NSRP ASE
Milestone 11 Report

"Final Report"

For

Second Tier Shipyard Design Enhancement Program

NSRP ASE
TECHNOLOGY INVESTMENT AGREEMENT #2004-322

Submitted by

BENDER SHIPBUILDING & REPAIR CO., INC.

On behalf of the project team

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Project Overview

The goal of this project was to use the existing design software of choice amongst the second tier shipyards (ShipConstructor), and to develop its capabilities further into a fully integrated design environment with the robustness needed to address future concerns and expansions. The intended purpose being, to have available, a complete design solution software package to meet or exceed the needs of the current state of shipbuilding design technology. With a state of the art design system in place the second tier shipyards would have at their disposal an effective tool to help increase their global competitiveness.

The primary draw of the ShipConstructor design package for most second tier shipyards was the core functionality already existing, and the affordability of the system. Coupled with the fact that the software runs on top of the already de-facto standard for CAD design in the U.S., AutoCAD justification for the choice of ShipConstructor become plainly obvious. With ShipConstructor having been independently chosen by the majority of second tier shipyards as the design software of choice for shipbuilding applications, it was a natural extension to seek a means to integrate furthers the capabilities of the software to address the many aspects that define the ship design process. The learning curve associated with new software had already been absorbed by the various members of the project team in-house as part of training and education to effectively use the existing tools in the ShipConstructor program, which poised the team members in an effective place to be able to beta test enhancements and improvements as they were being made available by ARL. Coupled with a real time feedback website that provided a means to monitor comments and suggestions by the design agents and shipyards, ARL was able to effectively make improvements and do bug tracking remotely and quickly.

Key to the integration into the rest of the design cycle for shipyards was also the capabilities added by using a Common Parts Catalog system for parts and materials. Leveraging the work already performed by the first tier yards, a CPC was developed for the use of second tier yards as well. Maintaining a common parts formatting system was crucial for the expandability into parts sharing and more effective collaboration between the different second tier yards, with the possibility of being able to collaborate parts with the first tier yards as well. This opens up a world of possibilities for future enhancements and integration between the various U.S. shipyards that has never been seen before.

To achieve these results, the overall areas of possible improvements and modifications were considered as separate modules that would all affect the design software and begin to mold it into a fully featured design suite. Originally proposed were the following modules:

1. Integration of custom object formats and outfitting part descriptions with Common Parts Catalog data structures. This key feature represented a substantial

step forward in the efforts at integration of the various shipyards throughout the U.S.

2. Utilizing development based on an Avondale specification, final development and integration of an HVAC design module into the ShipConstructor package.
3. Further improvements in the piping module that was already deployed in several shipyards and under heavy use. This included items such as flange rotation, pipe bending improvements to account for actual equipment capabilities, weld footage tracking, defining weld paths, formatted output for CNC cutting, flanging, beveling and saddle hole cutting, and development of a more efficient production drawing format. This included further refinements in the integration of the piping module with the structure and other outfitting modules.
4. Hull surface refinement and definition utilizing NURBS surfaces instead of meshes. This would improve plate expansion and lofting surfaces, leveraging a much greater accuracy in expanded parts.
5. Database merging where the development database structure and design protocols could be leveraged to allow concurrent work on a model between shipyards and design agents. Such parallelization of work effort would produce a significant amount of savings to both the design agent and the shipyards.
6. Integrating a revision control strategy. This was initiated with much interest from Electric Boat concerning a review of the methods of drawing structure, indexing, cataloging, and issuing.
7. Development of a technical education and training course that would greatly expand the pool of available talent. The course was envisioned to be a follow on course to a more advanced AutoCAD coursework.
8. Fully develop and implement an integrated electrical design system and database. Including cable and wire routing, pull schedules, penetration lists, pin and connector lists, and a complete materials list. Integration of the package with all existing piping, structural, and other outfitting modules was a critical part of this package to ensure full integration.
9. Development of a penetration approval modules, which would link identified penetrations with regulatory and design rule requirements, develop a penetration list, identify which penetrations would be lofted as opposed to field cut, and a complete tube, collar and packing list. The penetrations could then be coordinated with integration into other modules to ensure structural and outfit geometry would be matched accordingly.
10. Project planning interface integration. The module was intended to provide a direct, real-time interface between design and production planning, with links to the materials database allowing for real-time evaluation of material lead-time and its impact on the production schedule.
11. Incorporation of weld footage tracking utility into the software for structural weld footage categorized by weld prep, type and class of weld.
12. Determination of a method for redefining the database structure for the entire software suite to allow for compliance with STEP and internationally approved STEP application protocols.

13. Development of an integrated and semi-automated production process control system by integrating Vexcel's FotoG software with ShipConstructor to provide real-time process control and QA for plate cutting and panel fabrication.
14. Utilizing FotoG for a semi-automated ship hull repair system to provide true 3D shell plate and 2D shell plate expansions.
15. Design transition module to allow for preliminary and contract level design details to be imported directly into detailed design and modeling.

These modules were set up in such a fashion that each was independent of each other and could work in parallel. Due to funding constraints, all 15-project modules were awarded but only 3 of the 15 modules were funded. The following modules were selected for funding:

- Common Parts Catalog Module (Module #1)
- HVAC Module (Module #2)
- Piping Module (Module #3)

The during the project work, four additional modules were completed within the project timeframe & overall funding. Three of the modules were performed and completed within the project timeframe after an agreed revision to the work scope. One other module that was completed under this project and the development cost was offered up as cost share for the project. These modules were:

- Penetrations Development & Approval (Module #8) – Included in Work Scope
- FotoG Process Control (Module #13) – Included in Work Scope
- FotoG Ship Repair (Module #14) – Included in Work Scope
- NURBS - Non-Uniform Rational B-Spline Surfaces – Offered as Cost Share

Common Parts Catalog Overview

The Common Parts Catalog is a classification methodology that produces a framework standard by which parts can be identified and classified. Extensive work has already been accomplished by the ISE project on identifying and defining CPC data structures and relationships. The previous state of shipyard parts classification systems was extremely haphazard and ill defined. With no easily managed system for storing parts information, each shipyards parts catalog was unique to the yard, and often was very limited in any sort of ability for integration with any other software. The CPC provides a standards framework that can translate the disorganized methodology of parts information storing into a well defined and carefully executed classification system. The largest benefit to the CPC framework is the standards under which it exists. With a clearly defined structure to part data, there exists the opportunity to integrate any individual CPC with any other CPC provided that the rules of the CPC methodology are carefully adhered to.

In particular, the key features of the ISE project that were directly applicable to this project was the 1) data architecture being standards based and well-defined through the CPC schema and the Data Element Dictionary and 2) that the general infrastructure will be translatable into the eXtensible Markup Language (XML) which provides for a generic standards based methodology of information sharing through well defined rules in formatting.

Leveraging the work performed previously by the first tier shipyards, an important aspect of integration with the CPC schema was to identify to what extent the second tier shipyards could utilize a subset of the total CPC schema currently being used. The demands on a commercial shipyard are less than the first tier shipyards, and often the parts being used can be considered as simpler parts. There is also not a need for the nuclear component of the first tier shipyards parts catalog. As such, the overall CPC schema was studied, and the most pertinent parts were the only ones considered in generating a second tier CPC. Most importantly was the fact that the overall schema was strictly adhered to in every other sense; thus, still allowing for full integration with first tier shipyards in the future.

HVAC Module Overview

Based on specifications already determined by Avondale, ARL has the basic functionality and core elements required to integrate an HVAC design module into ShipConstructor. There previously was no method of purely HVAC design available in the ShipConstructor software, and any design work utilizing other software required a break out of the native design environment (ShipConstructor) to work in other software. This also included no ability to effectively manage the HVAC design through the design process as already used. This module enabled designers to design HVAC specific objects inside ShipConstructor, and to take advantage of the management features already available in modules such as piping to handle the new system. The new features developed specifically for the HVAC module were the ability to route rectangular and round ducts, mitered corners and connectors, penetrations just like the piping module already uses, and similar project management enhancements.

Piping Module Overview

The piping module was already a key component to the ShipConstructor software package in design. The full deployment was only at Bender Shipbuilding during beta testing before the beginning of this project. The key areas of concern were being able to generate penetrations as required through existing structural members, generating pipe spool drawings for pipe fabrication, and generating bills of material for parts ordering and tracking.

During beta testing of core functionality in the piping module, several new concerns were raised and questions regarding implementation of new functionality were asked. Designers found that they had already gained a generous boost in productivity due to the base piping module, and were now looking for specific feature sets that could also drastically reduce cycle time in early design phases.

Penetrations Module Overview

The Penetrations Module was a subset that ties together the Piping and HVAC Modules. Penetration identification and integration was identified as a key feature that has the potential to save thousands of manhours of fieldwork.

The penetration approval module identifies penetrations, links them to regulatory and design rule requirements, develops penetration lists, identifies those penetrations which will be lofted in and those which will be field cut, and output a complete penetration tube, collar and packing list. In addition, the penetration development was coordinated with structure and outfit geometry definition to identify potential interferences in the vicinity of the penetration.

FotoG Pilot Project Overview

The original intent of this combined module was to develop a methodology and proof of concept for integrating FotoG close range photogrammetry with ShipConstructor for process control and design of damaged repair components. Vexcel's FotoG was utilized to convert high-resolution digital photographs of both 2D and 3D components into CAD drawing formats. Leveraging from work performed on an SBIR grant, the focus was to integrate photogrammetry technology directly with the ShipConstructor design suite for both process control and rapid structural design for ship repair.

This combined module included 1) the development of an integrated, semi-automated production process control system, with ShipConstructor to provide real-time process control and QA for plate cutting and Unit/Block assembly; 2) to provide true shape 3-D shell plate and 2-D shell plate expansions to improve ship repair efficiency; 3) Wet berth repairs with CAD model creation. These modules were combined into one pilot project that completed five 3D CAD measurement projects in five days.

NURBS Non-Uniform Rational B-Spline Surfaces Overview

This module saw the modification of the ShipConstructor code for refinement of the hull surfaces definition to incorporate NURBS surfaces rather than 3-D mesh surfaces. This improved the plate expansion and lofting interfaces of the software, and increase the accuracy of expanded parts. Previous practice used a surface mesh and a mesh expansion algorithm to obtain the expanded plate. NURBS (Non-Uniform Rational B-Splines) provides a better mathematical definition of the surfaces, which is far more accurate when expanded into a 2-dimensional plane.

The ability to accurately reflect a mathematical surface provides the capability to take output from FotoG and use the information as an input to ShipConstructor. Areas of damaged hull can be identified in the FotoG software and outlined to identify the hull area to be cut away and replaced. The software interface will extrapolate the true shape of the hull and create an AutoCAD mesh, which can be converted to a NURBS surface. This enhancement allows ShipConstructor to provide both the true shape 3-D replacement plate, and the 2-D expansion for lofting and cutting.

Project Participants

The project was performed as a collaborative effort principally involving Bender Shipbuilding & Repair Co., Inc., Albacore Research Ltd., General Dynamics Electric Boat Division, Bollinger Shipbuilding, Northrop Grumman Ship Systems Avondale, VT Halter Marine, Alan C. McClure Associates, Inc., Elliot Bay Design Group, Murray & Associates, Ltd., Atlantec – es, Knowledge Based Systems, Inc., and Vexcel Corporation. Marinette Marine, Todd Pacific Shipbuilding, Genoa Design, Anteon Corporation (Proteus Engineering), Bishop State Community College, & University of Southern Mississippi were originally slated to participate in the project, but each of these organizations elected not to participate after certain modules that required their involvement were not funded at project award.

Bender Shipbuilding & Repair Co., Inc. was the prime contractor for this project. Bender's technical managers for this project were:

- Patrick D. Cahill – R & D Project Manager – cahi@bendership.com
- Patrick D. Roberts – Assistant Project Manager – prob@bendership.com
- Patrick L. David – Research & Development Engineer – davi@bendership.com
- Lee Douglas – Information Systems Manager – dugl@bendership.com

Albacore Research Ltd. was the lead software developer for the ShipConstructor 2005 design enhancements on this project. ARL's software developers for this project were:

- Rolf Oetter – President (Head Software Developer) – ARLmgt@shipconstructor.com
- Eric Dionne – Project Manager – ARL@shipconstructor.com
- Darren Larkins – Database Software Developer – ARL@shipconstructor.com
- Chris Bracken – HVAC Software Developer – ARL@shipconstructor.com
- Walter Langer – Pipe Software Developer – ARL@shipconstructor.com
- Jacob Trakhtenberg – Penetrations Software Developer – ARL@shipconstructor.com
- Jason Paterson – NURBS Software Developer – ARL@shipconstructor.com

General Dynamics Electric Boat Division was the lead in providing guidance to the development, adherence to the guidelines in creating the 2nd Tier Shipyard Common Parts Catalog database. The technical representative in this subject area was:

- Barry Espeseth – Common Parts Catalog Liaison – bespeset@ebmail.gdeb.com

Bollinger Shipbuilding was one of the 2nd Tier Shipyard participants in providing feedback on the CPC development, and the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representatives in this subject areas were:

- Dennis Fanguy – VP of Engineering – dennisf@bollingershipyards.com

- Brad Knight – CAD Manager – bradk@bollingershipyards.com

Northrop Grumman Ship Systems Avondale was one of the shipyard participants in providing the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representatives in this subject areas were:

- Gordon Marsh – Director Avondale Production Eng Site – gordon.marsh@ngc.com

- Terry Walley – Project Manager – terry.walley@ngc.com

- Cal Stein – Information Technologies – cal.stein@ngc.com

VT Halter Marine, Alan C. McClure Associates, Inc. was one of the 2nd Tier Shipyard participants in providing feedback on the CPC development, and the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representatives in the subject areas were:

- Randy Nixie – Engineering Manager – r.nixie@vthaltermarine.com

- David Perret – Computer Operations – d.perret@vthaltermarine.com

- Dave Ervin – Senior Design Engineer – d.ervin@vthaltermarine.com

Elliot Bay Design Group was one of the engineering design shop agents that participated in providing feedback on the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representatives in the subject areas were:

- Ken Lane – Executive Vice President – KLane@edbg.com

- Jim Towers – Senior Project Engineer – Jtowers@ebdg.com

Murray & Associates, Ltd. was one of the engineering design shop agents that participated in providing feedback on the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representative in the subject areas was:

- Allan Demmelmaier – Naval Architect – awd@murryandassociates.net

Alan McClure & Associates was one of the engineering design shop agents that participated in providing feedback on the enhancements made to the HVAC, Piping, and Penetrations Modules. The technical representative in the subject areas was:

- Scott McClure – ScottM@ACMA-INC.com

Atlantec – ES was one of the participants that provided assistance in the population of the document database for the Common Parts Catalog module. Atlantec-ES technical representative in the subject area was:

- Paul Rakow – Software Support Engineer – paul.rakow@atlantec-es.com

Knowledge Based Systems, Inc. was the lead software developer in creating the 2nd Tier Shipyard Common Parts Catalog interface and database. The technical representatives and software developers in the subject area were:

- Perakath Benjamin – Vice President – pbenjamin@kbsi.com
- Madhav Erraguntla – Research Scientist – merraguntla@kbsi.com
- Ron Phillips - Database Developer – rphillips@kbsi.com
- Shashikanth Hosur – Database Developer – Shosur@kbsi.com
- Ricardo Yepez – Sr. Information Systems Consultant – rhyepez@kbsi.com

Vexcel Corporation was the lead subject matter expert on the photogrammetry technology in use with ShipConstructor 2005. The technical representative in the subject area was:

- Jason Szabo – Close Range Engineering (FotoG expert) – szabo@vexcel.com

Best Practices

The state of the practice varies according to the different shipyards. Most of the member shipyards are using the ShipConstructor structural package to its fullest extent, and are usually producing full 3D models prior to construction. Some of the yards are also using the integrated piping module already to quickly design and spool the piping systems in vessels. Others use the Rebis Autoplant piping software package, which prior to the integrated piping system in ShipConstructor was the most reasonable OTS piping system available. 2D is used in all of the yards, with some of the yards occasionally using 3D AutoCAD for outfitting design. Each yard usually varies in its use of some sort of OTS or in-house scheduling and materials system.

One of the largest factors for a commercial shipyard in reference to its design software is the associated cost. Software and the required hardware to run it are a primary concern. Current pricing on ShipConstructor is approximately $20,000.00 per seat for all of the base structural package and associated modules. In addition, the individual modules can also be purchased as required and in different numbers than the base package to be used as needed. Depending on the size of the backend database required and the number of modules required, the base structural package can also be purchased on a varying price scale to reflect the overall size requirements of the end-user. This pricing contrasts sharply with the design software suites in use by the first tier shipyards, which can often run +$40,000.00 per seat.

At the beginning of this project, none of the second tier shipyards were leveraging any of the work done in the ISE project; in particular, no second tier shipyard was using any sort of Common Parts Catalog, or STEP compliant formatting to existing data. Each of the yards had to individually find and implement their own type of parts tracking and data storage format, which was often sub-standard when compared to the capabilities being offered by the CPC. Further, the design agents themselves were not really familiar with the actual practices and procedures involved at each of the shipyards including production support practices, or the structure of the underlying design databases in use.

There was at the beginning of this project no OTS software that could effectively integrate both the geometric model and data model in use by ShipConstructor. Many of the member yards have looked for a solution to the problem that was addressed in this project, but often found software packages more suited to other industries instead of being tailored specifically to the needs of a commercial shipyard. This project focused mainly on providing a solution to a common problem shared by all of the second tier shipyards concerning better data integration between the ShipConstructor geometric model, and the parametric design data underlying it.

Planning, scheduling, and production control interfaces have proved to be almost as scarce. There are OTS ERP systems available, but the end result has also proven to be extremely expensive as well as forcing the business model of the shipyard to adapt to the particular methodologies of the software. This was considered a hindrance in that the special needs of the commercial shipyard were not being met, but rather were being forced into the specific model envisioned by the software developers. The MIDAPS and WorkSIM packages were developed by KBSI under ONR grants and provided a flexible and extensible backend to allow for the customizations that are often required by the shipyard when considering the planning, scheduling and production procedures.

The most common method of handling HVAC design components in the commercial shipyards has often been to specifically plan during the modeling and design phase around what might be required to install and use an HVAC system. With no packages available to design and model the HVAC system effectively, they are often modeled as voids in spaces so that structural, electrical, and piping components can be routed around them. This has left serious room for errors and misalignments during the design phase to account for the HVAC system that has not been modeled.

The ship repair methodologies were often just as cumbersome in some respects as they have always been. With a varying type and age of vessel being repaired, it is often hard or impossible to locate and procure effective 3D cad models or even 2D drawings in some cases to effectively be able to plan the processes required in repair. This does not integrate well into the current system, with many of the tasks having to be completed by hand. Measurements that need to be made in the field are often done with the collaborative work of more than one field engineer, using old methods of manual measurement that can be extremely time consuming and costly. When not performing a manual method of measurement, there are oftentimes sub-contractors brought in to perform laser scans or to use laser measurement systems. The services of these sub-contractors becomes excessively expensive if used too often, thus exposing a need for the shipyards to find an effective means of integrating the ship repair business into the main flow of new design and construction. If repair requirements can be injected into the design stream such as a new construction job, then the rest of the processes become streamlined into the regular production methods, requiring no major changes in the overall process, and taking advantage of advances in technology and efficiency already gained.

Project Metrics

The project metrics can be separated into three separate categories:

- ShipConstructor2005 Enhancement Metrics
  - Modules tracked:
    - CPC
    - HVAC
    - Piping
    - Penetrations
- Common Parts Catalog Part Population Effort
- FotoG Cost Saving Comparison

The following tables provide the project metrics that were tracked during the project.

Table 1: ShipConstructor2005 Enhancement Metrics

	JANUARY 2004			
ENHANCEMENT METRICS	**CPC**	**HVAC**	**PIPE**	**PENETRATIONS**
FEATURE REQUEST	21	41	31	5
COMPLETED	9	28	12	5
INCOMPLETE	12	13	19	0

	JUNE 2004			
ENHANCEMENT METRICS	**CPC**	**HVAC**	**PIPE**	**PENETRATIONS**
FEATURE REQUEST	46	41	26	21
COMPLETED	29	27	19	13
INCOMPLETE	17	14	7	8

	SC2005 ENHANCEMENT METRIC TOTALS			
ENHANCEMENT METRICS	**CPC**	**HVAC**	**PIPE**	**PENETRATIONS**
FEATURE REQUEST	67	82	57	26
COMPLETED	38	55	31	18
INCOMPLETE	29	27	26	8
FEATURE REQUEST % COMPLETE	57%	67%	54%	69%
FEATURE REQUEST % INCOMPLETE	43%	33%	46%	31%

Table 2: Common Parts Catalog Part Population Effort

	CPC DATA ENTRY	
DATA POPULATION METRICS	**JAN 2004**	**JUNE 2004**
PARTS IDENTIFIED FOR CPC	5200	4092
PARTS POPULATED INTO CPC	300	2945
NON-CPC COMPLIANT PARTS	24	1108
PARTS CLASSIFIED W/NO DOCUMENT ASSIGNED	0	1147
# OF DOCUMENTS POPULATED	0	319

Table 3: FotoG Cost Saving Comparison

Current Method

- Ship check & QA ~ 760
- Subcontract Scan ~ 961
- Subcontract CAD ~ 500
- Overhead ~ 27
- QA ~385

=====

Man Hours ~ 2633

Travel Costs ~ $30K

FotoG (estimate for equivalent 3D model)

- Ship check & QA ~400
- Field Photos ~ 80
- Link Photos ~ 8
- CAD drawing ~ 40
- QA (CAD overlay) ~ 2

=====

Man Hours ~ 530

Travel Costs ~ $15K

Results

ARL was able to begin preliminary development of the modules concerned in the project early enough to ensure that a beta was delivered very early in the project for immediate feedback from project participants. Given the distributed nature of the development team at ARL and each of the member shipyards, a good forum and communication tool was required to enable team members to share thoughts and ideas, and to identify bugs and requests without having to double or triple the amount of messages and information being sent. This collaborative website was setup by the lead yard, Bender Shipbuilding to help facilitate this exchange of ideas.

The use of a central collaborative website was instrumental in effectively addressing problems across multiple participants in the project. Feature requests could be grouped accordingly, and bug fixes could be addressed more efficiently by the software developers as they were identified. The advantage of this mode of operation for feedback is that the features with the most comments and most requests could be quickly identified and dealt with. The same paradigm holds true for bug fixes in the software that could have had an adverse effect on the efficiency of using the tool.

An example of the efficiency of this model of collaboration is pointedly noticeable in the fact that by the time the first quarterly meeting was held, more than 50% of the requested features at the time had already been completed. Development already began on all of the proposed features, and many were near completion already.

CPC Module Results

The previous state of the parts cataloging methodologies in place at the various shipyards was haphazard at best. With no easily adaptable OTS software, the shipyards were forced into adapting resources that were immediately available. In some cases these were resources that had not been examined or updated to ensure their most efficient use in many years. Antiquated computer hardware and software carried over through many years had finally proven to be too cumbersome to be an effective data storage method. If the hardware and software had been updated, it had been done without a clear understanding of current database management methods. Often this consisted of nothing more than a few simple computer spreadsheets containing text fields that were filled out by various individuals according to their own personal styles. Or, in the case of Bender Shipbuilding, an old model IBM mainframe with a very limited database functionality utilizing the same type of free text fields. The data was carried over through many years of use, and never properly treated to be an effective data management tool.

With the work done in the ISE, standards and methodologies were developed that carefully examined what the best methods for storing and categorizing shipbuilding specific parts and materials. The first tier shipyards spent years examining their parts catalogs, and identified traits and attributes that best defined the different parts as well as the sections that were common to many different parts. These attributes include traits such as length, weight, other dimensional data. Electrical data such as amperage, voltage, resistance, etc were also considered. These traits were identified for their entire parts catalogs, and were categorized accordingly. Along with the traits that belonged to each set of parts, the parts were also categorized according to where they fell into a much more general hierarchy of parts. Similar parts were grouped together under a more general heading that was again grouped with other headings under even more general headings. This procedure was reproduced until all the possible parts being contained in the catalog had been effectively placed within a larger organization. As the different attributes were properly identified so too were the possible ranges of values, and the formats that would be the most easily extensible and translatable. In short, modern methods of data management and information sharing were carefully examined, and the parts catalogs were carefully restructured to take advantage of the latest in technology and information systems.

Implementation of a Common Parts Catalog system has produced great benefits in moving forward the entire ship design/production methodologies. With the data in a well-defined format, integration became possible between the parts catalogs, the design software ShipConstructor, and the various MRP systems in use. By using standards based XML formatting, each program could reliable expect the same format and data types for the parts information. This relieved the apparent randomness and confusion prevalent in the previous systems. KBSI leveraged the existing work done by the first tier shipyards to create a specific subset of the entire CPC that is customized for the demands of the second tier commercial shipyards. This included the database backend using current SQL databases as the storage mechanism, and a custom front end for direct access to the information. More importantly, though, was the XML export/import into ShipConstructor, which allowed a designer to pull parts directly from the CPC into the design environment thus integrating the entire process with the other pieces of related software.

Initial work in defining and outlining the required XML schema of the ARL database yielded a valid format for parts information. This led to the methodology of ShipConstructor querying the CPC database and requesting information on a part as an XML file with a pre-defined structure. Through the use of an XSL transformation, the data is converted into a format valid for the ShipConstructor database. Some data carried in the ShipConstructor database is not carried in the CPC by definition, and is prompted from the end user at runtime and as needed.

KBSI developed a library for ARL to use in querying data from the CPC database in an XML format that conforms to CPC XML. This data is then transformed into a format suitable for inclusion into the ShipConstructor data model. Figures #1 – 5 provide a visual representation of the development plan and schema for data abstractions, creation, and database population between the ARL and CPC databases.

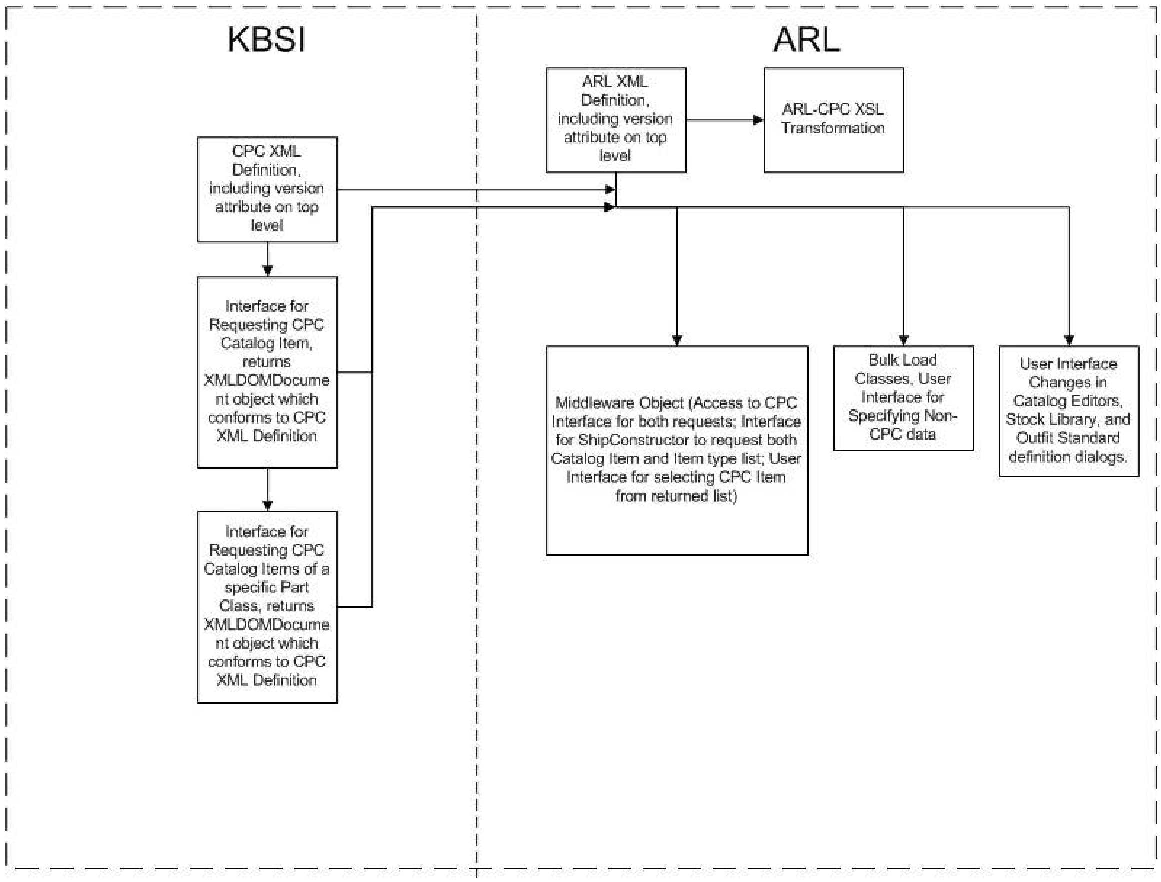


Figure 1: Overview of development plan between KBSI and ARL

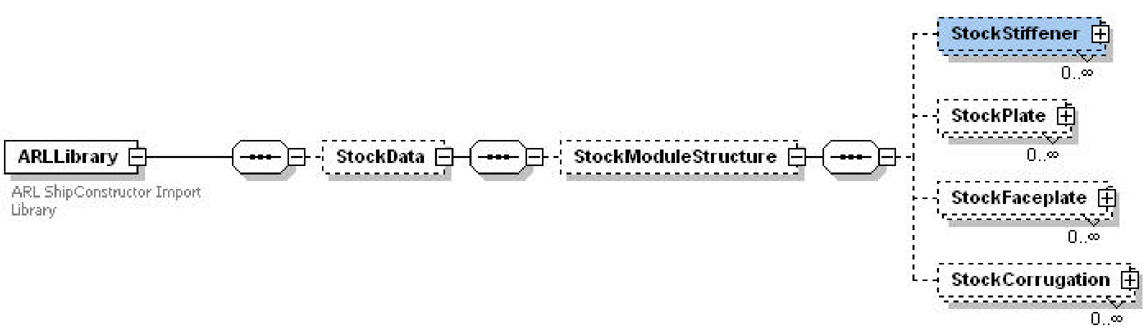


Figure 2: Highest Level Abstraction of ARL XML Schema

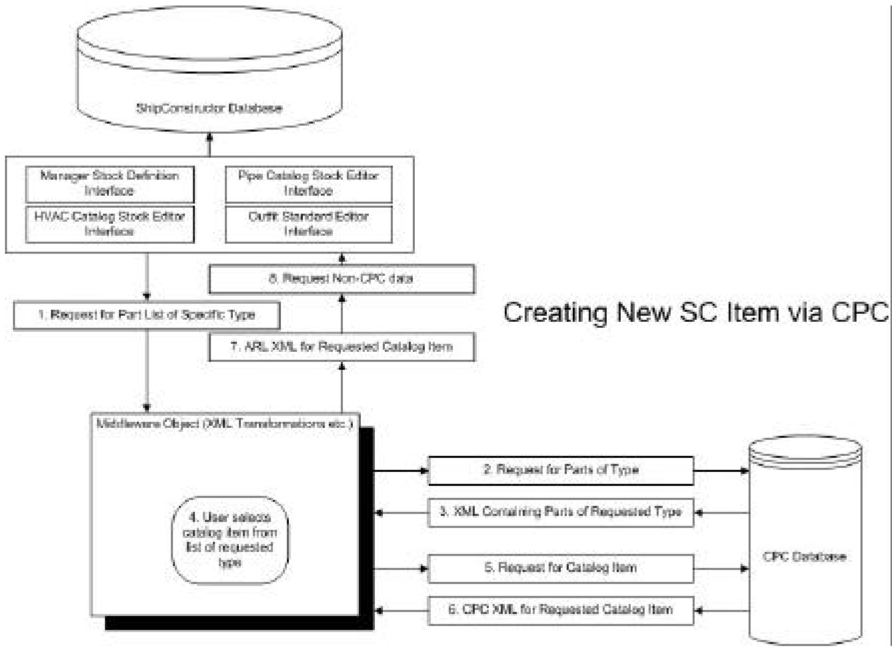


Figure 3: Creating a new ShipConstructor Item via CPC

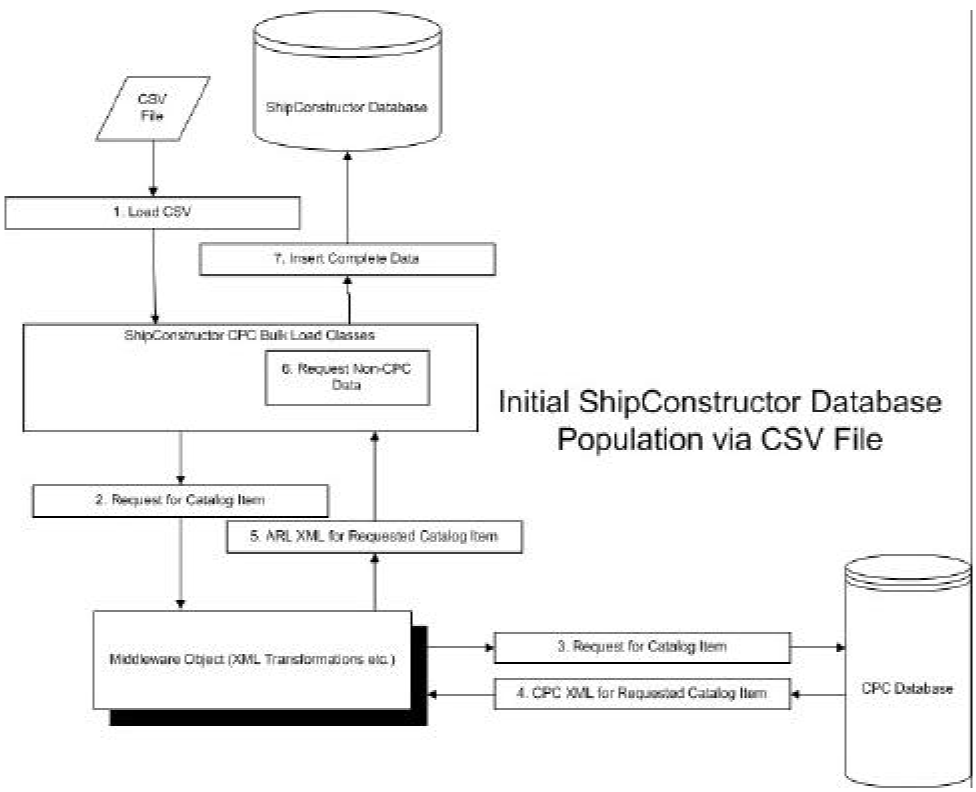


Figure 4: Initial ShipConstructor Database Population via CSV File

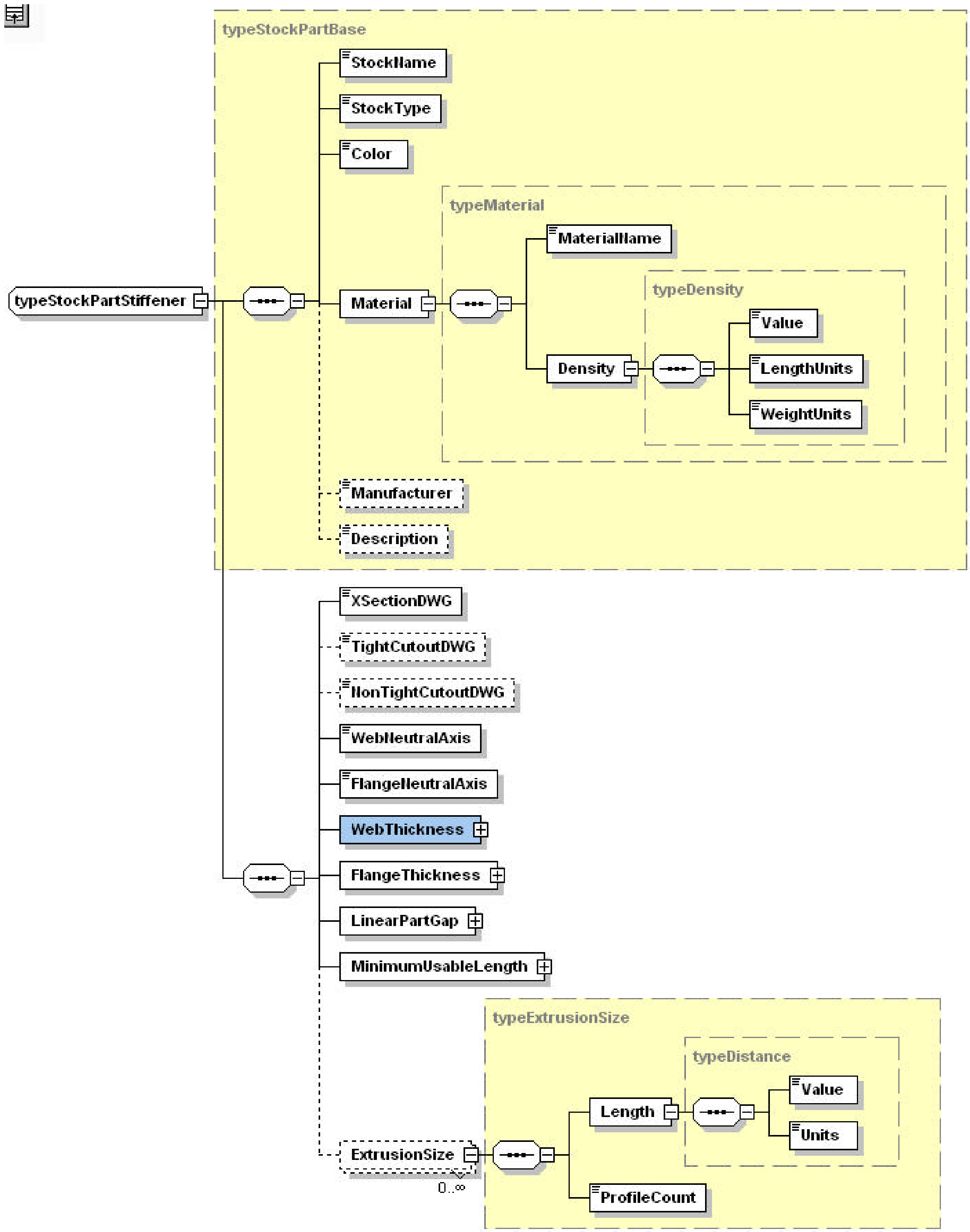


Figure 5: Detail Abstraction of Stiffener Part Entity (others are similar)

Part Class Manager

The Part Class Manager application within the 2nd Tier CPC allows for the management of the part classification hierarchy, attributes, and attribute value space that have been determined by the NIIIP Taxonomy and Data Element Dictionaries (DED) defined and revised by the Central Configuration Control Group (CCCG) that is regulated by the Tier One shipyards.

The Node Structure window displays the hierarchy structure. The inheritance can be viewed in the Inherited and Assigned Attributes windows as the user moves down through the node structure.

Attributes that are:

- Relevant for an organization or not
- Identifying or non-identifying
- Primary key or not
- Required or optional
- Enumerated or range values
- Data source

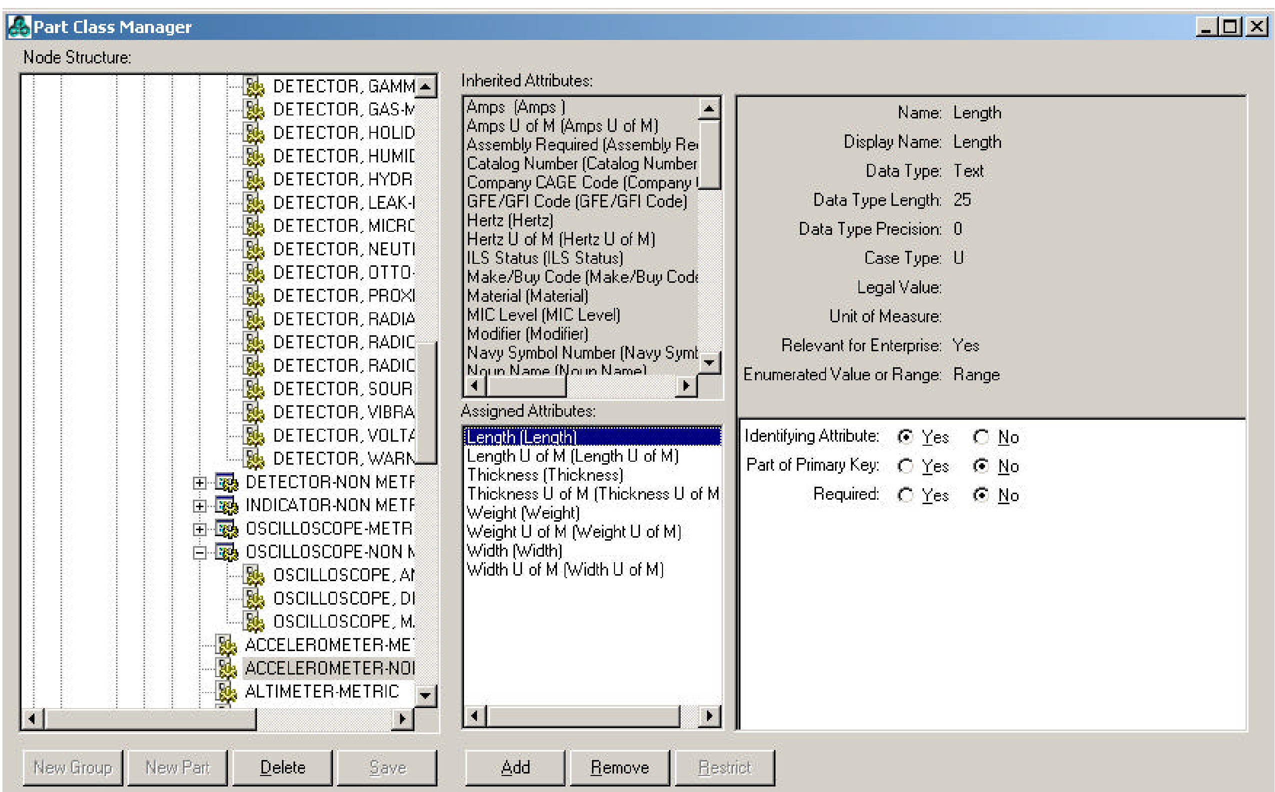


Figure 6: CPC Part Class Manager Interface

Part Master Manager

The Part Master Manager organizes the hierarchy of the class groups and classes to which parts in the CPC are associated. The role of the Part Master Manager in CPC is to create parts. Important to note that it provides a hierarchical list of part classes in CPC identical to the list provided in the Part Class Manager. The important difference between the two lists, is that, parts are created in the Part Master Manager by selecting the appropriate part class and specifying the attribute values.

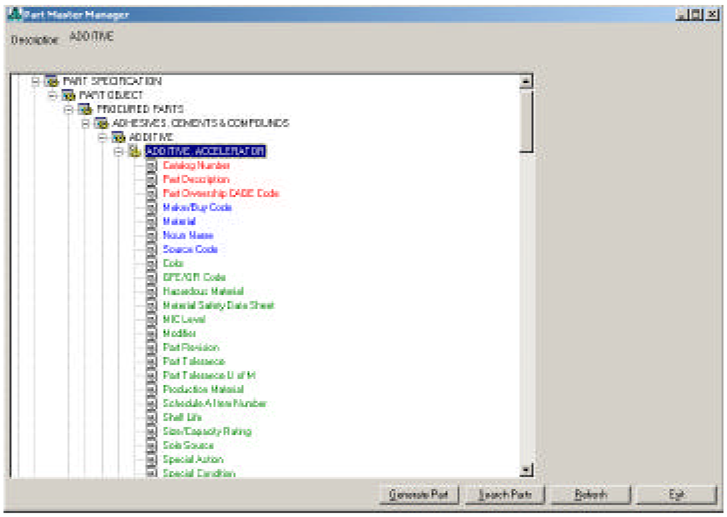


Figure 7: CPC Parts Master Manager

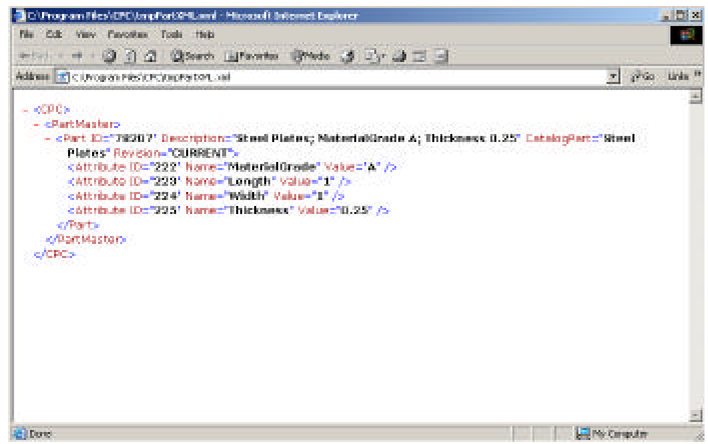


Figure 8: Example of a XML part definition

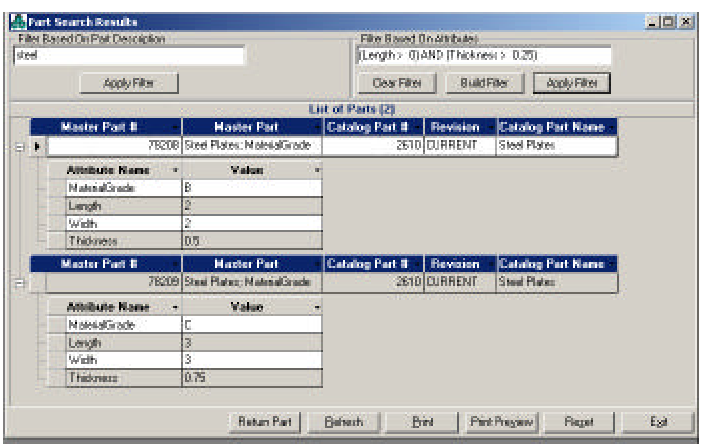


Figure 9: Example of Parts Search Capabilities

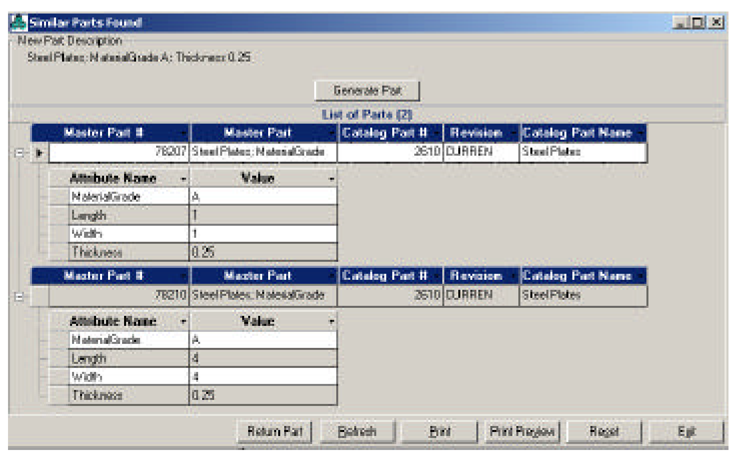


Figure 10: Example of Similar Part Definition

Document Database

In CPC, documents capture information related to manuals, specifications, or other document types. CPC allows for the creation of documents, but also the association of specific documents to specific parts within the database.

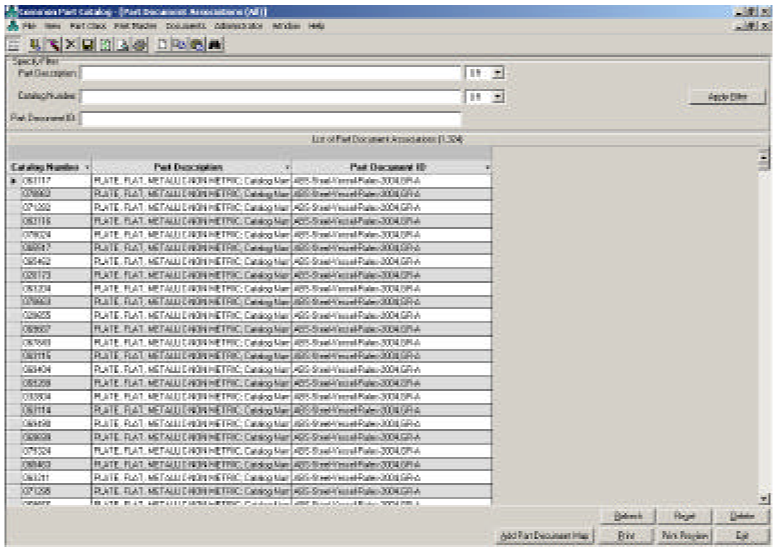


Figure 11: Example of the Part Document Association Screen

User Roles and Permissions

CPC's administration functionality is focused strictly on adding new users to CPC, disabling existing users, and defining access privileges for CPC users. The level of user privilege determines the functions that a particular user can perform. All administration functionality is performed in the Access Control window.

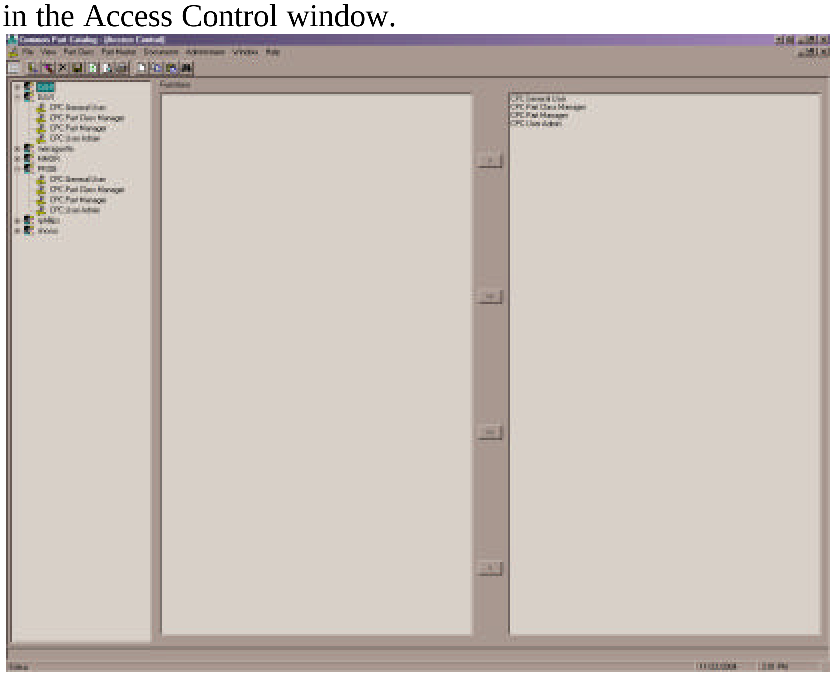
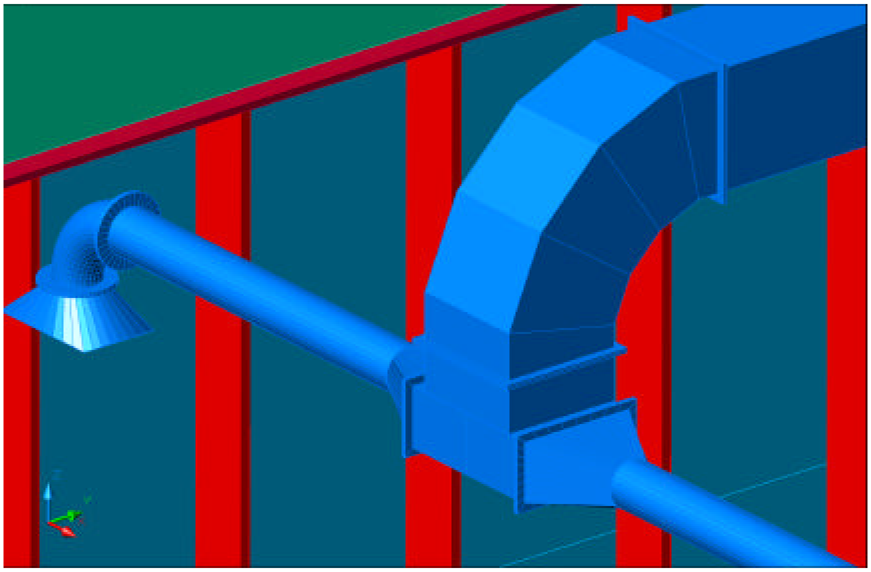


Figure 12: Access Control Assignment Window

HVAC Module Results



Design and consideration of a typical HVAC system is not a new practice. Traditional methods have involved only rudimentary engineering analysis of the requirements of the system, with general routes and requirements being defined. Often the final stages of actual construction and installation of an HVAC system was one left to field specific issues. While this does provide for a certain level of abstraction regarding the handling of HVAC design, it leaves a lot to be desired for a procedure that aims to fully model and design a system before the production process has to take over. Space is often at a premium on vessels, and generalizing requirements for an HVAC system have often left much to be desired as to efficient use of spaces. The capability to model the HVAC system inside the ShipConstructor model is a quantum step forward in better utilizing the existing space and layout of such systems. With the HVAC system now being able to be modeled alongside other systems in a vessel, more efficient use of space and availability can be considered, thus leading to more efficient placement and models. Integration into the design aspects of the model also allow for determination of better planning processes to support HVAC installation and use.

Early development in the HVAC module focused primarily on defining the geometric representations of ducts and fittings. This included calculation of critical design data such as weight, surface areas, centre of gravity, and geometric extents. Solid generation routines from this led to export drawings and interference checking, which greatly enhanced the capabilities. Overall HVAC geometries were finalized early in the design process of the project, and have enjoyed several iterations and feature integrations through constant feedback of team members as they became accustomed to the new features. With this feedback, a solid base was laid upon which to build better user interfaces, database tracking, and duct-to-duct connections. This also allowed the geometric data to be clearly defined for each part, as well as to track more efficiently within the database.

HVAC Spool Drawings

Staying consistent with the functionality of the Pips Spool drawings, ShipConstructor2005 will automatically generate dimensioned HVAC spool detail drawings. The user interface and commands are consistent with Pipe module for continuity. It also uses the new Smart BOM's and Auto-labeling functions.

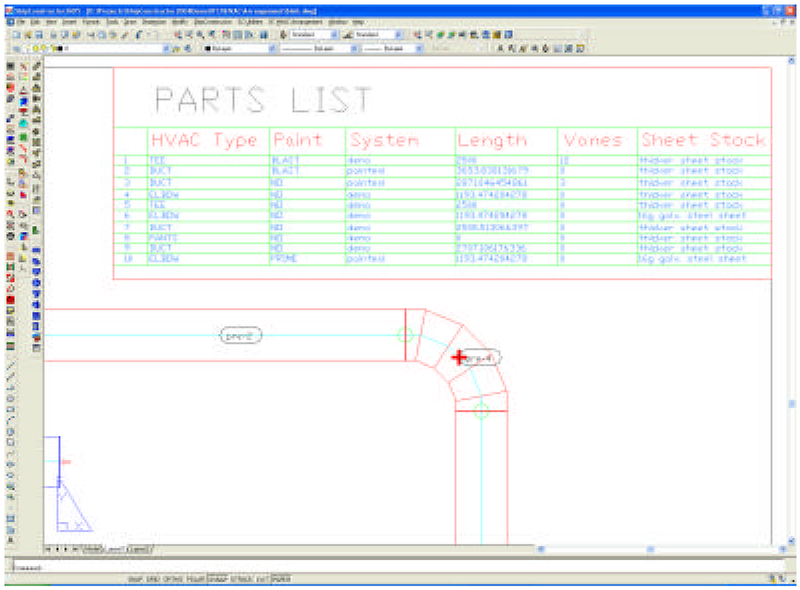


Figure 13: Example of a HVAC Spool Detail Drawing

HVAC Spool Manager

The process of defining a spool has been streamlined, from four steps down to two. The Spool Properties dialog now includes the hierarchy level, so that all the information of a spool is visible at once. The Define Spool Name dialog also displays available spool names more clearly.

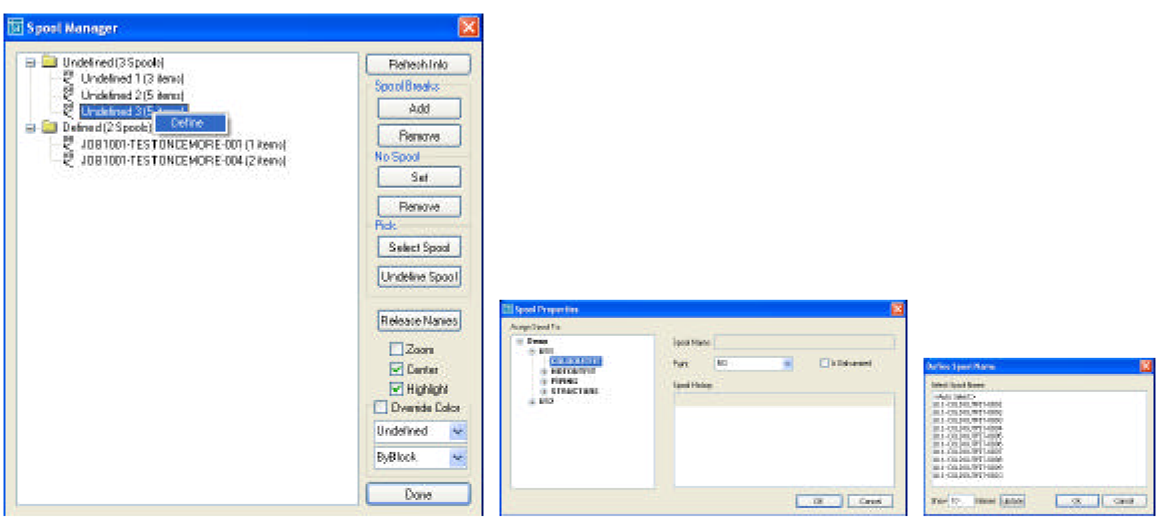


Figure 14: Defining a Spool

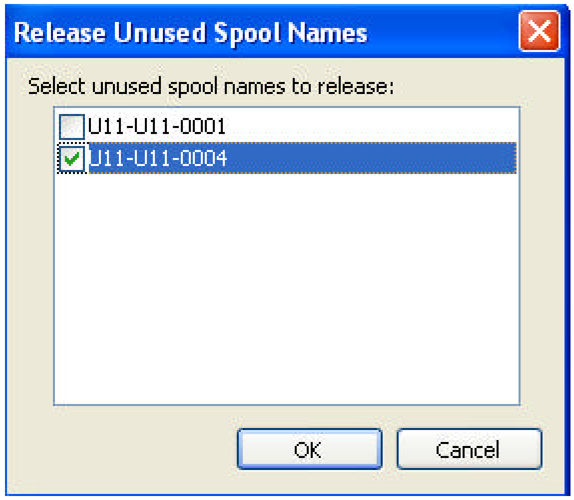


Figure 15: New feature: Release Unused Spool Names

Very important to the design process the developers were striving for was the ability to design both on-the-fly modeling as well as catalog based modeling in tandem. This included the ability to create spools composed of both types of parts, support for systems and specs, and connection handling. Common to both the HVAC module and the piping module was the use of new "intelligent" Bills of Material. These objects grew from simple text blocks in the modeling software to full fledged AutoCAD objects that have attributes and capabilities assigned to them. Most importantly, is having the ability to regenerate the information as changes are made throughout the model. This included ensuring that any labels attached to associated structure in the drawing would be updated and tracked accordingly as well.

Smart Bill of Material Entity

Bill of Material Definitions were expanded to include smart BOM attributes such as user-defined BOM titles and column titles, text formatting and border formatting, ARL's advanced list control for easy reordering and renaming of BOM columns.

Parts List

Type of HVAC	Sheet Stock	Paint	Insulation	Length
1 ELBOW	16g galv. steel sheet	NO	none	1193.474
2 ELBOW	16g galv. steel sheet	PRIME	none	1193.474
3 TEE	14g galv. steel sheet	PRIME	none	2500.000
4 TEE	14g galv. steel sheet	PRIME	none	2500.000
5 PANTS	14g galv. steel sheet	PRIME	none	0.000
6 ELBOW	14g galv. steel sheet	PRIME	none	1193.474

Figure 16: Example of a HVAC Parts List

Smart BOM's can be automatically refreshed rather than re-created each time a drawing is changed. Smart BOM Labels are also an enhancement feature. Columns can be resized with grip points; it's just like EXCEL. Text size, font, and color can all be set through properties. When the BOM is updated, all labels in the drawing are automatically updated to match as well. Customization of grid can be turned on and off as different modes like EXCEL. (just horizontal row lines, just column separators, etc). Can Osnap it in wherever you want in your drawing or title block. Can use it in your templates, and all drawings will fill it in exactly how you configure it. In HVAC now, but will be available in Piping and Structure in the future.

HVAC BOM definitions

In preparations during development of the HVAC module for anticipation of generic connections to pipe and other outfit parts, there was a complete redesign of the HVAC parts data that included significant improvements to the HVAC parts revision history.

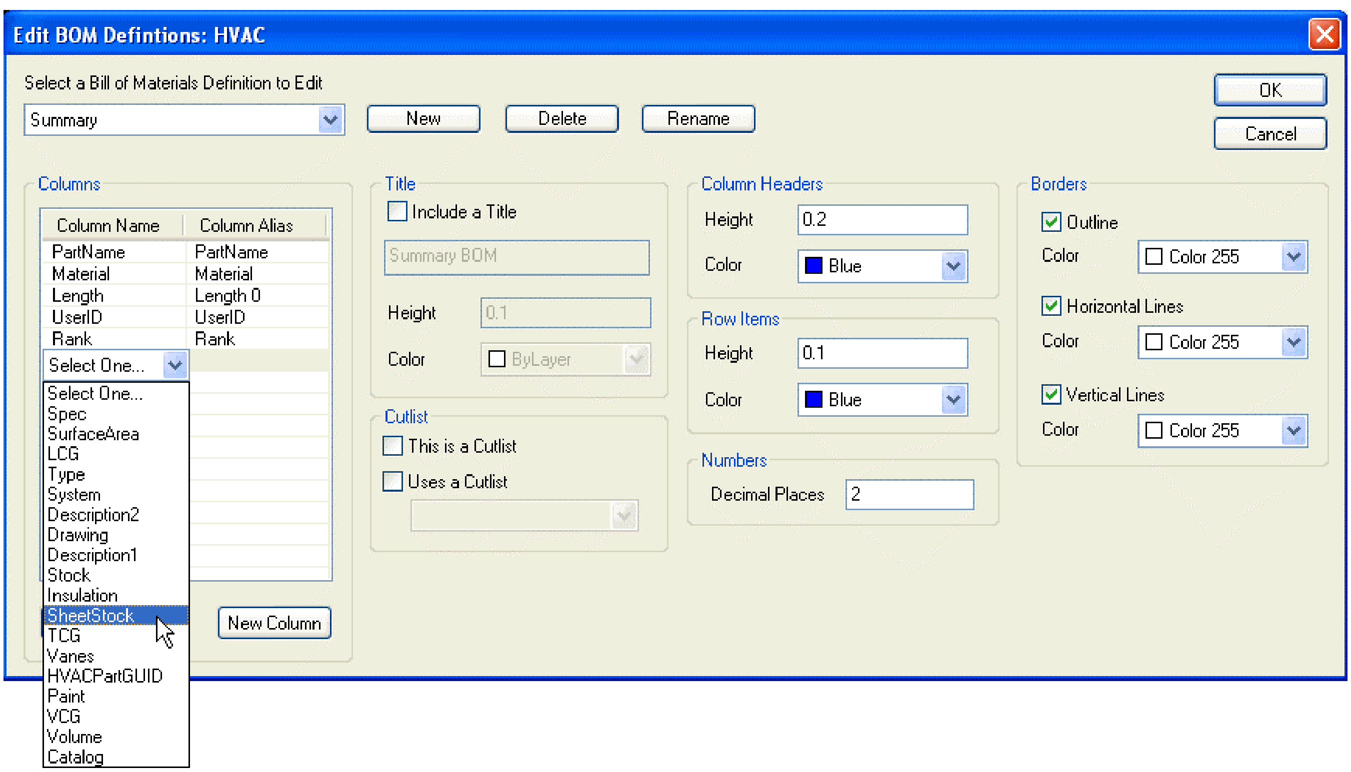
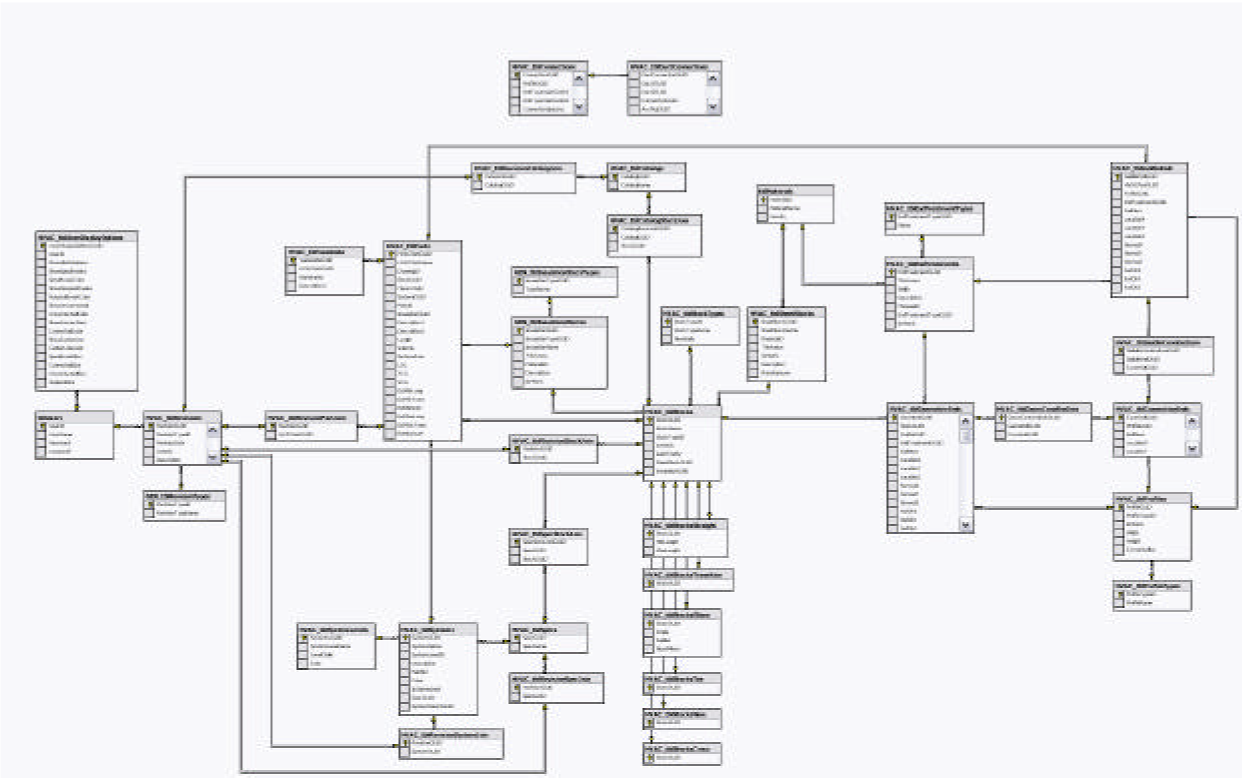


Figure 17: Edit of HVAC BOM Definitions

HVAC database design

Figure 18: Network diagram of the HVAC database design.



SWBS Part Extents in Custom Reports

ShipConstructor2005 now, optionally, includes Max/Min part extents for HVAC and Pipe items. These extend from a bounding box for the enclosed volume for the part.

Piping ARL SC2004 Demo

Name	Type	Stock	Quantity	MinL	MaxL	MinT	MaxT	MinV	MaxV
Piping	PROJECT		94	69.37	75.39	-4.48	4.67	0.47	4.53
BALLAST	SYSTEM		46	69.76	75.39	-4.48	0.92	0.47	0.92
E-90LR-CS_02.5_XS-A234 (29870)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	70.79	70.93	0.79	0.92	0.53	0.60
E-90LR-CS_02.5_XS-A234 (29876)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	70.85	70.98	-2.72	-2.59	0.53	0.60
E-90LR-CS_02.5_XS-A234 (29878)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	72.70	72.83	-2.78	-2.65	0.53	0.60
E-90LR-CS_02.5_XS-A234 (29893)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	70.79	70.93	0.79	0.92	0.53	0.60
E-90LR-CS_02.5_XS-A234 (29899)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	70.85	70.98	-2.72	-2.59	0.53	0.60
E-90LR-CS_02.5_XS-A234 (29901)	PIPE ELBOW	E-90LR-CS_02.5_XS-A234	1	72.70	72.83	-2.78	-2.65	0.53	0.60
E-90LR-CS_04.0_XS-A234 (29880)	PIPE ELBOW	E-90LR-CS_04.0_XS-A234	1	73.50	73.71	-2.84	-2.63	0.50	0.62
E-90LR-CS_04.0_XS-A234 (29882)	PIPE ELBOW	E-90LR-CS_04.0_X	1	73.40	73.61	-3.85	-3.64	0.50	0.62

Figure 19: Max/Min Part Extents for HVAC & Pipe items.

Catalog-based Modeling

Users can per-define HVAC catalogs of ducts and fitting including end treatments and standard profiles. On-the-fly modeling and catalog-based modeling can be combined, even within the same drawing or system. Full system and spec support is provided as in piping.

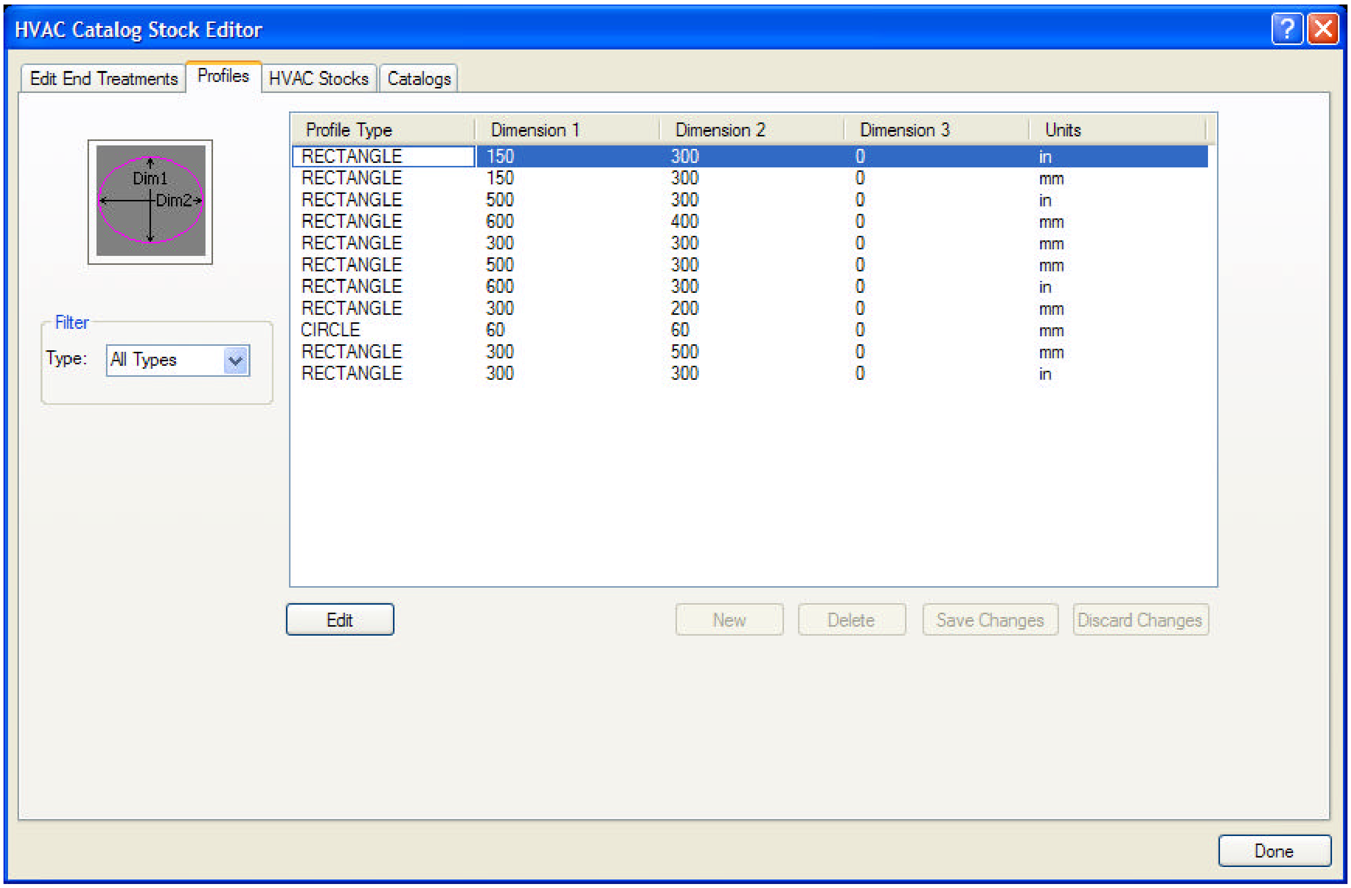


Figure 20: HVAC Catalog Stock Editor

HVAC Modeling Improvements

ShipConstructor2005 will now support multiple miter elbows with unlimited number of miters, which can now be defined by radius. It will also support HVAC-to-pipe connections. Outfit items can now support HVAC and Pipe connections simultaneously (ie. Pipe and HVAC items such as A/C units). New connection and routing options allows for easier elbow routing where the user can freely rotate an elbow attached to rectangular or elliptical profile (just like they can rotate HVAC and pipe elbows), and the radius will automatically be adjusted.

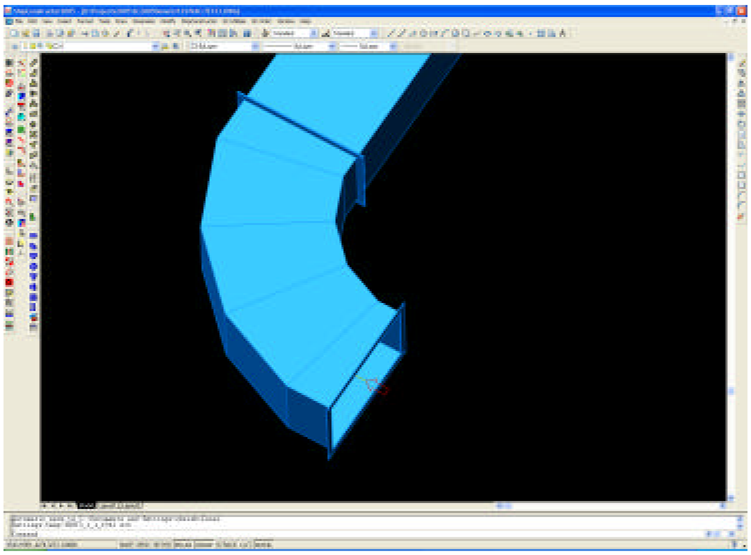
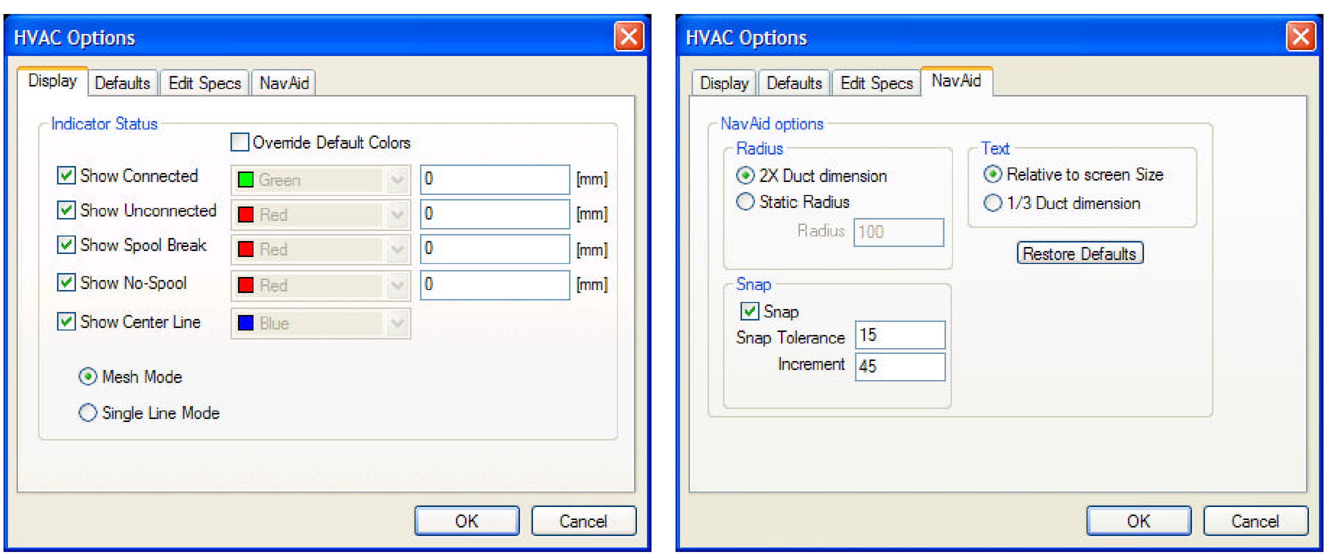


Figure 21: HVAC Duct Model Display

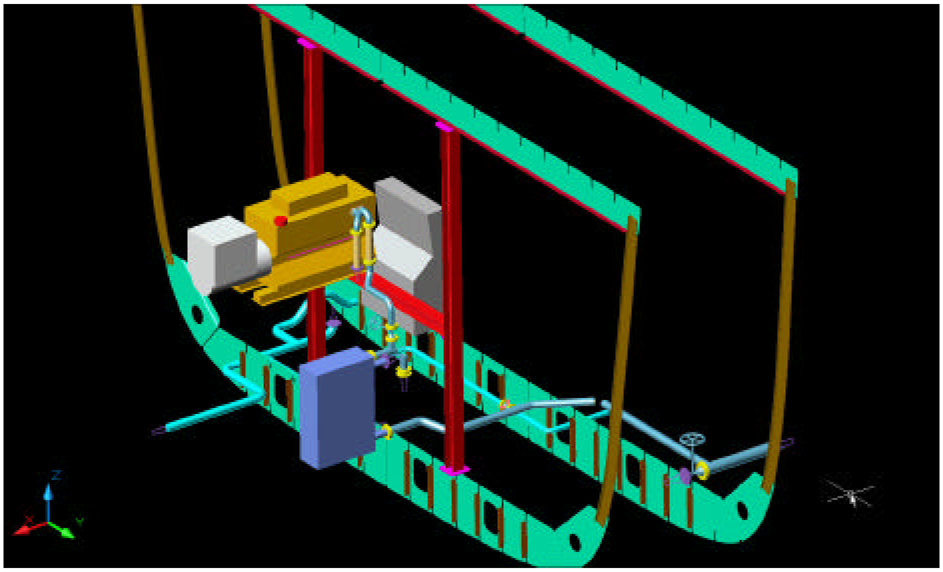
Improved HVAC Display Options

There were several improvements made to the display options provided in the HVAC module. By default, ShipConstructor auto-sizes its symbols. Now custom size, color, and visibility, or mix and match auto-size and custom size can be set and sized for any HVAC symbol in the program. A selection of either Mesh or Single-line display mode can be selected for the HVAC component. Additional NavAid options were added to provide a full set of NavAid options now matches Piping feature-for-feature.

Figure 22: HVAC Display Options Interface



Piping Module Results



The introduction of the original piping module greatly enhanced the capabilities of the ShipConstructor modeling package. Most of the users of the ShipConstructor package were already taking advantage of the bonuses offered by having an integrated piping package along with the structural modeler. This module aimed to leverage the already effective piping package, and to use feedback directly from the shipyards for input on improvements and efficiency of use.

Linked DWG Lock

The Linked Drawings Lock keeps files from accidentally being moved or deleted.

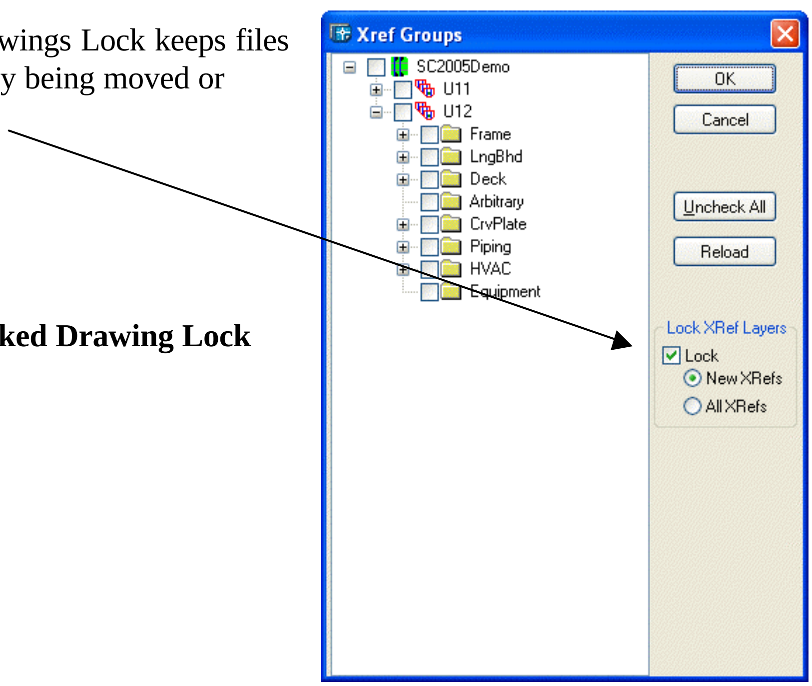


Figure 23: Linked Drawing Lock

Layer Control Manger

ShipConstructor users make heavy use of building complete or partially complete 'X-refed' drawings to get the required overview of how their model fits in with the models of all other departments involved. For example, it is not uncommon to quickly link dozens of structural, pipe and HVAC drawings to your own pipe drawing to check out in 3-dimensions what effects certain modeling options will have. AutoCAD provides a layer control manager. However, it takes too long to set up exactly what you need to see and be able to quickly make adjustments. This is the typical situation of not seeing the forest for all the trees. This function includes:

- Complete and predefined layer settings that can be recalled at any given time.
- Organize layers into groups of different types.
- Allows users to quickly hide/show or freeze/thaw layers from various drawing types.
- Specify layers directly or use wildcards to control layers

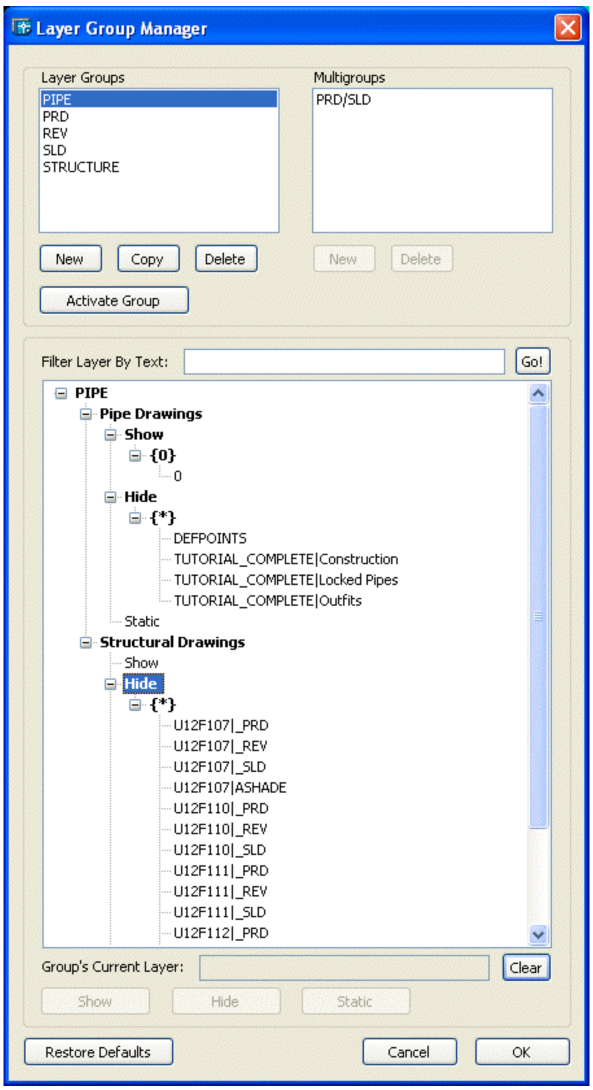


Figure 24: Layer Group Manager for Layer Control

Find – Replace Stocks

Search and replace capabilities were extended to allow for replacement of all pipes and fittings within the model. This will aids users in swapping components due to spec changes.

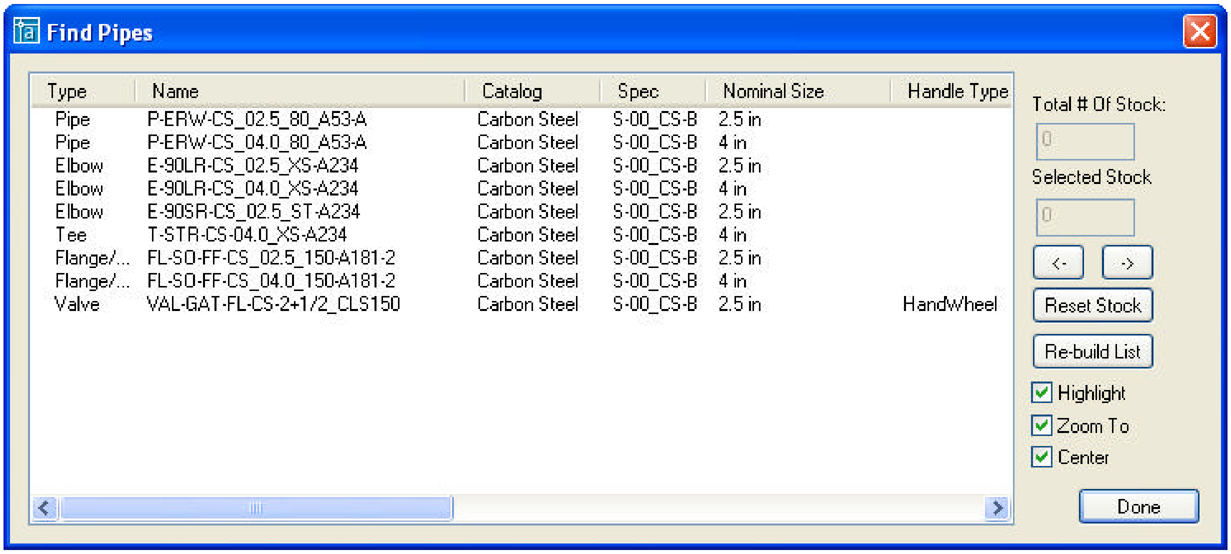


Figure 25: Interface for Finding Pipes

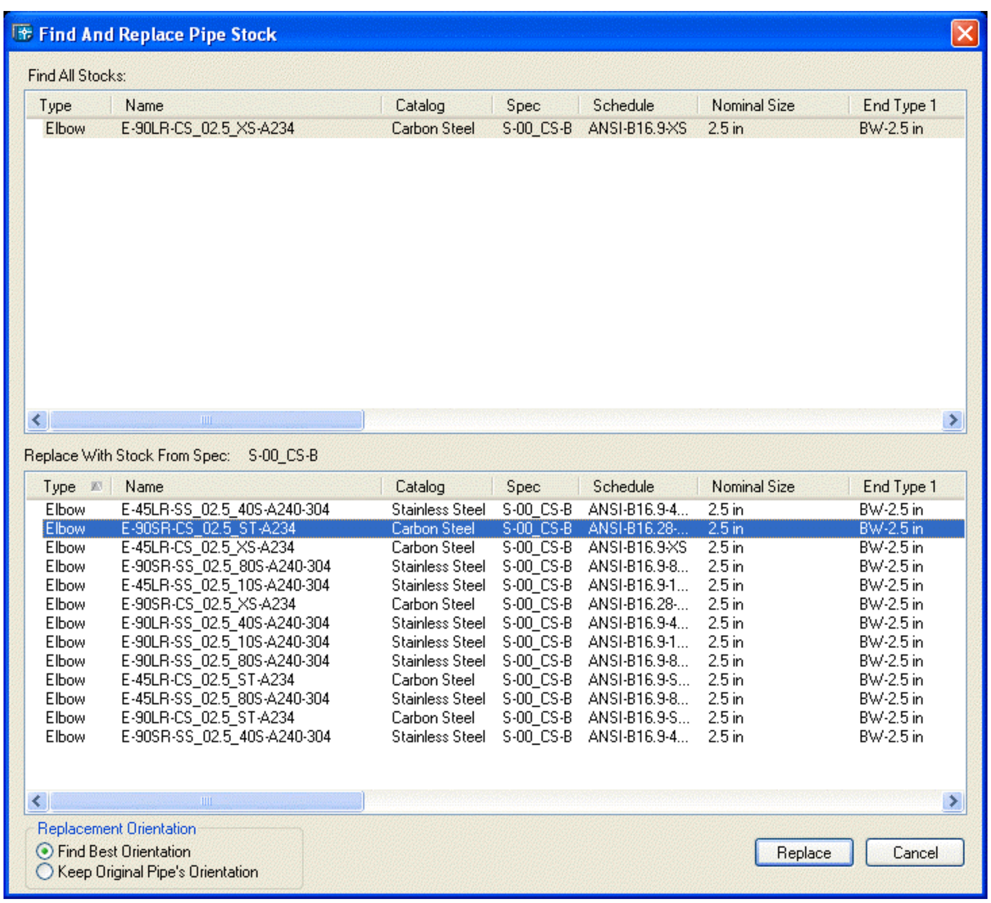


Figure 26: Interface for Find and Replace Pipe Stock

Smart BOM Integration

Smart BOM's can be automatically refreshed rather than re-created each time a drawing is changed. Smart BOM Labels are also an enhancement feature. Columns can be resized with grip points; it's just like EXCEL. Text wrapping, Text size, font, and color can all be set through properties. When the BOM is updated, all labels in the drawing are automatically updated to match as well. Customization of grid can be turned on and off as different modes like EXCEL. Item numbering was also included. Much of the same enhancements were made in conjunction to the HVAC module.

PIPE STOCKS				
	Stock	Catalog	System	End Preps
1	P-ERW-CS_04.0_80_A53-A	Carbon Steel	BALLAST	PL - PL
2	E-90LR-CS_04.0_XS-A234	Carbon Steel	BALLAST	BW - BW
3	P-ERW-CS_04.0_80_A53-A	Carbon Steel	BALLAST	PL - PL
4	E-90LR-CS_04.0_XS-A234	Carbon Steel	BALLAST	BW - BW

Figure 27: Example of Smart BOM for Pipes

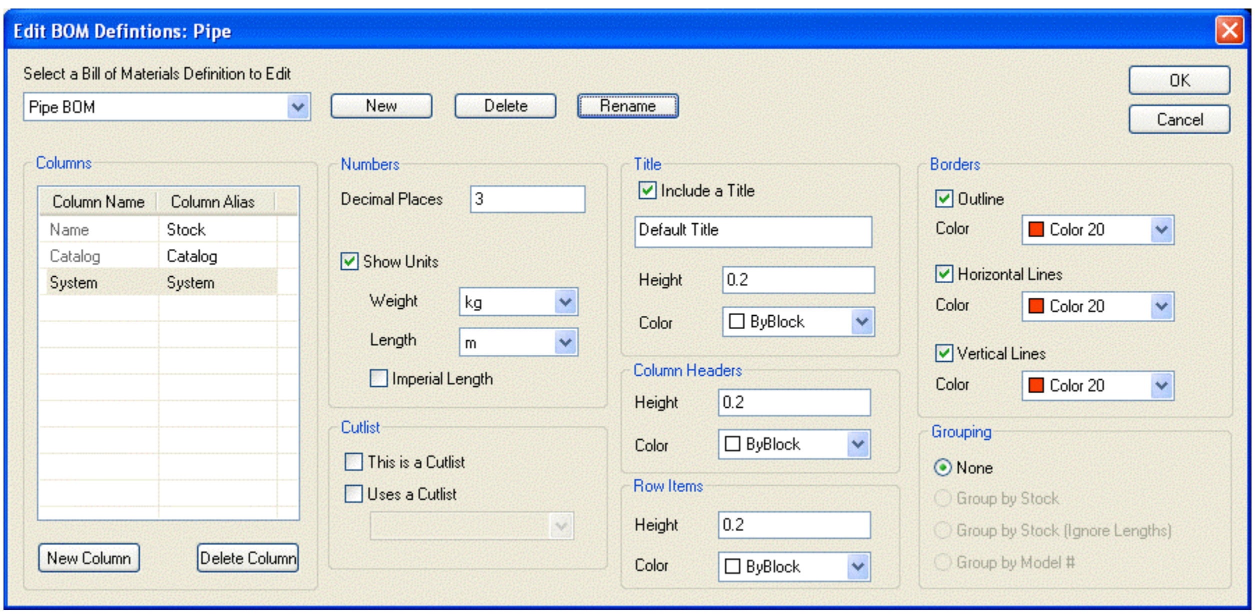


Figure 28: Edit of BOM Definitions for Pipe

Global dimensioning

Dimensions globally to the nearest or selected structure and optionally marks as dimensions or as label.

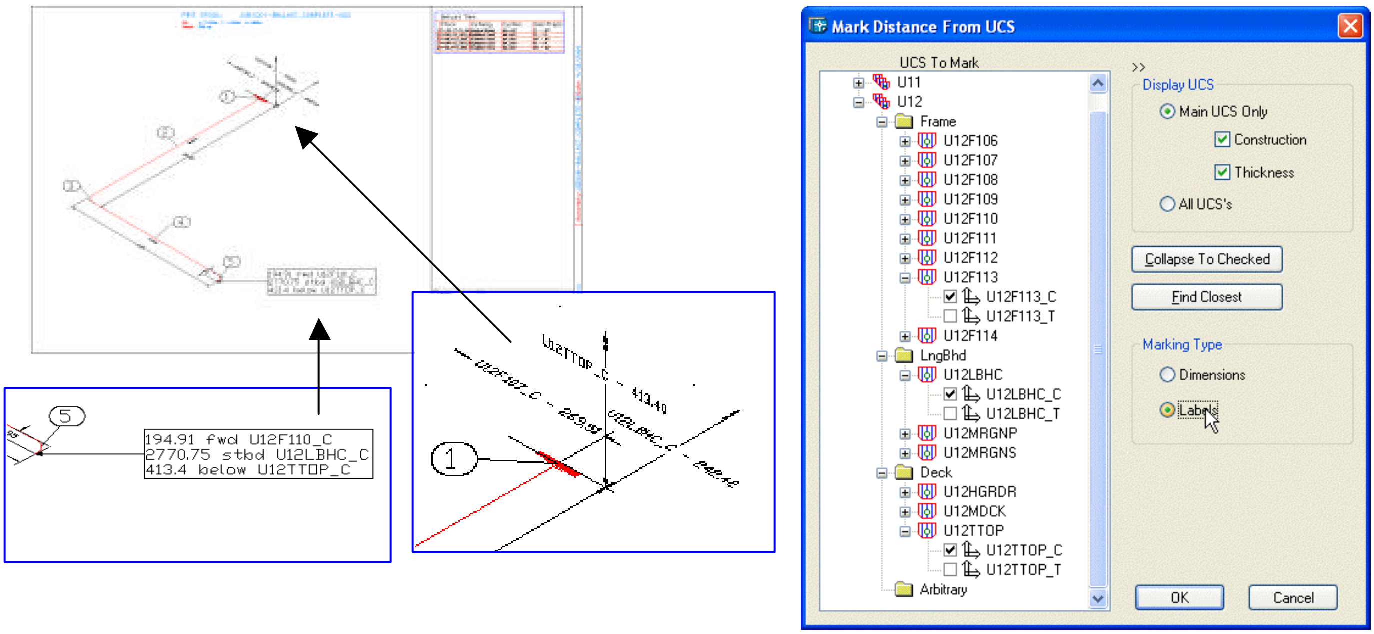


Figure 29: Global Dimensioning Marking Examples

Labeling of Adjacent Spools

Annotates connected spools using user-configurable, predefined label styles.

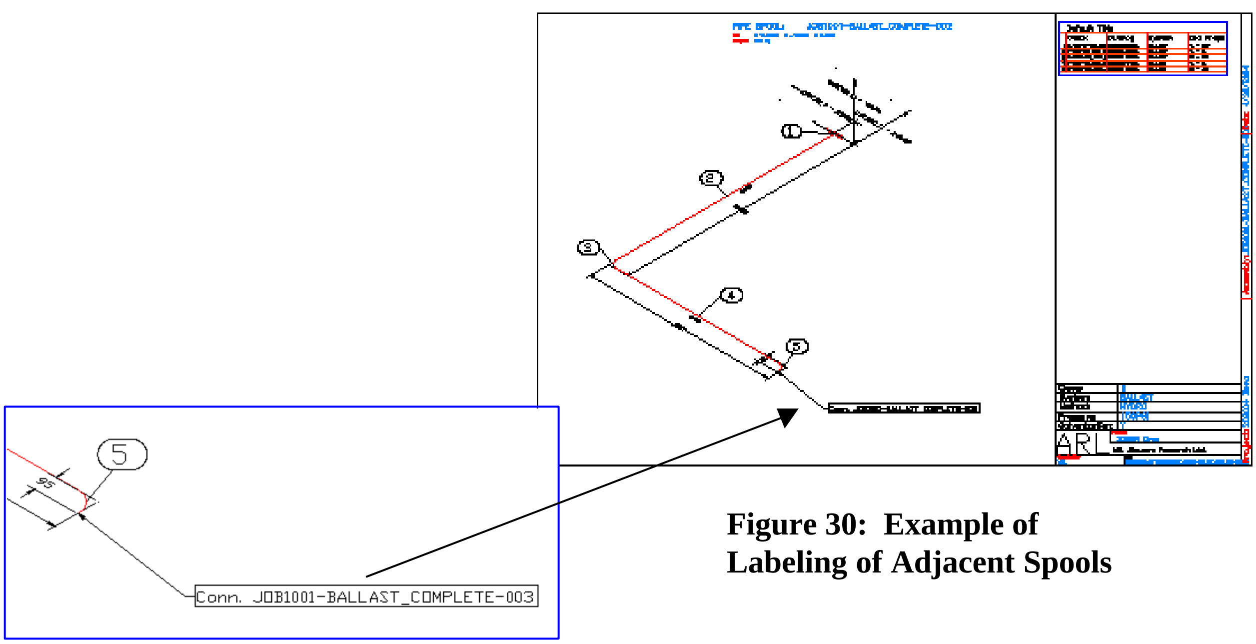


Figure 30: Example of Labeling of Adjacent Spools

Pipe Graphics Engine Improvements

Simplified pipe options dialog with no loss of functionality. Double Line + Hide and Mesh modules have been integrated with Double Line mode.

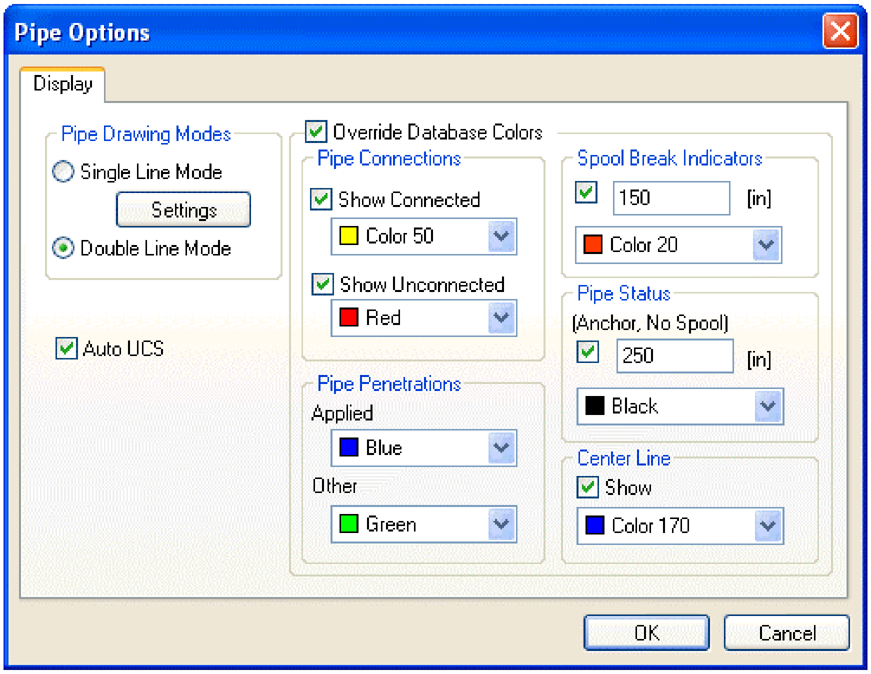


Figure 31: Example of Pipe Display Options

Draw speed for large pipe drawings can be done manually and dynamic pipe in background can be set to a definition of less detail.

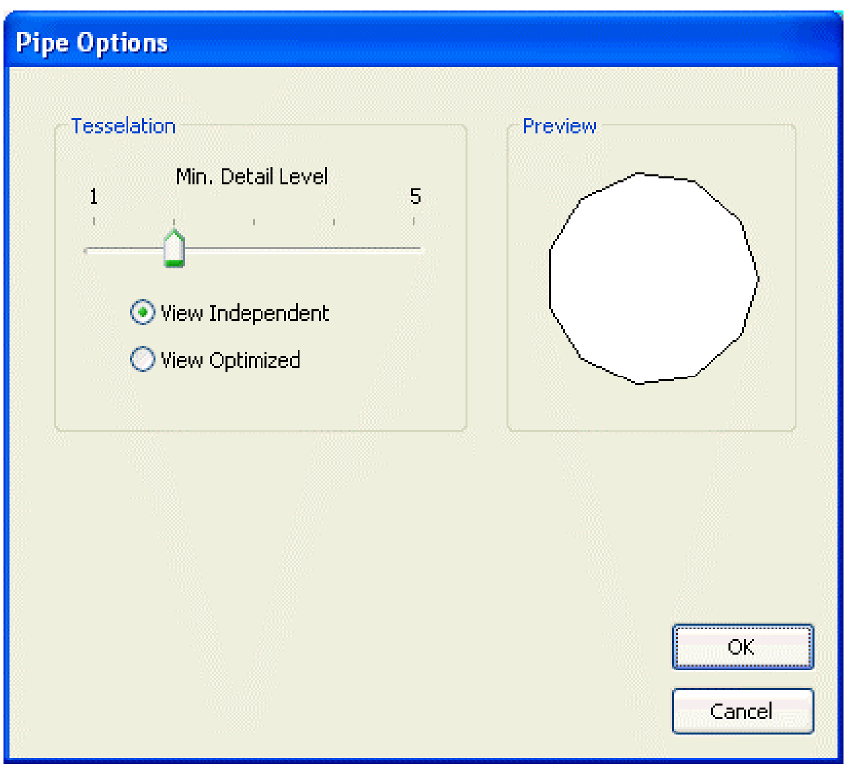


Figure 32: Example of More Pipe Display Options

During pipe editing a skeleton for more precise pipe placement is provided.

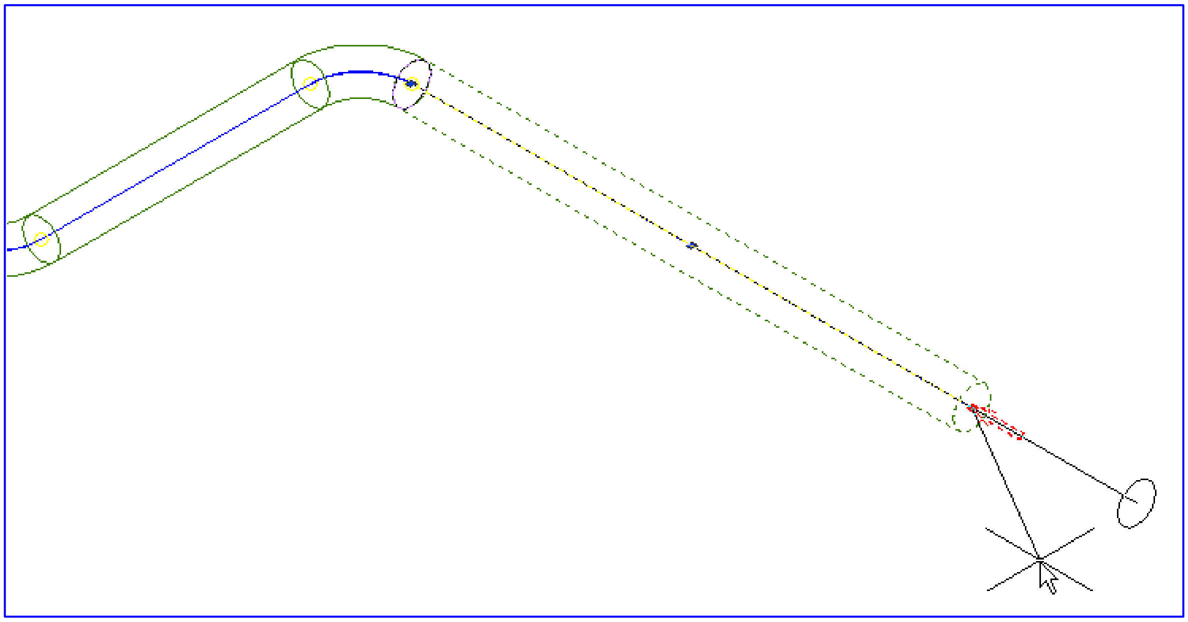


Figure 33: Example of Pipe Editing Options Display

Pipe-end & Connection Information

Users often require quick access to complete pipe connection information. This new function outputs all relevant information directly on the user screen. It provides an advanced listing of selected objects end treatments and a complete display of connected details including accessories.

Figure 34: Example of Pipe-end & Connection Information

```
Command: '_SCCONNECTIONINFO
Pick pipe near connection:
   Nearest End Treatment : FL 2.5in 150LB FF
 Connected End Treatment : FL 2.5in 150LB RF
         Connection Name : FL
       Acc. Package Name : FL-2.5-BU-150
           Package Items :
                           4 x Name : NUT-5/8-HH
                               Description : 5/8" HEX NUT
                               Acc. Type : NUTS
                           4 x Name : WSH-5/8-FL
                               Description : 5/8"FLAT WASHER
                               Acc. Type : WASHER
                           4 x Name : BLT-5/8x3-HH
                               Description : 5/8"x3"LG HEX HEAD BOLT
                               Acc. Type : BOLT
                           1 x Name : GSKT-02.5-1/8-BU-150
                               Description : 2 1/2"NB Buna Gasket 1/8" thk,
FF,150#
                               Acc. Type : GASKET
```

Improved Build Strategy

Pipe items are much better supported in the build strategy during the modeling and spooling process. Un-spooled items are now added to the Build Strategy. This allows for true reporting of weights and center of gravities off all modeled items and easy reference of items remaining to be spooled. All pipe items are now visible in Build Strategy Tree. This allows for quick identification of items contained within a drawing and identification of all items contained within a spool, as well as a quick zoom feature to selected items.

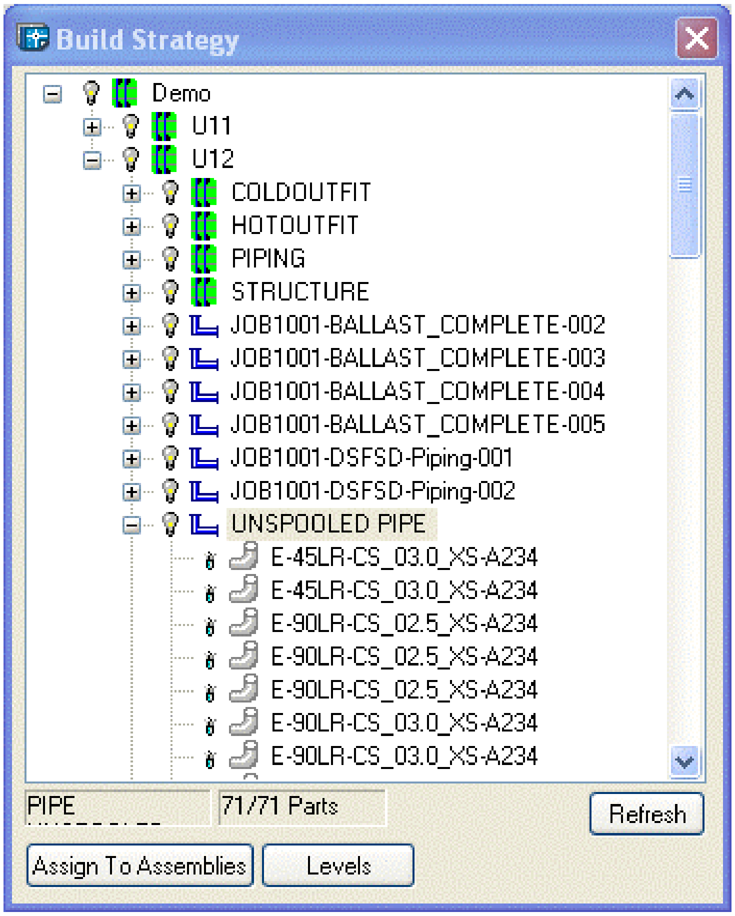


Figure 35: Example Build Strategy Display Screen

Improved Spool Drawing Output

Several enhancements were made to improve spool drawing output, they were:

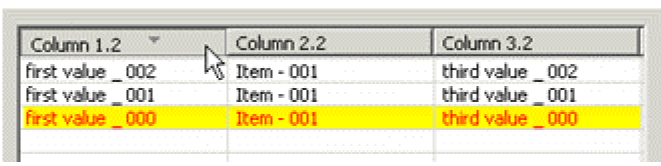
- Dimensioning of Bent pipes improved to avoid over-dimensioned or incorrectly dimensioned pipes i.e. Sloped pipes
- Global dimensioning to nearest Decks, Longitudinals, and Frames.
- Inclusion of new Penetration objects for accurate display and dimensioning.

Advanced List Control

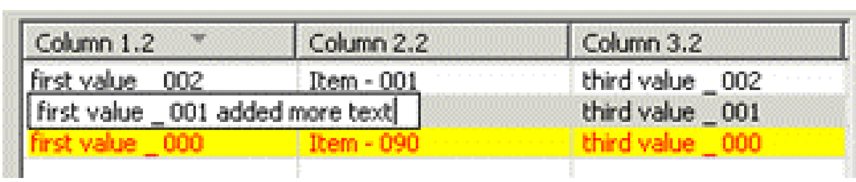
Current building projects by some of the involved yards and designers have are reaching very large data volumes that make traditionally used list controls cumbersome to use. A generalized new list control class is being developed to deal with very large data volumes in a better way.

Application was designed to include:

- Hi performance sorting & full color control
- Built-in column filtering
- Drag and drop columns
- Data volume exceeds typical available controls
- More speed and customization
- Smart Drop-Down and edit box sizing.
- Controls automatically resize to fit content.



- Smart Drop down and Edit box resize to fit content.
  - Used in Pipe BOM & HVAC BOM



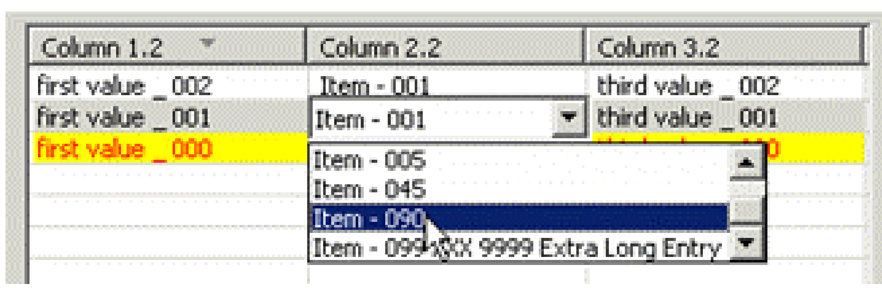
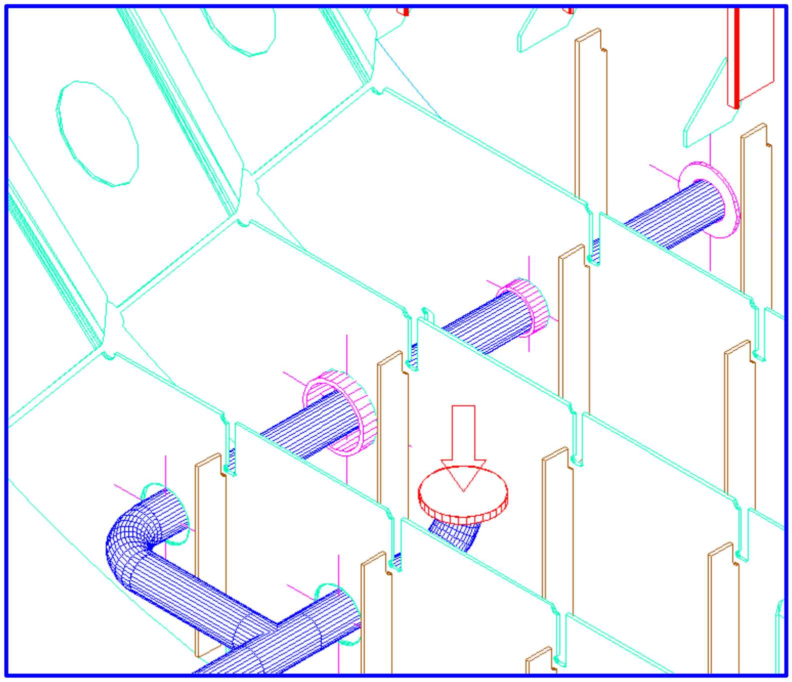


Figure 36: Example of Advanced List Control Displays

Penetrations Module Results



A "bonus" module, Penetrations (originally proposed as Task or Module #9) was also developed and released. The Penetration Manager is essentially a configuration control subset of the Piping and HVAC modules, allowing discrete control over penetration identification, approval and tracking.

User permissions

This application allows for the assignment of user permissions. Having authorized user assignments reduces errors and eliminates unauthorized modifications.

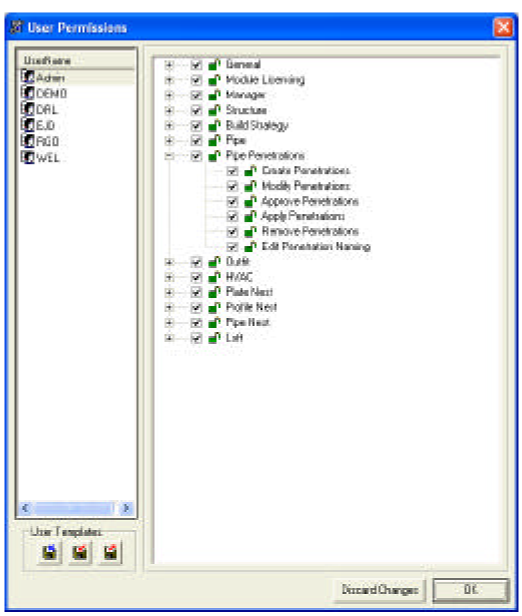


Figure 37: Example of the User Permissions Interface

Standardized Penetrations

This application allows penetrations to be based on standard packages defined in the Pipe Catalog. Packages contain all required penetration items such as; Doubler Plates, Sleeves, Collars, and Accessories. This application is specification driven and highly customizable.

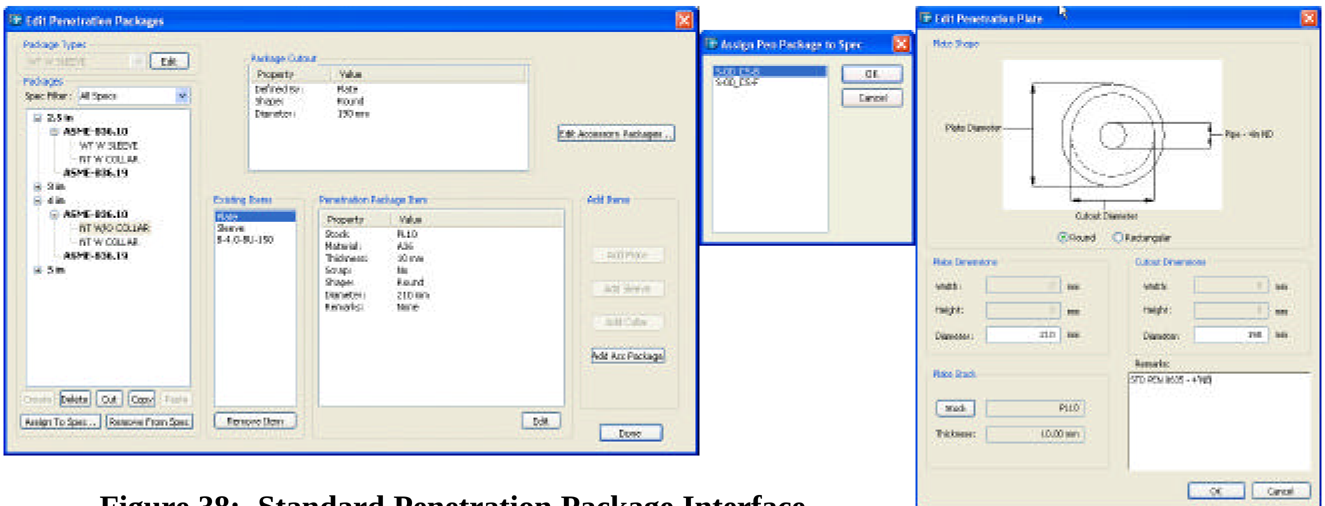


Figure 38: Standard Penetration Package Interface

Two creation methods

Penetrations can be created in two methods:

- o Automatic using interface check
- o Manually in piping model drawing

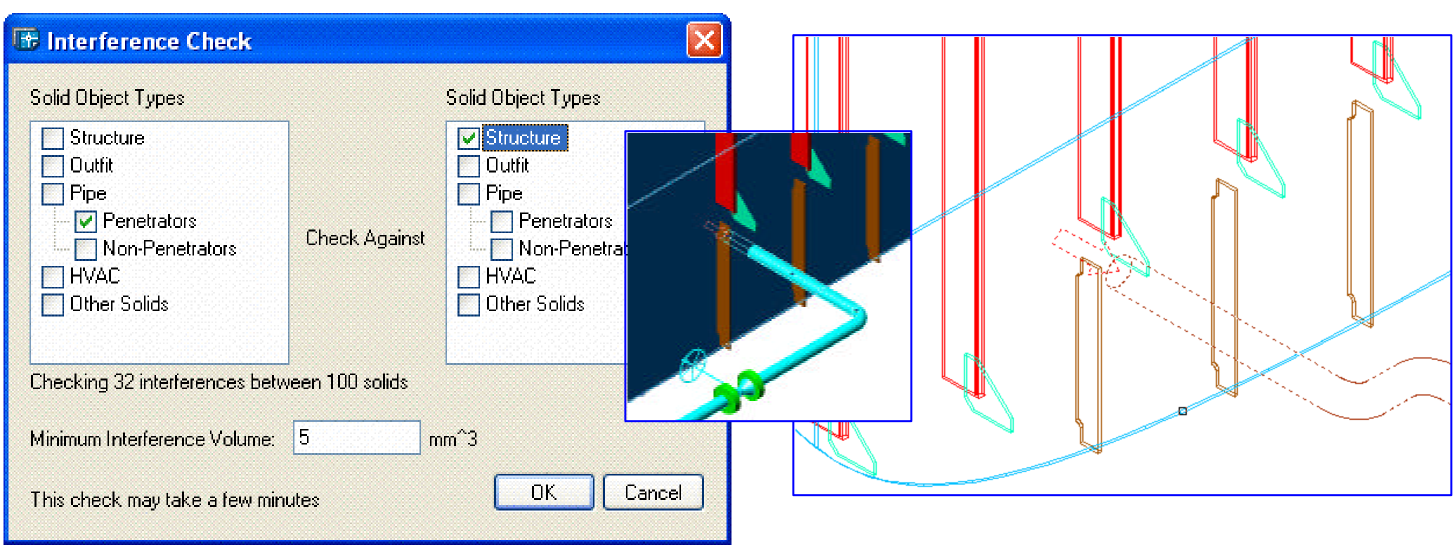


Figure 39: Penetration Creation Methods

Penetration Management

This application provides the user with the means to manage penetrations in the model. Penetrations are globally accessible through the database. It is easy to navigate to penetrations with the click of the mouse. Penetrations can be marked, cut, no process (on drawing only).

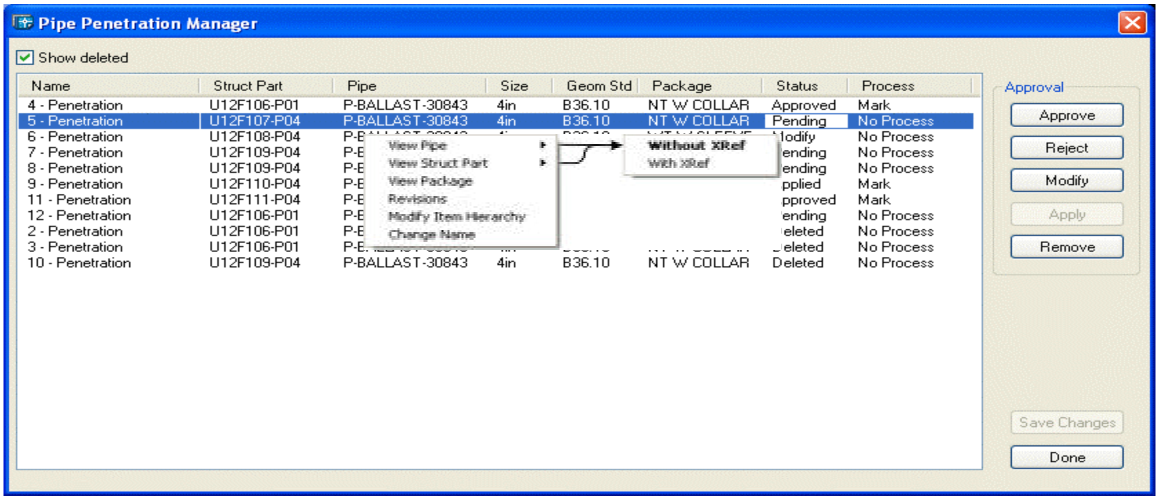


Figure 40: Pipe Penetration Manager Display

Integrated Approval Process

All penetrations must go through the approval process. Each penetration maintains links to the database and each can be changed, traced, etc. Every penetration must go through the approval process in order to be implemented into the model. Once in the model, the penetration maintains a link to the database record used to create it.

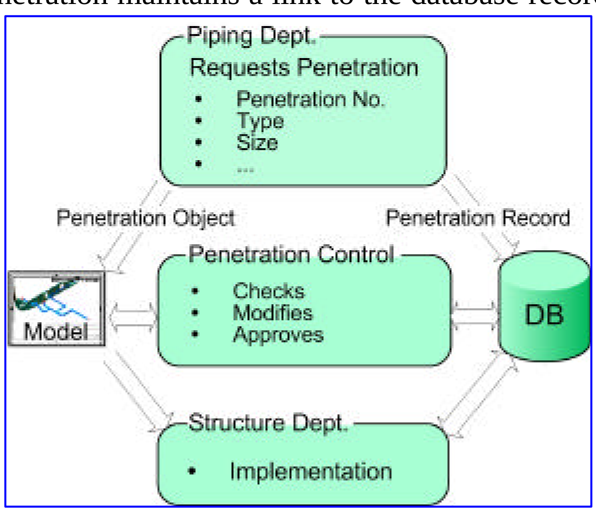


Figure 41: Information flow and Approval Process

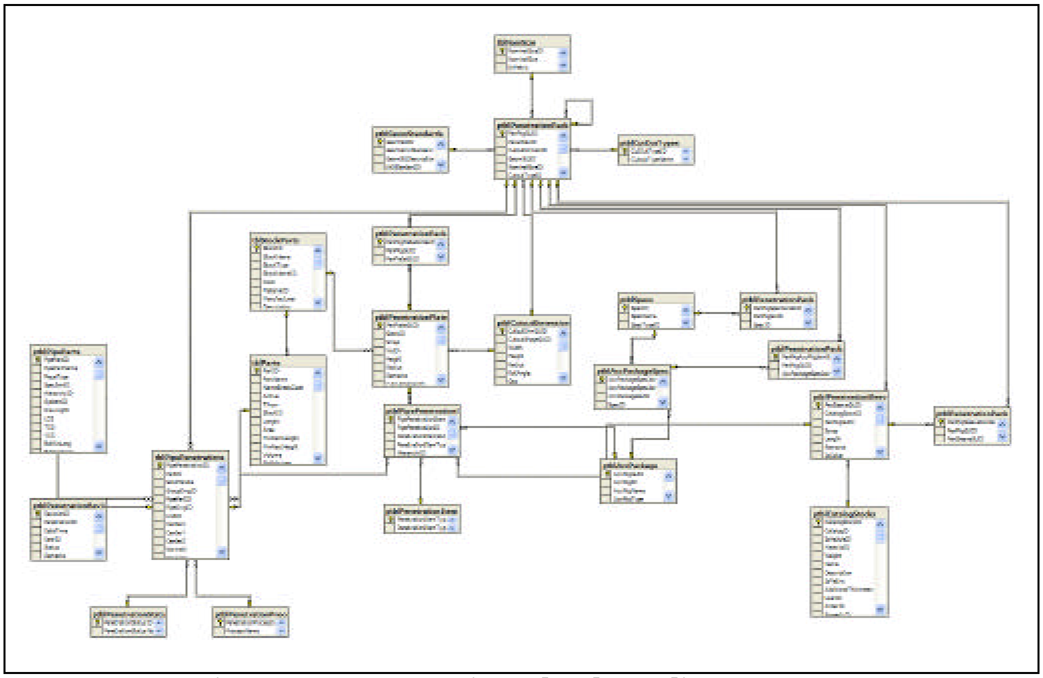


Figure 42: Penetrations database diagram

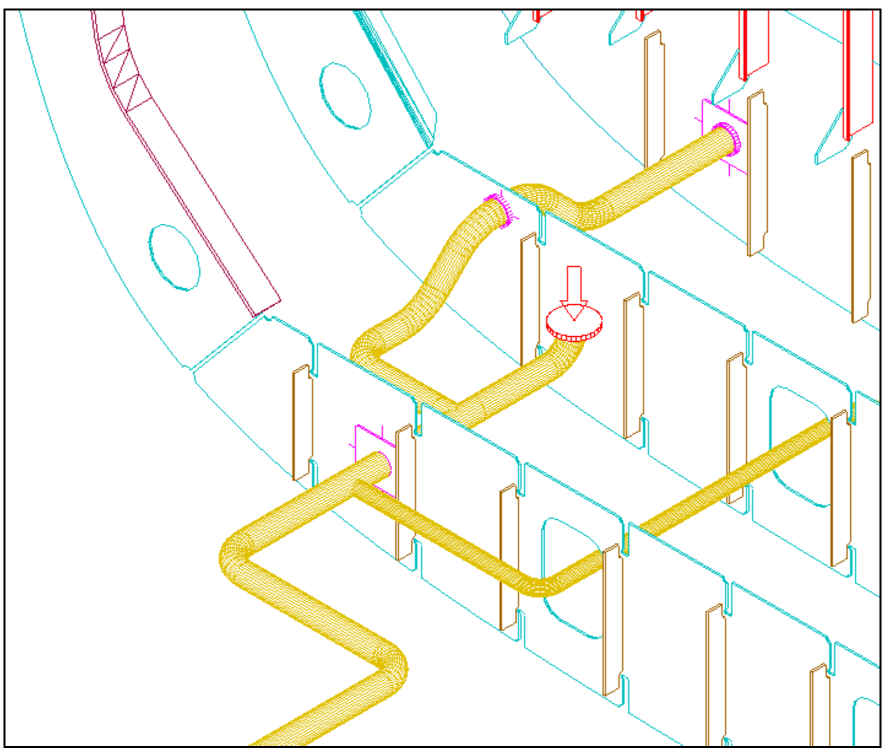


Figure 43: Example Pipe Penetration

Penetration Management

The Pipe Penetration Manager provides approval status that is used to keep track of the penetrations status. States selections are: Pending, Modify, Rejected, Approved, and Applied. The approval process ensures that only applied penetrations can be marked or cut in the model.

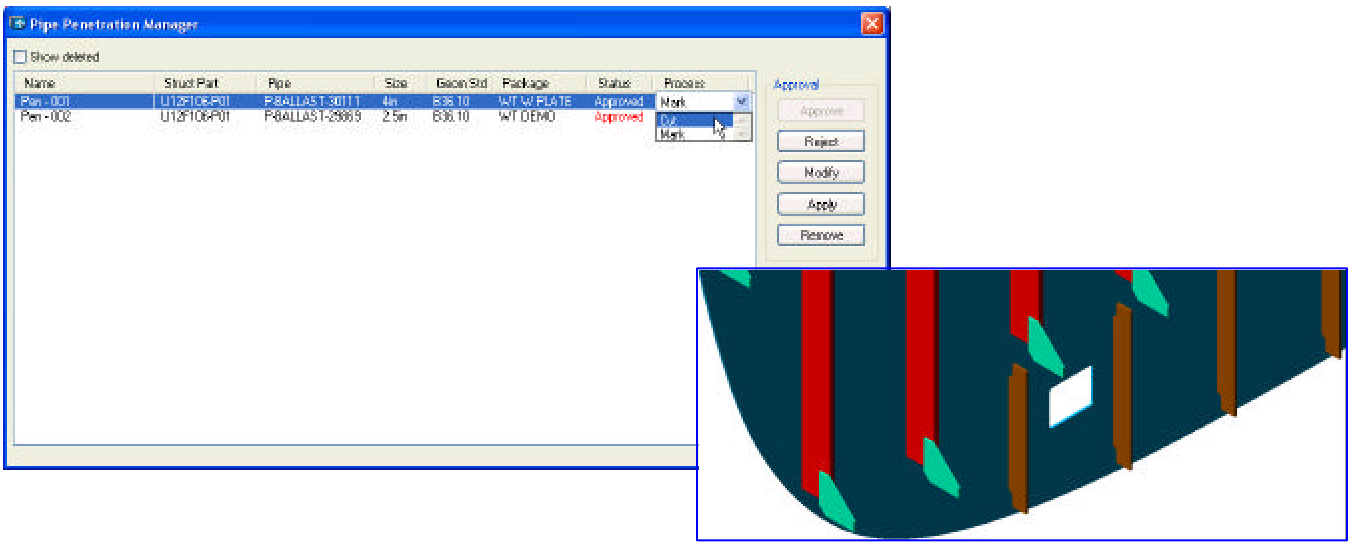


Figure 44: Pipe Penetration Manager Approval Process

Revision History

The database log keeps changes to each penetration. This Log records– user, action, date, time, and reason for the part revision. The automatic tracking of the modified structural parts allows for flags to be set for automatic re-nesting. Deleted penetrations are tracked complete with revision history.

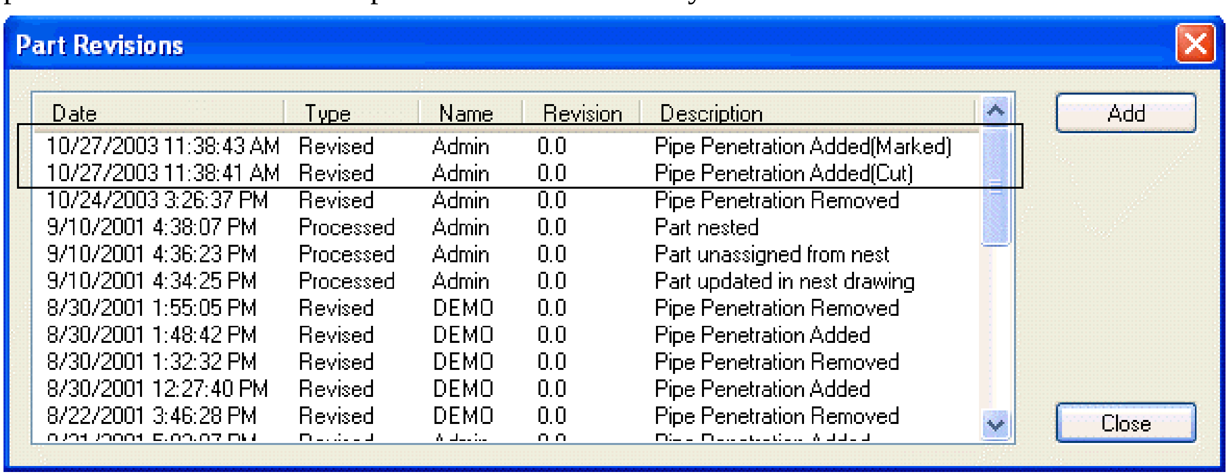


Figure 45: Revision History Display for Part Revisions

Reporting

Customizable penetration reports can be generated.

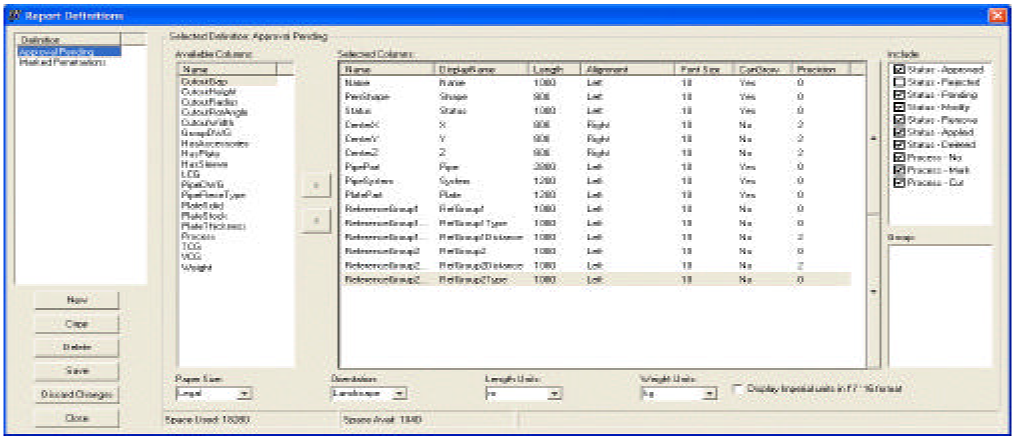


Figure 46: Report Definition Interface

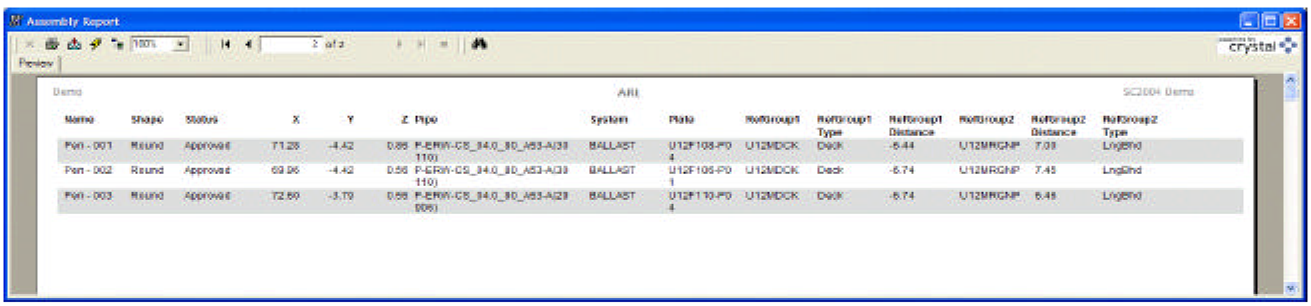
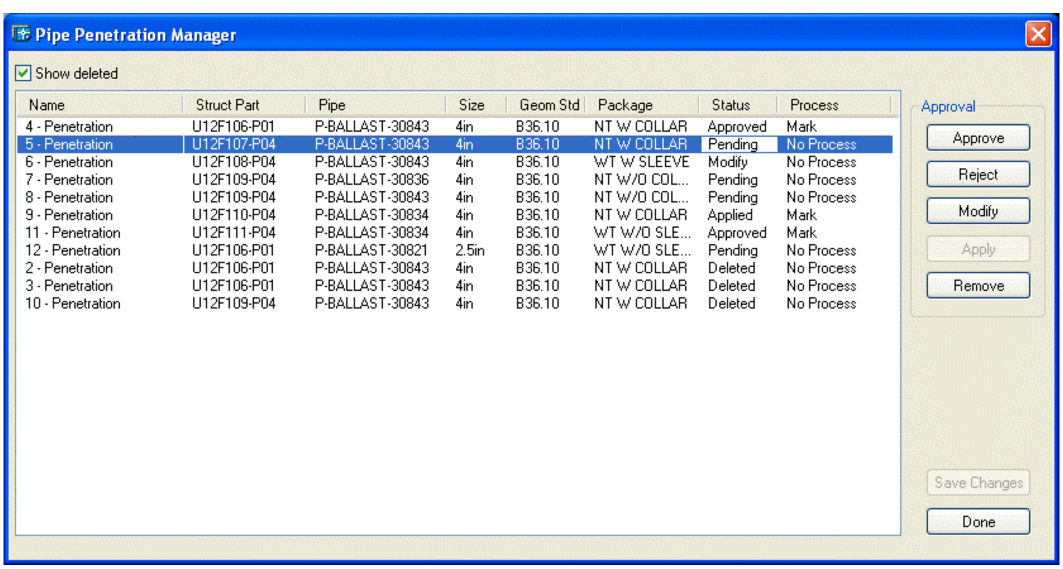


Figure 47: Pipe Penetration Manager Approval Process

Simplified Navigation

The Penetration Manager is universally accessible tools that can be used in zoom and navigate between penetrations with a click of a mouse.

Figure 48: Pipe Penetration Manager Navigation



FotoG Module Overview

In addition, the project statement of work was amended to include the initial project Module 13 & 14 to develop a methodology and proof of concept for integrating FotoG close range photogrammetry with ShipConstructor for process control and design of damaged repair components. The FotoG Pilot Project completed five 3D CAD measurement projects in five days.

The FotoG pilot project focused on both process control and ship repair activities. The following stages of construction were used to demonstrate the capabilities of the FotoG measurement technology system at Bender Shipbuilding:

1. Fabrication – Laser cut panel line
2. Unit/block – 210 Support Vessel, Units 03 & 04
3. On Launch Ways – Barge Hull Shape, double skin project
4. Wet Berth – Run to suit piping / control room

The laser cutting process was the first area that the measurement technology system was used. The process included the following:

- Placement of radial bar code autotargets on a selected laser cut steel cut part.
- Taking digital photo/images of the selected steel part and link photos within the FotoG software.
- Taking the nest drawing of the selected steel part generated from ShipConstructor in an AutoCAD format and importing that over the top of the digital photo/image (Figure 49 & 50).

The model/nest drawing was used as the process control file since it needed no independent dimensional measurement. The radial bar code autotargets were placed on the steel part that was cut. The autotargets set up directly on the plate provided the means to speed up, simplify, and improve the accuracy of the photogrammetic processing through the FotoG software. It was noted that, a more optimal way of setting the autotargets would be to permanently mount them on the outer edge of the cutting bed in the production system. The AutoCAD file and the image were then placed into the same file (overlaid). The two layers were then turned on at the same time to get an overlay of both images to check for accuracy.

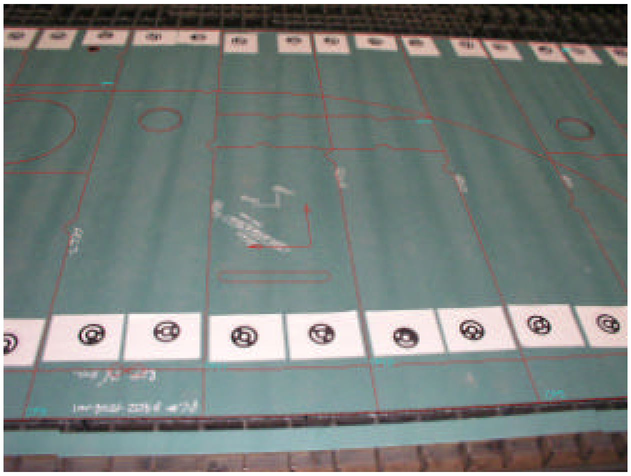


Figure 49: Digital photo with autotargets and AutoCAD model/drawing overlaid (red lines).

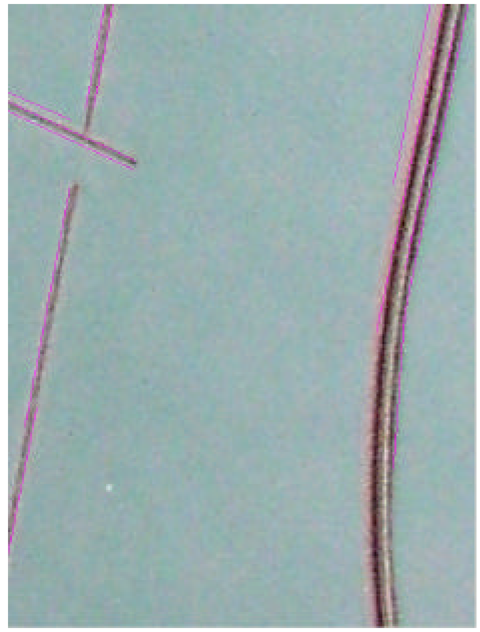


Figure 50: Digital photo with automatic edge image edge extraction overlaid.

During this process, an Automatic Image Edge Extraction tool within the FotoG software was used to draw automatic edges over the top of the digital image that was taken. The thought behind this exercise was for a possible future enhancement that would take the automated image edge extractions created from the digital image and *automatically* has FotoG check the associated AutoCAD nest drawing fits between the found image edges. In this exercise, the process was done manually through the software.

The unit assembly process was the second area that the measurement technology system was used. The process included the following:

- Making the selection of two unit assemblies that would be joined. Forward section of one unit and the aft section of another unit.
- Taking digital photo/images of the selected forward and aft sections of each unit to be joined together and link the photos within the FotoG software.
- Taking the ShipConstructor models for each of the forward and aft unit sections overlaying the AutoCAD file and the image file (Figure 51).

In the same process as the laser cut part, the model drawing was used as the process control file since it needed no independent dimensional measurement. However, no targets were placed on the forward and aft sections of the two units that would be joined prior to taking the digital photos. The images were then overlaid and were used to identify and check fabrication fits. The zoom function was used to get a closer look the tie in and fit up of the units.

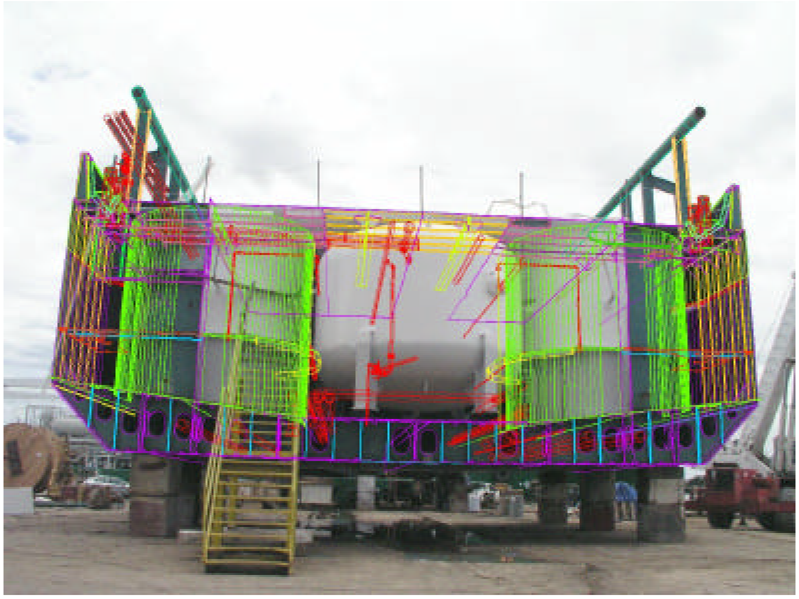


Figure 51: Unit assembly with ShipConstructor Model in AutoCAD format overlaid.

The third area that the measurement technology system was demonstrated came in the launch ways area. This process was done in the effort to compare an ongoing double skin project where the hull shape was measured in another fashion. The process included the following:

- Making the selection of the hull shape that was to be measured on the ways.
- Taking digital photo/images of the selected hull shape to be measured.
- Link & generate a 3D hull shape through FotoG from the photographs using visible surface features.
- Validation of the design by overlaying the 3D hull shapes, the ShipConstructor Model of the new designed hull shape, and the digital photographs (Figure 52 & 53).

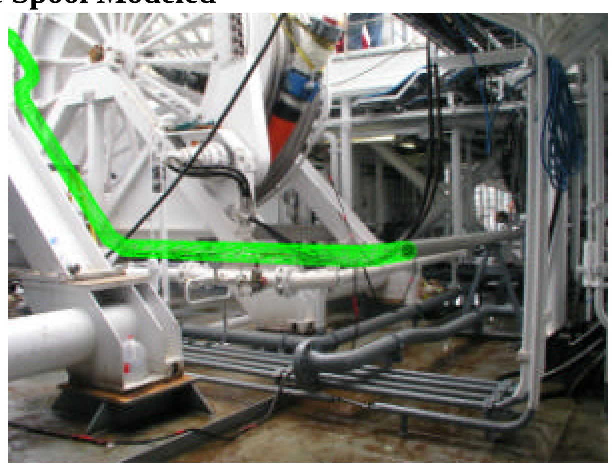
Figure 52 & 53: Generated 3D Hull Shape (red lines) & New model hull shape overlaid.

The same process as in the other areas was followed with the exception of the generation of the 3D hull shape. Also, there was no existing 3D hull control file available to compare the 3D FotoG generated hull shape. However, after completion of this exercise, because the design effort on this project was completed, a cost savings estimate was performed. The results were posted in the Project Metrics sections of this final report.

The forth area that the measurement technology system was demonstrated came in the wet berth area. This process was done in the effort to demonstrate that FotoG can provide measurements on a moving or floating platform. The task was to create accurate piping spool drawings without having to model an entire area. The process included the following:

- Making the selection of the area where the pipe spool needs created on deck.
- Taking digital photo/images of the selected area for measurement.
- Link the photos within the FotoG software and import the digital images into ShipConstructor/AutoCAD as layer.
- Route the pipe in ShipConstructor/AutoCAD and overlay with the image for QA. (Figure 54 & 55).

Figure 54 & 55: Pipe Spool Modeled



This process was also demonstrated by generating an AutoCAD drawing of an existing console control station that is installed on one of the Offshore Supply Vessels at Bender. The process included the following:

- Placement of radial bar code autotargets on a selected console control station.
- Taking digital photo/images of the console control station (Figure 56)

Figure 56: Photo of console with autotargets

- Link photos within the FotoG software.
- Import photos into ShipConstrutor/AutoCAD as a layer.
- Then use the photos were used as a measurement tool to draw the 3D model of the console control station (Figure 57).

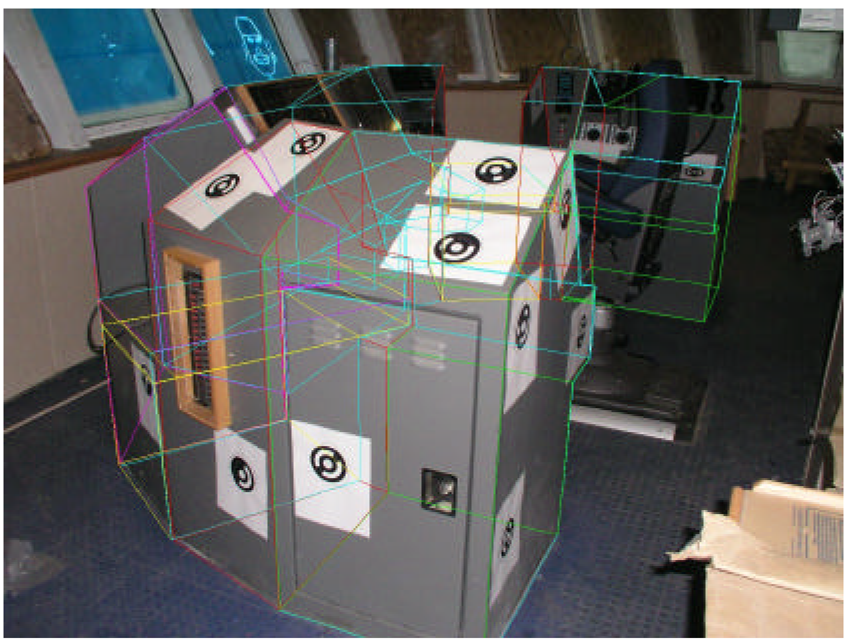


Figure 57: Photo of console with autotargets & 3D drawn model

- The photos were then turned on/off to check the accuracy of the 3D model as well as adding details without having to do a great deal of extra modeling effort (Figure 58, 59, & 60).

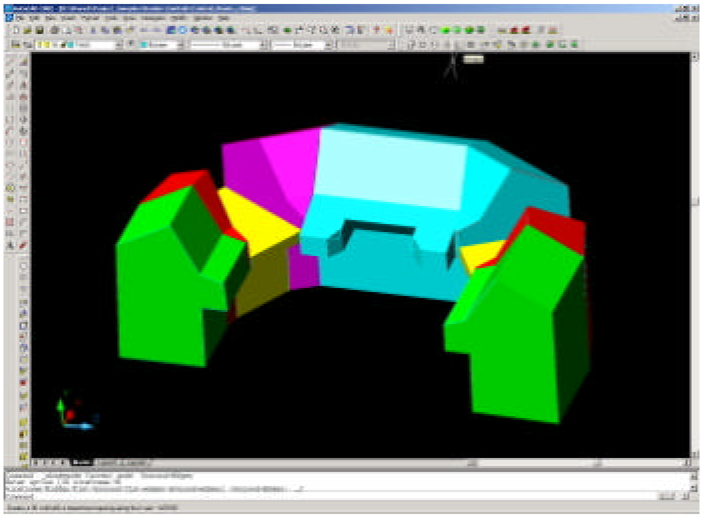


Figure 58: 3D Model constructed using the photographs of the console.

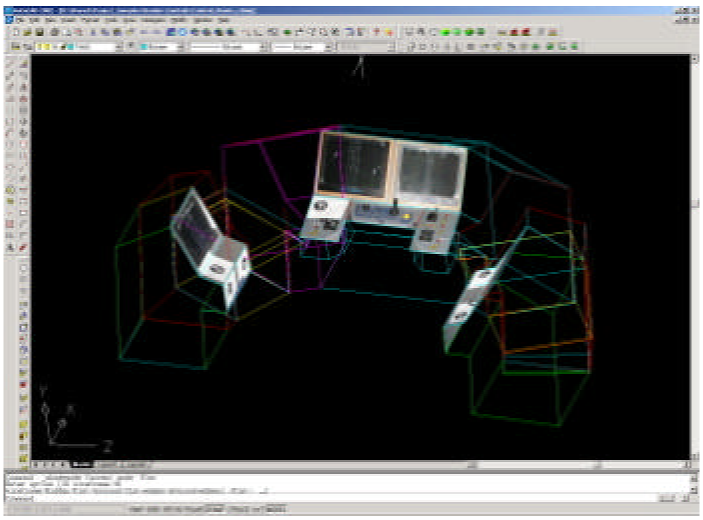


Figure 59: 3D Model with photo overlay of monitors and controls on console.

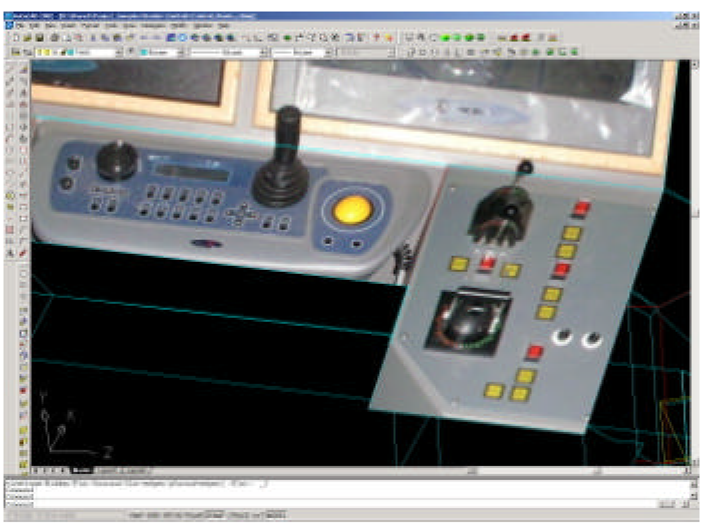


Figure 60: 3D Model with photo overlay of monitors and controls on console close-up.

The current methods of creating 3D CAD models are time consuming, prone to error, expensive, and do not provide for easy quality assurance checks. This pilot project demonstrated the versatility, accuracy, and speed of the FotoG system, cost avoidance potential and cost savings potential of implementation in any shipyard.

NURBS Module Results

This module implements ship hull surface creation and manipulation function to allow the shipbuilder to build an accurate surface representation inside of AutoCAD and produce all production information from the surface model.

In the past standalone program have been used to accomplish this task. Using AutoCAD provides the user with a familiar environment and allows him to use all his skills to do a better job.

AutoCAD does not support complex surfaces. As such several complex custom objects have been developed to deal with the tasks at hand.

Hull Module Import and Export

ShipConstructor supports these files formats for import:

- International Marine Software Associates (IMSA) Interface Definition File (IDF)
- Rhino 3D NURBS files
- Initial Graphics Exchange Specification (IGES)
- ShipCAM formats

The formats that are supported for export from Hull are:

- International Marine Software Associates (IMSA) Interface Definition File (IDF)
- General Hydrostatics System (GHS) Geometry File Format
- ShipCAM formats

These formats represent geometry in a variety of ways and translation capabilities have been implemented to cater for these formats differences. A method of previewing the contents of these files was developed and implemented.

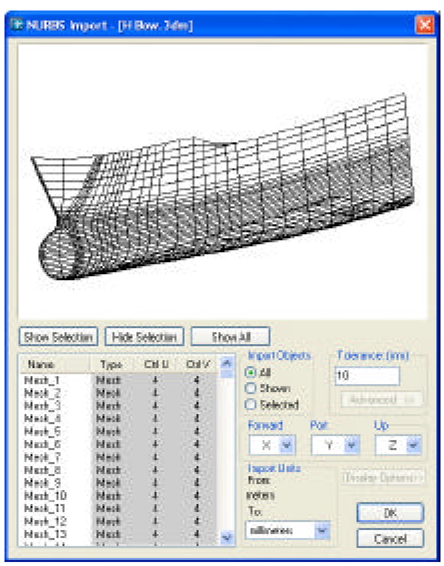


Figure 61: NURBS Import & Export Formats

Curve Blocks

Curve Blocks can be directly derived from Single or Double Curvature surfaces using a single command. This command produces a smart entity composed of a collection of curves called a Curve Block with inner and outer trim loops. The Curve Blocks themselves may be trimmed and manipulated before being converted back to surfaces.

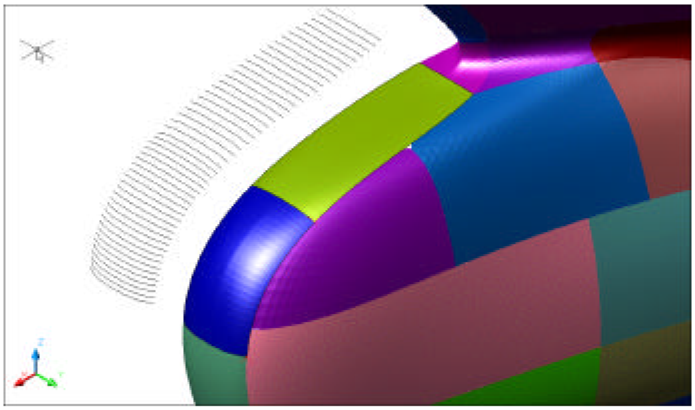


Figure 62: Curve Block

Curvature Mapping

A surface has a varying degree of curvature throughout its surface area. To get a relative understanding of the degree of curvature on a surface, users can use the fairing tools such as porcupines, or they can use the curvature color mapping.

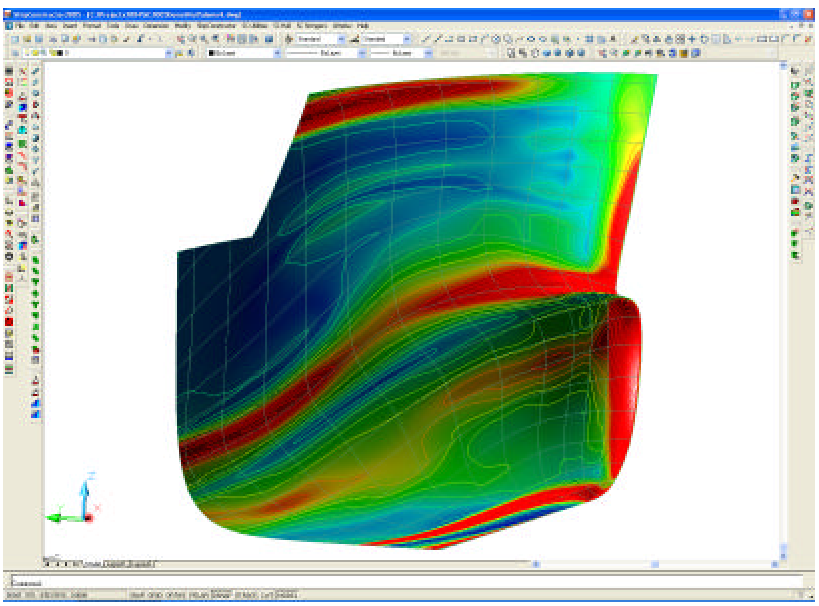


Figure 63: Color mapping of a surface with visible iso-curvature lines

Offsets

Offsets are a common method of representing hull surface data in the ship building industry. Offsets are a set of coordinates used to define a hull surface. The coordinates are made up of fixed values along the two principles axis on a plane to define the corresponding point on the surface. The planes used are either frames, waterlines or buttocks. This provides the flexibility allowing the user to decide where the most important offset values are and provide high-density data in areas of high curvature.

FRAMELINE OFFSETS ON WATERPLANES

DATE (d/m/y): 12/11/04 TIME: 10:37 AM
UNITS: millimeters
Mesh_03
HALF-BREADTHS

		000	001	002	003	004	005	006
	Location	236000.000	236050.000	236100.000	236150.000	236200.000	236250.000	236300.000
000	600.000	1957.388	1936.015	1914.641	1893.267	1871.893	1850.519	1829.145
001	620.000	1997.134	1975.760	1954.386	1933.013	1911.296	1889.142	1866.988
002	640.000	2036.880	2015.473	1993.319	1971.165	1949.011	1926.857	1904.703
003	660.000	2075.342	2053.188	2031.034	2008.880	1986.726	1964.571	1942.417
004	680.000	2113.057	2090.903	2068.749	2046.595	2024.440	2002.286	1980.132
005	700.000	2150.772	2128.618	2106.463	2084.309	2062.155	2040.001	2017.847
006	720.000	2188.426	2166.286	2144.147	2122.009	2099.865	2077.716	2055.562
007	740.000	2225.024	2202.884	2180.745	2158.606	2136.467	2114.166	2093.424
008	760.000	2261.622	2239.482	2217.343	2194.761	2172.020	2149.278	2126.537
009	780.000	2298.098	2275.357	2252.615	2229.874	2207.133	2184.391	2161.650
010	800.000	2333.211	2310.470	2287.728	2264.987	2242.245	2219.504	2196.763
011	820.000	2368.324	2345.582	2322.841	2300.100	2277.358	2254.617	2231.875
012	840.000	2403.437	2380.695	2357.954	2335.212	2312.471	2289.730	2266.988
013	860.000	2438.229	2415.497	2392.765	2370.033	2347.301	2324.570	2301.838
014	880.000	2472.399	2449.667	2426.935	2404.204	2381.472	2358.540	2335.383
015	900.000	2506.569	2483.837	2461.106	2438.065	2414.908	2391.750	2368.592
016	920.000	2540.739	2517.591	2494.433	2471.275	2448.118	2424.960	2401.802
017	940.000	2573.958	2550.800	2527.643	2504.485	2481.327	2458.170	2435.012
018	960.000	2607.168	2584.010	2560.853	2537.695	2514.537	2491.380	2468.222
019	980.000	2641.378	2617.220	2594.063	2570.905	2547.747	2524.590	2501.432

Figure 64: Offset Coordinate Table

Surface-Surface Intersection

Single Curvature and Double Curvature surfaces are supported in the new surface-surface intersection command. The command can intersect any combination of the listed two surfaces at a time.

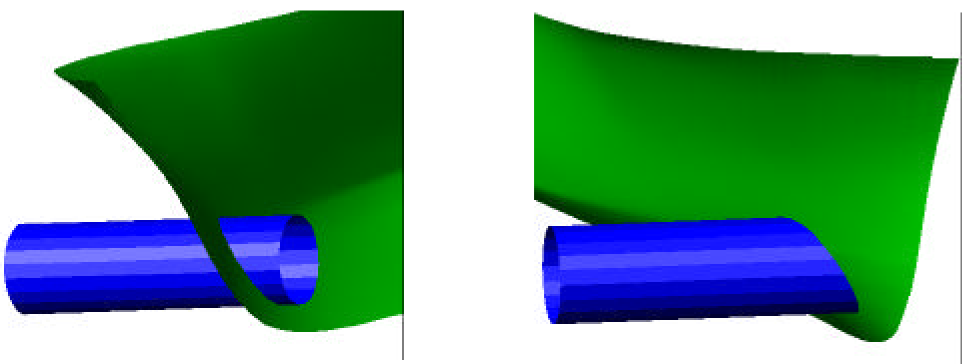


Figure 65: Single & Double Curvature Surface Example

The intersection of the two surfaces is shown in the figure. Mark lines can also be added to each surface and named after the intersecting surfaces name.**Error! Reference source not found.** These intersecting mark lines can be used to trim the surface.

Surface Trimming

Users now have several options for cutting a surface:

1. Users can cut a surface by selecting another intersecting surface, this will cut the surface at the intersection of the two surfaces,

2. Select an AutoCAD line, polyline, or circle which can be projected onto the surface and used to cut the surface,
3. Or select a current mark line on the surface that may have been created or added to the surface with another command.

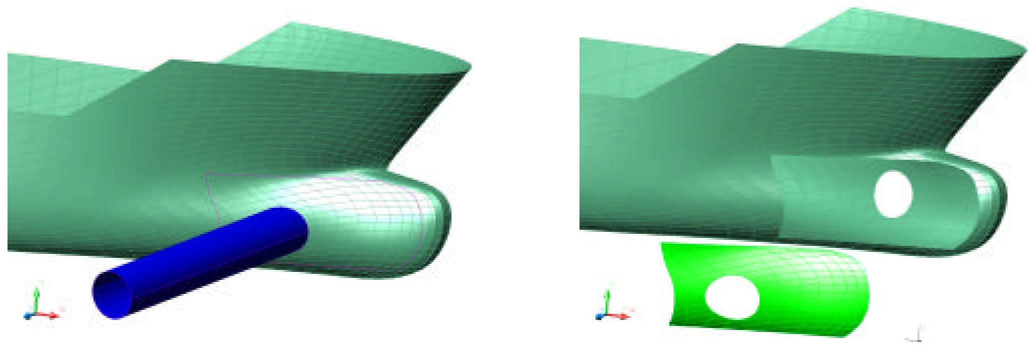


Figure 66: Surface before and after trimming

Stringers

ShipConstructor's representation of a stringer object is defined by a spline-like curve called a JURKS curve. JURKS Curves behave similar to degree 3 Bezier splines on the Stringer Shell. Its purpose is to minimize the stringer fairing effort while maintaining the precision of the hull shapes. These curves also have control points of differing properties to modify the JURKS for fairing.

In ShipConstructor Stringers are treated as if they where polylines that are glued to the parent shell surface. Internally stringers are computed using a degree-3 NURBS smoothing routine. This allows a user to drag a control point along a station and ShipConstructor will smooth nearby points to maintain continuity. Illustrated below is the smoothing effect in action as the user drags a control point. The curves are smoothened and nearby points are moved to create the new curve.

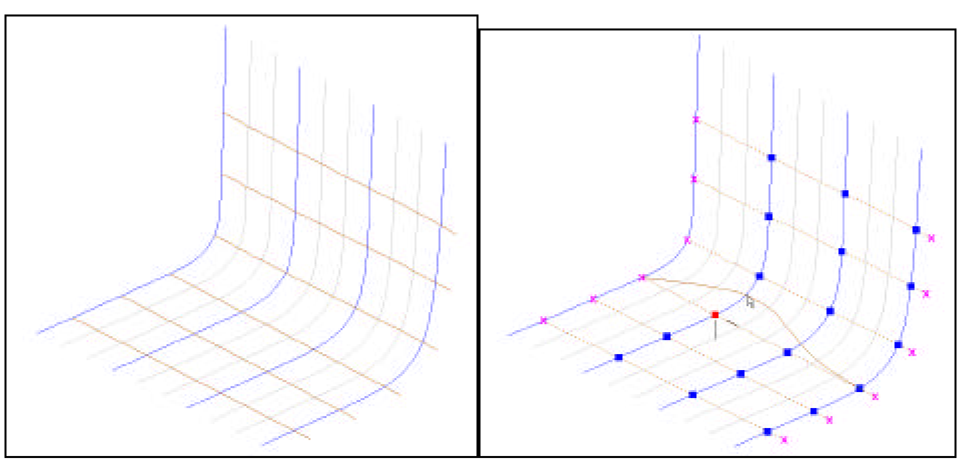


Figure 67: Moving points and smoothing curves

JURKS curves interpolate a normal NURBS curve until it passes through a given set of control points. From there it will generate a NURBS curve and display the end result to the user. Users will find stringers fast and reliable. They will now be able to add curves to the ships hull surface, and convert them to stringers inside the AutoCAD environment.

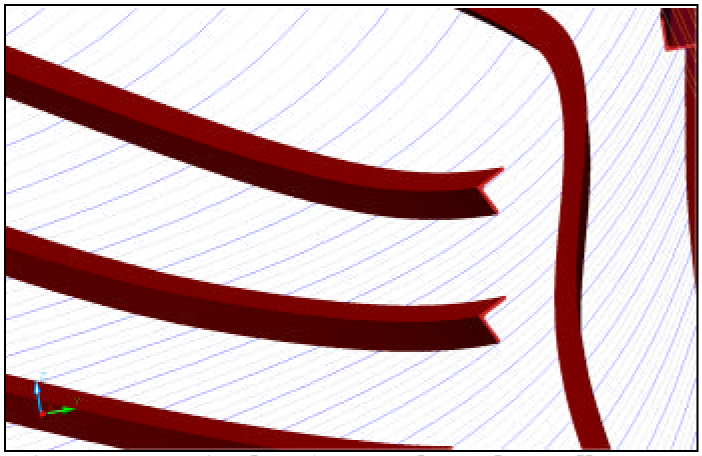


Figure 68: Faired Stringers along the Hull

Deck Surfaces

Several related objectives were developed to allow for the automatic creation of Deck Surfaces in the ShipConstructor HULL module. Deck surfaces can be created by either a centerline and side surface(s), or a sideline. The deck is always created about the global y axis. The following are supported shapes for creation of deck surfaces:

- Sine curve
- Parabolic
- Radius
- Radius by Camber
- Flat & Slope
- Faired Camber Board

The HULL modules trimming routines are intelligent enough to insert more vertices as needed (near the bow), to create a surface which has more detail in high curvature areas.

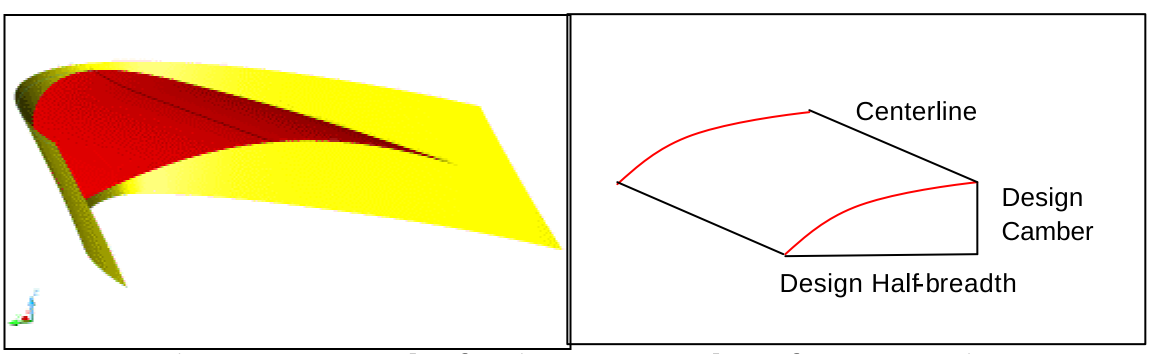


Figure 69: Example of a Sine Curve Deck Surface Generation

Mark Lines

Section Mark Lines are created by cutting through a selected surface using a particular section type at user specified locations. Frames, Waterlines, Buttocks, and skewed sections can all be used to create section Mark Lines. The following are supported in ShipConstructor Hull Module: Projected Mark Lines & Girth Lines

This distance is calculated along the surface at a frame, buttock or waterline as specified by the user. Girth Lines also make use of location groups similar to that of Section Mark Lines.

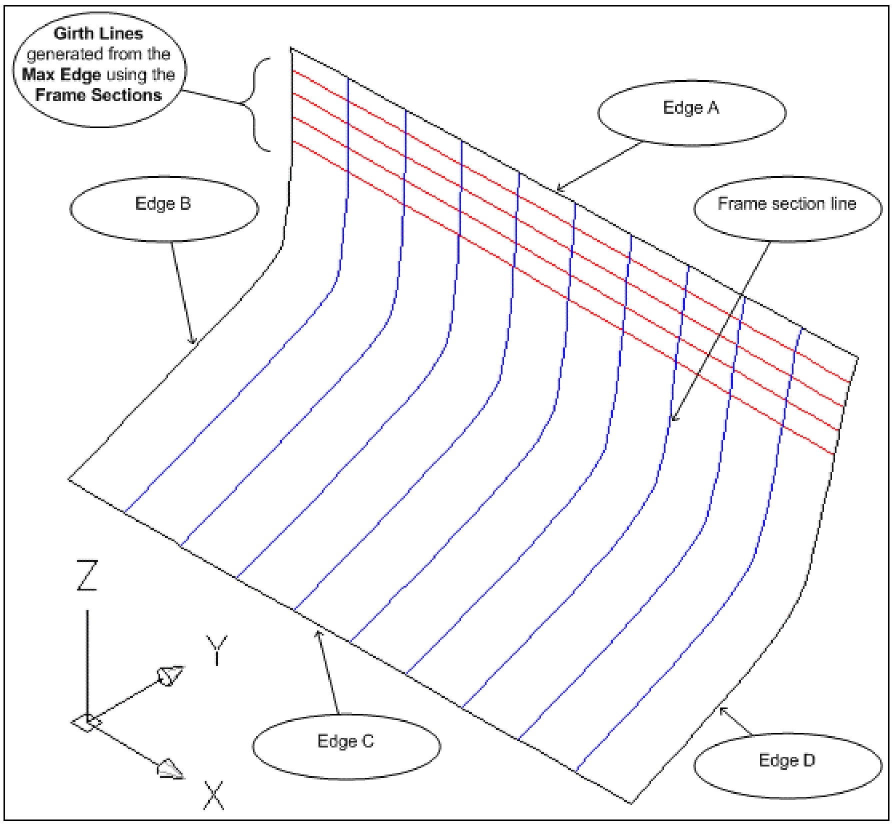


Figure 70: Girth Lines and Frame Sections

Girth Lines can also be girthed in any orthogonal direction from one reference such as another Mark Line, or max or min surface edge, or between two references.

Custom Mark Lines include Roll Lines used to bend a compound curvature surface from flat through its higher direction of curvature.

Shell Expansion

Shells in ShipConstructor have two views: Shell and Expanded. The shell view represents the actual shell in 3D space, while the expanded view represents an expanded 2D representation of the same surface. All objects which 'live' on shell surfaces are stored as an index, a length and a girth offset. From this, an object's 3D shape and position are calculated. This allows the shell itself to be manipulated without having to perform similar operations to its stringers and reference lines, which are located on the surface.

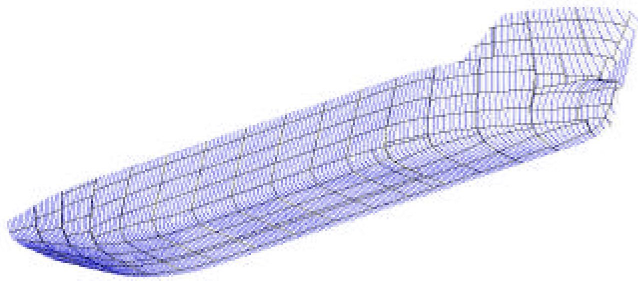


Figure 71: Stringer shell using frame lines before expansion

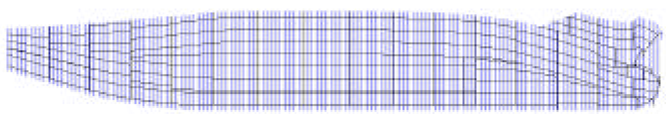


Figure 72: Expanded stringer shell

Porcupines

NURBS Curves and surfaces in the Hull Module have the ability to display Porcupines. Porcupines are a visual display tool for curvature analysis and are comprised of an exaggerated curve and Quills. The quills lead from the NURBS Curve or surface to the exaggerated curve and indicate the curvature direction and magnitude at its base point on the NURBS Curve. The longer the quill, the more dramatic the curvature of the curve or surface at the point the quill touches the NURBS curve or surface.

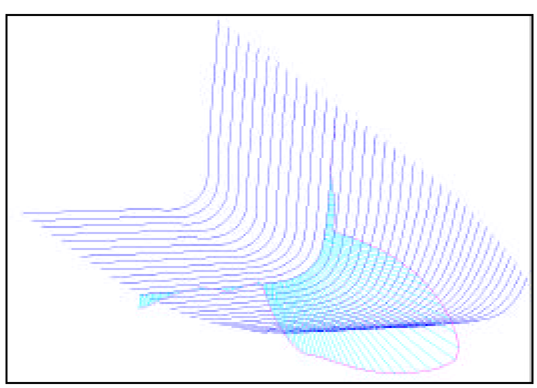


Figure 73: NURBS curve showing the exaggerated curve and quills

NURBS Curves in ShipConstructor

A NURBS object was developed to allow users to create and manipulate smooth curves in ShipConstructor using familiar AutoCAD type commands. A few special functions are described below.

Users require the capability to **trim** NURBS curves with a surface. As no algorithm could be found, a tangent-based telescoping approximation method was developed which greatly increased both the speed and accuracy of the intersection algorithms. Each successive approximation would shrink the bounding box and bring the tangent point closer until finally an intersection is determined.

ShipConstructor provides two possible ways of **joining** NURBS curves. When end points on both curves are close enough a straight join can be used leaving a 'kink' where the curves join. When the end points are far enough away a degree-5 NURBS curve is created to bridge the gap between the curves. The three curves are then joined using the generic join method.

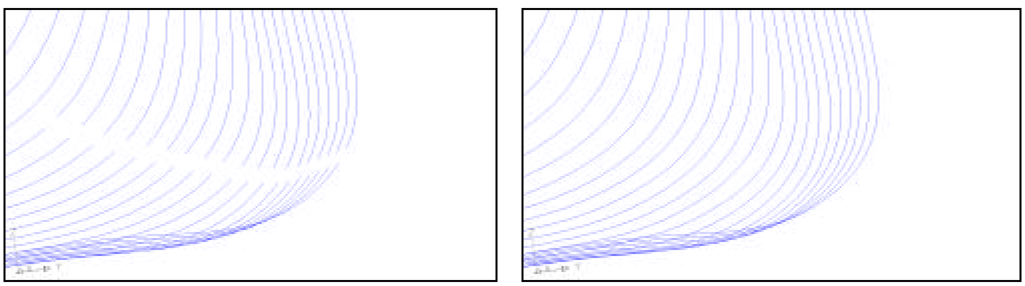


Figure 74: Before and after joining two NURBS curves

Traditional NURBS do not allow **extending** curves but ShipConstructor now has the functionality allow it. Users who already have a NURBS curve and want to make significant alterations to it without having to recreate the curve from scratch will use this application.

Return On Investment

ROI Assumptions & Calculations

Due to the large collaborative nature of this project, a comprehensive ROI is nearly impossible to generate. However, the savings in each area are significant even for the small shipyards, so certain assumptions have been made to generate a realistic ROI. In addition, the ROI assumptions have been changed to the number of participants that actively participated in the project and the number of design modules was reduced to include only those modules that were funded.

1. A typical small ship design requires 30,000 manhours with the following breakdown:
    a. 20% structure (6000 hrs)
    b. 30% piping and HVAC (18,000 hrs)
    c. 10% foundations (3000 hrs)
    d. 10% electrical and design drawings (3000 hrs)
    e. 30% administration (including materials), reproduction, production support (18,000 hrs)
2. A small shipyard does 3 designs per year. The same applies to design agents supporting the yards.
3. Bender, Halter, Bollinger are small yards
4. Avondale is a medium yard for the purpose of the ROI, and does 1 design per year, for 60,000 hrs
5. Avondale counts as a 2x multiplier in the ROI
6. Total shipyard multiplier is 5
7. Total design agent multiplier is 3
8. Total multiplier on per ship savings is 3 ships x 8 yards = 24
9. Electric Boat is not included in the ROI, despite obvious improvements to their efficiency.
10. The same percentage breakdown applies to the larger design.
11. Billing rates are $65/hr for design and planning, $45/hr for production
12. Percentage reductions are based combined percentages from the participating shipyards, in design manhours per small shipyard due the design module improvements, based on best practices assessment:
    a. **CPC** - 15% reduction in design category (e) = 2700 hrs/ship; x 24 = 64,800hrs/yr = $4,212,000/yr
    b. **HVAC** – 10% reduction in design category (b) = 1800 hrs/ship x 24 = 54,000 hrs/yr = $3,510,000/yr
    c. **Piping** – 9% reduction in design category (b) = 1620 hrs/ship x 24 = 38,880 hrs/yr = $2,527,200/yr
    d. **Penetrations** – 9% reduction in design category (b) = 1620 hrs/ship x 24 = 38,880 hrs/yr = $2,527,200/yr

e. **NURBS –** 2% reduction in design category (a) = 120 hrs/ship x 24 = 3600 hrs/yr = $234,000/yr (estimated due to release as cost share with no evaluation)
f. **FotoG Process Control –** savings of 200 manhours per ship in QA/QC. Assuming 5 ships per year x 5 yards, 5000 hrs/yr= $225,000/yr. Additional savings of 1200 manhours per ship in rework, 30000 hrs/yr = $1,350,000/yr. Scrap reduction (lost parts) of $10,000 per year.
g. **FotoG Ship Hull Repair –** savings of 1200 manhours per ship, assuming 8 major hull repairs per year; applicable to 2 repair yards = 19,200 hrs/yr = $864,000/yr.

13. Additional impacts from material savings attributed to the CPC, schedule compression due to the overall project impact, and direct production impacts from better design documentation, better integrated planning and better project management is difficult to quantify. Given the quantifiable benefit above, no attempt has been made to skew the projected savings with difficult to quantify benefits.
14. Total annual savings, as detailed in the following ROI spreadsheet equates to $14,057,200.00, broken down as $1,350,000 in rework, $10,000 in scrap reduction and $12,697,200 in direct or indirect labor as noted in Appendix A.
15. 40% of the total savings is realized in 2004 due to completed and implemented modules.

Recurring costs of $300,000 per year in license maintenance on the software will be incurred verses the $1,500,000 identified in the original proposal document.

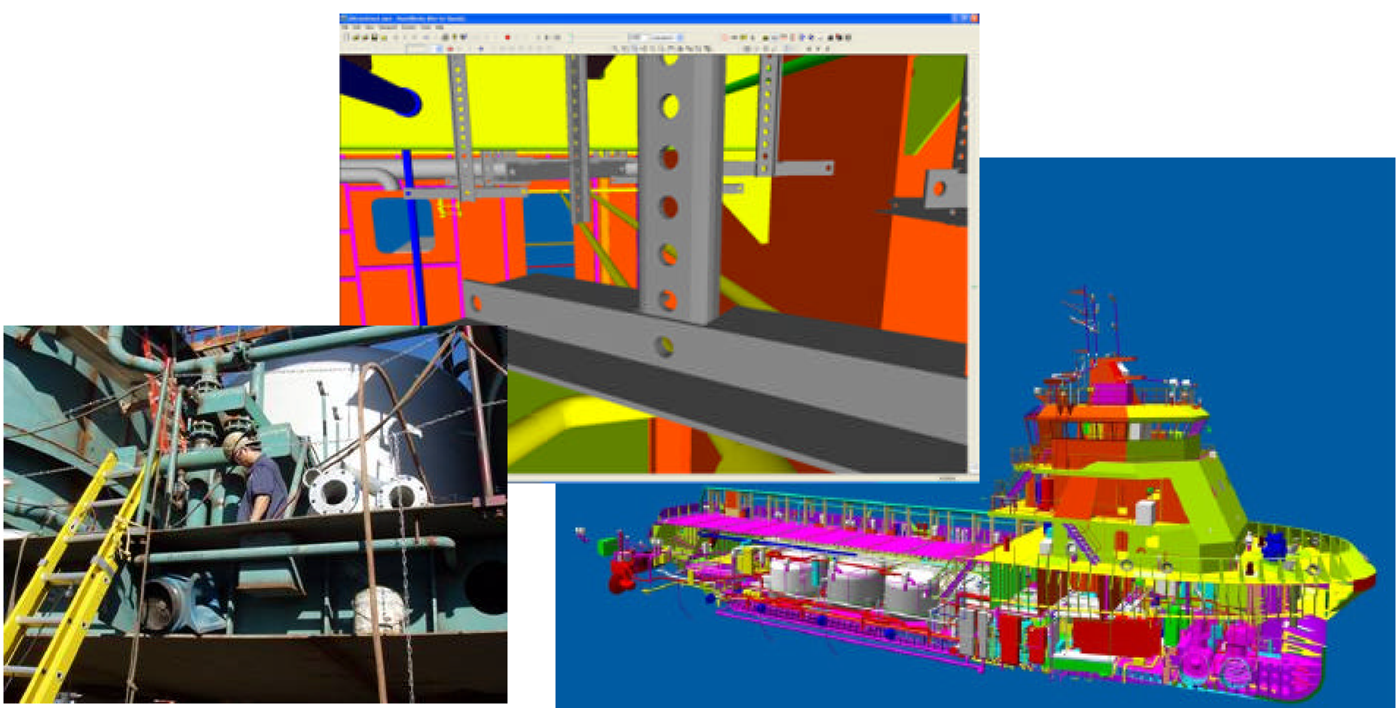
Project Summary Results

As discussed in the Project Overview of this final report, these project modules were set up in such a fashion that each would be independent of each other and could work in parallel. Although only 3 of the 15 modules were funded the project team still worked within the project to squeeze in the completion of 4 additional modules. Due to a great collaboration effort between all of the shipyards, design agents, and the software developers on this particular team; any and all other shipyards and design agents that use ShipConstructor2005 or the 2nd Tier Common Parts Catalog will benefit from the work performed.

In particular, NGSS USA will benefit in using the enhancements made to SC2005 on the US Coast Guard Integrated Deepwater System Program.

Bollinger Shipyards, Marinette Marine, and Gibbs & Cox will see the effects from the new functionality on the Littoral Combat Systems (LCS) program.

Both Bender Shipbuilding & Repair Co., Inc. and VT Halter will be able to utilize the new functionality in the commercial world where the integration of ShipConstructor with the majority of the business processes, production, and owners.



Appendix A: Final Project ROI spreadsheet

Project Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Program Funds and Cost Share from Cost Proposal (i.e., Investment)	1378492	1841599	0	0	0	0	0	0	0	0
Recurring Costs	0	0	300000	300000	300000	300000	300000	300000	300000	300000
Present Value of Investment	1378492	1674197.65	247920	225390	204900	186270	169350	153960	139950	127230
Savings	0	5622880	14057200	14057200	14057200	14057200	14057200	14057200	14057200	14057200
Labor (Direct & Indirect)		5622880	12697200	12697200	12697200	12697200	12697200	12697200	12697200	12697200
Maintenance										
Rework			1350000	1350000	1350000	1350000	1350000	1350000	1350000	1350000
Scrap			10000	10000	10000	10000	10000	10000	10000	10000
Services										
Equipment										
Inventory										
WIP										
Material & Supplies										
Schedule										
Cost Avoidance										
Time Value of Money										
Additional Income										
Other										
Present Value of Savings	0	5111760.21	11616870	10561174	9601067.6	8728115.48	7935289.4	7214155.04	6557683.8	5961658.52
Net Benefit	-1378492	3781281	14057200	14057200	14057200	14057200	14057200	14057200	14057200	14057200
Present Value of the Net Benefit	-1378492	3437562.56	11368950	10335784	9396167.6	8541845.48	7765939.4	7060195.04	6417733.8	5834428.52
Discount Factors	1	0.9091	0.8264	0.7513	0.683	0.6209	0.5645	0.5132	0.4665	0.4241
Cumulative Present Net Value	-1378492	2059070.56	13428021	23763805	33159973	41701818.1	49467757.5	56527952.5	62945686.3	68780114.8

Net Present Value 68780114.84

The method chosen to represent ROI for NSRP ASE ranking purposes. Equal to the Cumulative Present Net Value at the end of the 10 year period.

NSRP ASE

“Final Report”

FOR

<u>Second Tier Shipyard Design Enhancement Project II</u>

MARITECH ASE
TECHNOLOGY INVESTMENT AGREEMENT #2005-385

BENDER SHIPBUILDING & REPAIR CO., INC.
SHIPCONSTRUCTOR SOFTWARE INC.
NORTHRUP GRUMMAN SHIP SYSTEMS AVONDALE OPERATIONS
BOLLINGER SHIPYARD
MARINETTE MARINE
VT HALTER MARINE
GENERAL DYNAMICS ELECTRIC BOAT
ELLIOT BAY DESIGN GROUP
MURRAY & ASSOCIATES
GENOA DESIGN, INC.
GIBBS & COX, INC.
KNOWLEDGE BASED SYSTEMS INC.
PROTEUS ENGINEERING

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1 SUMMARY

The Second Tier Design Enhancement Project II will improve the design and engineering tools used by most second tier shipyards, some first tier shipyards and their design subcontractors. Bender Shipbuilding, four additional shipyards, and four design agents that have independently selected ShipConstructor as their product modeling software of choice will undertake intensive work with ShipConstructor Software, Inc. formerly known as Albacore Research, Ltd., Knowledge Based Systems Inc, and Anteon - Proteus Engineering. The additional project team members were comprised of the following companies: Bollinger Shipyard, Marinette Marine, Northrop Grumman Ship Systems Avondale Operations, VT Halter Marine, General Dyamics Electric Boat, Elliot Bay Design Group, Murray & Associates, Genoa Design, and Gibbs & Cox.

The proposed project was structured in 9 distinct modules, each addressing a different need. Due to funding constraints, only two of the modules were funded for development in FY2005. These were (1) integration of a second tier Common Parts Catalog (CPC) with the ShipConstructor design software; (2) development, release, testing of a ShipConstructor 3D Product Model Splitting & Merging capability.

Both the shipyards and the design agents functioned as beta test sites as the various modules and improvements were developed and released for testing and implementation. The design agents received specialized training in shipyard design methodology from working closely with the collaborating yards during the evaluation and testing of the software modifications.

Through the process of this project, fundamental design changes were made to the ShipConstructor database structure to allow use of CPC Integration and 3D Product Model Splitting and Merging modules. The following were some of the ShipConstructor software modules that needed amended to incorporate the new database structure: Hull Design, Structural Design, Piping, HVAC, Penetrations, and Build Strategy. Most of the SSI modules had to be significantly rewritten. Due to the immense change in the code, certain rewards became evident. ShipConstructor has released some significant enhancements that parallel the efforts of the project.

The project management website was updated to include those areas that would be evaluated and tested over the project duration. Each of the forums were separated so that they would be specific to each task, so developers could easily identify those messages associated with their development work.

2 PROJECT Overview & Recap

The Second Tier Design Enhancement Project II improved the design and engineering tools used by most second tier shipyards and their design subcontractors. ShipConstructor is the design software of choice for most second tier yards, as well as for NGSS Avondale on the Deepwater project. It is the design software that will be used on the Lockheed Martin led LCS design and construction team; including Gibbs & Cox, Bollinger Shipyard, & Marinette Marine. The second project saw two of nine modules funded for development. Again, these were (1) integration of a second tier Common Parts Catalog (CPC) with the ShipConstructor design software; (2) development, release, testing and improvement of a ShipConstructor 3D Product Model Splitting & Merging capability.

3 First Technical Status Review

The project team began with typical start-up contractual and planning issues.

3.1 Preliminary Project Activities

- Pre-agreement letters were sent out to get the project started at each project participant's location.
- The pre-agreement letters were signed.
- Revised cost documentation was submitted to align with funding awarded for the project, and satisfied all responses to all cost and technical issues.
- Statement of Work was submitted and approved.
- Draft Project Management Plan was submitted for approval.
- Bender Shipbuilding signed the contract with ATI.
- Set-up Kick-off Meeting

3.2 Kick-off Meeting

The Second Tier Design Enhancement Project II was signed into contract on February 5, 2005. Technical work on the project actually began following a project Kick-off meeting was held on March 10th, 2005 at Bender Shipbuilding & Repair Co., Inc. in Mobile, AL. Participants from each of the six shipyards, four design agents, and three software development shops were present at the project kick-off meeting. The kick-off meeting was held in the effort to provide general information put together the following documents required by the contract:

- Project Management Plan
- Draft Technology Transfer Plan
- Draft Software Development Plan

3.3 Project Web Site

A project web site was set up to allow project participants to collaborate on issues. All the users have been set up and issued usernames & passwords from the list of attendees from the project kick-off meeting and those submitted in addition as seen in figure 1.
All project information and presentations provided by Pat Roberts (Bender – Project Lead), Rolf Oetter (SSI – President), Madhav Erraguntla (KBSI – Software Project Mgr), and Barry Espeseth

(GDEB – MITL) have been posted on the Project Web Site for viewing @ **http://nsrp.sytes.net**

Figure 1. Project Web Site

3.4 KBSI CPC Workshop

The first CPC Workshop was held on April 5th, 2005 at Knowledge Based Systems, Inc. in College Station, TX. Participants from each of the four 2nd Tier shipyards (Bender, Bollinger, Marinette Marine, VT Halter) and one of the 1st Tier shipyards (NGSS – Avondale Operations) were present at the CPC Workshop. The intent of this session was to provide the shipyard CPC end users the opportunity to familiarize them with the 2nd Tier CPC that was developed on the initial project. In addition, information was provided on what was needed to install and deploy the CPC database and software on servers at their respective shipyards in support of the ship parts population effort.

This meeting was to provide a status update and discuss feedback on the incorporated additional functionality KBSI has provided in the latest version 2nd Tier CPC tool. As a result of the action items associated with the CPC Workshop, KBSI was able to generate code to upload all of the document database information from the spreadsheets that were provided by the General Dynamics Electric Boat at the very end of initial STSDEP project. After the document database upload was completed, KBSI released the revised CPC to the group for installation at the respective shipyards. All shipyards, with exception to VT Halter have the 2nd Tier CPC installed and running on their respective SQL servers/terminals. After installation, Bender worked with Bollinger Shipyards and provided some guidance on how to go about populating part information into the newly revised and installed 2nd Tier CPC. After the population effort, Bollinger and Bender worked out a system to note part equivalencies manually (through an added attribute field to note the equivalent Bender Catalog Number and Cage Code) as they entered parts into the CPC database. This was done to expedite the part equivalency identification due to the fact that KBSI's development of the part equivalency functionality within the 2nd Tier CPC was being developed in parallel to this effort. As a result, Bollinger Shipyard identified over 800 part equivalencies to Bender cataloged parts (project metrics are 1000 part equivalency associations). It is anticipated that with Marinette Marine and VT Halter part equivalencies the project team will most likely finish the project with over 2,400 part equivalency associations.

4 Second Technical Status Review

The first project quarterly status review meeting was held at ShipConstructor Software Inc. in Victoria BC, Canada. Participants from the 2nd Tier shipyards (Bender, Bollinger, Marinette Marine), and two design agents (Murray & Assoc., Elliot Bay Design Group), and both software development companies (SSI, KBSI) were present at the meeting. The meeting provided an update and feedback on the development efforts from the software development companies. The meeting insured that all parties were up to date, it furthermore established plans and schedules for the next quarters work:

- Purchase Orders for subcontracts have been issued to the project participants.
- Project Management Plan was approved.
- Technology Transfer Plan was approved.
- Software Development Plan was approved.
- Project Web Site had additional users set up and issued usernames & passwords as they were identified.
- Draft CPC Integration Software Specification was approved.
- Draft 3D Product Model Splitting & Merging was approved.
- 2nd Tier CPC was released and posted on the project website for download and installation at each project participant's shipyard.
- Project Quarterly Status review meeting was held at ARL in Victoria BC, Canada.
- With exception to VT Halter, all shipyards have confirmed installation of the latest 2nd Tier CPC release on their respective SQL servers/terminals at the Project Quarterly Status meeting.
- ShipConstructor Database Redesign effort is approximately 80% complete.
- ShipConstructor Structural Stock Library is approximately 70% complete.
- ShipConstructor Association to other ShipConstructor Databases is approximately 90% complete.

The STSDEP II project had progressed at an expeditious pace. The exception was the 3D Product Model Splitting & Merging Module, the remainder of tasked work was on schedule or ahead of schedule.

4.1 ShipConstructor Software Developments

SSI provided their status on the 3D Product Model Splitting & Merging development, at the Quarterly Status Review Meeting. It is also important to note that due to the fundamental design changes of the ShipConstructor database required by the CPC Integration and 3D Product Model Splitting and Merging modules, all software modules (Hull, Structure, Pipe, HVAC, Penetrations, BuildStrategy, and so on…) had to be newly interfaced to the database and, in most cases, significantly rewritten. Due to the monumental change in the SSI software code, certain "golden nuggets" seemed to fall out during the process. The "golden nuggets" will definitely add some significant enhancements that will parallel the efforts of the project work. SSI was approximately

90 percent complete with re-implementing the ShipConstructor database to allow splitting and merging of a ShipConstructor project. Current status shows that ~400 database tables, ~3000 stored procedures, and an API/ShipConstructor Data Layer have been re-written. The original project estimate was ~300 database tables, ~2500 stored procedures.

4.2 KBSI CPC Software Development

KBSI revealed at the first Project Quarterly Status Review Meeting, that they had completed the Bulk Import and Export functionality for the 2nd Tier CPC software. The mass export functionality allows parts to be searched, filtered, and then exported to a Comma Separated Value (CSV) / EXCEL spreadsheet. The mass import functionality considers two modes of importing parts; a) Override Old Data, or b) Do Not Override Old Data. Currently since the individual 2nd Tier CPC's are not sharing a centralized CPC database, all of the 2nd Tier CPC's are functioning independently. This functionality allows some flexibility in providing, 1) Inter-Shipyard data sharing without the CPC being centralized, 2) Intra-Shipyard familiar user interface for most users, 3) Data Collection and Clean-up can be performed in a larger data set. KBSI also revealed at the Quarterly Status Review Meeting, that they had completed the Part Equivalency Interface and Shipyard Part Association functionality in the 2nd Tier CPC software. As stated earlier, over ~800 Bollinger parts have part equivalency associations to Bender's cataloged parts. Through the newly developed part equivalency interface, personal could use the interface to search, filter, view, and print these associations through the 2nd Tier CPC software. The new functionality was added in the current release of KBSI's 2nd Tier CPC software.

4.3 Technology Transfer

Pat Roberts presented the project status at the NSRP ECB Meeting at General Dynamics Maritime Systems Office in Washington, DC on Tuesday June 7th, 2005. Presentation is available through the offices of ATI or the NSRP website.

5 Third Technical Status Review

The second project status review meeting was cancelled at Bollinger Shipyards in Lockport, LA due to Hurricane Katrina, but was rescheduled and held at Knowledge Based Systems Inc. in College Station, TX on October 19, 2005. However, work continued on the project in the following areas:

- 2nd Tier CPC version 3.3.0 was released and posted on the project website for download and installation at each project participant's shipyard.
- CPC i2 Demonstration & Workshop was held at GDEB in Groton, CT.
- CPC Integration effort was approximately 80% complete.
- ShipConstructor Structural Stock Library was approximately 99% complete.
- ShipConstructor Pipe Stock Library was approximately 90% complete.
- ShipConstructor HVAC Stock Library was approximately 95% complete.
- ShipConstructor Structural Stock Library was approximately 35% complete.
- ShipConstructor Database Re-design was approximately 97% complete.

- ShipConstructor Association to other ShipConstructor Databases was approximately 90% complete.

The team proposed a slight variation to Proteus Engineering's scope of work under the CPC task for this project. As noted in the meeting notes from the 2nd Quarterly Project Status meeting and presentations, the team began put forth an effort to integrate the CPC software with an early concept design software called FlagShip. This software was originally submitted in the project proposal as the Design Transition Module that was scoped to integrate FlagShip with ShipCostructor. The project team believed that FlagShip integration with CPC through the API layer that was already build on the project would be the first step toward future possible integration with ShipConstructor.

5.1 ShipConstructor Software Developments

The STSDEP II project was still progressing at a rapid pace but in certain areas. The CPC integration with ShipConstructor was currently on schedule. The 3D Model Splitting & Merging Module PM&S task has slipped 3 months due to the late SC2006 beta release schedule. It was determined that a project schedule extension would need to be submitted to ATI in the effort to complete this task. A contract modification was prepared and submitted to ATI & ECB for approval for a no-cost project extension. The contract extension was submitted once SSI revised it software release schedule.

An emphasis was placed on putting a strong foot forward on the evaluation and testing of the "later Beta" software releases since they had a more stable modeling version of the SC2006 software. SSI was in the process of writing User Manuals and related documentation for the SC2006 version of the software. The project management website was updated to include those areas that would need to be evaluated and tested over the remaining project duration and so that SSI's developers could easily identify those thread postings associated with their development work.

The 2006 ShipConstructor Software BETA 2 was delayed in being released. The Beta software version primarily focused on Pipe and HVAC, with a limited Alpha software version released the structure module, the 2nd BETA version of ShipConstructor 2006 was delayed into December. However, quality assurance and build work was preformed on the BETA 2.

Work done on Database Redesign consisted of issues within the DDROM engine in the SSI 06 software witch were dealt with. A new DDROM Mode option has been added that will allow users to select between 'simple' and 'advanced' modes as they become more comfortable with the software. The database tables in the SSI software increased to ~710 up from ~667 in previous quarter. The stored procedures in the software was increased to ~8200 up from ~6900. The pipe stock library has been completed during this period and it underwent finishing touches and quality assurance. The equipment stock library in the ShipConstructor software has been essentially completed with final production touches and quality assurance work still pending. The ShipConstructor software version module update, scheduled for release with 2006 R1 began during this period and is well underway towards migrating the library components of ShipConstructor 2005 to the redesigned ShipConstructor 2006 database.

General design considerations for the Split & Merge module has continued giving SSI developers a problem. The database redesign required for the Split & Merge is almost complete. Work began on the user interface and functionality behind the Split & Merge code will begin after the release of the ShipConstructor 2006 R1 and is scheduled for completion in the ShipConstructor 2006 R2 version. The documentation for ShipConstructor 2006 release has been essentially framed in and the manuals are waiting on finalization by the development teams and revision/editing.

5.2 CPC Software Development (KBSI CPC i2 Workshop)

General Dynamics Electric Boat in Groton, CT held the CPC i2 Workshop on October 4th-5th, 2005. Participants from three of the 2nd Tier shipyards (Bender, Bollinger, Marinette Marine), one software designer (Knowledge Based Systems Inc.), one design agent (Proteus Engineering), and of course GDEB representatives were present. This workshop was held to provide the shipyard CPC end users with the opportunity to familiarize themselves with a fully functional and deployed CPC in process at the Tier 1 level.

Also, Proteus Engineering has also been given the required .dll files that implements the API calls for data transfer between CPC and ShipConstructor. The API layer will be used to integrate the CPC with FlagShip software from Proteus.

KBSI's developments on the CPC integration task as KBSI incorporated additional functionality in the 2nd Tier CPC tool during this time frame can are as follows:

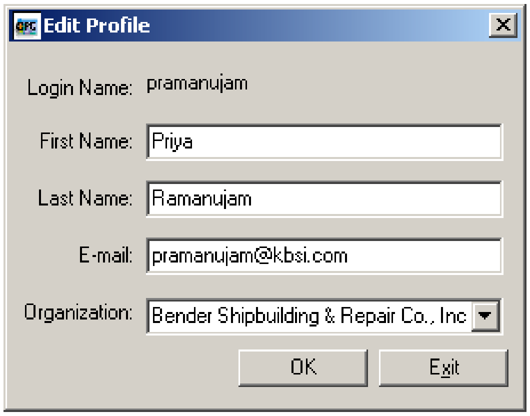

Figure 2. User Profile Edit Interface

Figure 2 shows the Edit Profile screen. The user can edit his/her own profile using this functionality. This feature allows the user to change his/her First name, Last Name, Email address or Organization.

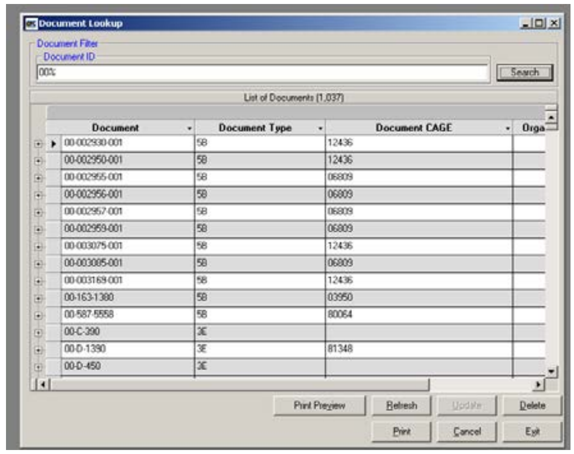

Figure 3. Document Lookup

Figure 3. shows the Document Lookup screen. The user interface changed so that the user can search for any document using the Document ID. This functionality will pull the list of documents that matches the document ID.

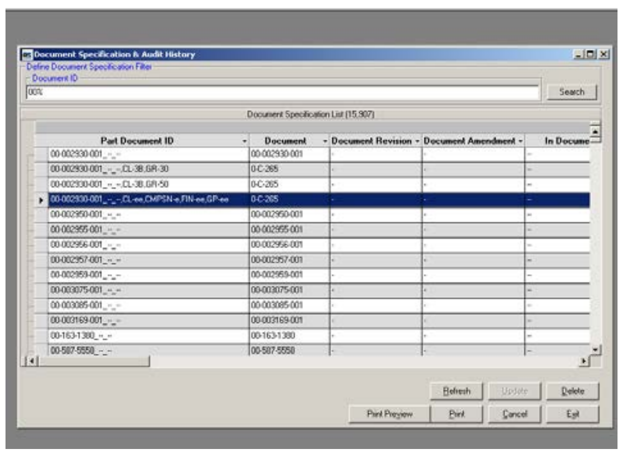

Figure 4. Type 1 Part Document ID Definition

Figure 4. shows the Document Specification & Audit History screen. The user interface changed so that the user can search for any document specification using the Part Document ID. This screen shows Category 1 method for calculating Part Document ID in CPC.

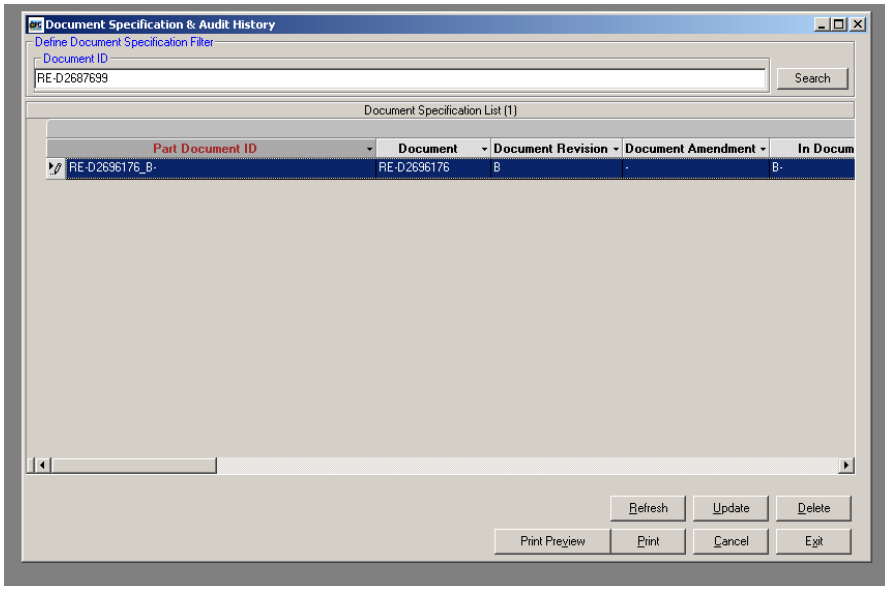

Figure 5. Type 2 Part Document ID Definition

Figure 5 shows the Document Specification & Audit History screen. The user interface changed so that the user can search for any document specification using the Part Document ID. This screen shows Category 2 method for calculating Part Document ID in CPC.

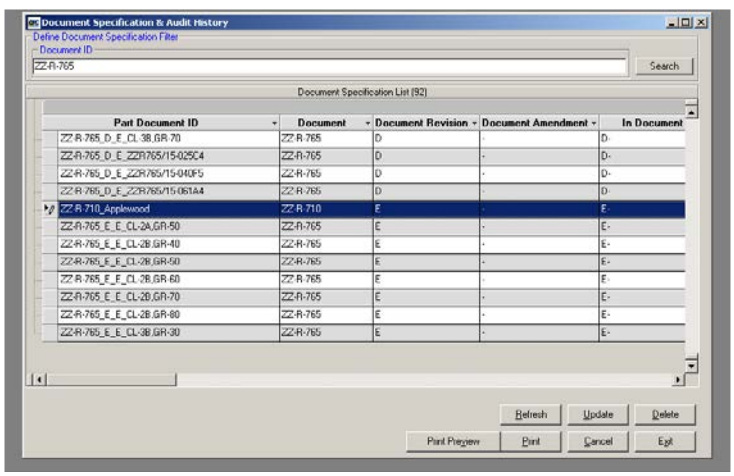

Figure 6. Type 3 Part Document ID Definition

Figure 6 shows the Document Specification & Audit History screen. The user interface changed so that the user can search for any document specification using the Part Document ID. This screen shows Category 3 method for calculating Part Document ID in CPC.

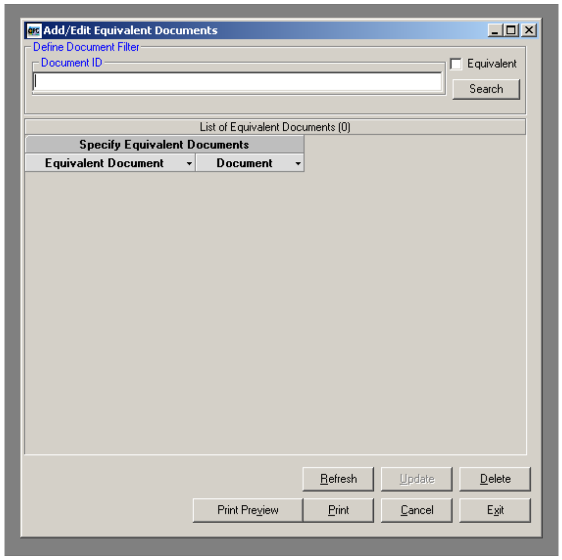

Figure 7. Searching for Equivalent Parts

Figure 7 shows the Add/Edit Equivalent Documents screen. The user interface changed so that the user can search for any document using either the Document ID or Equivalent Document ID. This functionality pulls the list of all documents that matches the ID entered.

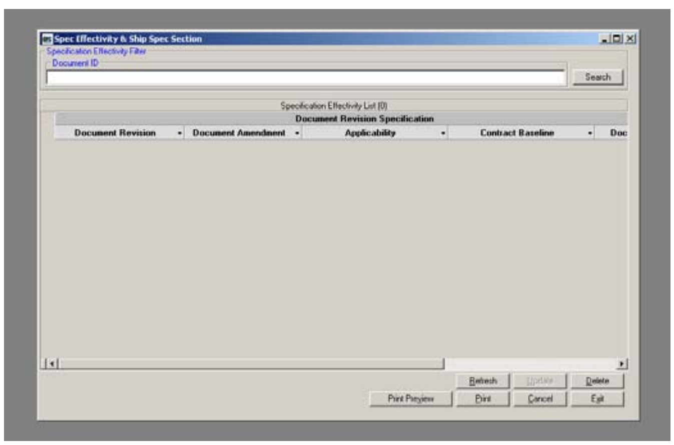

Figure 8. Spec Effectively & Ship Spec Documents

Figure 8 shows the Spec Effectively & Ship Spec Documents screen. The user interface changed so that the user can search for any Document Revision Specification using the Document ID. This functionality pulls the list of all specification documents that matches the Document ID entered.

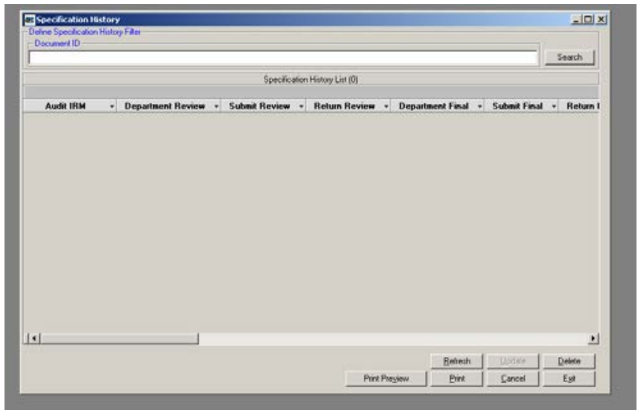

Figure 9. Document Specification History Interface

Figure 9. shows the Specification History screen. The user interface changed so that the user can search for any Specification History using the Document ID. This functionality pulls the list of all specification history that matches the Document ID entered. KBSI implemented the functionality to order the documents associated with a part. In the CPC methodology more important documents are associated at the top of the list, and less important documents at the bottom of the list. The part document association interface was modified to facilitate ordering of documents in Figure 10.

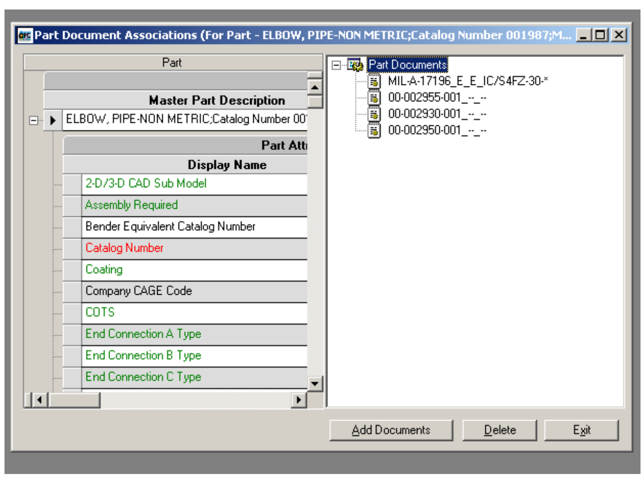

Figure 10. Ordering of Documents Associated With a Part ID

The mapping between the document type and the method to equate a part document id is performed using a lookup table.

5.3 Technology Transfer

Patrick Roberts, project team lead, provided a project presentation at the NSRP PDMT Panel Meeting held in Alexandria, VA on Thursday September 22nd, 2005. A similar presentation was provided by Rolf Oetter with SSI at the NSRP ST Panel Meeting held in San Diego, CA on Thursday September 22nd, 2005. Presentations were provided to the Panel Chairs for posting on the NSRP website.

During this period in time, both Pat Cahill & Rolf Oetter with SSI presented a paper and a presentation at the 2005 Ship Production Symposium in Houston, TX on October 20th, 2005.

6 Fourth Technical Status Review

The third Quarterly Project Status Review meeting was held at the ShipTech 2006 conference in Panama City, FL on January 26th, 2006. The Limited Release of the ShipConstructor 2006 software was released on March 6th. Work continued on the evaluation and testing of the ShipConstructor "Limited Release." SSI developers continued to work on the User Manuals and related documentation for the ShipConstructor 2006 software version. The project team's shipyards and design agents continued their User Testing and QA testing at their respective facilities. The project management website was maintained to reflect the current applications and issues involved in the project.

A contract modification was granted by ATI & ECB for a no-cost project extension to the project based on SSI's new revised software release schedule.

Bender Shipbuilding migrated over 15,000 parts with documentation over from its legacy catalog. Of which, 1600 have part equivalency associations that have been made to Bollinger Shipyard parts.

Also, Proteus Engineering completed implementation with the 2nd Tier CPC software. The API layer in the ShipConstructor software was used to integrate the CPC software with FlagShip software. A FlagShip workshop was planned to be held at Anteon/Proteus Engineering's office in Stevensville, MD on Tuesday, March, 21st, 2006. Other work done during this period was as follows:

- KBSI released version 4.2.0 of the 2nd Tier CPC software and posted it on the project website for download and installation at each project participant's shipyard on February 8th.
- CPC Integration effort was at 90% complete.
- ShipConstructor Pipe Stock Library was at 99% complete.
- ShipConstructor Equipment Stock Library was at 99% complete.
- ShipConstructor Splitting & Merging Functionality was at 60% complete.
- ShipConstructor Association to other ShipConstructor Databases was at 100% complete

No presentations were provided as technology transfer during this period of time. The PDMT Panel did have a meeting scheduled at ShipTech 2006, but did not invite our STSDEP II team to provide a status report presentation during that particular meeting.

6.1 ShipConstructor Software Developments

A Limited Release of SC2006 was introduced in March and testing began soon after. The product had been stabilized considerably after several QA builds and cycles were undertaken. Other work done to improve the ShipConstructor software was as follows:

- Database Redesign – Only minor changes and bug fixes had been undertaken during this period. The Database Tables were increased to ~750, up from the ~730 in last reporting period The Stored Procedures increased as well to ~9700 up from ~9200 in last reporting period.
- Pipe Stock Library – The pipe stock library was at 99% complete and only usability changes were done based on user and QA testing feedback.
- Equipment Stock Library – The equipment stock library was also at 99% complete, with only usability changes were done based on user and QA testing feedback.
- Version Converter (from ShipConstructor2005 to ShipConstructor2006) – The version converter module is still well underway. The stock libraries portion of the migration of the software was at ~ 90% complete during this period.
- Documentation – The documentation for the 2006 release was largely framed in as of this period in time. The manuals were waiting on finalization by the development teams and revision/editing and QA followed.
- There was little change on the CPC integration with the exception of some required database changes.
- There was little change on the Split & Merge with the exception of the database changes that were made necessary as a result of this project. Work began on the user interface and functionality behind the Split & Merge process after SC2006 R1 and was scheduled for completion in SC2006 R2.

ShipConstructor Software Inc. held a special evaluation, training, & testing workshop in Victoria, BC on February 6th – 10th, 2006. Attendees arrived at Victoria on or before Sunday, Feb 5th, and left no earlier than Friday, Feb 10th, 3:00 pm (as late arrivals or early departures would have disrupted the intensive training schedule that was prepared). PowerPoint presentations and a full documentation of the feedback & bugs identified during this week session were captured and placed on the project management website upon completion.

6.2 KBSI CPC Software Development

Major developments were made on the CPC integration task as KBSI incorporated additional functionality in the 2nd Tier CPC tool. The CPC project was focused towards the 2006 R1 timeframe release. The Structural, Pipe and HVAC CPC integration was stable in the Beta2 software version. However, the Equipment library CPC integration was expected to be testable at SSI later in the process. Implementation of three different methods of Part Document ID creation in CPC was released. The Type I, Type II and Type III methods of part document id creation were implemented depending on the document type, the respective method was followed to calculate the part document.

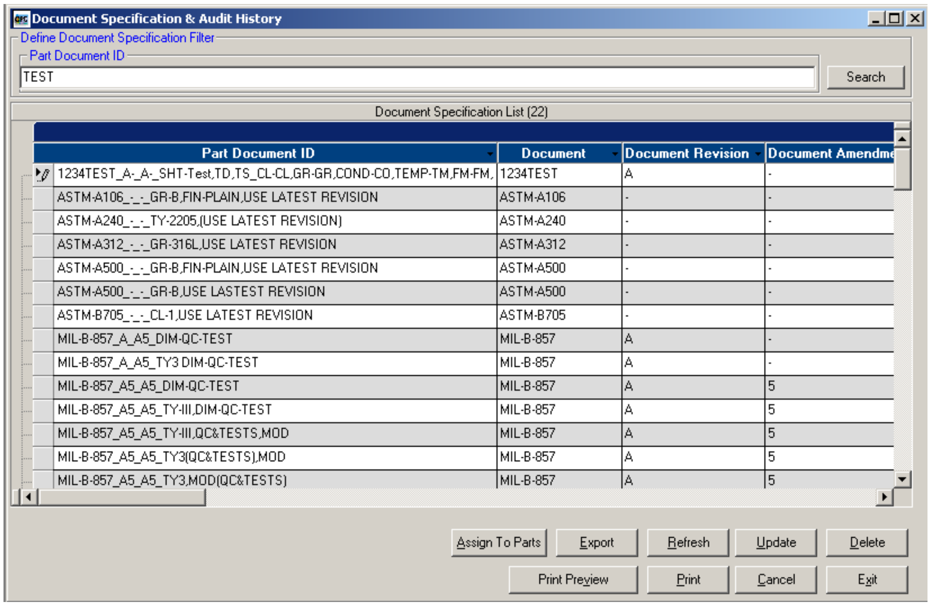

Figure 11. Type I method of Part Document ID creation

Figure 11. shows the type I method of part Document ID creation. The User Interface was changed in all of the forms to have the search based on either Document ID or Part Description. Some color schemes were implemented in the application. A new submenu called View Part Document Associations was added to the Document menu.

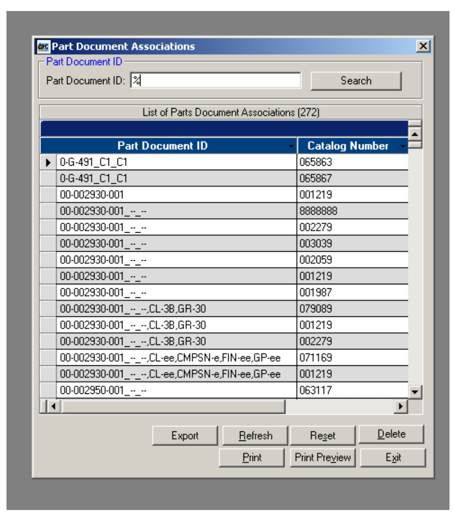

Figure 12. Part Document Associations

Figure 12. shows all the part document associations. Depending on the part Document ID entered in the search criteria, the list of all part document associations that match the part Document ID is retrieved. The list of all functionalities such as Export, Delete and Print are available at the bottom of the form. When a new Document Specification is created, only relevant document revision and document amendment corresponding to the Document ID will be displayed. This makes the user interface more friendly. KBSI spent time resolving issues from shipyard users: John Gilliam, at Bender found an issue that dealt with Import Parts functionality and Kevin Uren of Marinette Marine, experienced problems installation process. Both the faults with importing parts with an overwrite option and the installation with Power Users of the system were resolved.

KBSI released version 4.2.0 of CPC to the project participants. This version supports both SQL Server® and Oracle® databases. KBSI assisted Bender and Bollinger in the set-up of the new version of CPC.

The user groups identified CPC new enhancement requirements, the requirements are as follows:

- A dialog box interface where the user are able to map NSN numbers to different Parts
- A dialog box interface where a user can define new Ship Classes
- A dialog box interface where the user will be able to map Document ids to Ship Classes,
- A dialog box interface were the user will be able to map Parts to Ship Classes.
- A validation scheme was implemented when a document is mapped to a part. When a document is mapped to a part, there is a check to see if the document being mapped is associated with any of the Ship Classes.

KBSI created an interface for NSN/Part Mapping the user can enter new NSN(s) and assign NSN(s) to different Parts. The user then can search for existing Parts/NSNs by entering the keyword and clicking on the search button. The list of records that match the search criteria is then displayed.

7 Fifth Technical Status Review

As of the end of April, the project was essentially complete. The ShipConstructor 2006 software version was planned for release on June 16th, 2006, incorporating all of the features scoped for the project. A "Super User" training seminar was conducted in March 2006, and a follow-up SC2006 training session was held in April, 2006. All project team participants have received beta releases through Limited Release 2 (LR2).

KBSI's current version 4.2.0 of the CPC database and interface software has been placed on the project management website for download and installation by the participating shipyards. All of the changes identified at the 3rd Quarterly Meeting in Panama City, FL at ShipTech 2006 have been incorporated into the latest release.

Proteus Engineering was given the .dll files that implements the API calls for data transfer between CPC and ShipConstructor. Proteus used the API layer to integrate the CPC with FlagShip software. Proteus Engineering held a workshop at their facility in Stevensville, MD on

March 28th, 2006, to train and demonstrate the use of the Flagship software and the CPC integration that was developed in conjunction with this project. George Hazen conducted the workshop on the FlagShip software. Proteus had laptops available for attendees to use at no charge. FlagShip also loaded their software onto attendee laptops. The Flagship CDs and locks were provided to all attendees as cost share to the project. Four project participants were able to attend the workshop. At the end each project team member participating in the workshop received a copy of the latest FlagShip Designer software with the dongle hardware locks to run the software during the project timeframe. A tutorial document was also prepared and sent to the project team members that participated.

7.1 SSI Development Progress

Ship Contructor has progressed well in the past reporting period. Developers have moved head on many of the stock libraries interfaces as well as the Split and Merge module.

- Stock Libraries

ShipConstructor had updated many of the stock library interfaces to create the same usability as seen in the Structure library. Stock Library editor was mostly complete with usability, QA and stability being the primary focus items at this time. The structure stock library was complete. Each type of structural stock in the ShipConstructor Structure library is logically linked to a Part class in the CPC. When import is attempted on a CPC item, the list of items is filtered to only show those items which belong to the associated CPC Part class. Clicking the CPC Import button opens the dialog window shown in figure 13.

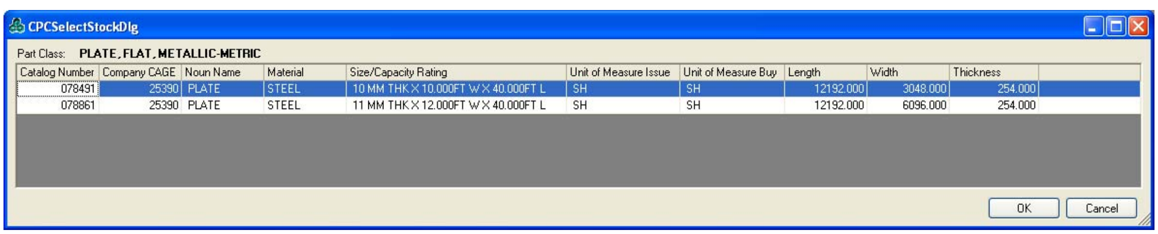

Figure 13. CPC Select Stock Dialog

The following libraries are complete: Pipe Stock, HVAC Stock, Equipment Stock. This redesign of the library interface will allow integration with the CPC. The Interface is similar to the interface used for structural stocks.

The associating of ShipConstructor Project databases are complete. ShipConstructor developers need SC2005 databases to test functionality of the associating databases. The project team members were to supply existing ship model data.

- Split & Merge Module

Splitting and Merging Module's database rework was complete. The remaining changes have been finalized based on the last minute requirements changes in the supported software. Concurrency issues and transactional behavior problems were being found and resolved as well. The usability testing had commenced. Split and Merge Functionality was at 60 percent complete.

The SSI developers and other project team members finalized the specification for Project Split and Merge module, which was also the basis for the Users Manual. The final specification was restricted to internal and NSRP project management only. At this time the shipyards and design agents have were asked to provide SC2005 projects that can been used to test the merging of the project database into a SC2006 database.

7.2 KBSI Development Progress

KBSI has continued to improve and revise the CPC software as the shipyards and ShipConstructor require the software to function. The following lists of features were implemented in CPC software:

- Implemented NSN Part Mappings

The interface for Part-NSN Mappings was implemented. The user can enter the Part-NSN mappings using this interface shown in Figure 14.

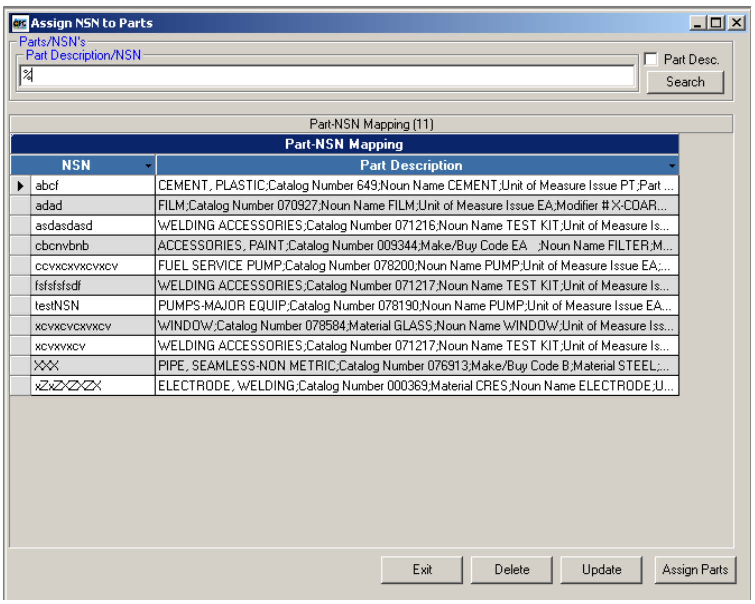

Figure 14. Part-NSN Mapping

- Part Master Interface

This interface was implemented in the menu Part Master->Part Master/NSNs. The user can enter a new Part-NSN mapping by right clicking on the form and choosing Add Part-NSN Mapping as shown in Figure 15.

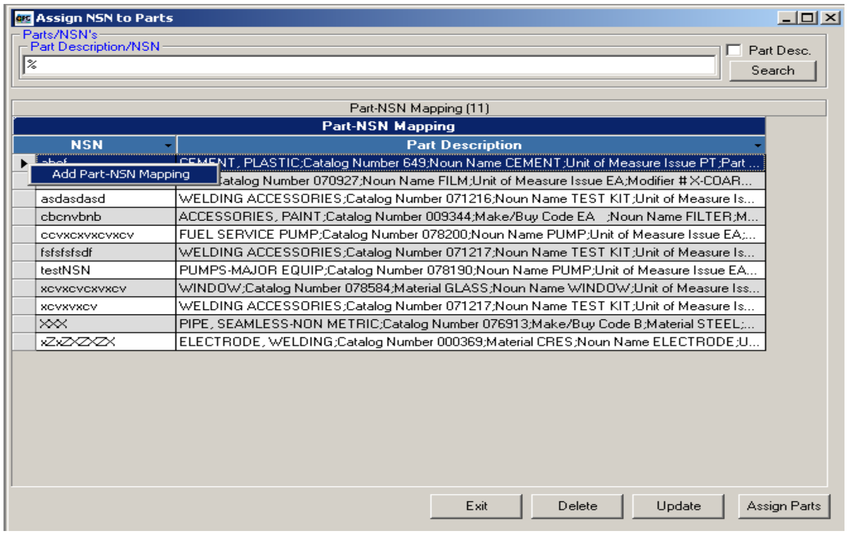

Figure 15. add Part-NSN Mapping

The user can enter the NSN, click on *Assign Parts* to search for parts, and then assign it to the NSN. The user can update/delete existing mappings using the buttons at the bottom of the form. The user can search for existing mappings by entering the search criteria and clicking *Search*.

- Ship Class/ Application

The Applicability-Applicability/Ship Classes interface was implemented in the CPC. The user can enter the new Ship Classes using this interface. Figure 16 shows the Ship Class interface.

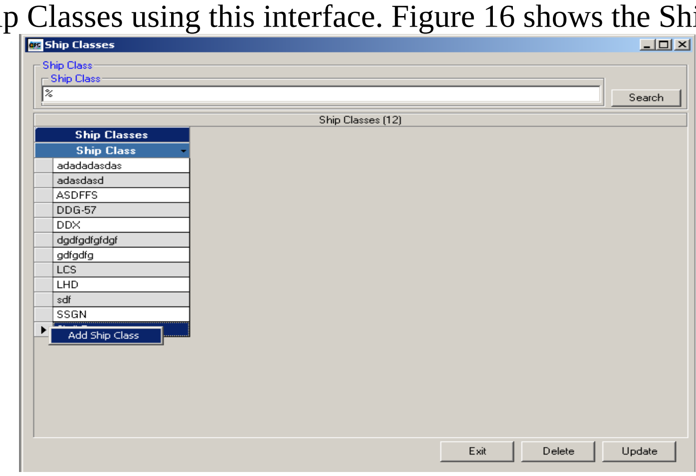

Figure 16. Applicability Ship Class

The user can enter a new Ship Class by right clicking and choosing Add Ship Class.

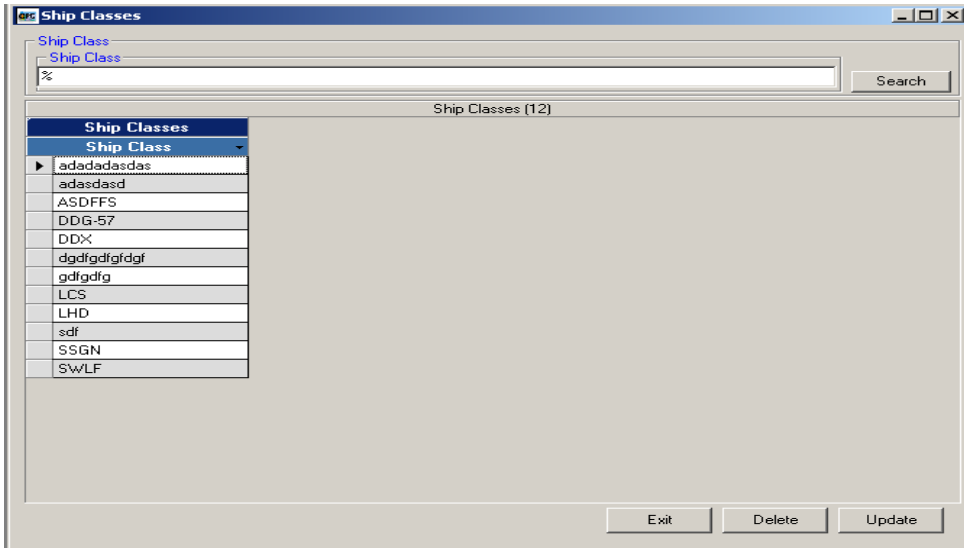

Figure 17. Add New Ship Class

After adding ship classes, the user can click on *Update* to refresh the data. Existing ship classes can be deleted by choosing the ship class and clicking on *Delete*. The user can also search for existing ship classes by entering the search criteria and clicking on *Search*. This interface is available in Administrator->Ship Classes.

- Implemented Document to Applicability Mapping

This interface for documents to be mapped to ship classes was completed. The user can map documents with ship classes using this interface. Figure 18 shows the screen shot of the Document Applicability Mapping form. This interface is accessible through Document->Document/Applicability Mappings.

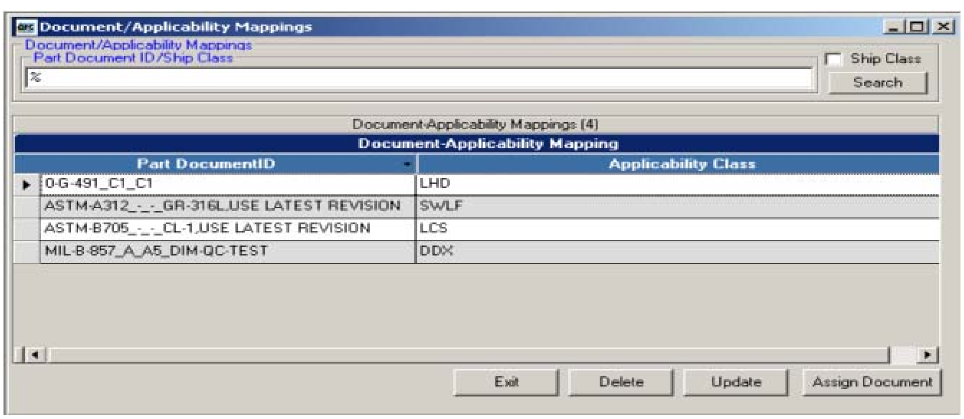

Figure 18. Document Applicability Mappings

The user can enter new mappings by right clicking and choosing Add Document-Applicability Mapping as shown in Figure 19.

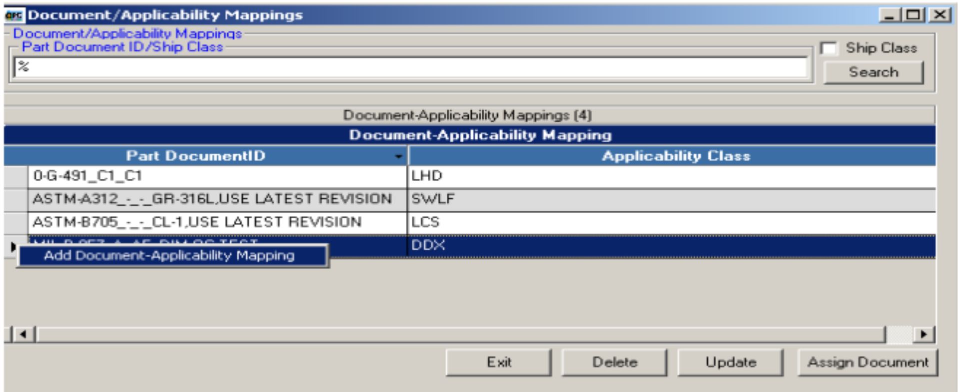

Figure 19. Add Document Applicability Mapping

- Part Document ID Mapping

The user can choose the Part Document ID by clicking on *Assign Document* and then choose the ship class to assign it to. The user can update/delete existing mappings by simply using the buttons at the bottom of the form. The user can search for existing mappings by entering the search criteria and clicking *Search*.

Implemented Part and Applicability Mapping interface where parts are mapped with ship classes was implemented. The user can map parts with ship classes using this interface.
Figure 20 shows the screen shot of the Part Applicability Mapping form. This interface is accessible through Part Master->Part Master/Applicability Mappings.

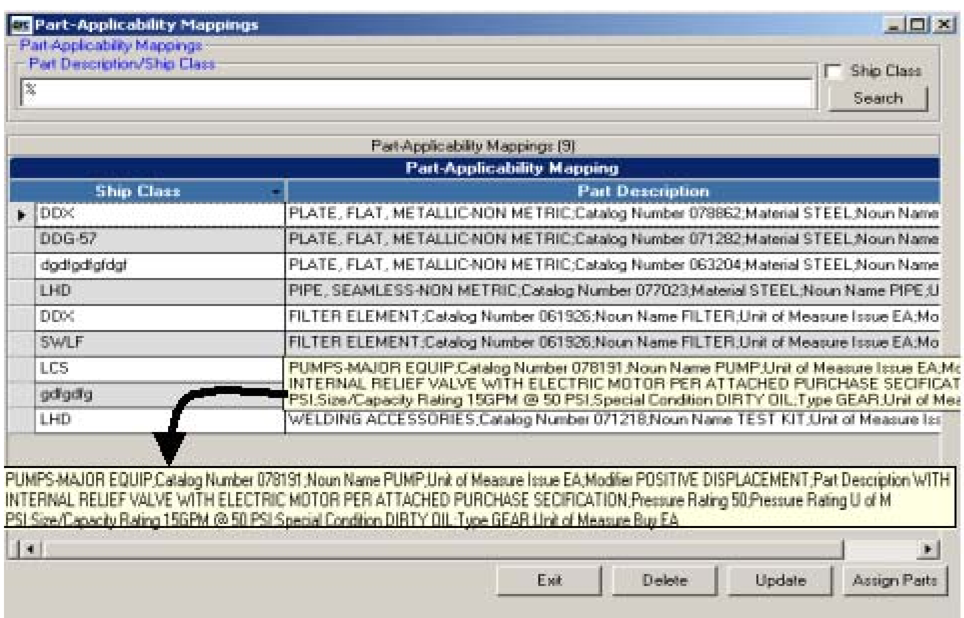

Figure 20. Part-Applicability Mapping

The user can enter new mappings by right clicking and choosing Add Part->Applicability Mapping as shown in
Figure **21**.

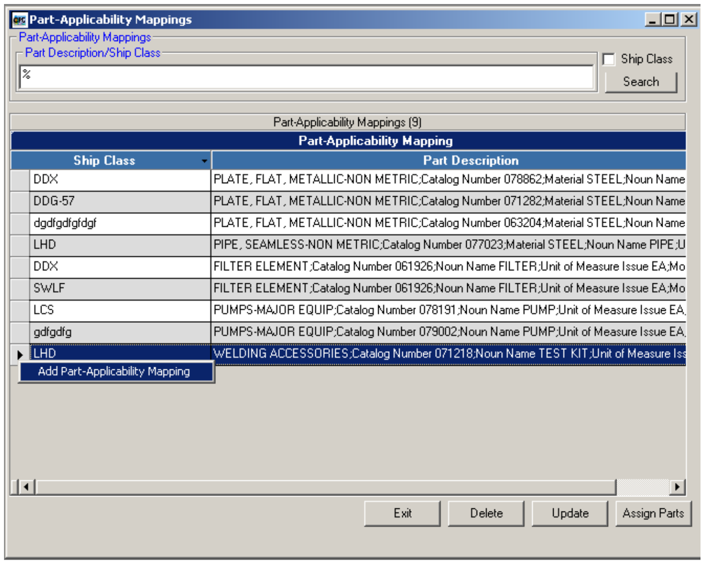

Figure 21. Add Part Applicability Mappings

The user can choose the Part by clicking on *Assign Parts* and then choose the ship class to assign it to. The user can update/delete existing mappings using the buttons at the bottom of the form. The user can search for existing mappings by entering the search criteria and clicking *Search*.

- Part Document Validation

KBSI implemented Part Document Validation. When a document is associated with a part, there is a validation check as to whether the document is associated with any of the ship classes that the part is associated with. If not, there is a message displayed on the screen as shown in
Figure 22.

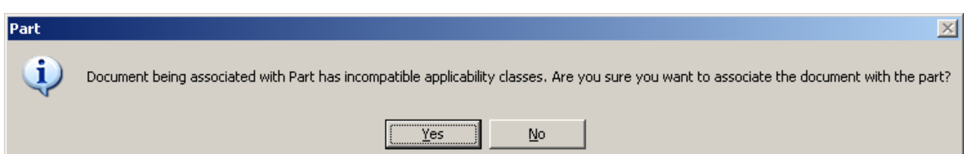

Figure 22. Validation

The option to enable/disable this validation is available in View->Options menu seen in figure 23.

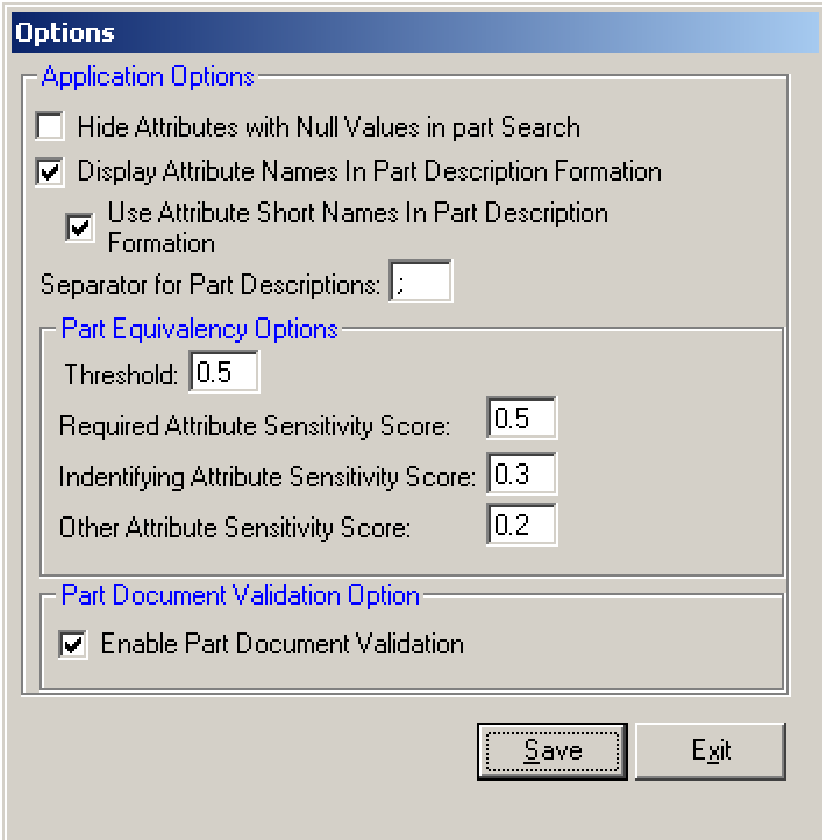

Figure 23. Options

All of the new features have been implemented in both the SQL Server and Oracle.

- CPC meeting with Bollinger

KBSI attended a CPC meeting with Bollinger on March 24, 2006. Bollinger was interested in using the CPC in their operation environment. KBSI is in discussions with Bollinger to achieve this goal. KBSI also received positive feedback and feature requests during this visit. The project team began to prioritizing and the designing these new features.

7.3 CPC/Flagship Integration – Proteus Engineering Development Progress

On March 28, 2006, a workshop was held at Anteon/Proteus in their Stevensville, MD offices. The goals of the workshop were to:

- Train attendees in the use of Designer and its linkage to the Common Parts Catalogue (CPC)
- Provide attendees with baseline version of Designer software
- Collect attendee comments for enhancement of Designer.

The following organizations were invited to send representatives: Bender Shipbuilding, Bollinger Shipyards, Gibbs & Cox, Murray & Associates, Elliot Bay Design Group, General Dynamics, Electric Boat, Genoa Design, KBSI, Marinette Marine, Northrop Grumman Ship Systems – Avondale Operations, and VT Halter Marine.

The following organizations sent the noted representatives, who participated in the workshop:

- Bender Shipbuilding – Daniel Cavalier
- Elliott Bay Design Group – John Waterhouse
- Gibbs & Cox – Mark Masor
- Murray & Associates – Drew Hanes

The workshop commenced with introductions, and providing all participants with a laptop computer on which Designer and sample data were loaded. This was followed by George Hazen (developer of Designer) presenting Designer and its linkage to the CPC. George Hazen then trained the participants in the following areas, using a Surface Effect Ship initial design as an example case study:

- Development of vessel requirements and missions
- Data retrieval from the CPC
- Initial design wizard (resistance and power, lift system, hydrostatics, weight, and cost)
- Noise analysis and noise-reduction treatments

At the conclusion of the training, each of the participants were given an installation CD and a software dongle to allow them to install Designer on their own computer(s). While the Designer software can be installed on multiple computers at the customer's site, it will only run if the supplied dongle is attached to the computer. The training itself is captured on a tutorial that is available from within Designer by selecting 'Tutorial' under the Help menu.

7.4 Technology Transfer

Patrick David with SSI USA provided a project presentation update at the NSRP PDMT Panel Meeting held in San Diego, CA on May 9-10th, 2006. Also, Rolf Oetter with SSI, provided a project presentation update at the NSRP Joint Panel Meeting with SPPT, BPT, & ST held in Seattle, WA on May 16-17th, 2006. The presentations were provided to the Panel Chairs for posting on the NSRP website.

8 Final Technical Status Review

As of the end of May, the project was complete. The ShipConstructor 2006 software version was scheduled for released on June 16th, 2006. The final builds were compiled for QA testing prior to release. CPC integration was complete for all stock libraries, although further development will be required to complete the integration with the Equipment module, due to the total redesign of the module, both in design approach, database structure and user interface. ShipConstructor Splitting & Merging project was complete and functional, at the Unit level only. Further development is required to get down to the individual component level. SSI believes this functionality could be completed by sometime in October 2006.

KBSI has released version 4.3.0 of the CPC database and interface software on June 9th, 2006. The software has been placed on the project management website for download and installation by the participating shipyards. Major change was the identification of over 6400 defined part equivalencies between Bender, Bollinger, VT Halter & Marinette Marine. Each of these shipyards now has approximately 1600 CPC parts defined in the database under their respective company cage codes.   Also, an updated user manual has been released and was posed on the project management website for download.

8.1 SSI Development Progress

Stock Library Interfaces - the stock editor is complete with usability. As noted in the final status overview, equipment stock libraries need additional work although the module is functional.

Split and Merge Module - database rework is finished. The final adjustments have been made and effectively the database restructuring has been finalized.

Split and Merge Module's functionality is 90 percent complete. PS&M is well developed but has restrictions. The most significant issue that could be developed further is the Unit level limitation, which restricts splits to the unit level. Future work focused on Configuration Management issues could explore the feasibility of Split and Merge at levels defined in the topology breakdown, possibly all the way down to the individual component level.

Importing the ShipConstructor 2005 software version database is complete. ShipConstructor continues testing the import capability with model databases supplied to them from the project participants. Preliminary results show from the model data from a SC2005 project, supplied by Bender Shipbuilding, has been moved over within the 8 hour project metric. QA and in-house evaluation continues at ShipConstructor.

8.2 KBSI Development Progress

The following tasks were performed during this reporting period.

- **CPC Part Equivalencies**

The project metric/goal for the CPC task was to test the establishment of 1000 equivalent parts between at least two 2nd Tier shipyards. Figure 24, currently shows that the 2nd Tier CPC database has over 6400 part equivalencies defined between Bender, Bollinger, VT Halter, and Marinette Marine.

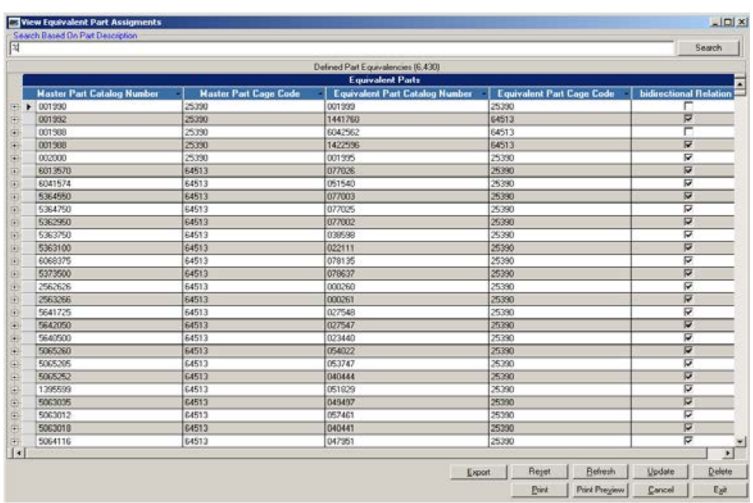

Figure 24. CPC Part Equivalenices

Figure 25. also shows that interface that allows an end user to view Equivalent Part Assignments from some identified part description that is defined by the part attributes.

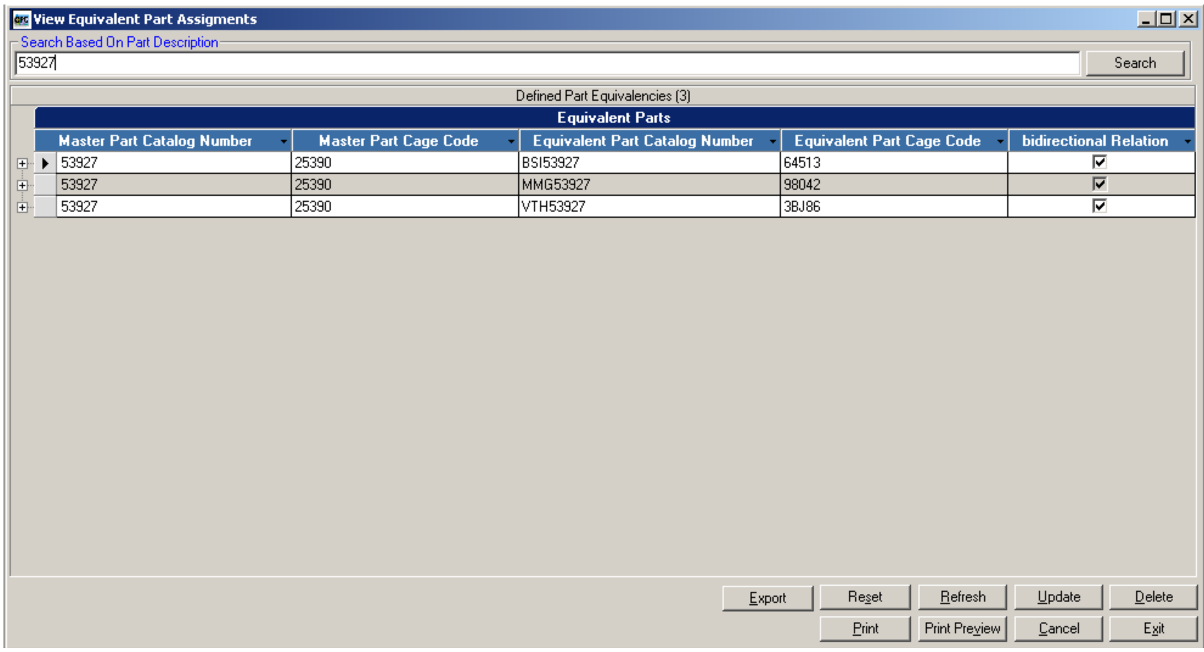

Figure 25 Equivalent Part Assignments

- **CPC User Manual**

KBSI has release and posted the latest revised CPC user manual associated with version 4.3.0 on the project management website for download. The path name is supplied below: http://65.5.80.202/phpBB2/download.php?id=179 - _Toc135188336 If you do not have access to the project management website, please send an email to prob@bendership.com to receive access.

8.3 Proteus Engineering Development Progress

The integration of the CPC database and the concept design software of Flagship Designer were completed with great results seen in the workshop put on by Proteus Engineering.

9 ROI Evaluation

The project team received a direct benefit from this research and technology by reducing ship design costs and improved productivity of CAD operators.

By integrating process improvements with full exploitation of state of the art tools, the project team will achieve a reduction in unit cost, an increase in unit production and an increase in net profits.

Return on Investment (ROI) is, as presented in the included ROI Worksheet. For the purposes of this project, we used the model for a small sized commercial shipyard, as done in the original proposal document. These model characteristics are as follows:

	Medium Size Commercial Shipyard	Small Size Commercial Shipyard
Throughput	**1 design/year 4 ships/year 72K tons of steel/year 360K feet of pipe/year 1,200K feet of cable/year**	**3 designs/year 5 ships/year 16K tons of steel/year 90K feet of pipe/year 260K feet of cable/year**
Employees	**200 pre-construction staff 150 design 20 material 30 planning & production control 2,400 production staff 1,200 steel production 720 outfit production 480 paint & service production**	**50 pre-construction staff 35 design 5 material 10 planning & production control 600 production staff 280 steel production 230 outfit production 90 paint & service production**
Billing Rates	**$60/hour – pre-construction $45/hour – production**	**$60/hour – pre-construction $45/hour – production**
Cost per Ship	**$120 million/ship $72 million material $48 million labor & overhead**	**$30 million per ship $18 million material $12 million labor & overhead**

9.1 ROI Assumptions

Due to the large collaborative nature of this project, a comprehensive ROI is nearly impossible to generate. However, the savings in each area are significant even for the small shipyards, so certain assumptions have been made to generate a realistic ROI.

To account for full implementation time, savings will not realized until the year 2007. Development work prior to implementation of the finished system does not contribute to savings. Approximately 3 months in year 2006 will the savings be realized.

1. A typical small ship design requires 30,000 manhours with the following breakdown:
   a. 20% structure (6000 hrs)
   b. 30% piping and HVAC (18,000 hrs)
   c. 10% foundations (3000 hrs)
   d. 10% electrical and design drawings (3000 hrs)
   e. 30% administration (including materials), reproduction, production support (18,000 hrs)
2. A small shipyard does three designs per year. The same number applies to the design agents supporting the yards.
3. Bender, Halter, Bollinger, and Marinette are considered small yards.
4. Avondale is a medium yard for the purpose of the ROI, and does 1 design per year, for 60,000 hrs.
5. Avondale counts as a 2x multiplier in the ROI.
6. Total shipyard multiplier is 6.
7. Total design agent multiplier is 4.
8. Total multiplier on per ship savings is 3 ships x 10 yards/design agents = 30.
9. EB is not included in the ROI, despite obvious improvements to their efficiency from their CPC Implementation.
10. The same percentage breakdown applies to the larger design.
11. Billing rates are $65/hr for design and planning, $45/hr for production
12. Estimated percentage reductions in design manhours per small shipyard due the design module improvements, based on best practices assessment:
    a. CPC - 10% reduction in design category (e) = 1800 hrs/ship x 30 = 54,000hrs/yr = $3,510,000/yr
    b. DB Merging – 15% reduction in design category (e) = 2700 hrs/ship x 30 = 81,000 hrs/yr = $5,265,000/yr
    c. Design Transition – savings of 10% in total design. 3000 hrs/ship x 30 = 90,000 hrs/yr = $5,850,000/yr
13. Additional impacts from material savings attributed to the CPC, schedule compression due to the overall project impact, and direct production impacts from better design documentation, better integrated planning and better project management are difficult to quantify. Given the quantifiable benefit above, no attempt has been made to skew the projected savings with difficult to quantify benefits.
14. Total annual savings, as detailed in the following ROI spreadsheet equates to $15,610,420, broken down as $950,420 in rework, $10,000 in inventory and $14,625,000 in direct or indirect labor.
15. 25% of the total savings will be realized in 2006 due to completed and implemented modules.
16. Recurring costs of $300,000 per year in license maintenance on the software will be incurred.

ROI WORKSHEET

oject Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Program Funds and Cost Share from Cost Proposal (i.e., Investment)	2117679	500832	0	0	0	0	0	0	0	0
Recurring Costs	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000
Present Value of Investment	2417679	728036	247920	225390	204900	186270	169350	153960	139950	127230
Savings	4622920	15610420	15610420	15610420	15610420	15610420	15610420	15610420	15610420	15610420
Labor (Direct & Indirect)	3662500	14650000	14650000	14650000	14650000	14650000	14650000	14650000	14650000	14650000
Maintenance										
Rework	950420	950420	950420	950420	950420	950420	950420	950420	950420	950420
Scrap										
Services										
Equipment										
Inventory	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
WIP										
Material & Supplies										
Schedule										
Cost Avoidance										
Time Value of Money										
Additional Income										
Other										
Present Value of Savings	4622920	14191433	12900451	11728109	10661917	9692510	8812082	8011268	7282260.9	6620379.1
Net Benefit	2505241	15109588	15610420	15610420	15610420	15610420	15610420	15610420	15610420	15610420
Present Value of the Net Benefit	2205241	13463396	12652531	11502719	10457017	9506240	8642732	7857308	7142310.9	6493149.1
Discount Factors	1	0.9091	0.8264	0.7513	0.683	0.6209	0.5645	0.5132	0.4665	0.4241
Cumulative Present Net Value	2205241	15668637	28321169	39823887	50280904	59787144	68429876	76287183	83429494	89922643
Net Present Value	89922643		The method chosen to represent ROI for NSRP ASE ranking purposes. Equal to the Cumulative Present Net Value at the end of the 10 year period.							