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OAK RIDGE Y-12 PLANT

MARTIN MARIETTA

CIM: It All Starts with Product Definition

A. E. Stephens

Product Engineering Department
Product Engineering and Scheduling Division

Date of Issue: December 29, 1986

Preprint for submission to:
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Prepared by the
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
Martin Marietta Energy Systems, Inc.
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CIM: It All Starts with Product Definition

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ABSTRACT

The logical starting place for computer-integrated manufacturing (CIM) is at the front end of the production process—product definition. It consists of the part/assembly drawings, material lists, specifications, and procedures. Product definition starts at the design agencies: two nuclear design laboratories (Los Alamos National Laboratory and Lawrence Livermore National Laboratory) and a non-nuclear design laboratory (Sandia National Laboratories with two site locations). These laboratories perform the basic part design which is then transferred over a secure communications network to the Oak Ridge Y-12 Plant, where weapon components are produced by Martin Marietta Energy Systems, Inc., under contract with the Department of Energy (DOE). Initial Graphics Exchange Specifications (IGES) and DOE Data Exchange Format (DOEDEF) translation software is used to transfer part designs between dissimilar graphics systems.

Product-definition data flow is examined both external and internal to the Y-12 Plant. Software developed specifically to computerize product definition is covered as follows:

- Electronic File Manager (EFM)
- Manage Design Documents
- Distribute Product Definition
- Manage Manufacturing Procedures and Product Specifications

Trident II is the first program to beneficially use CIM technologies plant-wide. Prototype software was written to add a layer of user friendliness through multilayer menu selects to enable access to a number of existing application software packages.

Additional software was developed and purchased that enables a single personal computer to meet many needs. These product-definition needs include procedures generation, graphics viewing, and office automation.

What Is Y-12?

The Oak Ridge Y-12 Plant is one of three Oak Ridge facilities operated by Martin Marietta Energy Systems, Inc., for the Department of Energy (DOE). Y-12 is one of eleven production plants and design agencies within the DOE Nuclear Weapons Complex (NWC). The primary mission of the Y-12 Plant is to manufacture and deliver high-quality nuclear weapons components on schedule at minimum cost.

The Oak Ridge Y-12 Plant is a large manufacturing complex originally constructed in 1943 by the U.S. Corps of Engineers as part of the Manhattan Project. The present configuration:

- 811 acre tract (2 miles long, 0.7 mile wide)
- 600 acres enclosed by perimeter security fencing
- 391 total buildings (43% built prior to 1945)
- 6.5 million ft^2 of operating area (72% constructed prior to 1945)
- 380 organizational units
- 7300 employees
- 65 separate manufacturing and certification areas

Computer-integrated manufacturing (CIM) is being implemented at Y-12 as demonstrated in Figure 1. The following Y-12 CIM objectives are contributing toward improving plant performance:

- Meet DOE CIM directives.
- Reduce product cost.
- Increase asset utilization.
- Integrate Y-12 operations.
- Improve product quality via quality assurance at point of origin.
- Meet production schedules with minimum contingency costs.
- Minimize in-process inventory and improve inventory control.
- Reduce product lead time.
- Improve production flexibility.

CIM investments today are building the Y-12 factory of the future for the 1990s. CIM capital investments in excess of $140 million should result in a savings of operating funds that will break even in 1992 and then reap significant gains thereafter. Average turnaround time for hemispherically shaped, special production parts should be cut from 40 to 9 days. Asset utilization should increase from 35 to 75% in this time frame.

Over 110,000 parts are produced annually at Y-12, resulting in an interfacility product definition traffic of 1460 documents received and 5400 documents transmitted and intraplant product definition traffic of 8700 documents transmitted.

Product Definition

Product definition consists of the part/assembly drawings, material lists, specifications, and procedures. Product definition starts with the design process, which is performed by the DOE design agencies—Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Sandia National Laboratories (SNL). Under the leadership of DOE's CIM Program Office, the NWC is participating in a total integration approach between the four design agency sites, the seven production agency sites, and the DOE-Albuquerque site.[1] Several project initiatives working toward this end are currently under way.[2]

One such initiative is the wideband communications network (WBCN)[3] that interconnects the various sites. The WBCN provides the NWC with identical gateway computers and communications software that is centrally supported. It uses primarily 56-kilobits-per-second, leased telephone circuits with encryption devices so that classified messages can be handled. WBCN has been operational at most of the NWC sites since March 1986.

Another initiative is the DOE Data Exchange Format (DOEDEF), which is aimed at creating a heterogeneous environment for multivendor computer-aided design (CAD) systems at the various sites so that part drawings can be exchanged with 100% accuracy of design intent. This exchange process uses both the Initial Graphics Exchange Specifications (IGES) software for each CAD system and the custom-generated DOEDEF software. DOEDEF performs a deflavor/reflavor operation that removes the vendor flavoring of IGES, which is allowable within IGES. The exchange of design drawings has been an ongoing activity since July 1986.

Trident II is the first program to use CIM technologies plantwide at Y-12. One of the primary objectives is to fully utilize CIM for manufacturing Trident II components by October 1988 through the electronic exchange of product-definition data to benefit tool-and-gage design, process engineering, numerical control programming, and quality control functions.

Business Methods

The current "paper system" used to manage product-definition information has been evolving for over 25 years. This system is defined in the Product

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[1] J. K. Garberson, "The DOE Multi-Facility CIM Environment—Pursuing Vertical and Horizontal Integration Goals," in proceedings of The Automation Technology Institute Conference, February 4-6, 1986.

[2] R. J. Sikorski, "Access, Control, and Release System—ACARS" in proceedings of the Automation Technology Institute Conference, February 4-6, 1986.

[3] R. L. Elliott, "A General Description of the Nuclear Weapons Complex Network" in proceedings of the Automation Technology Institute Conference, February 4-6, 1986.

Engineering procedures manuals. A few of the major documents and procedural activities are described below to emphasize the significant task of computerizing the current "paper" product-definition system.

Drawings, procedures, specifications, and other product-definition information are distributed to the Plant for review and approval using a Product Engineering Transmittal (PET). The PET is the official release mechanism for product-definition data within Y-12. The PET updates the necessary configuration control data bases that are used to verify individual component certifications prior to submittal of that component to DOE. A Document Transmittal Form (DTF) is the official Y-12 transmittal of product-definition data to the design agencies for review and approval. Both DTFs and PETs are numbered and recorded for future reference. Product-definition information is generated and controlled differently as required by each design agency.

Y-12 has a software project under way to convert the "paper" system to an electronic system. The intent for this new electronic system is to satisfy all the requirements of the current system. Reliability, configuration control, document control, quality assurance, and other important requirements are being closely maintained.

Product-Definition Data Flow

The product-definition data flow, both external and internal to the Plant, for the CIM approach on Trident II is significantly different in many respects from the same data flow in Y-12 today. The envisioned data flow paths from the design agency down through the Y-12 Plant are graphically illustrated in Figure 2. The data flows between the design agencies and Y-12 as the hardware design develops and as manufacturing processes are defined. Electronic text flows directly through Operation Center computer number 2 (OC2) to the Product Engineer, but graphics drawings are sent through the IGES processor for translation to the Anvil 4000 format before reaching the design draftsman's part drawing file.

The Product Engineer uses the PET to officially transmit the product-definition data to the Plant production, process, and inspection engineers. Critical path schedules are developed early in the program to ensure that all activities are started and completed as required.

Upon design agency approval, the Plant is released to begin design of tooling and gaging. As shown in Figure 2, tooling, gaging, machining, and inspection engineers develop designs and numerical control (NC) programs with the Anvil 4000 system based on the part drawing file. Tools and gages are fabricated and sent to the shops where parts are to be made. NC programs are downloaded to direct numerical control (DNC) host processors for machine tool control and to NC units for inspection machine control. The DNC host computer uploads process control data and inspection data to ensure that manufacturing processes are under control. The inspection DNC equipment collects and analyzes data to provide documentation for Y-12 and DOE certification of the parts and assemblies.

Procedures are also produced in a parallel path in the same time frame to be used in manufacture and certification of parts and assemblies by shop floor personnel.

As a major policy decision, Y-12 plans to concurrently run both the existing "paper" system as well as the new electronic system during the transition from the current operational system to the electronic mode. The current system will be maintained as the official system until the electronic system has been sufficiently checked out and approved.

Product-Definition File Management

As the Trident II program progresses through the weapon life cycle, more and more electronic files will be generated to handle product-definition data and derivatives of these data. These files consist of graphics, narrative, and a combination of graphics and narrative. The proliferation of these data files presents a significant data management problem. One of the elements in the solution of this problem is to create an electronic vault for the following reasons

1. DOE requires an aperture card as the master copy of record.

2. Aperture cards are created from CAD electronic models.

3. CAD electronic models require at least as much control as aperture cards if the CAD system ability to quickly change models is effectively utilized as a productivity improvement vehicle.

4. The electronic vault applies equally to CAD models, word drawings, and text files.

5. The electronic vault is essential in effectively controlling the large quantity of files envisioned for the various users.

An interim file manager was developed for FY 1986 activities. The entire problem of file management is illustrated in more detail in Figure 3 and will require several years to implement.

Product-Definition Software Projects

The following software projects are being developed specifically to computerize product definition internal to the Y-12 Plant:

- Electronic File Manager (EFM)
- Manage Design Documents
- Distribute Product Definition
- Manage Manufacturing Procedures and Product Specifications

These projects are requiring about 4 years of elapsed time (FY 1985 - FY 1988) and several tens of employee-years of labor to complete.

Electronic File Manager is an electronic document filing system that stores and retrieves electronic documents, controls access to these documents, logs successful and unsuccessful access attempts, and maintains document header information. EFM consists of a group of callable interfaces used by authorized applications to manage electronic documents. EFM routines do not interface directly to tne user. The desired screen interaction with the user must be addressed by the calling application. A status value is returned to communicate any error conditions to the calling application.

Requirements of EFM include

- store and retrieve electronic documents,
- delete documents,
- modify document status,
- verify that user is authorized to perform specified action on the specified document,
- log all document accesses, and
- query document header information.

The objective of the Manage Design Documents project is to provide facilities for creating, editing, viewing, commenting, and approving CAD files, manufacturing procedures, and product specifications.

The Distribute Product Definition software project will allow a responsible individual to release a document for use by Plant personnel. The software will allow for notification to key personnel that a given document has become "effective" and will update the necessary configuration control data bases of the Plant certification system.

The Manage Manufacturing Procedures and Product Specifications project automates the procedure and specification generation process using a computer terminal with word processing capability. Procedures and specifications with both pure text and a combination of graphics and text are accommodated. A standard format is used for all procedures, and routing for comment/approval within a division is handled.

Trident II Prototype of Product-Definition User Interface

Development work has been completed on software known as the Trident II Prototype of the Product-Definition User Interface, subsequently referred to as the Interface. The Interface software is a new twist of an old technique—the use of menus and simple prompts to replace numerous computer commands and strict syntax.

The Interface is a collection of layered menus, which allows a user to invoke numerous applications and utilities associated with product definition without having to be familiar with computer commands or syntax. It is a prototype, meaning that the Interface is being made available to users in order to solicit feedback for the production system.

The Interface provides a path to create SXRs (Specification Exception Releases) and Deviation Requests (for Product Engineering personnel) and for query of the data base (for Plant personnel). SXRs are formal reports to the design agencies for approval of products that are slightly out of specification. It provides a simplistic means for commenting on and approving documents and for forwarding those comments to the appropriate individual. It provides a means for viewing Trident II drawings and specifications. It provides an easy way to view a listing of current documents needed to manufacture parts, part routings, part inventories, status of a given piece part, listing of piece parts clocked into an assembly, outstanding reject and deviated parts, clocking histories, and mechanical properties data.

More recently, a user's manual was designed and produced to assist Plant personnel in using the Interface. It was conceived to be both pleasing to the eye and easy to comprehend. In addition to this manual, a videotape was prepared for training. A DEC VT240 was connected to a video cassette recorder during a demonstration of the Interface. The result is a videotape that demonstrates to users how the Interface works. The tape can be "played back" to a composite monochrome computer monitor, to a regular television set, or to an Electrohome projector. The demonstration can be presented for only one person or for a filled conference room (without problems with the computer or the network hardware "going down").

We believe that the combination of the manual and the videotape will solve the problem of training users.

Product-Definition Terminal

The demands for a single terminal to perform all of the product-definition functions are stringent. The system must be able to:

- generate, review, and approve documents consisting of both text and text and graphics combined;
- view and comment on the graphical content of design drawings generated on a CAD system;

- emulate a variety of terminals to communicate with multiple-vendor host computers; and

- perform normal office automation functions.

Due to economic and space limitations, a single terminal per office is much more desirable than two or more.

A personal computer was chosen that from the outset capably performed activities such as word processing, spreadsheet analysis, data base management, and terminal emulation for interaction with host computers (text only). The missing activity, though, was the ability to view and manipulate CAD drawings with ANVIL-4000. Therefore, a commercial software package was procured which enables the personal computer to perform the CAD viewing function. This package, TGRAF-07 by Grafpoint, Inc., serves practically all asynchronous terminal communication activities for a personal computer. In addition, the package will allow the user to store and view CAD files locally in order to lessen the load on the Plant's Anvil 4000 system. A graphics interface board and color monitor were added to the personal computer to provide 640 x 480 pixel resolution.

Conclusions

The Y-12 Plant has made a sizable investment in CIM, and it all started with product definition. The Trident II Program was selected to spearhead the implementation of CIM technology. A significant software effort is required to change the "paper" business system to an electronic mode of operation. The schedule for development and production of the Trident II parts is fixed, and the CIM effort is being scheduled to match these dates.

It is imperative that basic policy decisions and follow-on implementation efforts be accomplished in a timely manner and with high quality to produce an electronic system that is easier and faster to use and possesses the proper reliability so that all users (production plants and the design agencies) will perceive it as a better way to do business.

Projected cost savings due to the implementation of CIM are estimated to be significant for the entire Plant throughout its future.

The resulting electronic system that is envisioned to replace the paper system offers significant potential for higher reliability, improved quality, shorter schedules, and, ultimately, lower costs. The Trident II CIM Project provides a foundation for Y-12's "Factory of the Future" concept.

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FIGURE 1

COMPUTER-INTEGRATED MANUFACTURING IS BEING IMPLEMENTED AT Y-12

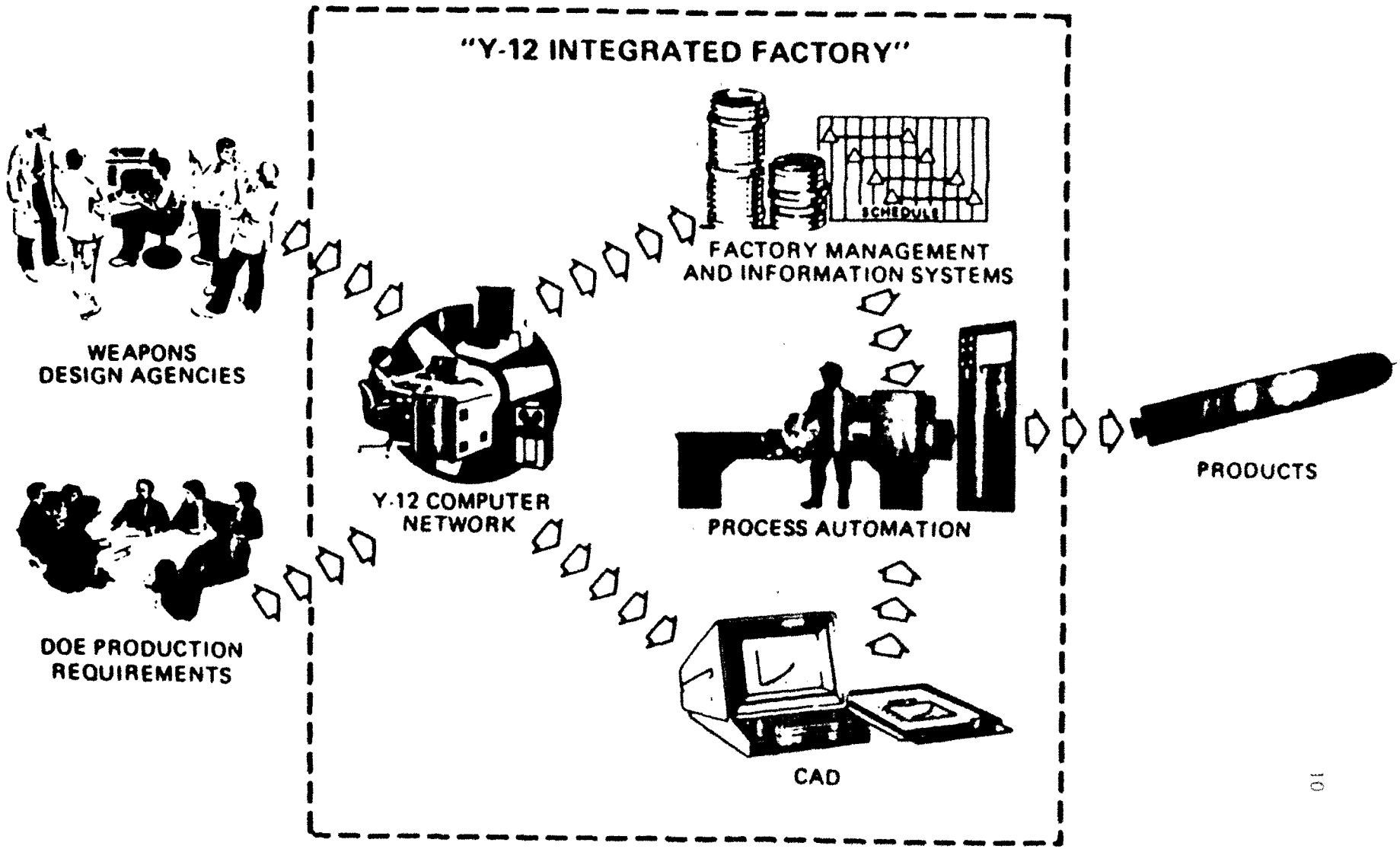
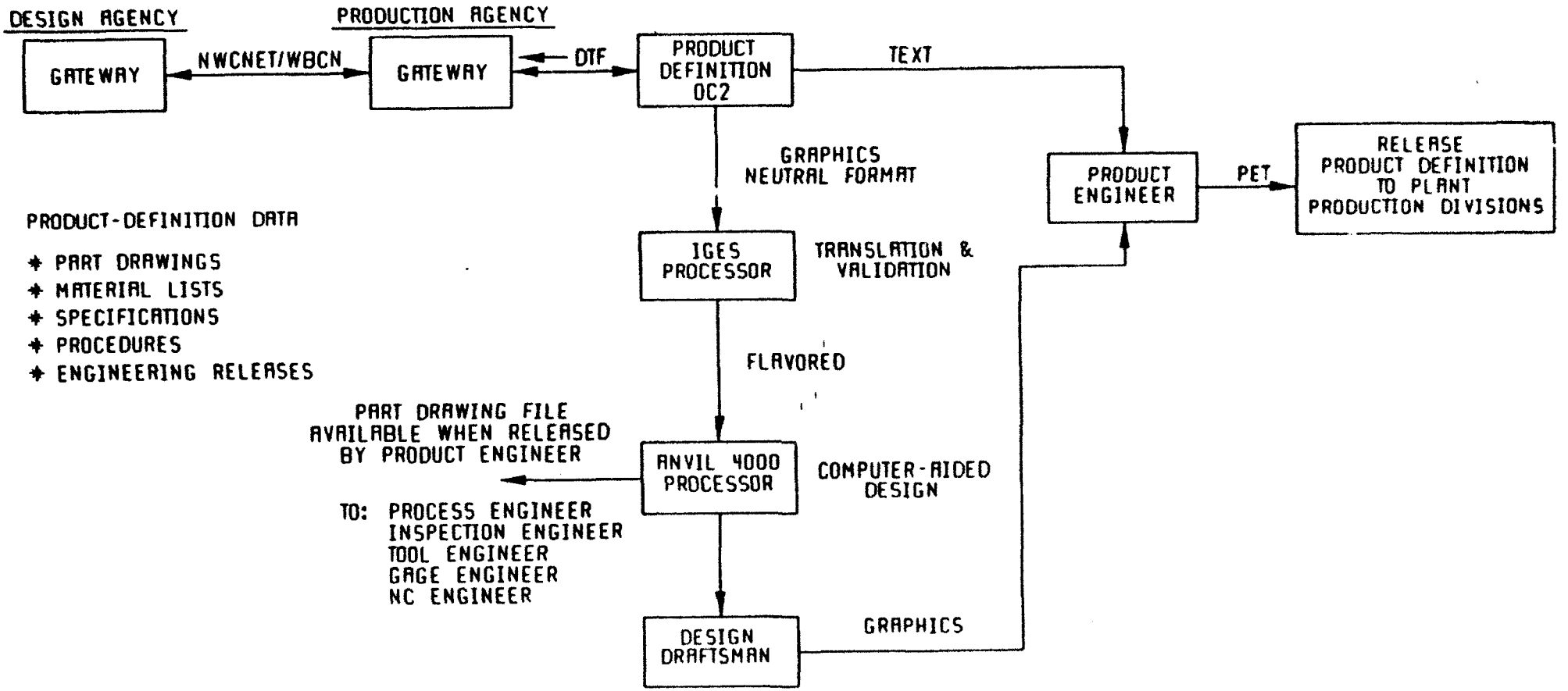
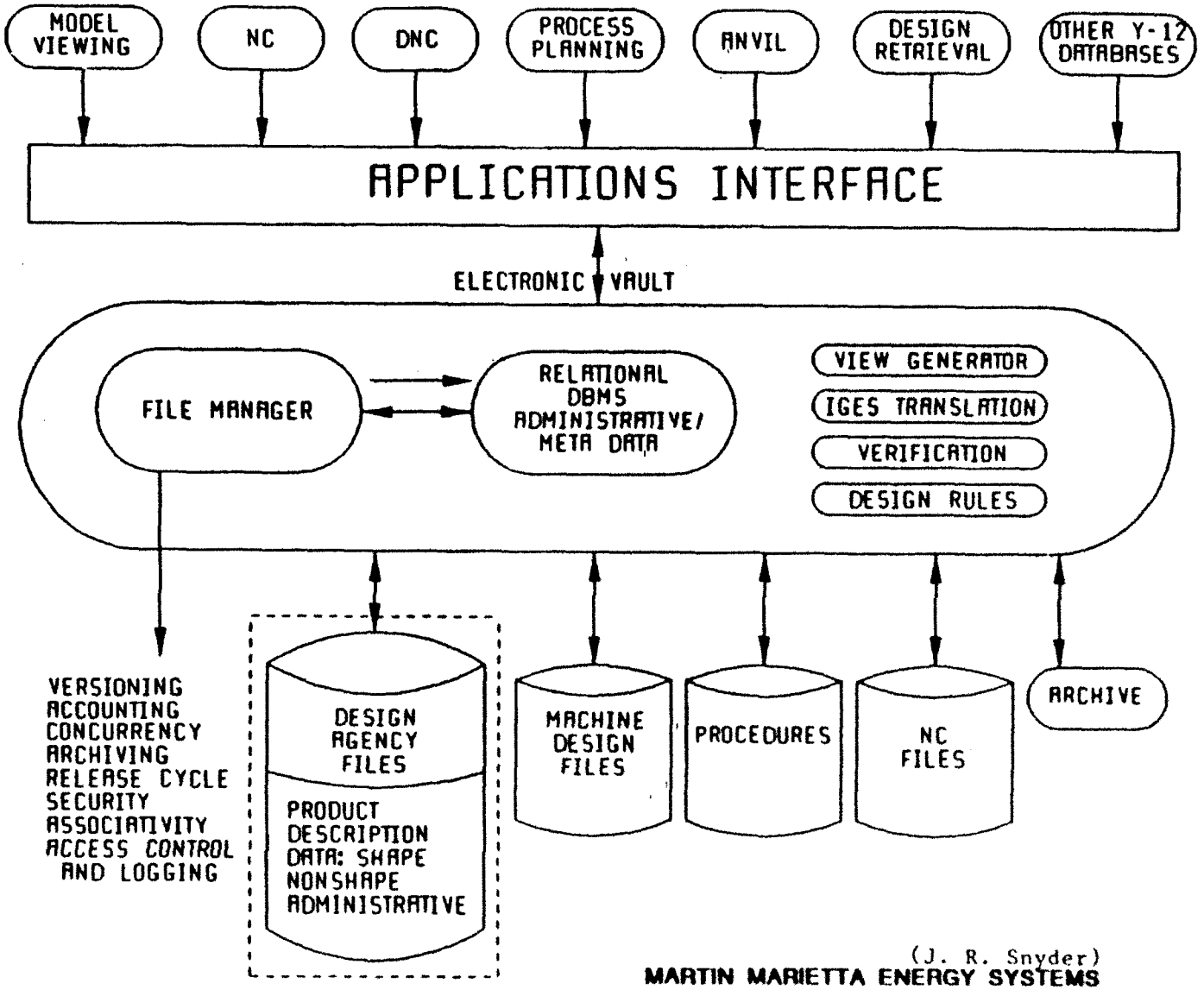


FIGURE 2

PRODUCT-DEFINITION DATA FLOW



DATA MANAGEMENT FILE SYSTEM



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