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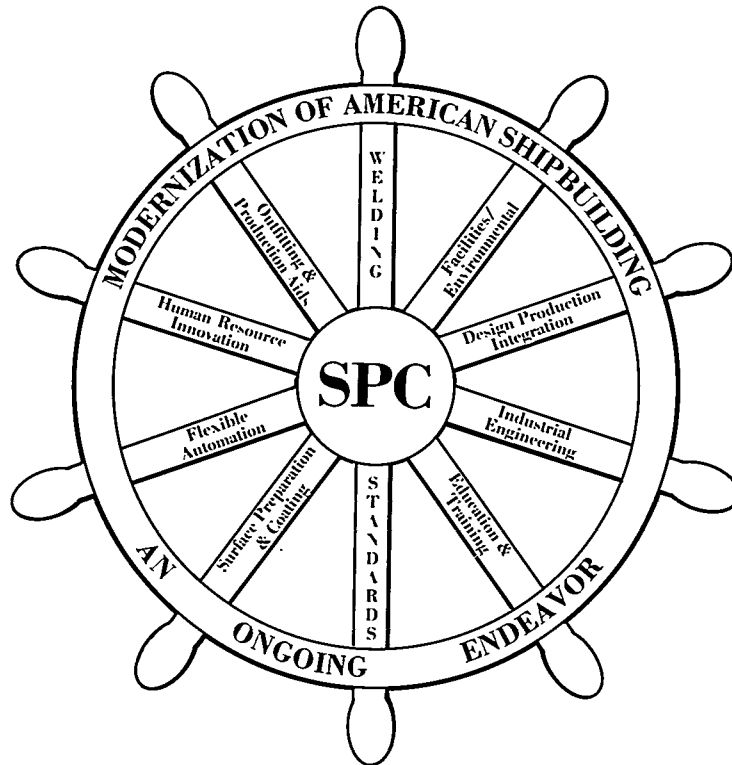
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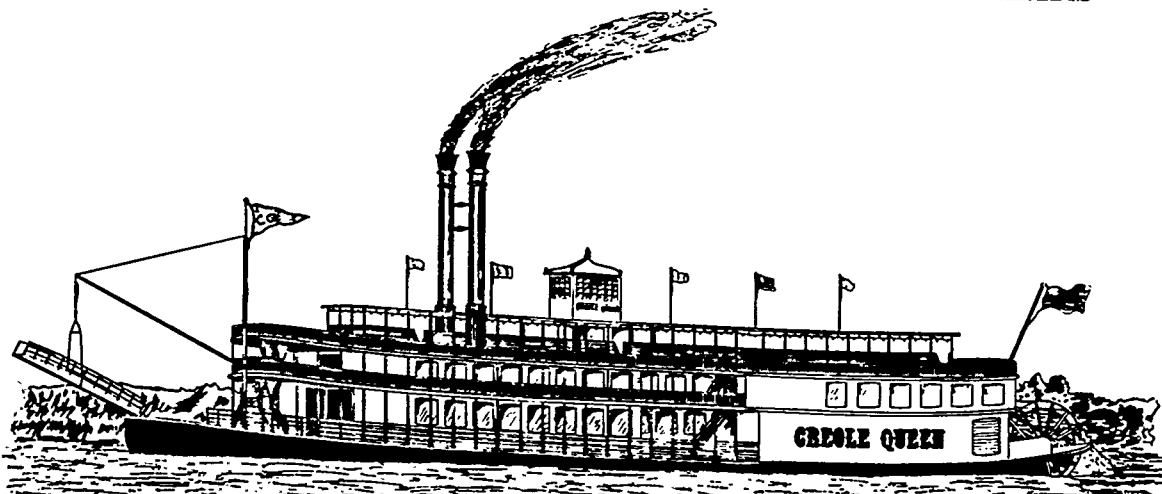
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Applications of Digital Transfer of Computer Aided Design Data for Production Usage

No. 26

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ABSTRACT

This paper addresses efforts to provide the capability to transfer data between Computer Aided Design (CAD) systems currently in use on the CG 47 contract. The paper will discuss experience with the use of Initial Graphic Exchange Specification (IGES) and direct translators. The pros and cons of both approaches will be addressed. The issue of transferring data between the two different hull design and lofting systems in use in shipbuilding is explored.

INTRODUCTION

The use of Computer Aided Design (CAD) is having a major impact on shipbuilding. NAVSEA, shipyards and design agents use a variety of CAD systems to develop design data. In this multiple vendor environment, transfer of data between agencies and even within the same agency having different types of CAD systems makes transfer of data difficult at best. This is due to the fact that the CAD vendors store data in unique and proprietary formats. The ability or the lack of ability to transfer data between the different parties has been called by some the greatest problem facing the United States shipbuilding industry today. Ingalls Shipbuilding, under a CG 49/50 technical improvement contract, is entering 1400-plus CG 47 detail design drawings on its CAD systems. This will result in productivity improvements for the program, because of the reduction in time required to incorporate changes and the elimination of change paper. In addition, the quality of the drawing being delivered to the Navy and the follow yard will be vastly improved.

The next logical step is to provide this data in digital form to both the Navy and the follow yard(s). This led to a special engineering

study contract under Class Services that addresses the ability to transfer data between the CAD systems in use at Ingalls Shipbuilding and the builders of follow ships.

The use of structural design and numerical control lofting systems offers unique challenges for effective data transfer between lead and follow shipyards. In the case of the CG program, Ingalls Shipbuilding uses Ship Production and Design Engineering System (SPADES) and Bath Iron Works (BIW) uses AUTOKON. To facilitate a totally effective transfer of data, the interface between the structural systems must be addressed. This would include transfer of data between SPADES and AUTOKON and from both to turnkey CAD systems.

INGALLS CG 47 CLASS SERVICE EFFORTS

Ingalls, under the CG special study contract, is pursuing the use of IGES to the maximum extent possible, plus having direct translators developed to transfer data between dissimilar CAD systems. Other CAD-related efforts being performed by Ingalls to assist in transferring and accessing CAD data are:

- 1) Developing a SPADES to Calma translator. This shall provide the gateway from Ingalls structural system to the turnkey CAD systems.
- 2) Evaluating the use of low-cost stations to view and modify CAD created drawings.
- 3) Conducting a study and developing detailed specifications on transferring data between SPADES and AUTOKON.

Figure 1 depicts the overall approach and integration of CAD systems in use on the CG 47 Class

The diagram illustrates the IGES Neutral Format system architecture. At the top is a box labeled **AUTO-TROL**. Below it is a central cylinder labeled **IGES NEUTRAL FORMAT**. To the left of the center is a box labeled **CALMA**, and to the right is a box labeled **COMPUTERVISION**. Below these are two boxes: **SPADES STRUCTURE & NC** on the left and **AUTOKON STRUCTURE & NC** on the right. At the bottom center is a cylinder labeled **STRUCTURE NEUTRAL FILE**. Arrows indicate data flow: **AUTO-TROL** connects to **IGES NEUTRAL FORMAT** via **IGES IN** and **IGES OUT** arrows. **CALMA** and **COMPUTERVISION** connect to **IGES NEUTRAL FORMAT** via **IGES IN** and **IGES OUT** arrows. **CALMA** and **COMPUTERVISION** are connected by a **DIRECT TRANSLATOR**. **SPADES STRUCTURE & NC** and **AUTOKON STRUCTURE & NC** connect to **STRUCTURE NEUTRAL FILE** via **IN** and **OUT** arrows. **SPADES STRUCTURE & NC** has a **1 WAY** arrow pointing to **CALMA**. **AUTOKON STRUCTURE & NC** has a **1 WAY** arrow pointing to **COMPUTERVISION**. Annotations include: "In use at Ingalls, Gibbs & Cox, and J.J. McMullen." near **AUTO-TROL**; "Bi-Directional Direct Translators being developed by Octal, Inc. Funded as a task under CG 47 Class Services." near the **DIRECT TRANSLATOR**; "Computervision (CV)-In use extensively at Bath and E.B. Limited at CDI Mar & Cox, and Bethlehem Steel." near **COMPUTERVISION**; "Autokon- The Functional equivalent supported from Oslo, Norway. In use at Newport News, Bethlehem Steel, and..." near **AUTOKON**; and "Specifications for this file are presently being developed by cooperative effort between Call & Associates, Autokon, and Ingalls as Class Services funded task. Both vendors have agreed to productize and support this effort in the future if software is eventually developed." near **STRUCTURE NEUTRAL FILE**. A vertical dashed line separates the **LEAD YARD ENVIRONMENT** (left) from the **FOLLOW YARD ENVIRONMENT** (right).

APPROACH: ADDRESSES 3 CAD VENDORS ASSOCIATED WITH CG 47 PROGRAM.
ADDRESSES STRUCTURAL DATA ISSUE.

Service contract. Ingalls is utilizing Calma and Auto-trol for loading the 1400 Class Service drawings. SPADES is utilized for hull design and lofting on major changes. Computervision and AUTOKON are being utilized at Bath. Ingalls is working with the three turnkey CAD vendors (Calma, Auto-trol, and Computervision) on development of usable IGES translators.

In addition, Ingalls has OCTAL, Incorporated developing three bi-directional translators for the turnkey systems. Advantages regarding the two different approaches are addressed later in this paper. Ingalls has developed the SPADES to Calma interface. Bath and Computervision have developed the AUTOKON to Computervision translator. Detail specifications for the SPADES AUTOKON translator have been developed, and if the two vendors are funded, a full function, closed-loop approach to data transfer will be in place for the CG 47 program.

DATA TRANSFER BETWEEN CAD SYSTEMS

This section addresses the subject of two-dimensional (2D) graphics and text data transfer between CAD systems and is restricted to interchanges between Calma, Computervision, and Auto-trol systems. The vendors of these systems are actively participating in the project by reviewing reports regarding difficulties experienced with their software applications of IGES, and by coordinating and forwarding potential solutions to resolve the problems. Figure 2, entitled "IGES Problem Status Report," gives a representative sampling of the types of difficulties encountered in testing and some of the resolutions provided by vendors. It additionally points out that some of the problems are not presently addressable and will not be resolved in the near term.

IGES testing has also shown that even in cases where data is correctly transferred, certain conditions are encountered that may have an adverse impact on users. While the use of standard formats has many benefits, it cannot account for the differences in the ways software may be designed. For this reason, efficiencies in the relationship between software and hardware may suffer in some cases. As an example of this, certain test cases have resulted in the count of instances of element types being increased three to four times as a result of conversions. In other

tests, storage requirements have been increased dramatically, thus altering system performance for access times as well as consideration for hardware configuration.

From the outset, the principal emphasis in this project has been placed on the transfer of data through the neutral IGES format. However, in instances where this technique was unable to accomplish complete data transfer, direct translators will be used. Regardless of which procedure will be ultimately employed, it is recognized that significant testing will be required, and that the quality and completeness of the test data will directly affect the quality of the translation.

Early in the project, test cases were created or secured to represent typical cases for the following systems and modes:

- . Calma (Calma native format and IGES)
- . Auto-trol (Auto-trol native format and IGES)
- . Computervision (CV) (CV native format and IGES)

Note: CV test cases were acquired from BIW, NAVSEA, and CDI Marine

The above cases have been further supplemented by IGES data obtained from the National Bureau of Standards. Data originating from an Optigraphic scanner processor used for loading drawings has been successfully tested through IGES transfers to both Calma and Auto-trol. As new releases of IGES are received, problem test cases are being reapplied to ensure that reported solutions actually work. In addition, transfers have been accomplished from Optigraphics to Calma and Auto-trol via direct translators.

In spite of considerable progress with IGES, problems with its implementation still exist to a degree that makes its usefulness questionable in a production environment today.

In order to achieve a rapid and accurate transfer of data between systems by whatever means necessary, ISD has placed an order with Octal, Inc., of Mountain View, CA, to supply direct translators intended to overcome current shortcomings in present IGES implementations. These translators

FIGURE 2 - IGES PROBLEM STATUS REPORT

I/R NUMBER	DATE RPTD	PROBLEM DESCRIPTION AND RESOLUTION
17424	013087	DAL PROGRAM WHICH DOES A NMD AND THEN GIVES A NIL FOR THE IGES FILENAME 0202 SUPPORTING DOCUMENTATION SENT 0219 SOFTWARE PR.RPT #002937 ASSIGNED 0223 VERIFIED FIXED BY INGALLS
17432	020287	IGESOUT ON MODEL VLD110211-GOO2 GENS ERR 0202 SUPPORTING DOCUMENTATION SENT 0219 SOFTWARE PR..RPT #002935 ASSIGNED 0223 VERIFIED FIXIED BY INGALLS
17433	021087	IGESIN CAUSES DATA NOT TO BE DISPLAYED. RDI OR VIEWFIL 0210 SUPPORTING DOCUMENTATION SENT 0219 SOFTWARE PR #002936 ASSIGNED 0223 VERIFIED FIXED BY INGALLS
17609	022587	IC2'S NOT CORRECT AFTER IGES TRANSLATE 0226 SUPPORTING DOCUMENTATION SENT 0318 SOFTWARE PR #003086 ASSIGNED 0318 TESTED BY VENDOR 0506 VERIFIED FIXED BY INGALLS
17610	0225	IGESOUT DOES NOT OUTPUT FRACTIONAL DIM 0226 SUPPORTING DOCUMENTATION SENT 0318 SOFTWARE PR #003087 ASSIGNED 0506 VERIFIED FIXED BY INGALLS

NOTE: The above is a sample of ISD'S Problem Tracking System -
Report #U98830R3

will be implemented for use between combinations of systems as follows:

- . Auto-trol to Computervision
- . Auto-trol to Calma
- . Computervision to Calma
- . ComputerVision to Auto-trol
- . Calma to Computervision
- . Calma to Auto-trol

A trip was made to the Octal offices to review progress. Satisfactory results are being achieved by the vendor. In fact, the initial offerings for the Auto-trol to Computervision case has progressed to the point that a transfer of live data between Ingalls and BIW is in the process of being tested.

STRUCTURAL DEFINITION SYSTEMS

This task defined the requirement to develop the specifications for a software interface between the two major structural definition systems in use in the shipbuilding industry: Autokon, a widely used system throughout the world, supported by its authors in Oslo, Norway; and Ship Production and Design Engineering System (SPADES), marketed and supported by Cali and Associates in Metairie, Louisiana. One of these two systems is licensed for use by every major shipbuilder in the United States.

Following Navy approval, representatives from AUTOKON and Cali & Associates began a series of working sessions to define all geometry and data residing in both of the current data bases. Also, known shortcomings, as well as data expansions, were considered in the design of the transfer. A philosophy of using a neutral file was implemented with both parties agreeing to productize their respective pre- and post-processors should the specified software be eventually developed.

The contracted specification has been developed and has been reviewed by ISD. It has also been forwarded to the Navy-Industry Digital Data Exchange Steering Committee working group. While some of the people involved in this activity have stated a preference for the use of IGES rather than the neutral file specified, the consensus is that the document is presently the most complete picture of structure data element definitions for shipbuilding

available today, and it will be adopted as the basis for future structural work by the Navy-Industry group. There is also an admission that while the IGES preference does exist, it is not presently known that IGES will successfully handle all of the data types required. Most of the shipbuilders surveyed readily agree that development of the software is a worthwhile endeavor and will benefit many U. S. shipbuilders regardless of the neutral file used.

LOW ORDER CAD DEVELOPMENT PROJECT

In recognition of the fact that the uses of CAD extend past those of initial design data creation, ISD has taken steps to investigate the uses and vendors of systems we refer to as Low Order CAD. Low Order CAD is a term intended to connote a less capable design software tool available on a less expensive hardware platform that may address requirements of a less complex nature. In other words, you pay less, you get less, but you need less! Ingalls has formed a team of experienced CAD personnel to fully evaluate the cost-effectiveness of applying Low Order CAD to disciplines that support lead-to-follow yard functions with such products as sketch generation, proposed change configurations, evaluations of graphic alternatives, and preparation of technical illustrations and manuals. Written requirements have been developed and furnished to prospective vendors, describing functionality mandatory in their offerings. Among these requirements is the ability to communicate with the system on which the data is originally defined.

Ingalls has already evaluated numerous software packages on several hardware platforms and is convinced of the potential to apply this type of technology to reduce costs.

SPADES TO CALMA TRANSLATOR

The SPADES to Calma translator has been developed to address the common shortcoming of all present CAD vendors: the ability to efficiently define the common shipbuilding structural characteristics into a database to be used as the basis for distributed systems design. Ingalls has developed this software for the two systems in question and has demonstrated the value of defining data only once and being able to use it for multiple purposes, i.e., design and the creation of numerically controlled instructions for manufacturing.

The Ingalls process involves the extraction of data from the IBM mainframe that processes the SPADES software and formats it for use in the Apollo ring network that services the Calma workstations. Figure 3, SPADES to Calma Process Flow, depicts the functions involved in the transfer process and defines the environments in which they take place. The entire process may be performed by an operator at an Apollo workstation. The basic activity is the extraction of data from the IBM-housed data base, which is processed through a protocol converter to take care of dissimilarities in communications features. The data is then moved via telephone line to a program running on an Apollo, which converts SPADES surface data and associates material data and other intelligence with appropriate structural members. The data is then organized and stored in an Apollo directory. It can then be accessed for construction of a structural product model format for use in system design. Figures 4 and 5 are examples of data cases which have been successfully transferred by the processes shown in Figure 3.

THREE DIMENSIONAL TRANSFER SPECIFICATIONS

The efforts documented in the SPADES to Calma translator and in the specifications for the hi-directional translator between SPADES and AUTOKON give detailed requirements at a data element level for a three-dimensional transfer for shipbuilding hull structure. This structural data comprises the vast majority of data available in digital form in the majority of today's ship design and shipbuilding programs. While much work is being done by other industries with similar problems to those of shipbuilding for disciplines such as piping, electrical, and ventilation design, Ingalls intends to actively pursue the transfer issues for design data, so that when such data does exist on a significant scale, means may exist to beneficially exchange it as needed.

CONCLUSIONS

It is technically feasible with current technology to transfer data between dissimilar CAD systems. Currently the most effective approach is through the use of direct translators. This should not detract from efforts to force the CAD vendors into developing cost effective, reliable IGES and in the future Product Definition Exchange Specifications (PDES) translators.

IGES and PDES should be pursued to the maximum, and the Ingalls and PMS400 efforts have greatly assisted in this task. Low cost workstations have a place in a network of high performance CAD workstations and can perform low level drafting functions and serve as "view only" terminals.

It is technically feasible to develop an interface between two structural design and lofting systems (SPADES and AUTOKON). This development effort should commence as soon as funding can be obtained.

ACKNOWLEDGMENTS

R. V. Shields III
W. A. Solitario

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R. V. Shields III, B. T. Jeavons, "Computer-Aided Design Digital Data Transfer System", Class Services Task 86-059, Fourth Quarterly Status Report and Annual Summary, June, 1987.

FIG. 3: SPADES – CALMA PROCESS FLOW

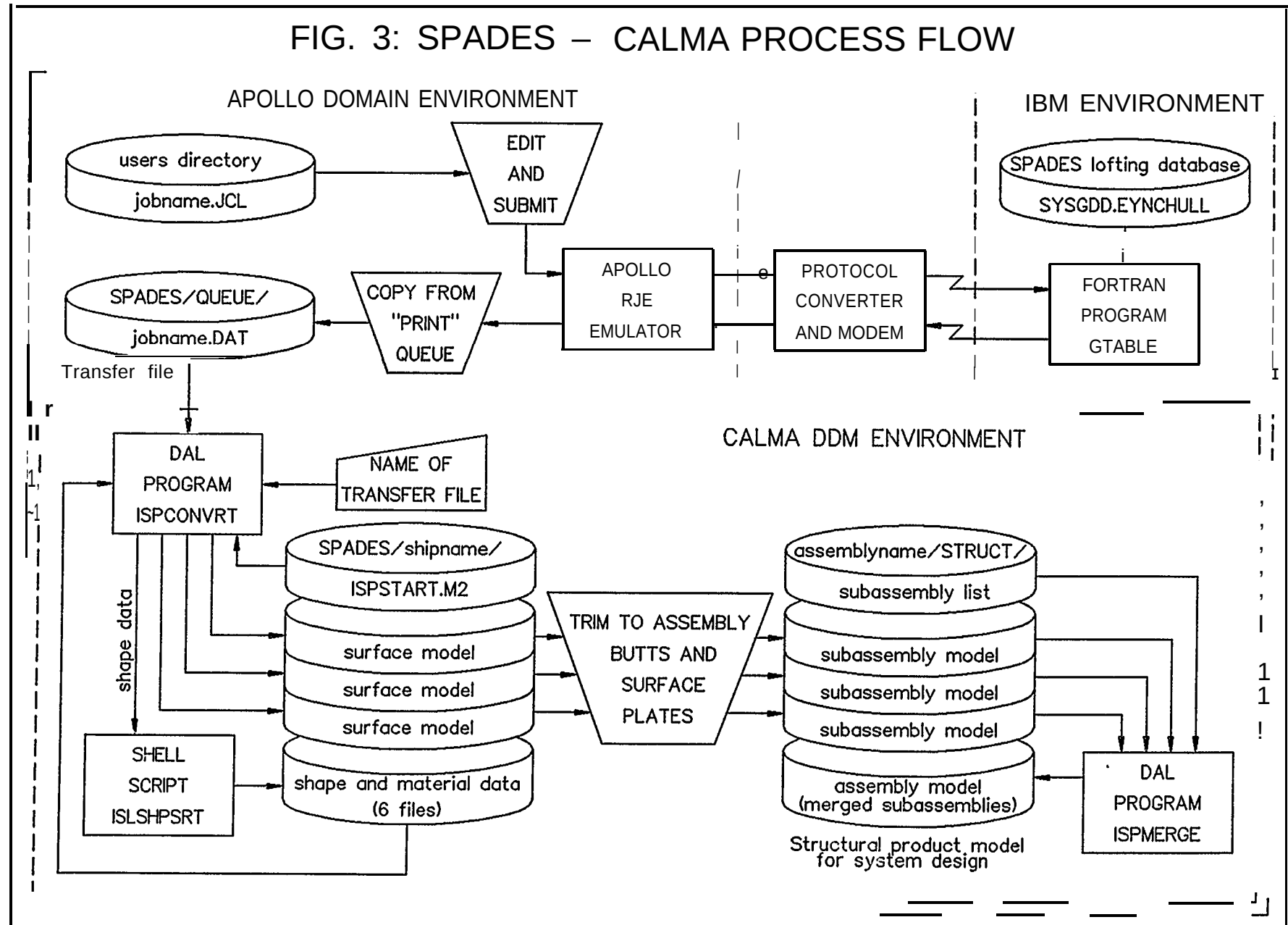
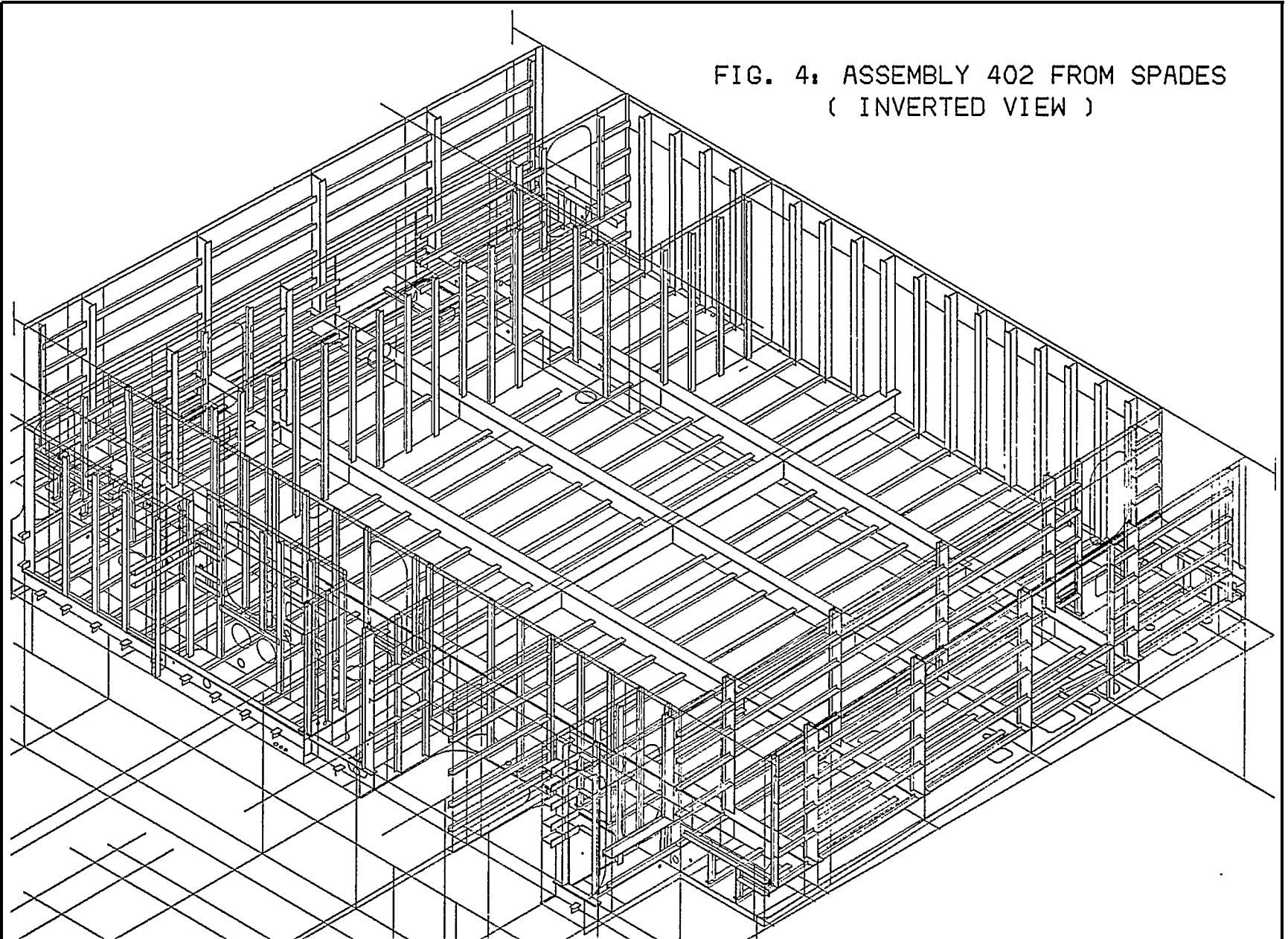


FIG. 4: ASSEMBLY 402 FROM SPADES
(INVERTED VIEW)



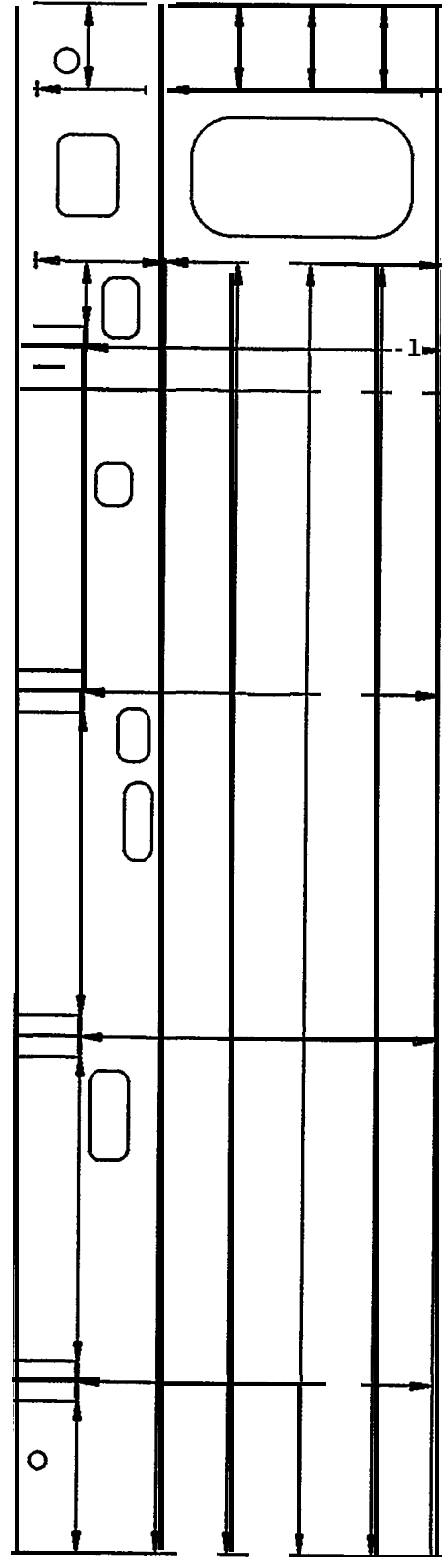


FIG. 5. SPADES LBHD B2 P PROCESSED BY
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