Integrating the Marine Enterprise

A White Paper

Process, Power & Marine, a division of Intergraph

INTERGRAPH

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1. Introduction

Advances in software tools have enabled shipbuilders, marine engineers, and production organizations to move forward. While these trends are likely to continue, they will only produce step-wise improvements in their vertical segment. To achieve major productivity breakthroughs, manage the accelerated speed of changes, and provide significant returns on investment in technology and tools, a broader, more horizontal strategy is needed that extends the domain across engineering, business, material management, and production systems.

Given the scope of such a task, no single product or vendor will likely address all the requirements. What is needed is a scalable, open solution that can serve as an integration and data repository platform such that global project information can not only be created, but also managed in a controlled and integrated manner throughout the project life cycle.

This paper describes solutions for the marine industry consisting of one or more products from an integrated suite of tools, in conjunction with a number of third-party tools integrated into the platform. It will outline production proven methodologies for implementing effective data exchange and integration between enterprise resource planning (ERP), engineering and design, and production systems. The author will also present an overview of the components of an enterprise solution and discuss the application of this technology to the focus area of material management in the context of structural piece-part nesting.

2. Shipbuilding Industry Trends

A trend in the shipbuilding industry is for shipbuilders to implement enterprise resource planning (ERP) systems such as SAP. One of the keys to effective ERP implementation in a shipyard is effective data exchange and integration between ERP elements of work planning and material management, engineering and design systems, and production systems, such as nesting and shop floor management. Effective integration can yield benefits up to eight times more than derived from automation alone [1].

3. Required Data Exchanges

Figure 1 below outlines the effective data exchanges that will be the basis of the discussion.

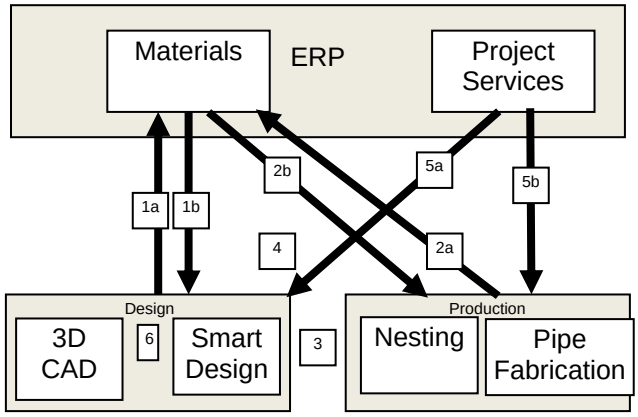

Figure 1: *Data Exchanges*

Arrows marked with a 1 represent exchange between materials management and design systems. Design tools are a major source for bills of material (BOM) in a typical shipyard. Arrow 1a represents that exchange. For any effective data exchange to ERP's material management system, there must be synchronization from the design tool's material codes and ERP's material codes. Arrow 1b represents the synchronization of material codes with ERP.

Arrows marked with a 2 represent the exchange between production applications, such as pipe fabrication, plate nesting, and profile nesting. These applications create a BOM (Arrow 2a) and require synchronization of material codes (Arrow 2b).

Arrows marked with a 3 represent the publishing of data from design to production applications. This exchange includes part information and geometry for plate and profile nesting and piping materials and connectivity for fabrication. The data exchanged inherits material codes from ERP.

Arrows marked with a 4 represent the publishing of top-down early design production planning information to seed the work breakdown structure (WBS) in the ERP project services system.

Arrow 5a represents the WBS information published from ERP to detailed design tools, enabling the detailed design tools to conduct further bottom-up assembly planning. Arrow 5b represents the WBS published from ERP to production systems.

Arrow 6 represents data exchange between design tools. (e.g., functional to detailed design for hull structure and outfitting piping.)

4. Managing Data Exchanges

Consider exchanges 1 through 5 in the context of steel plates. Exchange 1a and 3 contain duplicate information, but for different contexts. In the case of 1a, early in the design cycle, the exchange is primarily for refining steel estimates. Later, it provides detailed BOM information in the context of the WBS (5a). Exchange 3 contains the same information that each individual part contained in 1a, plus the additional geometric information required for nesting. However, the detailed bottom-up assembly information exchanged in 1a is not required during the 3 data exchange. Number 2a contains the individual parts from 3, plus the additional plate and profile stock information.

Three conditions exist in this scenario:

- Three systems (design, production, ERP) share common information about steel.
- The shared information needs to stay consistent.
- Each system needs to add, modify, and delete its data throughout the project life cycle while maintaining consistency.

Data exchanges for Arrow 6 in Figure 1 often have the same conditions.

To ensure the data exchanged is complete, consistent, and correct, the solution is to have a common technical data and document repository. This is depicted in Figure 2 below, with the data exchanges from Figure 1 moving in and out of the common repository as a central hub, rather than point-to-point exchanges.

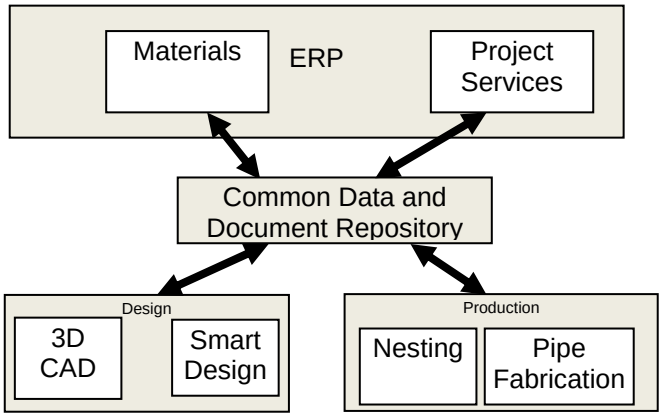

Figure 2: *Data Exchanges with Common Repository*

5. Common Data and Document Repository Characteristics

For the common data and document repository to be effective in maintaining complete, consistent, and correct data, it must contain the following characteristics:

- Integration with leading out-of-the-box ERP and design and production tools to reduce implementation costs and reduce the time to productivity.
- Open and extensible tools to enable exchange with data and documents with other vendor's design and production tools and in-house systems.
- Information regarding what changes occurred, what specifically changed, who changed it and when – all in an easy-to-understand context.

The following characteristics add additional value:

- A workflow engine and/or integration points for work process integration from ERP
- Creation of new applications (or applets) that utilize the high-quality, high-integrity integration previously integrated

6. Material Management Integrations

There are three parts to material management integration from the scenario presented in Figure 1.

- BOMs from design and production tools contain correct material codes for ERP (1b and 2b from Figure 1)
- BOM information from design and production tools to ERP (1a and 2a from Figure 1)
- BOMs contain work breakdown consistent with ERP (5a and 5b from Figure 1)

These parts must all contain the following required characteristics:

- Standard out-of-the-box integrations
- Open and extensible components
- Change management

6.1 Material Catalog Synchronization

Each piece of the integration triad – ERP, design and engineering, and production – requires different material information for their tools. Figure 3 depicts two examples: Hull and Outfitting, and Steel Plates and Valve Information.

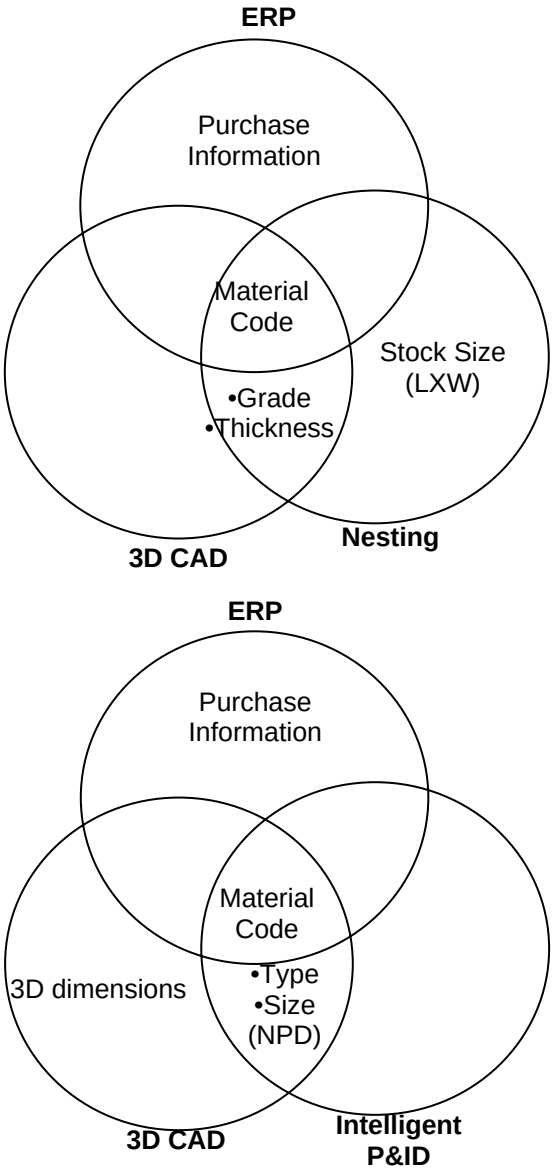

Figure 3: *Steel Plates and Valve Material Requirements*

In both examples and for most materials, the ERP system contains purchasing information that is not explicitly required in design and production tools. There must be a way of identifying materials that is common to more than one application. This is indicated by the overlaps of all three circles, with material code in the middle.

In the case of plate parts, raw stock sizes (length and width) are required for nesting. This data is not widely used in design applications. The overlap between nesting and 3D CAD includes material, grade, and thickness. No additional information is required in 3D CAD.

In the case of valves, 3D dimensional information is required for 3D CAD, while all information required for Intelligent P&ID is contained in the overlap between 3D CAD and intelligent P&ID. Examples of characteristics include valve types and sizes.

The Intergraph SmartMarine™ Enterprise offers SmartPlant® Reference Data to manage and synchronize catalogs between ERP and design and production systems. SmartPlant Reference Data is a Web-based application that offers a single database catalog for all disciplines and tools. Developed for the plant and offshore industries, SmartPlant Reference Data is used at more than 90 client sites worldwide. It contains standard integrations to Intergraph and AVEVA design tools (Figure 4) and SAP MM. The AVEVA integrations are in production at Technip, an offshore design and construction firm, Toyo Engineering Corp, Technip, JGC, BE&K, and COSTAIN.

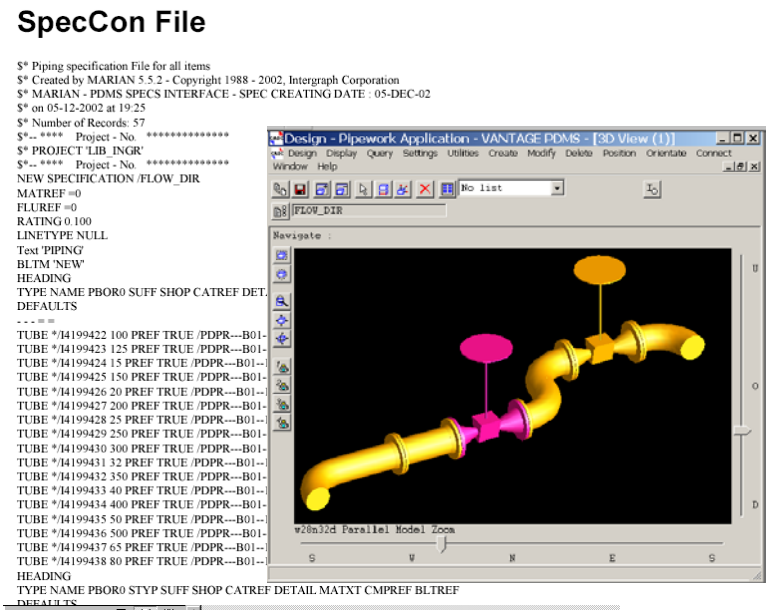

Figure 4: *AVEVA Integration*

SmartPlant Reference Data is completely configurable with supported input/outputs in Microsoft® Excel, XML, comma delimited, etc. It manages change with revision management internal to the application. It also allows for defining corporate standards for materials and configuring material availability from the corporate standard to a per-project basis.

6.2 Design and Production BOM to ERP

As described in the Managing Data Exchanges section above, exchange 1a (design BOM to ERP) and 3 (design nesting information to nesting) from Figure 1 contain duplicate information, but for different contexts. Early in the design cycle, 1a and 3 could be combined to provide more detailed material estimates to ERP, bottom-up assembly information, and nesting information without marking lines and beveling for pre-nesting. The data from 2a is combined with 1a to provide ERP a complete picture of parts to be eliminated, and where they fit in the assembly hierarchy. As the design progresses, more detailed information can be added until final nest. The BOM is not limited to steel, but includes all piping, equipment, electrical, and HVAC materials from a myriad of applications, lists, etc.

The Intergraph SmartMarine Enterprise offers the Engineering and Procurement Interface (E&PI) module for SmartPlant Materials as a solution to managing the BOM from various sources, consolidating them, and providing information to procurement. Like SmartPlant Reference Data,

the E&PI module, used by more than 40 clients worldwide, is Web-based and was developed for the plant and offshore industries.

The E&PI module allows users to verify the BOM and add additional information before sending to procurement. This includes:

- Checking items against catalog (SmartPlant Reference Data)
- Checking data consistency
- Calculating attribute values using rules and adjusting bulk quantities (cut length, waste, etc.)
- Creating material summaries into requisition packages with attached documents and vendor document requests

Like SmartPlant Reference Data, E&PI contains standard integrations to Intergraph and AVEVA design tools and SAP. The same clients that use SmartPlant Reference Data's AVEVA Integration use the E&PI integration. The SAP integration allows users to preset SAP mandatory fields with defaults like network activity code, job type, material group, general ledger, etc.

The E&PI module is completely configurable with exchanges conducted via files and direct exchange between application databases. Since E&PI is one database for all projects, users can even use ship data from other projects to accelerate the procurement process. Of the 40 E&PI implementations, 22 include interfaces to ERP as per Figure 5.

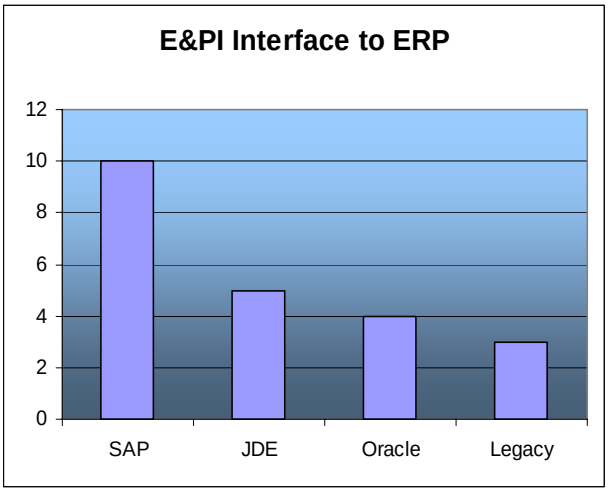

Figure 5: *SmartPlant Materials E&PI and ERP Integration*

The E&PI module manages change through the following functions:

- Send individual BOMs and/or grouped materials to procurement. (e.g., group by block)
- Summarize bulk materials into requisition packages
- Manage different phases of BOMs, such as estimate, final design, and revisions
- Track what came from the design system and what was sent to procurement
- Manage changes and compare phase/revisions to items sent to procurement
- Analyze change to enable faster decisions

6.3 Work Breakdown Structure (WBS) Integration

Consistent WBS information is required to effectively complete production design and exchange BOM information. Intergraph SmartMarine Enterprise has a general purpose application for managing exchanges of information like WBS. This application is SmartPlant Foundation, and it provides a built-in data model for WBS. Intergraph's design tools support exchange to/from this data model. This WBS exchange is used in production at plant design and owner companies like Chiyoda, Dow Chemical, and Air Products.

7. Smart Integration Framework

Like SmartPlant Materials and SmartPlant Reference Data, SmartPlant Foundation allows data exchange in a myriad of ways, but the preferred methodology is through Smart Integration Framework. Smart Integration Framework provides an effective way of maintaining complete, consistent, and correct data across software systems and applications, and provides the information of what change occurred, what specifically changed, and who changed it, all in an easy-to-understand context.

The Smart Integration Framework includes an open, extensible common schema and documented, supported software components for publishing and retrieving of data and documents. Implementations of the software components in the Framework are called adapters. All the Intergraph tools in SmartMarine Enterprise, such as SmartMarine 3D and SmartPlant Materials, include supported adapters that use the same software toolkit available for customers and other software vendors. Intergraph clients, such as Siemens, Shell, Chematur, Doosan HI, and Neste, have created their own adapters. Intergraph integration partners AspenTech and Honeywell created adapters that integrate their applications into the SmartPlant Enterprise.

The following features are included automatically in applications that integrate using the Smart Integration Framework:

- **Security and Audit** – The Framework provides a full history of all data changes, with the ability to turn the clock back in time to see what the project looked like at any point. Configurable to only allow only users with appropriate privileges to publish, retrieve, view, and manipulate data.
- **Document Management** – The Framework provides integrated document management with SmartPlant Foundation's document management capabilities.
- **Drawings and Data Relationships** – Figure 6 shows the relationships between equipment in SmartPlant Foundation and its drawing and individual graphic elements within the drawing. In the example below, if the equipment item also appeared in the equipment location drawing from SmartMarine 3D, Smart Integration Framework would have automatically created a relationship from the equipment item to that drawing. End users can use that relationship to navigate from the tag in the context of the schematic drawing to the location drawing.

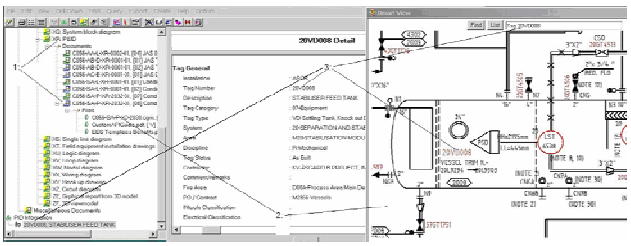

Figure 6: *Relationships between Data and Documents in SmartPlant Foundation*

- **Intelligent Comparisons of Document Revisions at the Data Level.** Figure 7 shows the comparison of two revisions of the same schematic, indicating items that were added, modified, and deleted – down to individual attributes on specific items.

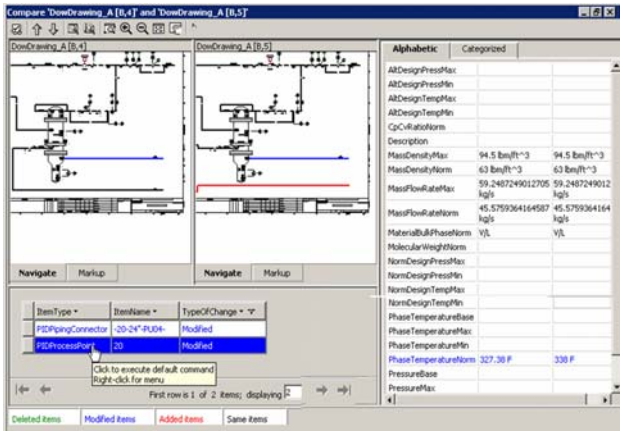

Figure 7: *Comparing Data and Visual Representation of Two Document Revisions*

8. Additional Value: Workflow and Applets

Up until this point, this paper has focused on the three common data and document repository characteristics that must exist for effective management:

- Standard out-of-the-box integrations
- Open and extensible components
- Easy and effective change management

This section will focus on the two tools that enhance these characteristics – a workflow engine and the enabling of new applications.

Intergraph's SmartMarine Enterprise application, SmartPlant Foundation, includes a workflow engine. The workflow engine allows users to model work processes, which can enhance the ability to effectively manage change. SmartPlant Foundation's open architecture allows users to easily integrate work processes modeled in SmartPlant Foundation with workflows in ERP. Figure 8 below shows a graphical view of a typical workflow, along with a checklist that can be associated with each step. This same interface enables users and managers to see the status of tasks, helping them determine where the bottlenecks are and what is behind schedule.

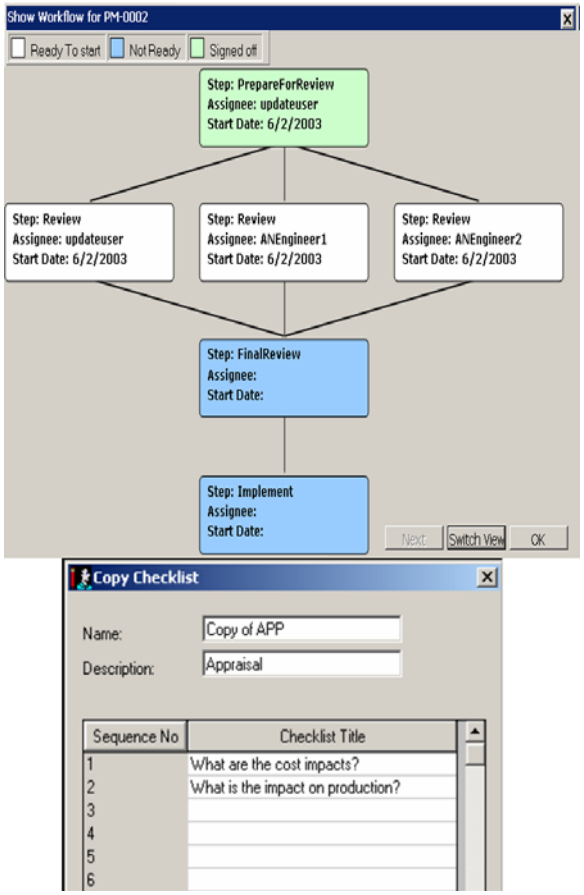

Figure 8: *Workflow configuration in SmartPlant Foundation*

The workflow engine can be configured to notify users of tasks to be completed within SmartPlant Foundation, with an option to receive notifications via e-mail. It also includes the ability to attach drawings, documents, or other data objects to the workflow. Workflows are fully auditable as per the rest of objects, documents, and data in SmartPlant Foundation.

An additional value is to have the ability to plug-and-play elements of the SmartMarine Enterprise solution into a larger enterprise application to further enhance user experience in terms of managing change and seeing the bigger picture. In support of this value, the Intergraph SmartMarine Enterprise is fully equipped with components that can plug into SAP's NetWeaver Portal.

In July 2007, the SAP Integration and Certification Center certified that SmartPlant Foundation integrates with the SAP NetWeaver Exchange Infrastructure (SAP NetWeaver XI) component of the SAP NetWeaver platform to exchange critical data with instances of the SAP Business Suite family of solutions. It is integrated successfully with business functions exposed through the SAP NetWeaver Portal.

Figure 9 below shows an example of a NetWeaver portal using SmartPlant Foundation's 3D model to navigate from individual elements in the 3D model to data in SAP data and a reliability system.

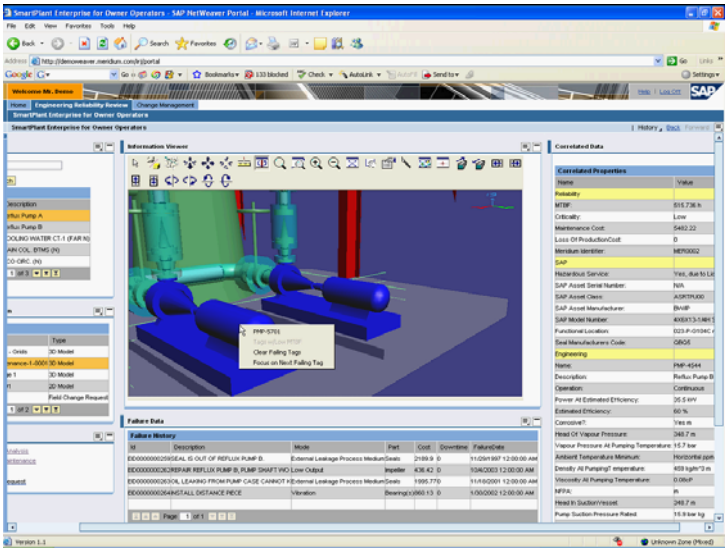

Figure 9: *Intergraph Marine Enterprise Elements Playing in SAP NetWeaver Portal*

9. Conclusions

- ERP implementation provides an opportunity for shipyards to transform their businesses.
- A major aspect of ERP implementation and business transformation is providing effective data exchange and integration between design, production, and ERP.
- Implementing a common data and document repository is an effective way to ensure data exchange is complete, consistent, and correct.
- The Common Data and Document Repository must contain the following characteristics to be effective in maintaining complete, consistent, and correct data:
    - Integration with leading out-of-the-box ERP and design and production tools to reduce implementation costs and increase productivity
    - Open and extensible components to enable exchange of data and documents with other vendor's design and production tools and in-house systems
    - Easy-to-understand change information, specifically what change occurred, what specifically changed, and who changed it and when
- The following characteristics of common data and document are not mandatory, but provide additional value:
    - A workflow engine and/or integration points for work process integration from ERP
    - Creation of new applications (or applets) that utilize the high-quality, high-integrity integration previously integrated
- Intergraph's SmartMarine Enterprise contains all the elements required to support integration between ERP, design, and production at client sites around the world.

10. References

1. Guidelines for Specifying Integrated Computer-Aided Engineering Applications for Electric Power Plants EPRI (Electric Power Research Institute) report NP-5159M, Research Project 2514-3, May 1987

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