# COMPUTER AIDED DESIGN

# A TOOL FOR PRODUCTION

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## ABSTRACT

This paper demonstrates the role that a modern computer can play in achieving a cost effective, quality product, by providing a Tool to enhance the skills of the designer and engineer.

An evaluation of the system configuration and startup activities as well as performance goals will be examined for the interactive graphics area.

## I. INTRODUCTION

For more than twenty-five years, architects and engineers within the Marine Design Community have used computer-based systems to collect and analyze data related to ship design. Chief among these uses are finite element modeling using NASTRAN and ANSYS programs, piping flow and piping flexibility analysis, computer-directed plate preparation, structural shape forming, pipe bending, and manufacturing planning control. J. J. Henry Co. has utilized the computer-based SPADES (Ship Production and Design Engineering System) developed by CALI Associates, for some of these purposes over the past several years.

The objectives of this paper are to describe briefly our use of computers in engineering analysis, to introduce you to our approach to the automation of our design and drafting functions, and share our plans for their integration through the establishment of a single, centralized database.

## II. THE CAD/CAM INDUSTRY

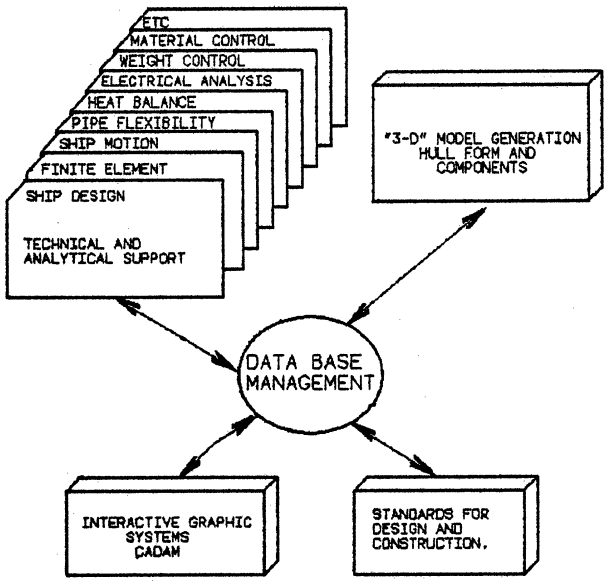
CAD/CAM (Computer Aided Design/Computer Aided Manufacturing) is a technology which has experienced rapid acceptance by industries throughout the world in recent years. In its fullest sense, the term refers to the integration of the design and manufacturing proceses through the creation of a single computer database.

The Marine Engineering community is well versed in the creation of databases for analytical engineering and manufacturing processes. Databases of this kind are typically created to solve a particular problem and require the repeated input of the design geometry each time another new analysis is performed. New sets of model geometry may be completely recreated for the separate functions of FEM/FEA study, for toolpath programming, and other functions.

CAD/CAM replaces this fractionalized approach through the establishment of an interactive database, which fully describes the geometry of a particular model. Initially, the model database is constructed by designers on a CAD/CAM system. Subsequently, the design database is used by engineers for their analytical studies, and by drafters to create detail drawings. Each group not only uses the model database as raw input, but adds to it, making it a more complex and thorough description of the model. (Fig.1)

Once complete, the database geometry is used by manufacturing for tool design, toolpath routing, NC machine control, bill of material extraction, and many other functions.

The end result of these processes is the representation of a ship as a single database, with subsets representing, for example, electrical, structural, and architectural portions. Each part to be manufactured, whether a beam or a bolt, has its geometry description and its manufacturing instructions as part of the database.



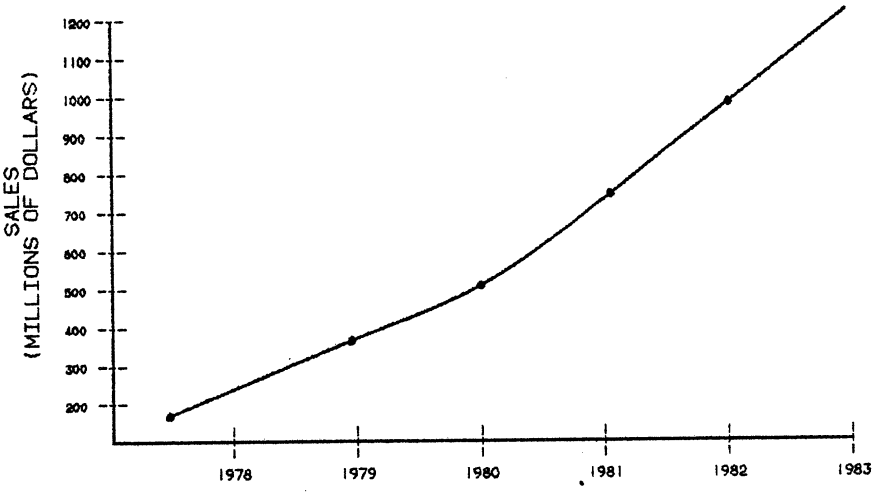

**COMMON DATA BASE**

FIG. 1

The alluring promise of the CAD/CAM concept has propelled the industry along at a rapid rate since 1978.(Fig. 2) The real payoff in CAD/CAM, however, is linked to its appropriateness as a solution to the problems of decreasing worker productivity and increasing labor costs.

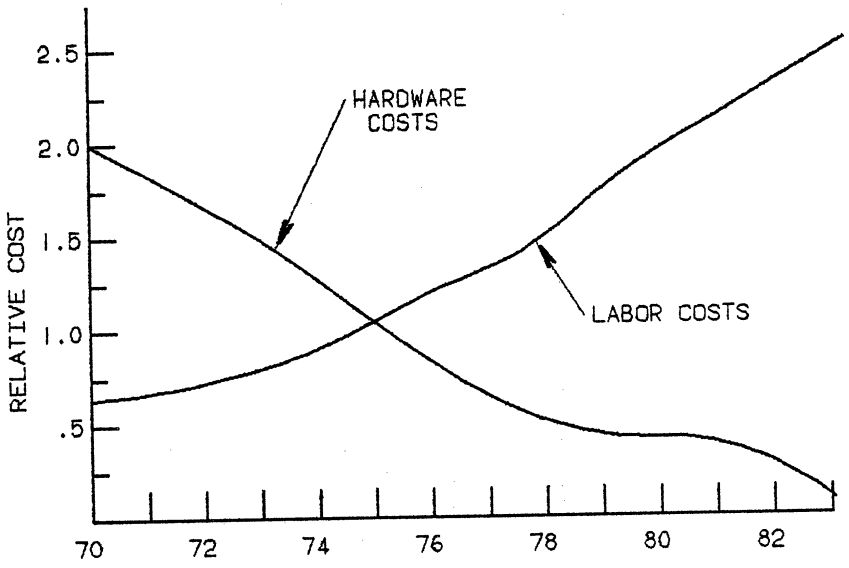
Drafters and designers work many times faster because CAD/CAM systems automate many processes which are tedious and time consuming. Redrawing due to intital error, engineering change order, or other reasons is greatly reduced. Furthermore, the database is always up to date, reflecting the latest changes.

Recent declines in the costs of CAD/CAM hardware have accentuated the cost-effectiveness of this approach. Hardware is cheaper, software more capable, and productivity higher than ever before.(Fig. 3) J. J. Henry has made a significant commitment to CAD/CAM as part of our strategy to maintain a leading role in the marine design industry.




CAD CAM INDUSTRY GROWTH

FIG. 2




CAD CAM COST EFFECTIVENESS

FIG. 3

III. CAD/CAM at J. J. HENRY

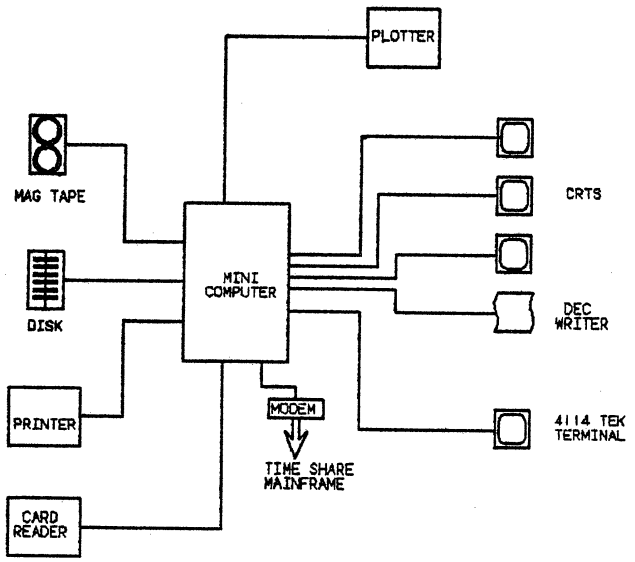
J. J. Henry has adopted a three-way approach to support our CAD/CAM requirements.

- Mainframe-based engineering software, linked to us through one of our inhouse mini-computer systems, runs complex engineering analysis programs and analyzes CAD models.

- SPADES, ship design and production software, is available via timeshare with the CALI and Associates computer in Metairie, Louisiana.

- Resident Perkin-Elmer CAD/CAM systems are used for interactive drafting, detailing, and design.

Each resource is carefully structured to ensure a match between computer system capability and task requirements.




ENGINEERING COMPUTER SYSTEM

FIG. 4

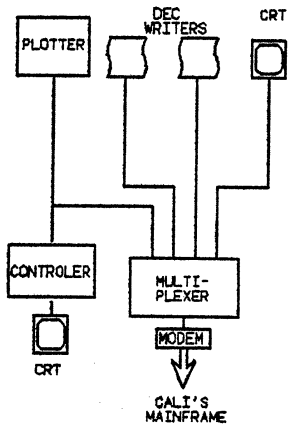
## ENGINEERING COMPUTER SYSTEM

The Engineering Computer System, under the direction of our engineering analysis group, utilizes both general purpose and customized software tools in the design of Naval and commercial hulls, and other Marine structures. Our capability includes a full range of naval architecture programs, finite element analysis, propulsion, shafting, ship motion studies, speed/power estimates, propeller design, shock analysis, and others. Standard software modules for pipe stress and flow, electrical design, hanger placement, load analysis, sizing, and structional analysis of CAD models are also available.

Programs are run on large time sharing systems (CDC, UCC, and GE) linked through an inhouse mini-computer. The system includes magtape drive, floppy disk, 300 MB disk drive, high speed printer, card reader, plotter, 3 CRTs, DEC writer, and a Textronix 4114 intelligent graphics work station.(Fig. 4)

## SPADES FACILITIES

SPADES is an acronym for Ship Production And Design Engineering System and consists of a number of software modules developed specifically for ship building. SPADES chief use is in the production of a database used to support NC lofting and steel cutting and shaping. Modules provide J. J. Henry with the capability to generate the hull form shape, define all major ship structure, calculate naval architecture variables, and support detail drafting and design.




**SPADES FACILITIES**

FIG. 5

J. J. Henry uses SPADES in a time share mode on CALI and Associates computer in Metairie, Louisiana. Our in-house facility, through which we access the CALI machine, includes a 9600 Baud Modem and eight line multiplexer for communications; two DEC writers and two CRTs for data entry and output; and a Calcomp 960 pen plotter (34"x60") with 909 and 907 controllers for drawing output.(Fig. 5)

## INTERACTING GRAPHICS SYSTEM

The interactive CAD/CAM system consists of two (2) Perkin-Elmer 3210 minicomputer, each supporting six graphics work stations. Each work station is made up of a video display, alphanumeric keyboard, function keyboard, light pen, table and chair. Output from the system is directed to either of two (2) 36 inch-wide Versatec electrostatic plotter for hard copy, or to magtape for archiving, conversion to microfilm, or NC tape generation.

J. J. Henry decided to utilize a "distributed", rather than mainframe-based CAD system approach in order to establish flexibility in serving multiple clients. A "distributed" system is one featuring a mini-computer resident in our design area and linked to mainframe or other local computers via communi-cations lines. Each inhouse mini-computer is capable of operating as a stand alone CAD/CAM system, which can be linked via phone line to a client's mainframe if desired. The capability will also exist to link minis together where the capacity to do a large job is required.(Fig. 6)

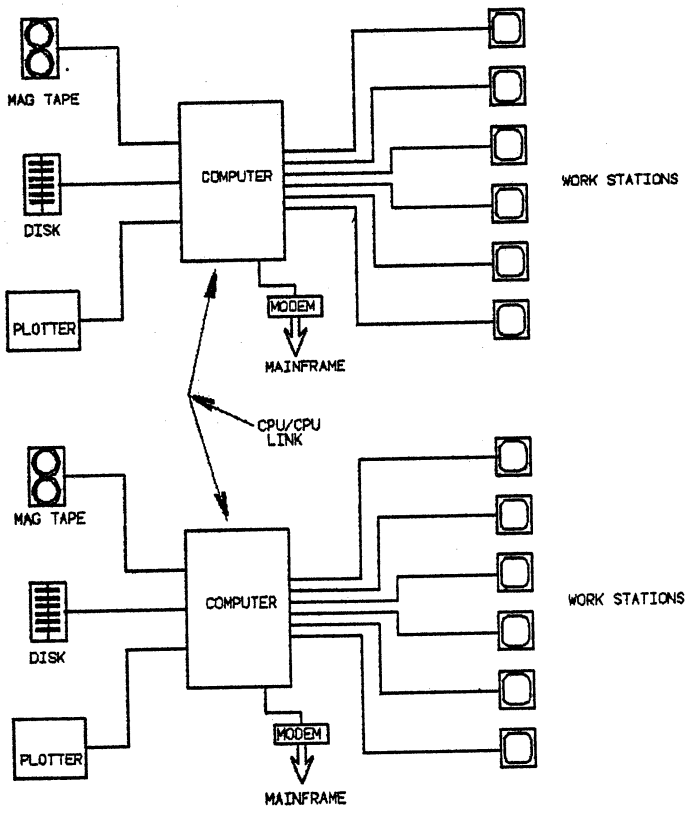
Our choice of Perkin-Elmer CAD/CAM system and CADAM applications software was based upon our evaluation of four criteria.

- First, our wish to improve the productivity of the highly skilled ship designers and engineers who work for us. Our goal was to shorten the time between concept and the creation of working drawings.

- Second, we wanted a system which was easy to use, and easy to learn. By bringing our users up to speed in a short period of time, we were able to begin paying back startup costs quickly.

- Third, CADAM software is a proven productive system for drafting, detailing, and design.

- Fourth, the system supplier's ability to support J. J. Henry's current and anticipated usage.




**DISTRIBUTED CADAM SYSTEM**

FIG. 6

## CADAM SOFTWARE FUNCTIONALITY

CADAM is an acronym for Computer Augmented Design and Manufacturing system. Developed by the Lockheed Corporation, it represents over 15 years of development.

The CAD portion of the system is a high performance, multi-function design/drafting package which includes a number of design analysis aids.

As drafting time represents a major part of the total cost of delivering a detailed working drawing, overall cost can be reduced by simplifying drafting practices. As a result, we believe that working drawings can be best developed using techniques void of complex operations.

Using techniques similar to conventional drafting, operators place geometry on the screen using light pens. Geometry can be rotated, moved or copied anywhere on the screen. A powerful mirroring capability permits the operator to construct only one portion of a symetrical drawing, then reflect that portion across one or two axis to complete the part.

When changes are necessary, they can be made on the screen prior to generating a plot of the drawing. Geometry can be erased by selecting it with the light pen, line types may be changed without redrawing the line.

Hand lettering of drawing is no longer necessary. The operator, using the alpha-numeric keyboard, types the note and places it on screen at the desired location.

Dimensioning is done automatically with the operator selecting the geometry to be dimensioned. CADAM calculates the distance and displays the dimension with dimension lines and arrows.

Once the design is completed, the drawing is filed as part of the data-base. Since the database contains all of the geometry, drawings and other information related to the project; engineers, designers, and draftsmen have access to current design information.

## IV. SYSTEM IMPLEMENTATION

Installing a graphics system of the kind we have described required us to do some careful planning. We wanted the introduction of this system to go smoothly and we wanted to achieve a high level of productivity as quickly as possible. More specifically, we took the following approach:

- We planned for some skepticism and resistance to change on the part of drafting and design personnel.

- We planned operator selection and training carefully.

- We implemented a specific drawing file naming convention and a standard parts library.

OPERATOR SELECTION

The introduction of a CAD/CAM system into a non-automated drafting and design environment constitutes a "cultural" change. As such, we expected the system to be perceived in a variety of ways. Some drafters and designers embraced it enthusiastically as the wave of the future. Others were less enthusiastic, voicing concerns over job security and their ability to learn how to use it.

Our approach, therefore, was tailored to leave options open for drafters and designers, and was intended to result in the most enthusiastic and capable people becoming our system operators. Those who chose not to learn the system, and those who tried and chose to return to the drafting board, were welcome to do so without criticism from management.

We discovered some general traits among drafters and designers which we feel point to success on the CAD/CAM system.

First, solid knowledge of descriptive geometry and the job he is presently doing.

Second, a strong desire to learn and an inquisitive nature.

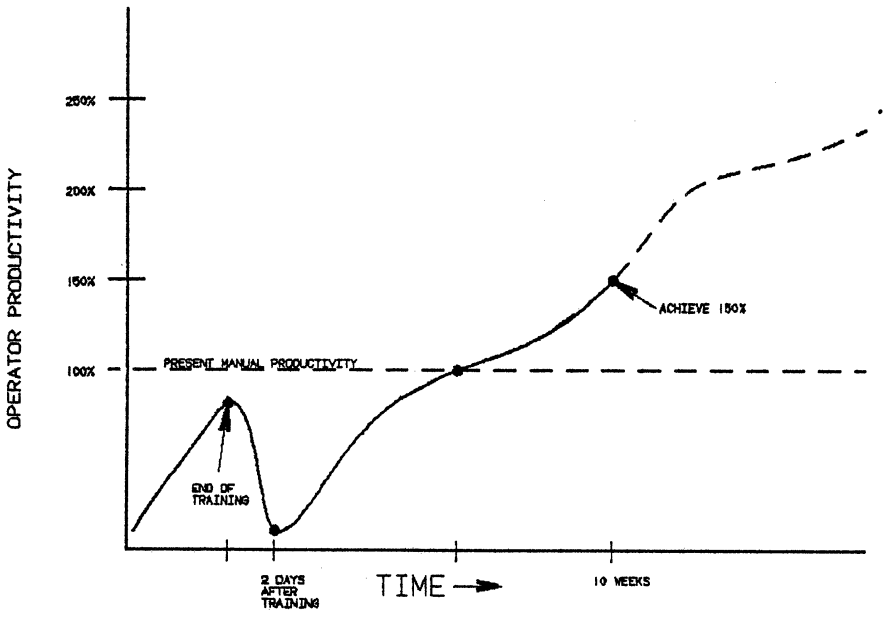
Both the ability to type and computer programming experience have little, if any, role in shaping the successful operator.

When the operators had been selected, it was our turn to make the commitment to their training and temporary reduction in productivity. The importance of this commitment to the satisfactorily long learning period cannot be underestimated, and it may be one of the more difficult commitments you will have to make and maintain. Your investment in time to train your people at this point, pays off dramatically soon after, when significant increases in productivity become the standard.

## TRAINING

J. J. Henry has established its own in-house training program to teach operators the fundamentals of CADAM usage. Although training for operators is available from CADAM, Incorporated in California, we found training at our location to be a far more cost effective approach to take.

Our training consists of the basics in interfacing with the system, constructing geometry, view manipulation, and dimensionsing. Further training will emphasize the inherent analytical capabilities of the system. Trainees typically follow the pattern shown in FIGURE 7. Their proficiency increases during training, then drops off sharply when they are first on their own. They improve rapidly thereafter and are soon exceeding their past "drafting board" productivity. At J. J. Henry we have been able to develop a training program which builds skills and productivity while reducing the likelehood of frustration and disappointment.




OPERATOR TRAINING

FIG. 7

## CAD/CAM SYSTEM FILES

Our previous experience with computer systems enabled us to understand the importance of establishing procedures for structuring and managing the system drawing files.

Drawing files which are resident on a computer data base bear similarities to those housed inside folders within metal cabinets. The process of creating a naming convention for the files requires creating a hierarchichal structure within which all drawings and designs can be slotted. The drawing is then named fully at the outset, when the drawing begins.(Fig. 8)

The development of a structured part filing system is the key to retrieving drawings from the database. The concept of a single, interactive database that we are pursuing requires that numerous individuals have access to data. For this access to be usable thoughout the company, naming conventions must be adhered to by all.

Drawing files can be protected through the use of passwords and designation as "read only". Managers and supervisors, therefore, can control access to certain drawings, as well as protect them against unauthorized modification. Protection capabilities may entail several levels of authorization and access.

In addition, it is important that copies of files are made periodically. Computer data, as you know, exists on magnetic media and is subject to loss under certain environmental conditions, or because of operator error.

At J. J. Henry, the database is backed up on a daily basis. At the end of the work day, a magtape copy of all work-in-progress is made. In this way, we limit our maximum risk to the loss of one day's work.

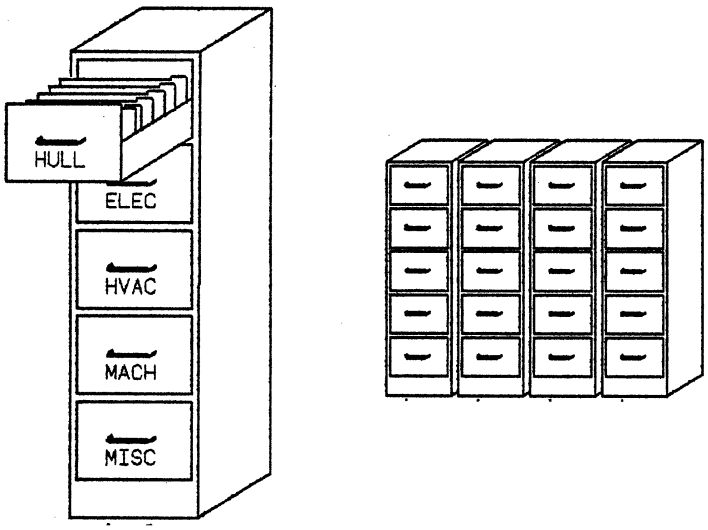



FIG. 8

DATA MANAGEMEMT FILES

## PARTS LIBRARY

One of the chief contributions that CAD/CAM Systems make to our productivity lies in the computer's abilities to store completed designs and then permit the designer nearly instant access to them. We have used these capabilities to establish a library of commonly used parts and design elements such as centerlines with frame marks, arrangements, deck and bulkhead outline, equipment outlines, and so forth.

Once created and filed, a part is available to be called up and placed within a drawing or design under construction as often as required. Similarly, certain new drawing components may require only slight modification of existing library parts. In this instance significant design time is saved because the new element does not have to be completely redrawn.

## V. LOOKING TO THE FUTURE

These systems allow us to interact with the design process in such a way so as to approach optimum configuration through iterative design refinements. Further, we visualize the product before fabrication which allows us to evaluate design/production tradeoffs.

Our goal at J. J. Henry is to maintain our practice of developing a high quality product at a lower overall cost. Our planned growth does not imply an absolute commitment to any one system, but rather, emphasizes the best operating approach to service the work to be accomplished.

We believe the key to maximizing productivity gains throughout the entire shipbuilding cycle lies in the implementation of interactive, cost-effective, 3D modeling techniques which are suited to large complex ship component databases. The utilization of the common database by numerous functions promises improvements in cost-engineering, planning, interference control, and engineering and design. None of these applications, however, precludes the use of skilled people throughout the design process. Interactive graphics does not make good designers out of bad ones, but instead permits good designers to make better designs.

We believe our industry can constitute an attractive market to spur software and hardware development. J. J. Henry expects to participate to the fullest possible extent in stimulating the CAD/CAM industry to expand their efforts at directing solutions to the marine design industry.

We see substantial growth in this complex and rapidly changing environment over the next five years. CAD/CAM is a major part of our strategy to achieve the productivity gains that will enable us to provide a top quality, cost-effective product in the 1980's.