, the cost, quality or value of a product is more than that just associated with the item itself, but includes the entire process of getting it into the ship (and perhaps out again, when the ship is disposed of). Those products that are less expensive to get into the ship will be specified, even if they cost more to buy. In addition, sales and product support costs will decrease. In the case of the valve, a sales engineer accompanied the author, so that the sales overhead went up by at least 10% of the valve's cost.

The enhanced Product Model based on linking databases can greatly improve productivity and maintainability. So how do we get there?

BUILDING AN OPEN PRODUCT MODELING SYSTEM

First, we have to build a Product Model. The shipbuilding and other industries have seen many Product Modeling systems in the decades past. In general these systems can be associated with high cost for the software license purchase and high cost in training and re-training. Most importantly, these systems are completely based on proprietary software modules, which make integration with any outside software systems either impossible or cost prohibitive.

However, the whole concept of extensible linking requires open systems. An open Product Modeling system has to be based on industry standard CAD and database platforms in order to provide a practical and cost efficient solution that can be adopted by all players in the supply chain.

A Product Modeling system stores all CAD geometry in a large number of CAD drawings, while all data associated with the drawings, parts, assemblies etc. are stored in the database. Every part, every drawing, each piece of raw material each revision of each nest

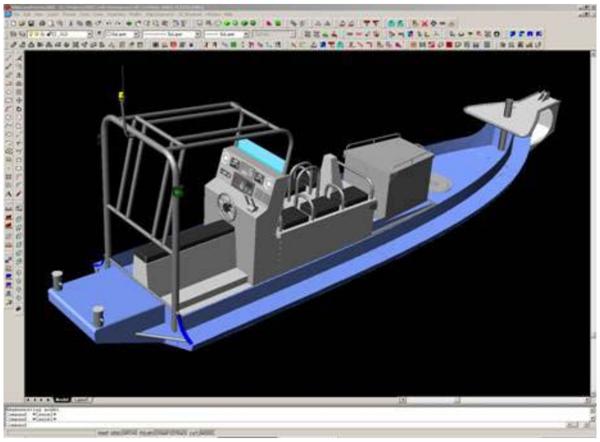


Figure 1: 3D Product Model of small boat builder (Mustang Marine)

are tracked using the central database system. The relationships between the different tables are most often constructed using indices. However, a much more flexible approach is to link all records together using global unique identifiers (GUID).

A GUID is a term used for a number that a program generates to create a unique identity for an entity. A GUID is will be unique from any other GUID generated by any other program, thus allowing the item to be uniquely identified for all time. GUIDs are widely used to identify interfaces, replica sets, records, and other objects. A GUID is required in order to differentiate a supply chain item uniquely from any item from other suppliers.

GUIDs together with procedures to solve conflicts allow Product Model databases split into two or more copies, be modified at different locations, and be merged at any given time. This allows yards and designers to cooperate on a single project without the need to have high-speed real-time data connections to the same central Product Model database. A typical implementation of this is shown in the frontispiece.

ShipConstructor is a typical open Product Modeling System. It is based on AutoCAD and an SQL server database and by using the industry standard CAD and database linking system lowers the cost of operation significantly.

Most designers, engineers and drafters are versed in the use of AutoCAD. Many even have had some exposure to MS Access, a low-end database system. It has been proven over and over that a small mom-and-pop shop can economically use the same software tools for the production of small vessels, as can large yards assembling more than 50,000 parts to structure with more than 10,000 tons in steel weight alone.

This is facilitated by the use of special tools, residing within AutoCAD and using the well-known

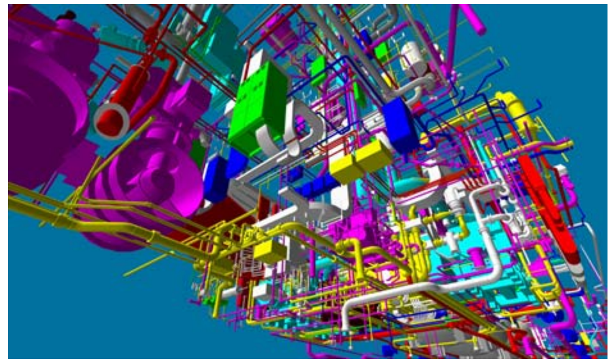


Figure 2: Partial 3D Product Model of large shipbuilder (Bender Shipbuilding and Repair Co.)

AutoCAD core programming features to not only automate many otherwise difficult modeling tasks, but also tie everything also to an SQL database.

For example, most drafters are used to working in 2D, and the translation of planar representations of components into 3D objects is unambiguous and straightforward for software, so the designer works in 2D in the system. The tools automatically translate the 2D edges of plates, for example, into 3D solids, flanges them on command, extracts the edges into separate files for subsequent nesting, and so on. None of these tasks require any design decisions on the part of human beings, they are just exacting, picky and tedious, and software is ideally suited for exacting, picky and tedious repetitive tasks. At the same time these 3D parts are tied to a stock library that may at some point be linked to the supply chain.

In the case of piping, the designer prefers to think in terms of pipes and fittings, not lines and circles. The combination of software tools and parts libraries allows the designer to build a model in his own terms and the software translates a command to place a fitting as instructions to insert a block (with attributes) from a library. The fitting has data that allows a pipeline to be generated that fits it – the software knows what size pipe the fitting fits and can generate it automatically along a simple line requested. The software won't allow a tube fitting to connect to a pipe, and can send all the pipe length, weight and other data to any other database. Gribskov (1999) describes this as giving the parts "behaviors" and the modeling software can have behaviors for any type of part; a door could "know" that it lives in a cutout, for example, and automatically generate it when inserted.

An open Product Model System provides the great opportunity to combine the many existing disparate island solutions, such as sales, purchasing, accounting, and planning with the Product Model to one highly effective organism. Most systems used in the various departments are usually based on one of the major SQL

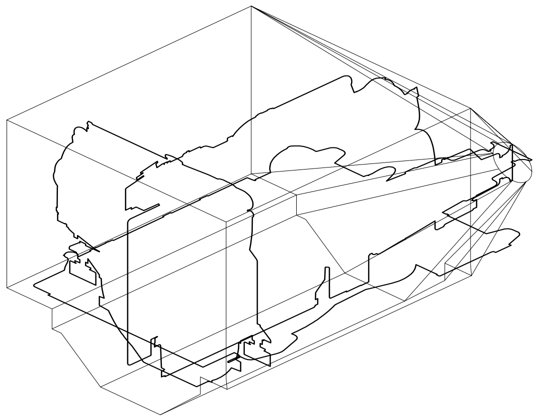


Figure 3: Minimal part depiction

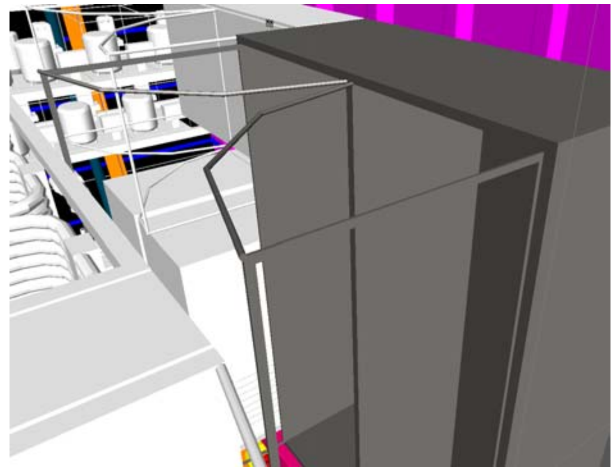


Figure 4: Door swing space (Royal Huismann Shipyard)

compliant database engines, such as IBM DB2, Oracle, MS SQL Server, or similar. Every town has experts that are well trained in SQL programming. Connecting the databases and installing data mining stored procedure to automate tasks is well within the realms even of smaller yards. Important here is that there is a consensus in all departments to make this happen. Bender Shipbuilding is well underway to achieve a company-wide integration of all departments.

Using an open and common database system, such as SQL server, allows each user to extend the capabilities of the database itself. Additional fields are easily added to any table that store additional information crucial to this user. Furthermore, any record in one database can be linked directly to any other record in a customer-defined database to extend on the capabilities.

Recent initiatives like Microsoft's .NET and Sun's Java Enterprise software architectures, along with the growing adoption of emergent technologies like XML and digital signatures for information exchange, should further enhance the ability of multiple vendor's tools to effectively and efficiently collaborate within the framework of a distributed and open Product Modeling system.

INDUSTRY COOPERATION

"Plays well with others"

The technical aspects of linking suppliers to the Product Model are not complicated. The main challenge is going to be developing the cooperative structures that will enable data sharing. These include standards making and maximizing site visibility.

The actual requirement for a vendor Product Model can be minimal, and readily achievable. The model need only have a reasonable space claim and interface data. Simple solid models are enough, because many attributes can be added as text in a separate database or as links to other databases. Early users of Product Models used "crossed paper dolls" in wire frames (Figure 3), and for some uses, even this is still enough.

There is only a minimal level of standardization required, and in fact, the less the better, (as long as open extensible systems are used) because elaborate standards will not be enforceable.

Today, manufacturers often employ 3D modeling for the equipment design. Several 3D modeling tools, such as AutoCAD, Mechanical Desktop, Inventor, SolidEdge, and Pro-E, are commonly used. All these tools can save the models in a variety of formats that allow easy interchanging of the data without resorting to a difficult to implement standard. However, these 3D models carry too much detail as they are used to generate detailed production documentation. Thus, these models are large in terms of file size and computing power required for displaying and manipulating them, and in many cases the yard will often remove the engine again from the engine room design, as the drawing becomes so 'heavy' that it becomes unusable for the operator. Under the time pressure in the yard, the operator does not find the time to generate a simplified model of the engine. The result is often that interferences are not detected, resulting in rework, or opportunities for better use of the available space are not realized. Thus the ship will be operated in non-optimal conditions for decades to come. Inserting thousands of such 'heavy' equipment items into a ship Product Model will bring even the largest computer to a grinding halt. A simplified 3D solid model that defines the general dimensions of the item with enough definition that enables a user to recognize the type of item will suffice. Clearly this 'light' equipment item model should be produced by the manufacturer and be

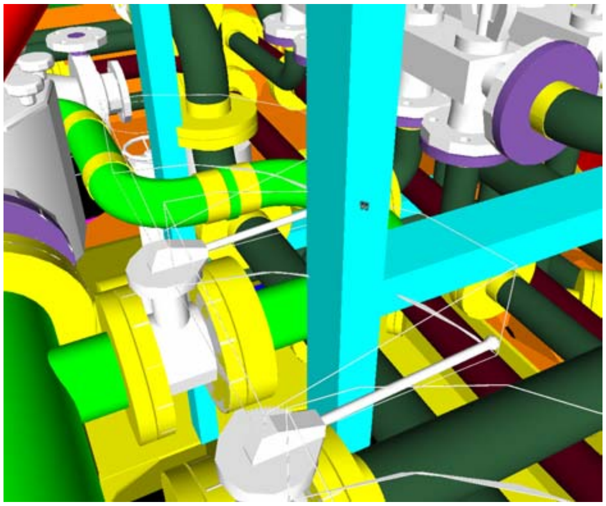


Figure 5: Valve operating space (Royal Huismann Shipyard)

easily accessible by any user down the supply chain. There is some extra work involved by the manufacturer to strip superfluous detail information from the production vendor model, but at least this is only performed once, not hundreds or thousand of times by each end users. Additionally, maintenance space or the space required for moving parts will be valuable for the yard. Many yards are now modeling simple things into their ShipConstructor models, such as the swing of a valve handle or the opening volume of an electrical cabinet door.

A shipyard is interested in features such as mounting, connections for pipes, electrical and HVAC. These connections require not only the 3D location, but also require directional information of the connection and logical connection data, such as connection type and size. Pipe connections for example require nominal size, pressure class, and connection type. Electrical connections require cable size, voltage, amperage, and / or signal specifications. Mechanical connections may specify bolt size and quality.

Imagine just 500 such items used in a single ship 3D Product Model. It would not be uncommon for a designer to spend 30 minutes or more looking up and verifying detailed connection information from catalogs or even calling suppliers. Thus a saving of 250 engineering hours would be easily achieved using this method alone. ShipConstructor users are already realizing these savings by defining equipment items once and adding them to the ShipConstructor database. Any one of these items can not only be used in the current design, but also can be easily transferred to a central database to be used in future designs. Now the designer, by simply placing an equipment item into the model, will automatically solve many problems in the yard without any extra work. The equipment will not only carry with it the correct pipe connection size and type, but also weight, center of gravity and order numbers. Simply placing an item will populate the bill-of-material, and update the weight and CG of the vessel. (And since the weight is carried in a separate linked database, when the item comes in at a different weight, the ship mass properties will update automatically.) When pipe is later routed to the equipment item the database will automatically narrow the thousands of pipes and fittings in the catalog to the correct pipe item that will fit. The order number in the bill-of-material together with the time of installation allows just-in-time purchasing of exactly the right quantity. All this comes on top of the ability for a virtual reality flythrough, which already reduces production time through weekly engineering production meetings, on top of monthly virtual reality owner meetings, and the ability of sales to show a potential customer exactly what kind of vessel he can expect, based on the library of ships the yard has already built.

There are ongoing efforts in electronic linkage that can be adapted to providing appropriate data. STEP (Turner, 2003) is a set of Application Protocols (APs) for neutral exchange standard that has been under development since the mid 80's. This allows software developers to produce a single "translation" interchange file format that another product can use. A number of APs have been approved as ISO standards and are ready to be used. The STEP data interface is very complex and implementing it into a software package can be very costly, driving up the cost of the software, but the concept of STEP is that third party translators can be developed as needed.

Although directly linking to individual vendor's websites is readily possible, there are other models that might be more cost effective, more readily maintained in the long run, and more useful in terms of product choice.

A number of initiatives were developed during the heydays of E-commerce to provide Business-to-Business portals. These included Buzzsaw and BricsCAD in the construction field and Redspark in manufacturing. The business case was generally that a third party would maintain bidding drawings and similar documents on a site as well as product data so that vendors and buyers could meet online. The third party either charged for the space used or got a commission on sales. Some of these services have changed or gone to the wayside, and others have evolved and are still going strong, but they provide a model for the marine industry as well, though the authors believe some changes are in order.

First, the idea that such a portal is itself a profit-making venture is, we believe, a potential problem. Investors looking to see a profit can pull the plug, leaving users high and dry, and this possibility will in turn stunt the growth of such portals. In addition, multiple competing portals will reduce the key benefit of such a portal, being able to readily find and communicate product data. Thus we feel that a key initiative in this industry is a cooperative, not-for-profit organization that maintains a portal and develops standards for its members.

Whether or not such a portal should be a repository for the Product Model itself is a second question. There have been trials of on-line cooperative design efforts that have been very successful, and these efforts have included multiple CAD products in use by the participants. Such a portal may also therefore, host translators as required to translate to and from STEP. There are clearly some design efforts where this would be appropriate: In the case of ships that have significant efforts required by vendors of specific products, so that the vendors have to have high visibility of the model, this might be appropriate. Obviously, there are issues of security involved, but these have been successfully resolved in many other contexts. Here too, the fact that a portal was a non-profit, neutral organization may help in this issue too.

It is worth noting that there are already cooperative organizations in place: The organizations supporting development of STEP evolved out of such organizations, since such data interchange is one key to successful marine e-business. These too could be built upon to develop the needful structures.

CASE STUDY: BENDER SHIPBUILDING

Bender Shipbuilding quite possibly has the most sophisticated Product Modeling and planning environment to be found in any shipyard worldwide.

Bender has almost complete integration of the Product Model in all major departments company-wide. In the next step Bender plans to integrate four yards through the means of the common parts catalog and exchange of ShipConstructor equipment library data. It will be interesting to see how this will be done and how successful it will be.

In 1997 Bender was the first US 2nd tier shipbuilding company to fully embrace 3D CAD modeling using AutoCAD based CAD-Link integrated with a MS Access database. Bender quickly moved from the traditional 'stick-building' method commonly used by many yards on the Gulf of Mexico to a 3D modeling, with pipe penetrations pre-cut and automatically generated 3D assembly drawings. Furthermore, work packages would be created that group similar tasks, for example for profile cutting. Using this initial approach Bender reported a 50% savings of man-hours for unit assembly.

Since the introduction of ShipConstructor's SQL server database, Bender has consistently developed methods, procedures and software, to connect and mine the information stored in it to other databases within the company environment. Most notably among these are the MIDAPS and WinShip developments.

The ShipConstructor Product Model with the SQL server database takes the central position in this system.

Every new purchase item in the model is automatically identified and reported to the purchasing system. This is a dynamic process that does not have to wait until all work on a special unit has been finished. This provides enough lead-time for purchasing to order most parts just when they are needed, cutting down drastically on inventory storage requirements and capital cost. Additionally, every item, purchased of manufactured, is tracked via a build strategy, which is dynamically linked to a commercial production planning system. Every day production activities are automatically generated by the two systems, and presented to the planner for checking and detail adjustments. This procedure not only reduces the time spent on planning, but also allows the planner to plan with much more detail than ever economically possible before.

COMMON PARTS CATALOG AND BEYOND

The common parts catalog is a work effort first taken on by the 1st tier US shipyards. (Bolton 2001) The definition of this work is almost complete and the 2nd tier shipyards through the PDSTEP program are now ready to embrace this technology. An integration of the Common Parts Catalog with ShipConstructor is well underway at Bender Shipbuilding.

The common parts catalog goes to great length to standardize how a part has to be defined to make it usable through not only at one yard but also many yards. Current database catalog implementations lack rules for defining parts. The lack of rules means that a designer cannot find a needed part in the catalog, and so he defines a new one. In the end, when carefully searching the catalog, one will find the same items defined multiple times with slightly different naming and parameter definition. The common part catalog eliminates this problem when properly used. This is a great improvement in itself. However, as so often, more advantages can be uncovered with careful thinking.

Quoting Patrick David of Bender Shipbuilding: "

The CPC is just the tip of the iceberg". …

Assuming for a moment that the CPC is up and running at most of the yards in the U.S. With a small amount of careful up-front programming, the capabilities now exist for us to complete the last few steps of integration between all of the yards. Without *releasing any of the more important shipyard-specific data, such as pricing or vendors, we can now track movement and stock of all major pieces of shipbuilding hardware throughout the U.S., and between all of the yards.*

The next important step to the CPC effort would be a central warehousing database server feeding to all of the member yards. There is no reason this could not be set up for nationwide CPC usage amongst all of the member shipyards. A single CPC master server located somewhere in the U.S. would be able to feed to all of the other yards in-house CPC databases, such that changes made in one place (say Bender), would propagate throughout the system to feed to any other yard (say, Bollinger, or Electric Boat). This would not only cover almost every conceivable needed part in the chain amongst all the yards, but would help to consolidate resources and materials. If we needed parts that Bollinger had in stock, we could just check the CPC to find the part, then call Bollinger and ask if we could buy it from them instead of waiting through a possibly large lead-time.

Things that also begin to happen due to adoption of the CPC system are consolidation of information in a large way. If the vendors supply the 3D CAD model of their product, it can be cross-referenced through the CPC to allow all yards access to it.

Really, there is no end to what we can put together to allow for a seamless integration of the shipbuilding industry as a whole. And if these advances are seized upon quickly and efficiently, it has to potential to allow us to become quite competitive in the industry again."

CONCLUSIONS

The value of the Product Model can be greatly enhanced by effective, early linkage with the supply chain. Tools to develop an effective Product Model and supplier requirements to interface with it are here now and are essentially those commonly used on the Internet in general, and in specific applications like computer gaming, as well as well established systems such as ShipConstructor.

The needful developments are in the area of standards and cooperative structures to provide support for interchange of information. These are technically simple, but complicated from a viewpoint of a business model, standards and other aspects. The authors suggest that a cooperative non-profit effort by the marine industry, either in North America or internationally, would be the optimum vehicle to accomplish these standards.

Finally, though the authors have given examples using particular products, the most important concept we see is to use open, rather than proprietary products, especially those enabling Internet and Internet–like arbitrary linkage. The key is to allow for future, unanticipated users to evolve a model freely, and only open, cooperative standards will allow this.

REFERENCES

Bolton, R., "B2B Initiatives for US Shipbuilding", *2001 Ship Production Symposium*, 2001, SNAME, 601 Pavonia Avenue, Jersey City, NJ 07306

Gribskov, J., personal correspondence, 1999

Hammer, M., and Champy, J., (1993) *Reengineering The Corporation; A Manifesto For Business Revolution* HarperBusiness, HarperCollins, New York, NY

Jolley, E. "AUTOTOOL/DB; A Solution for Ship Design", *CADalyst*, Jan 1992

Mahoney, R., (1997) *High-Mix Low Volume Manufacturing*, Hewlett-Packard Professional Books, Prentis Hall, Upper Saddle River, NJ

Mercier, L. Byington, T., Senkwic, W., and Barry, C. "Implementation of Integrated CAD/CAM Systems in Small and Medium Sized Shipyards, A Case Study" *Ship Production Symposium*, 1997, New Orleans, Society of Naval Architects and Marine Engineers, Jersey City, NJ

Oetter, R., Barry, C., DeCan, L., Sorensen L., "Integrating Manufacturing And Lifecycle Information Into The Product Model" *2003 Ship Production Symposium*, October 16 - 20, 2003, SNAME, 601 Pavonia Avenue, Jersey City, NJ 07306

Suzaki, K., (1987) *The New Manufacturing Challenge, Techniques for Continuous Improvement,* The Free Press, Simon & Schuster, New York, NY

Turner, T., Lazo, P., AP Development Guidelines for Shipbuilding" ISO TC184

Young, Ryan, Comments to Oetter, *et al*, "Keys to CAD/CAM in Small Shipyards" *Transactions of SNAME*, 1998, Society of Naval Architects and Marine Engineers, Jersey City, NJ

The views and opinions expressed herein are those of the authors and are not to be construed as official policy or reflecting the views of the U. S. Coast Guard or the Department of Homeland Security.