## Title
5TH DOE WORKSHOP ON COMPUTER AIDED ENGINEERING. PROGRAM AND ABSTRACTS



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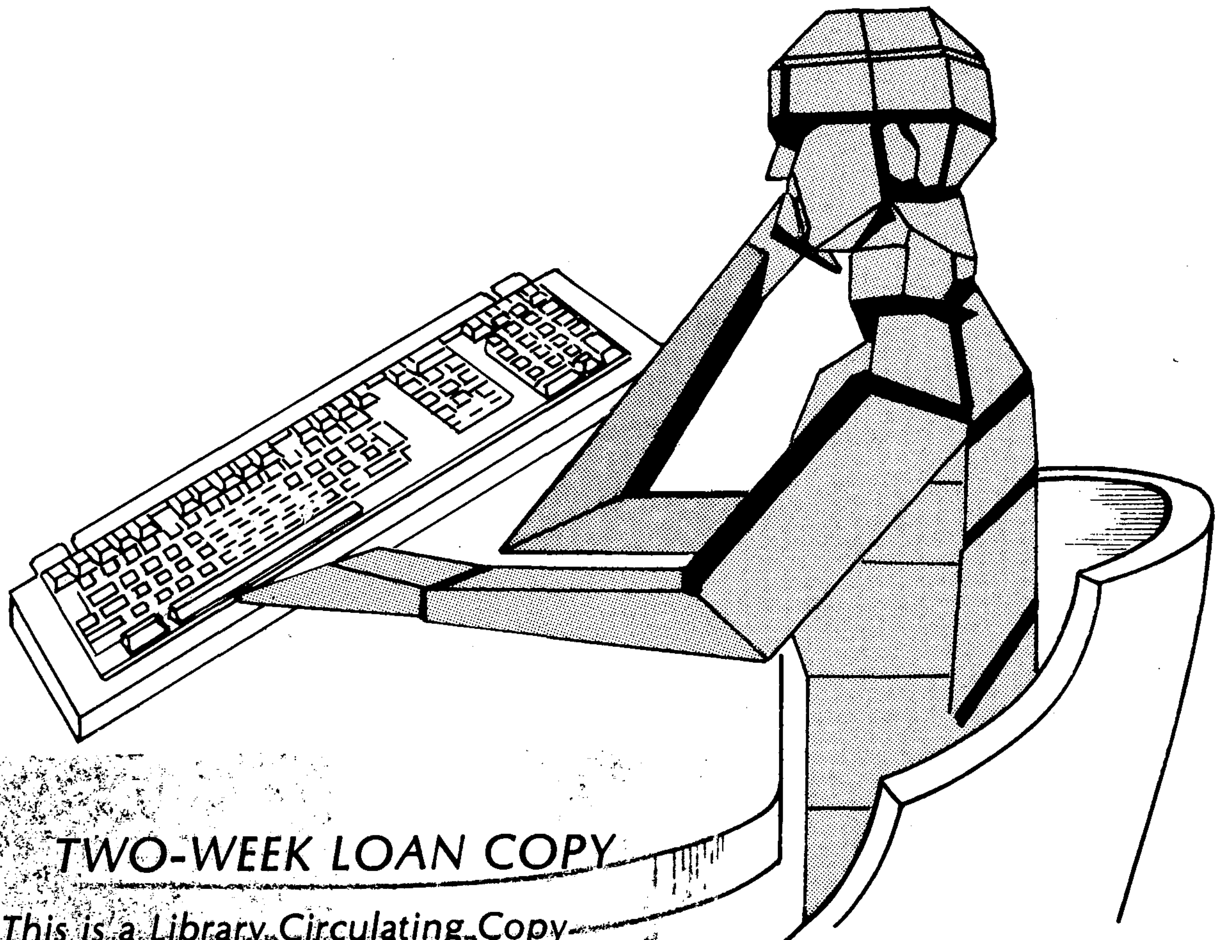
# 5th DOE Workshop on Computer Aided Engineering



## Program and Abstracts





**October 26–27, 1987**

Hosted by
Lawrence Berkeley Laboratory

Lawrence Berkeley Laboratory/University of California
Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

## DISCLAIMER

LBL-24130
October 1987

# Fifth DOE Workshop on Computer Aided Engineering

## October 26–27, 1987

## Program and Abstracts

Hosted by

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

MONDAY, OCTOBER 26, 1987

| | | |
|---|---|---|
| 7:30 AM - 8:30 AM | REGISTRATION | |
| 8:35 AM | WELCOMING ADDRESS | David A. Shirley - *Director, Lawrence Berkeley Laboratory* |
| 8:45 AM | KEYNOTE ADDRESS | Paul Losleben - *Center for Integrated Systems, Stanford University* |
| 9:35 AM - 12:15 PM | SITE REPORTS | CHAIR: Richard Kropschot - LBL |

| | | |
|---|---|---|
| 9:35 AM | CAD/CAE SITE REPORT - LAWRENCE BERKELEY LABORATORY<br>F. S. Goulding - *LBL* | (20 min.) |
| 9:55 AM | NEW DIRECTIONS FOR CAD AND CIM AT BROOKHAVEN NATIONAL LABORATORY<br>T. A. Daniels - *BNL* | (20 min.) |
| 10:15 AM | SITE REPORT - LOS ALAMOS NATIONAL LABORATORY<br>Jerry N. Beatty, Raymod L. Elliott, Michael L. Smith - *LANL* | (20 min.) |
| 10:35 AM | CAE PROGRESS AND GOALS AT LAWRENCE LIVERMORE NATIONAL LABORATORY<br>Kevin O. Blackwell - *LLNL* | (20 min.) |
| 10:55 AM | MECHANICAL COMPUTER-AIDED DESIGN AND ENGINEERING AT THE OAK RIDGE Y-12 PLANT<br>Colman C. Wright - *Oak Ridge Y-12 Plant* | (20 min.) |
| 11:15 AM | UPDATE ON THE CENTRALIZED CAD/CAE SYSTEM AT SLAC<br>R. Larsen, C. Perkins, J. Steffani - *SLAC* | (20 min.) |
| 11:35 AM | SITE REPORT FOR SANDIA NATIONAL LABORATORIES ALBUQUERQUE<br>W E. Alzheimer - *SNLA* | (20 min.) |
| 11:55 AM | SITE REPORT FOR SANDIA NATIONAL LABORATORIES LIVERMORE<br>Robert C. Dougherty - *SNLL* | (20 min.) |

12:15 PM - 1:30 PM LUNCH

1:30 PM - 5:00 PM PARALLEL SESSIONS

ELECTRICAL SESSION 1

CAE Tools for Microelectronics

CHAIR: *Jerry Allen* - SNLA

| | | |
|---|---|---|
| 1:30 PM | *CAE TOOLS FOR DESIGNING RADIATION HARDENED CIRCUITS*<br>D.J. Allen and J.J. Everts - SNLA | (20 min) |
| 1:50 PM | *DIGITAL LOGIC SIMULATION USING A HIGH LEVEL LANGUAGE*<br>Paul Kunz & Gerard Oxoby - SLAC | (15 min) |
| 2:05 PM | *HARDWARE ACCELERATORS APPLIED TO IC DESIGN*<br>B.D. Shafer - SNLA | (20 min) |
| 2:25 PM | *CAD ACTIVITY WITHIN THE ESONE COMMITTEE*<br>followed by: | (10 min) |
| | *ASIC's AND PCB DESIGN AT SACLAY*<br>Pierre Gallice - CEA/CEN Saclay-FRANCE | (10 min) |
| 2:45 PM | *VLSI FOR THE SUPERCONDUCTING SUPER COLLIDER*<br>Stuart A. Kleinfelder - LBL | (15 min) |
| 3:00 PM | *NET 1-2-3 NETWORK ANALYSIS PROGRAM (An Update)*<br>Waldo G. Magnuson, Jr. & Terry G. Allison - LLNL | (15 min) |
| 3:15 PM | *PROGRAMMABLE LOGIC DEVICES*<br>Michael Stewart - SNLL | (15 min) |

MECHANICAL SESSION 1

CAD/CAE Integration

CHAIR: *Charles Perkins* - SLAC

| | | |
|---|---|---|
| 1:30 PM | *DESIGN AND FABRICATION OF THE NSLS X-RAY SCRAPER: AN INTEGRATED APPROACH*<br>Rudy Alforque and Sushil Sharma - BNL | (20 min) |
| 1:50 PM | *ROTARY SOLENOID DESIGN USING AOS/MAGNUM*<br>Eugene Aronson - SNLA | (20 min) |
| 2:10 PM | *DESIGNING SUPERCONDUCTING MAGNETS USING THE CAD/CAM SYSTEM*<br>Charles Briening - BNL | (20 min) |
| 2:30 PM | *DYNAMIC ANALYSIS OF ELECTROMECHANICAL MECHANISMS*<br>Richard N. Harris and Robert Palmquist - SNLA | (20 min) |
| 2:50 PM | *THE GENERATION OF MESHES FOR FINITE DIFFERENCE ANALYSIS FROM A SOLID MODEL DATA BASE*<br>Gary Laguna - LLNL | (20 min) |
| 3:10 PM | *AN UPDATE ON SOLID/FEM INTEGRATION AT SNLA*<br>Patrick F. Chavez - SNLA | (20 min) |

ELECTRICAL SESSION 2

A Panel discussion on Electrical CAD/CAE Integration

CHAIR: *Waldo G. Magnuson, Jr.*- LLNL

Panel Members:

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|---|---|
| B.L. Gregory | SNLA |
| Paul Losleben | Stanford University |
| A. Richard Newton | University of California, Berkeley |
| W.M. VanCleemput | CAD Consultant |

MECHANICAL SESSION 2

A Panel Discussion on Mechanical CAD/CAE/CAM Integration

CHAIR: *Jack Tanabe* - LBL

Panel Members:

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|---|---|
| Jerry Beatty | LANL |
| Jerome Cummings | LBL |
| Charles Perkins | SLAC |
| Arnold Peskin | BNL |
| Mark Strauch | LLNL |
| Richard Tankersley | SLAC |

6:00 PM CONFERENCE BANQUET - *Speaker:* Fred S. Goulding - LBL

*Topic:* The Circuit Designer - A Dying Species

## TUESDAY, OCTOBER 27, 1987

### General Interest Topics

CHAIR: *TED DANIELS* - BNL

| | | |
|---|---|---|
| 8:00 AM | *CAD/CAM NETWORKING - WHAT YOUR SALESMAN NEVER TOLD YOU*<br>A M. Peskin - BNL | (15 min.) |
| 8:20 AM | *ENGINEERING DRAWINGS AND CHANGES: STORING AND CONTROLLING BY THE TENS OF TERRABYTES* Jerry D. Stauffer - SNLA | (15 min.) |
| 8:40 AM | *DESIGNING A SCIENTIFIC DATA SYSTEM: SOME SOFTWARE DEVELOPMENT PARADOXES*<br>Jonathan W. Lee - SNLA | (15 min.) |
| 9:00 AM | *A MATRIX OF CAD/CAM APPLICATION REQUIREMENTS/DBMS CAPABILITIES*<br>M A. Ketabchi - University of Santa Clara | (15 min.) |
| 9:20 AM | *THE EFFECTS OF CONSOLIDATION ON CAD/CAE IMPLEMENTATION AT HANFORD*<br>Bary D. Elison - BCS Richland, Inc. | (15 min.) |
| 9:40 AM | *MECHANICAL COMPUTER AIDED ENGINEERING AT BENDIX KANSAS CITY*<br>William R. Freeman - Allied Bendix Aerospace | (15 min.) |
| 10:00 AM | *ELECTRONIC CAD AT THE RUTHERFORD APPLETON LABORATORY*<br>D R.S. Boyd - Rutherford Appleton Laboratory U.K. | (15 min.) |
| 10:15 AM | *SITE REPORT - CAE ACTIVITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY*<br>Dale E. Evans - Idaho National Engineering Laboratory | (15 min.) |

10:30 AM - 12:15 PM PARALLEL SESSIONS

### ELECTRICAL SESSION 3

Selected Topics in Electronic CAE

CHAIR: *Kevin Blackwell*- LLNL

| | | |
|---|---|---|
| 10:30 AM | *GATE ARRAY CIRCUIT DESIGN AT LLNL*<br>Michael D. Pocha, J. Courtney Davidson and Waldo G. Magnuson, Jr. - LLNL | (15 min) |
| 10:45 AM | *THE FUTURE OF COMPUTER INTEGRATED MANUFACTURE IN THE CENTER FOR RADIATION HARDENED MICROELECTRONICS*<br>J.A. Wisniewski - SNLA | (15 min) |
| 11:00 AM | *PROJECT WHITSTAR: THE SANDIA NATIONAL LABORATORIES SEMICONDUCTOR RADIATION EFFECTS DATA BASE*<br>S.B. Roeske, J.K. Sharp and L.J. O'Connell - SNLA<br>D.R. Alexander and J. Caudle - Mission Research Corp. | (15 min) |
| 11:15 AM | *DATA ENGINEERING: A NEW CHALLENGE IN THE CAE ENVIRONMENT*<br>James R. Yoder - SNLA | (15 min) |
| 11:30 AM | *AN ENGINEERING DATA MANAGEMENT AND ANALYSIS SYSTEM FOR DIAGNOSTIC MEASUREMENT SYSTEMS*<br>Roy D. Merrill and Edward E. Domning - LLNL | (15 min) |
| 11:45 AM | *THE PRODUCT DATA NETWORK: A PROTOTYPE CIRCUIT TO THE QA SYSTEM TEST LAB*<br>Ronald C. Hall and Cheryl.K. Haaker - SNLA | (15 min) |
| 12:00 PM | *NETWORKING PERSONAL COMPUTERS AT SANDIA NATIONAL LABORATORIES*<br>Bradley J. Wood - SNLA | (15 min) |

### MECHANICAL SESSION 3

Selected Topics in Mechanical CAE

CHAIR: *Charles Anderson* - LANL

| | | |
|---|---|---|
| 10:30 AM | *AN OVERVIEW OF ROBOTICS AT LOS ALAMOS NATIONAL LABORATORY*<br>W. Dan Powell - LANL | (18 min) |
| 10:48 AM | *PRODUCT DEFINITION MODELING AND THE SRAM II PROGRAM*<br>Donald L. Vickers and Derek Wapmam - LLNL | (30 min) |
| 11:18 AM | *STRUCTURAL ANALYSIS USING PATRAN AND ABAQUS-RESULTS FROM TWO RECENT PROBLEMS*<br>Steven P. Girrens and Peggy A. Goldman - LANL | (18 min) |
| 11:36 AM | *CPRF/ZTH TOROIDAL CONDUCTING SHELL FINITE ELEMENT STRESS ANALYSIS USING GFEM (GRAPHICS FINITE ELEMENT MODELING)*<br>C.L. Baker and G.D. Dransfield- LANL | (18 min) |
| 11:54 AM | *PROVIDING AN INTERFACE BETWEEN COMPUTER AIDED DESIGN (CAD) AND FINITE ELEMENT MESH GENERATION*<br>Vera D. Revelli - SNLL | (18 min) |
| 12:12 AM | *MATERIALS INFORMATION FOR SCIENCE AND TECHNOLOGY (MIST):*<br>John L. McCarthy - LBL | (18 min) |

12:15 PM - 1:30 PM LUNCH

1:30 PM - 3:30 PM PARALLEL SESSIONS

### ELECTRICAL SESSION 4

CAE Systems for Electronic Engineering

CHAIR: *Charlotte Ackens* - SNLL

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|---|---|---|
| 1:30 PM | *A UNIQUE APPROACH TO THE EVALUATION AND SELECTION OF AN ELECTRONICS COMPUTER-AIDED DESIGN AND DRAFTING SYSTEM*<br>Teresa Hauck and Jim Kucala - LLNL | (17 min) |
| 1:47 PM | *BUILDING AN INTEGRATED CAD/CAE/CAM OPERATION USING SEVERAL SOFTWARE PACKAGES*<br>J. Millaud, F.S. Goulding, G. Obegi and A. Whichard - LBL | (17 min) |
| 2:14 PM | *MANAGEMENT OF ELECTRONIC LIBRARIES IN A MULTI-SOFTWARE/ HARDWARE CAD/CAE ENVIRONMENT*<br>J. Millaud, G. Obegi and A. Whichard - LBL | (17 min) |
| 2:21 PM | *EXPERIENCE USING AN IBM PC BASED CAE PACKAGE FOR A LARGE PROJECT*<br>Paul Kunz and Gerard Oxoby - SLAC | (17 min) |
| 2:30 PM | *LOW-COST CAD TOOLS CHALLENGE HIGH-PRICED SYSTEMS FOR ENGINEERING PRODUCTIVITY*<br>Timothy A. Cushman and Michael H. Barron - LANL | (17 min) |
| 2:55 PM | *SCHEMATIC DESIGN TRANSFER USING NEUTRAL FILE FORMATS*<br>I. Robert Corey and Jim Kucala - LLNL | (17 min) |
| 3:12 PM | *INTEGRATING PRINTED WIRING BOARD CAM MACHINES INTO THE LABORATORY-WIDE NETWORK*<br>Roland Portman - LLNL | (17 min) |

### MECHANICAL SESSION 4

CAD/CAM Applications

CHAIR: *Jerry Beatty* - LANL

| | | |
|---|---|---|
| 1:30 PM | *THE AUTOMATIC GENERATION OF PIN WIRING DIAGRAMS*<br>Cary B. Skidmore - LANL | (20 min) |
| 1:50 PM | *INTERCONNECTIONS 3-D ROUTING WITH SOLID MODELING*<br>Edwin D. Machin - SNLA | (20 min) |
| 2:10 PM | *INTEGRATION OF CAD INTO LOS ALAMOS LINEAR ACCELERATOR PROTOTYPE DESIGN*<br>T.O. McGill - LANL | (20 min) |
| 2:30 PM | *AUTOMATIC GENERATION OF UNIFORM GROUP TECHNOLOGY PART CODES FROM SOLID MODEL DATA*<br>Arlo L. Ames - SNLA | (20 min) |
| 2:50 PM | *AN INTELLIGENT CAD-CAM SYSTEM*<br>Alan H. Bond, Basuki Soetarman, Dong H. Kim, Ozia Ahmed, and Kang Chang - UCLA | (20 min) |
| 3:10 PM | *IGES EVALUATION AND SITE PRESENTATION*<br>H. Fulton, B. Kross, M. Leininger, F. Markley and J. Rauch - FNAL | (20 min) |

# SITE REPORTS

# CAD/CAE SITE REPORT - LAWRENCE BERKELEY LABORATORY

F.S. Goulding
Lawrence Berkeley Laboratory, University of California,
Berkeley, California 94720

Lawrence Berkeley Laboratory is a multi-purpose laboratory whose programs span a wide range of subjects including accelerator design and construction, physics, applied science, materials, biomedicine and molecular biology. Present and developing applications of CAD/CAE fall broadly into the following areas.

1. Mechanical design of the components of accelerators such as magnets, beam lines, shielding, wigglers undulators, etc. and overall layout of the components.
2. Mechanical design of large high energy physics detector systems and other research instruments.
3. Plant engineering applications including some building design as well as maintenance of a graphics data base containing building data and information in services, etc. for the overall site.
4. Electronic design of large electronic systems associated with accelerators.
5. Electronic design, printed circuit layout and the associated generation of data for fabrication of a broad range of electronic instruments used in our wide ranging programs.
6. Integrated circuit design, particularly related to the design of high packing density circuits for use in the mega-channel detector systems required by high-energy in the future.

Some local facilities are used at LBL for fabrication of both mechanical and electronic systems and the CAD/CAE systems are designed to link to these facilities, as well as production capabilities in industry.

Extensive work is proceeding at LBL in areas 1 and 2. Almost 30 workstations are devoted to this work. Nearly all are based on the ME10 Hewlett Packard 2D software running on HP series 4000/300 desktop computers. We are close to the point where all mechanical design is carried out on these systems and all archiving of drawings is by machine. Some 3D modelling is also planned on the same machines.

Area 5 has also been a major focus of work at LBL. Approximately 15 HP Series 9000/300 machines are used for PC board layout, autorouting, preparation of fabrication data, circuit simulations and associated tasks. A unique system has been designed to permit engineers to input schematics to the central complex using IBM AT computers and the CASE TECHNOLOGY schematic capture software. The AT computers are located in engineering areas. Area 4 will fit within this same conceptual system and libraries special to this area are being developed at the present time.

Area 6 is presently being pursued on a small scale using the Magic integrated circuit software on a remote terminal to a Berkeley campus computer. We anticipate a broader effort in this area in the next few years.

Finally, Area 3 is beginning to receive attention. A demonstration of the abilities of the Engineering Graphics Software (EGS) (used mainly for electronics) as a tool for maintenance and operation of a graphics data base for plant purposes has been made. It is not clear at present what direction our plant engineers will take but it is evident that major time and cost savings would result from proper application of CAD/CAE in this area.

This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

# NEW DIRECTIONS for CAD and CIM at BROOKHAVEN NATIONAL LABORATORY

T. A. Daniels
BNL CADCAM Project Manager
Brookhaven National Laboratory
Upton, New York, USA

During the past three years, since an organized CADCAM effort was launched on a Labwide basis, more than 100 designers, drafters and engineers have been trained and now benefit from the use of modern design tools in the course of their work. A central support staff provides training, support with problem solving, standards and procedures, system integration and database management in a coordinated approach to the interfaced Labwide CADCAM system.

Brookhaven National Laboratory is a multiprogram laboratory operated by Associated Universities, Inc., and as a prime contractor for the Department of Energy carries out basic and applied research in the physical, biomedical and environmental sciences and in selected energy technologies. The Laboratory employs about 3,200 persons, and another 1,500 scientists and students from other institutions do research at BNL for varying periods during the year.

**The overall objectives of the Lab's CADCAM program are to:**

1] Increase productivity and quality of work of a broad spectrum of user applications through the introduction and support of standardized CADCAM tools;

2] Develop workstations at various price/performance levels that could be integrated into the Labwide system. System integration, communications and networking solutions are provided by the CADCAM support team;

3] Provide workstations (4) at a central location in popular configurations for the evaluation and training by new users, and to accommodate the overflow of existing resources;

4] Provide access to all centralized CADCAM resources, where practical;

5] Upgrade capabilities with the newest proven technologies using networking standards, an open systems environment, graphics standards and a centrally managed engineering database. The goal is CIM for better management of an organizational engineering database.

These objectives have only partially been realized. The BNL CADCAM system is currently an "interfaced" system allowing the transfer of CAD graphics data between all supported workstations and access to output devices that has been achieved through a switched telecommunications scheme.

The support of various CAD databases that could be easily accessed in a consistent manner will require much attention in the near future. More work must be done also in the creation of standard parts and procedures, and overall system integration in an organizational context. System topology and CIM issues will be discussed.

*Work performed under the auspices of the U. S. Department of Energy under Contract No. DE-AC02-76CH00016.

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# 5th DOE WORKSHOP ON COMPUTER AIDED ENGINEERING

## SITE REPORT

## LOS ALAMOS NATIONAL LABORATORY

**Jerry N. Beatty, Los Alamos National Laboratory**

**Raymond L. Elliott, Los Alamos National Laboratory**

**Michael L. Smith, Los Alamos National Laboratory**

The Los Alamos National Laboratory, by virtue of its multi-disciplined activities, uses a wide variety of CAD/CAM/CAE systems and tools to meet program goals. Some activities require networking and data sharing with other organizations and remote sites.

This report will provide an update of the various using groups, their activity, and future direction.

In addition, an updated status of the Wide Band Communications Network (WBCN) and DOE sponsored CAD/CAM project will be presented.

# CAE Progress and Goals at Lawrence Livermore National Laboratory

Kevin O. Blackwell
Electronics Engineering Department
Lawrence Livermore National Laboratory
Livermore, California

Significant progress has been made in meeting the CAE goals of Engineering at LLNL. The primary goal of CAE is to provide computer-based tools to technical, professional, and clerical staff that enhance their ability to complete programmatic assignments and improve response time.

CAE activities can be categorized into three areas: systems, services, and applications. The systems area covers computational resources including workstations, the network which provides interconnection of resources, and various servers for storage, printing, and plotting. The network has shown the most notable change - it now has more than 600 nodes, includes nine local area networks connected by LabNet, a broadband backbone for unclassified work. The VAX computers in Electronics Engineering are set up as a cluster on iCAEn, the EE LAN. Numerous terminal servers are installed for providing users of character-oriented terminals with access to the assorted computational systems available on the network. The number of workstations is now starting to increase with recent price reductions.

The services area includes providing cost effective maintenance for the computers and software being used. Lab-wide agreements with vendors are being put in place to take advantage of the large installed base of systems. More attention is being paid to Continuing Education to provide the needed training for these new systems. Engineering, Computations, and Office Technology are cooperating to deliver on-site courses.

The applications areas include logic and circuit engineering, modeling and simulation, signal processing, software engineering, project management, and technical office automation systems. Strategic planning is taking place to provide guidance in these areas. Work is also progressing with the integration of existing CAE Systems with the CAD and CAM Systems throughout Engineering.

A new CAE effort has been organized within Engineering which will provide even more cooperative development. This will provide the strategic directions as CAE moves forward into the future.

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

# MECHANICAL COMPUTER-AIDED DESIGN AND ENGINEERING AT THE OAK RIDGE Y-12 PLANT

COLMAN C. WRIGHT
OAK RIDGE Y-12 PLANT

The goal of Computer-Aided Design and Engineering (CAD/CAE) is to further the missions and objectives of the Y-12 Plant and the DOE Nuclear Weapons Complex by applying computer technology to design, drafting, analysis, and numerical control programming. Effective and practicable use of established capabilities for computer integration both within the plant and with other facilities is stressed. Progress toward this goal is accomplished through (1) participation in relevant CIM activities supported by the Nuclear Weapons Complex, (2) awareness of leading-edge and state-of-the-art technology in CAD/CAE and development of appropriate staff capabilities in these areas, and (3) evolutionary implementation steps that will effectively move the plant through the exploitation of these CAD/CAE tools. As a primary CIM technology zone, the CAE/CAE work includes two major work areas: (1) manufacturing engineering and (2) CAD data base.

Key concepts in the CAD/CAE strategy for progress toward the envisioned Factory of the Future are (1) definition and application methods, (2) integration, and (3) standards. Initial methods involved the use of CAD as a drafting tool (the electric pencil era) to improve quality and productivity in the creation of engineering drawings. Subsequent migration steps beyond the "drawing" method include two-dimensional wireframe definition, three-dimensional (3-D) wireframe, 3-D wireframe with surfaces, and solid modeling. Integration benefits can be derived from both the interfacility and intrafacility points of view. Between design laboratories and production contractors, for example, the challenge is to effectively exchange design information among unlike CAD systems. In the Y-12 Plant the migration concept provides that the definitions of products to be manufactured (tooling and parts) are accurate, complete, and suited to all the downstream design and manufacturing applications. Furthermore, such product definitions are created, maintained, and managed as a shared data base. National and international standards set by the Department of Energy and internal standards set by Martin Marietta Energy Systems are essential to the timely and effective realization of these beneficial changes. At the lowest level, but just as important, company conventions (CAD user rules) relevant to the CAD processes are developed and used to guide and validate CAD/CAE work.

UPDATE ON THE CENTRALIZED CAD/CAD SYSTEM AT SLAC

R. Larsen, C. Perkins, J. Steffani

The centralized CAD System at SLAC has evolved from its initial configuration consisting of a VAX 780 with 5 workstations and a single 36" production plotter and associated archival disk drives to an expanded configuration consisting of 28 workstations shared between two VAX computers and with considerably expanded memory capacity. In addition, a significant thrust has been made toward the introduction of engineering workstations based on IBM PC compatible hardware and third party software. These "clones" are configured to emulate Intergraph workstations but operate essentially as stand-alones. The main system configuration is shown in Figure 1. The salient features are the use of Ethernet to network all new workstations, and the use of regular terminals accessing the CAD System over RS232 to run a program called BITS which allows the ability to edit generic drawings for rack and cable assemblies as well as certain repetitive kinds of field installations. This expands the base of available workstations in a manner which minimizes the load on the central design capabilities of the computer system. The overall system has a very open architecture and plans are being laid to expand both production design as well as engineering capabilities. A major acquisition in procurement includes a Route Engine for the expedient turn-around of first design printed circuit boards.

The short-term future plan for Electronics engineering support is to begin to acquire basic design tools and make these available at every engineer's desk. These will include circuit simulation tools, both logic and analog design, schematic capture, initial pc definition, and circuit analysis tools suitable for high speed circuit design, Fourier analysis, etc. Along with the acquisition of these tools, we intend to provide training classes and systematically upgrade the capabilities of the design engineering staff. At the high end of the scale, the Electronics Department has already acquired a single workstation running MAGIC, the Berkeley-designed integrated circuit design package, and has begun a collaboration with the Center for Integrated Systems at Stanford to enhance the support of development of custom integrated circuits. The department is also working to acquire additional tools such as an existing hybrid design package in order to make prototype turn-around of custom chips and custom hybrids more efficient.

The Experimental Facilities and Plant Engineering Departments have 3 workstations. They are using Intergraph's Architectural and Engineering Design software for site plans, floor plans, electrical power and lighting, HVAC, plumbing, and steel design. Most of their CAD work has been in regard to modification of existing campus facilities and design of the Stanford Linear Collider (SLC). The Site Plans package has been very productive

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as it allows facilities to be located very accurately in the SLAC coordinate system. The Architectural Floor plans package has also worked well in that the building floorplan can be used by the various disciplines (lighting, HVAC, etc.) in developing their specific details, and changes to the floorplan can readily be seen. The software is designed as an intelligent data base system with attributes attached to the graphics. This feature has not been used, however, because the software is so unwieldy and cumbersome to use. They feel that the most valuable feature of the CAD system is the ability to quickly and easily change drawings.

The Mechanical Engineering Department has 11 workstations located in 4 different groups. We are currently using Intergraph's 2D/3D surfaces modeling software (MDDS) in the design of SLC magnets, vacuum chambers, klystron, and the SLD detector. We are doing 90% of our design work in 2D as the 3D software has proven to be very time consuming for our purposes. The MDDS software is also designed to be a data base system, but we have not used this feature as there were a number of problems with the software. We have procured 2 IBM AT's and an Intergraph software subset which we hope will give us a relatively low cost workstation for simple drafting, plotting, etc. We have developed our own operator training programs complete with lesson plans, training exercises, manuals, etc., which teaches our operators how to use the system specifically for the kind of work that we do at SLAC. This has worked out extremely well. Our operators have come up to speed in a relatively short period, their productivity is very good, and no one thus far has had to be dropped from the system.

We are presently using ANSYS on our IBM 3081 for stress analysis as well as several PC analysis software packages for the IBM PC and the Macintosh. We are using the ANSYS pre- and post processors rather than Intergraph's as there are problems passing graphic model files between the two software systems.

The Mechanical Fabrication Department has one CAD workstation which is used with Intergraph's NC software to generate APT NC toolpaths for milling machines and lathes. We have completed approximately a dozen mill parts and are now working on our first lathe part. The latter is a complicated 82 inch diameter end shell for the SLD detector. Their greatest problem at this point is slow processing time due to heavy CPU loading.

Future plans include increased use of our NC capabilities, creation of a computer generated bill of materials system in conjunction with the manufacturing group, expansion of our standard part libraries, and implementation of parametric drafting for standard components and magnet lattice layouts. We are now in the process of developing a sitewide document control system which integrates control of CAD files, microfilm cards, and manual drawings with our existing document control system on our IBM 3081.

# SITE REPORT FOR SANDIA NATIONAL LABORATORIES ALBUQUERQUE

**W. E. Alzheimer**

During the past year Sandia National Labs in Albuquerque has experienced continued growth in all areas of computer-aided engineering (CAE). Fiscal year 1987 saw the number of CAE workstations grow by 90 to a total of 370. This included increases of 25 in electrical CAE, 25 in mechanical CAE, 34 in design definition, and 6 in fabrication.

Largest numbers of workstations continue to be used in five primary areas, electrical CAE, electrical computer-aided design (CAD), mechanical CAE, mechanical CAD, and computer-aided manufacturing (CAM). The electrical workstations are supporting the full range of circuit design, analysis and physical layout at Sandia. The supported technologies include printed wiring boards, hybrid microcircuits, gate arrays, standard cell designs, and custom integrated circuits. Primary support for mechanical design is in the areas of finite element analysis, mechanism analysis and design definition. Sandia's prototype fabrication facilities are using CAM for generation of numerically controlled machining and for delivery of instructions to the machinist on the shop floor.

Several new applications are making an impact. The need for high quality in the ever increasing amount of software being used for weapons and weapons support is driving the growth of computer-aided software engineering (CASE) tools at SNLA. Work on robotics has increased with the creation of a new organization to work on research in that area. Expert systems are also being developed in several areas including the routing of cables in weapons systems.

Several important developments took place during 1987. They included installation of new mechanical and electrical CAD systems for design definition and evaluation of standards for workstations to be used at Sandia. The new mechanical CAD software, Anvil 5000 from Manufacturing Consulting Services, will be used for drawing creation, solid modeling, and some analysis tasks. It is being used by design definition and a number of line organizations. The electrical CAD system, Circuit Board Design System from Bell Northern, will support printed wiring board layout in design definition. Also during the year, Sandia studied the problems of workstation standardization. Adoption of software and hardware standards is currently under consideration.

Integration activities focused on projects to provide the infrastructure necessary to support the diverse range of CAE applications. Fiscal year 1987 saw the completion of the Access Control and Release System (ACARS) prototype which supports the DOE CIM program. The first production version of ACARS is scheduled to be installed at Pantex in the second quarter of calendar year 1988. Two internal projects were started that integrate the drawing control of the Center for Radiation-Hardened Microelectronics and provide support to electronics designers by providing support for analysis tools in the form of data about devices on Sandia's standard parts list.

# SITE REPORT
# SANDIA NATIONAL LABORATORIES, LIVERMORE

**Robert C. Dougherty**
Engineering Support Department
Sandia National Laboratories
Livermore, California

The Livermore site of Sandia Laboratories (SNLL) is nearly ready to support a full program in the Computer Aided Design (CAD) environment. This talk addresses the architecture and implementation of the changes which are taking place in order to achieve a functional status.

The profile of the SNLL CAD business is a central facility (COMPUTERVISION) which is networked to the drafting room, a training facility, engineering and analytical workplaces, plant engineering, and the fabrication model shop.

The traditional output of the design definition activity at SNLL has been photographic representation of hard copy material (Aperture cards). Although CAD workstations have been in use for 8 years at this site, their only output has been hard copy plots which were processed for distribution in the same manner as board drawings.

SNLL is now preparing to initiate a complete development program which will have as much output in electronic form as can be managed. Changes in hardware, software, business system, communications, support, and personnel are all involved.

The changes which are taking place will extend communications from the CAD system to the SNLL central computing facility (file storage and communications hub for data), add file administration software for electronic definition elements, complete the transition of the drafting room from board drafting to electronic workstations, start a transition to a distributed design system, and add more CAD presence on site. In addition, the electronic links to the DOE production complex will be brought into use.

# ELECTRICAL SESSION 1
## CAE Tools for Microelectronics

# CAE TOOLS FOR DESIGNING RADIATION-HARDENED CIRCUITS

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Electronic designers at our national laboratories are faced with the challenge of designing circuits for unique applications that must function predictably under diverse conditions of radiation and temperature. Meeting functional and environmental specifications and predicting the circuit's behavior and performance over life require complex CAE tools. Some commercial tools are available, but the remainder must be developed through applied research in the fields of device physics and computer science.

Limited radiation effects analysis can be accomplished with CAE tools available today, such as SPICE. The analyst is generally concerned about circuit transient and long-term effects associated with photocurrent, total dose, and displacement phenomena. Long-term effects such as beta degradation, changes in leakage current, and threshold voltage shifts can be analyzed in a straightforward manner by changing the model parameters and rerunning the analysis. Transient effects analysis, effects during and shortly after the radiation event, present a considerably more interesting and potentially-useful challenge to the CAE community. To answer this challenge, CAE simulators need to provide designers with tools which address upset, recovery times, and transient beta changes. This need calls for modifications to analog circuit simulators, such as SPICE, which will allow the analyst to include data and predictions about device response.

The analysis of a CMOS circuit, presented as an instructive example, highlights the shortcomings and inaccuracies of our current capability and suggests research and software development needed for more accurate radiation effects analysis. These needs include: (1) a convenient way to add current sources that represent photocurrents generated at each p-n junction, (2) tools to help estimate or measure minority carrier lifetime, (3) a process for estimating how photocurrent divides between competing p-n junctions, (4) tools that will help extract physical dimensions from device layouts and automatically estimate photocurrent collection volume, and (5) software changes that will allow time-varying device parameters such as transistor gain.

## Digital Logic Simulation Using a High Level Language *

*By Paul Kunz and Gerard Oxoby*
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*Stanford University, Stanford, Ca 94305*

We have used a high level language, FORTRAN in our case, to simulate digital logic designs. Although the simulation is purely static, it does provide any level of detail from only the design algorithm or the full design, down to the gate level. Not only is the simulation very fast since it is compiled code but obviously it is inexpensive since the compiler already exists on the computers we used. After the circuit board is built, the simulation can also be used interactively as an aid to debugging.

We used this method in the design of the 3081/E main frame emulator. With such a complex system some operations are too overwhelming to be done with pencil and paper. For instances signed integer division is done iteratively two bits per machine cycle. There are three operations occuring in parallel each cycle: the divisor, two and three times the divisor are respectively subtracted from the partial remainder and the decision is made from the results to generate two bits of the quotient. This goes on for twenty cycles then a correction cycle occurs to provide the true quotient, remainder and the sign.

First of all we wrote a rough FORTRAN simulation to figure out the algorithm to extract two quotient bits per cycle. We assumed that the logic blocks were 32 bit wide and did simple shifts. Once the algorithm was understood we drew a block diagram of the subsystem and wrote a detailed simulation of the logic down to the gate level before generating the logic diagrams. Typically during the detailed logic design a designer will find some *better* alternatives, these were always tested with the simulation before being committed to paper.

During the debugging of the prototype we used the simulation to help in diagnosing errors; they were few and mostly due to drafting and wiring errors. The corrections to the few design errors were first verified with the simulation, the simulation was corrected and then the necessary wiring changes were made to the board.

Later on the FORTRAN program was cleaned up, comments were added to indicate the drawing sheet numbers and was used as documentation for testing the production of the boards.

As an example; let us simulate a two input multiplexer such as a 74LS257 integrated circuit. The data input are A and B, the data output is Y, the select line is S, and the output enable is E. The simulation would be a subroutine called MUX257, for example, with integer arguments A,B,Y,S and E it would be as follows:

```
IF( E .EQ. 0 ) THEN
F = 0
ELSE
IF ( S .EQ. 0 ) F = A
IF ( S .EQ. 1 ) F = B
ENDIF
```

One of the main advantages we found in using FORTRAN to simulate the logic was that the learning curve was very smooth since most of us have used this language before, also in an environment like SLAC it is very easy for the engineer to find help with the simulation software.

* Work supported by the Department of Energy, contract DE-AC03-76SF00515

# Hardware Accelerators Applied to IC Design

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Over the last four years, Sandia National Laboratories's Integrated Circuit Design Group has developed a state-of-the-art design system centered around Mentor Graphics software and Apollo workstations. While the vendor-supplied tools supply excellent front-end support, the Mentor tool set lacks high performance logic and fault simulation, as well as significant computational performance on such problems as circuit simulation and process, and device modelling.

Sandia National Lab has transparently integrated computational servers for logic simulation using the ZYCAD Silicon Solutions Mach 1000 Logic/Fault Engine. In addition, Sandia has developed a transparent interface for SPICE (MSPICE) simulation on an Alliant FX/8 computer. User interaction with the Mentor tool set is identical to that of operations performed strictly on an Apollo workstation. The designer sees a real-time performance improvement of approximately 5x to 10x using the Alliant computer as a computational server.

This paper describes Sandia's utilization of point accelerators to facilitate the design of integrated circuits and will also cover in depth the design environment around which this capability is structured.

# CAD ACTIVITY WITHIN THE ESONE COMMITTEE

*Pierre GALLICE*
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*91191 GIF SUR YVETTE CEDEX (France)*

In 1983, a Computer Aided Design working group (ECADE) has been set up in the ESONE Committee in order :

. to exchange information on CAD methods and systems for electronics between european laboratories ;

. to contribute to the portability of libraries used by CAD tools ;

. to coordinate the ESONE members efforts in the development of dedicated components.

This group comprises about 15 active members among 40 interested people. Up to now, its main activity was oriented to ASIC design. Beside the organization of 2 seminars (PADOVA in 84, dedicated to CAD equipments, and SACLAY in 87, dedicated to ASIC's) the group prepared 3 main documents :

- CAD system evaluation (ESONE/CAD/01) which is a matrix description of CAD equipments, commercially available in 1984, against a long list of criteria. Although the commercial information is partially absolete, the criteria list is still helpfull for new comers.

- List of CAD systems used in the ESONE laboratories (ESONE/CAD/02).

- List of dedicated components designed in or for ESONE laboratories (ESONE/CAD/03).

The group is also very much interested by the EDIF activity and maintain good connections with the international, european and national EDIF Committees. However, ECADE members being more CAD systems users than CAD designers, the practical EDIF activity in the ESONE laboratories is very weak.

Futures activities will be devoted to test facilities and Silicon compilers.

# ASIC's AND PCB DESIGN AT SACLAY

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Since 1983 CAD Systems are used for electronic designs at the CENTRE D'ETUDES NUCLEAIRES in SACLAY. The first activity was for ASIC's design in the framework of industrial instrumentation R and D. Three APOLLO-MENTOR GRAPHICS stations are in use for that purpose and several digital ASIC's have been designed on ECL or CMOS. Gate arrays in the range of 600 to 25000 gates.

Thse components are used for spectrometry in association with analog ASIC's also locally designed for peak sensing or charge measurement, for time of flight measurement, for radiation protection or for display.

APOLLO based CAD equipments are also used in the same department and in the Physics Department for PCB design. The PCB SECMAI software is used for schematics placing and routing ; MENTOR GRAPHICS software will also be used in the next future for simulation. VME, MULTIBUS I, IBM-PC and FASTBUS boards have been successfully design.

# VLSI for the Superconducting Super Collider

Stuart A. Kleinfelder
Lawrence Berkeley Laboratory

The SSC will be a historic engineering achievement requiring many advances in high speed instrumentation. Massively parallel systems of application specific integrated circuits will help achieve the fantastic levels of performance demanded. The Physics division at LBL is designing integrated VLSI systems for the present and future generation of High Energy Physics experiments.

LBL's first integrated circuit design was the SVX silicon detector instrumentation I.C. containing 128 channels of amplifiers, comparators, and digital logic. Next came a 30,000 transistor, 2,000 capacitor very high speed (100Mhz) analog waveform sampling integrated circuit. A unique and fast (100Mhz) 2Kbyte static FIFO/random access memory for flash analog to digital converters began fabrication recently. Our long term goals include the development of intelligent integrated pixel detectors suitable for use in the expected SSC environment.

Our successful approach to VLSI starts with the availability of robust design and verification software available from U.C., Berkeley. Our present generation of tools supports the creation of hand optimized analog and digital systems. Magic is a physical layout program for full custom designs. Technology independent, Magic performs continuous background design rule checking, automatic routing and hierarchical layout extraction. Extracted circuits are simulated using SPICE or ESIM. Synthesis utilities allow automatic generation of optimized programmable logic array and finite state machines.

A new generation of software that de-emphasizes physical layout in favor of abstract representations, synthesis and testing tools are now run too. Examples: VEM allows graphical editing of various symbolic and physical views of a design stored in the OCT database system. BDSYN and MIS automatically generate optimized multi-level combinational logic networks. Timberwolf and YACR are superior automatic placement and routing tools. Another set of programs are approaching a complete synthesis system for the sea of gates implementation style. The RPC package allows transparent execution of programs on multiple machines in a local area network environment.

After design, layout and simulation, circuits are expressed in a standard interchange format and sent via computer network to the Mosis prototype fabrication service. Mosis compiles multi-project wafers in 1.25, 2 and 3 micron CMOS (double poly or double metal), 3 and 4 micron NMOS (single poly, single metal). Mosis performs quality control tests, parametric measurements, and generates simulation parameters for each wafer run. Fabricated parts are tested at LBL using a micro-probe station, semiconductor parameter analyzer, a digital pattern generation and timing aquisition system, computers, and various analog signal generation and analysis hardware as needed.

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NET 1-2-3
Network Analysis Program (An Update)

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For several years we used the NET-1 program and, since 1975, the NET-2 network analysis program. NET-2 runs on the CDC-7600 computer but CDC-7600s are being replaced by Cray-1s. Because of the reliance of many engineers on NET-2, about a year ago we searched for a Cray-1 version of the program. This talk will describe what we found and where we stand in a Cray-1 NET-2 version.

The NET network analysis program had its origins at Los Alamos National Laboratory in the early 1960s. Allan Malmberg was an engineer involved with the design of high speed memory for the MANIAC computer, a high speed scientific research computer designed and built at LANL (then LASO). Research in developing computer programs electronic circuit analysis was being done within IBM by Frank Branin. Branin and his co-workers developed a program TAP (Transient Analysis Program) in 1958. Branin spent a summer at LANL and interested Malmberg in the development of a circuit analysis program. NET-1 was released in mid-1964 and included many new and unique features not present in earlier circuit analysis programs. When released, NET-1 ran on IBM 7090/94 computer, was written in IBM 7090 assembly language (FAP) and required that the user control the program at the operator's console. NET-2 was released in 1973 and had been rewritten in FORTRAN. CDC-6600 and IBM 360 versions were available. Later the CDC-6600 version was adapted to the CDC-7600 computer. At Livermore we have been running NET-2 (Release 9, September 1973) on CDC-7600 computers and have used it extensively over the years.

NET-2 offers many analysis features not found in more-widely known circuit analysis programs like SPICE-2. Defined subnetworks, stored models and stored model libraries, optimization, sensitivity, Monte Carlo, frequency domain, and time domain analyses are just a few of its features. The NET-2 program is one of the more powerful computer programs for analyzing linear and nonlinear electrical circuits and systems.

However, even though NET-2 is written in FORTRAN, it is largely undocumented and has only a hand-full of comments. Further, it makes intimate use of the computer it runs on. It is difficult to work with (from a programmers point of view) and to maintain. To overcome some of these drawbacks, a project was started at LANL by Tom Kelley to develop NET-3. NET-3 is now operational on the DEC VAX and Cray-1 computers. It uses essentially the same input semantics and syntax as NET-2, but nothing else is common to the two. NET-3 uses modern programming techniques and is well documented. Maintenance and program extensions will be much easier to do.

This talk will cover a little of the history of the development of the NET programs and will discuss many of their features by way of examples of analyses done at LLNL. The talk will also present some of details of our conversion of the NET-2 program to the Cray-1 computer and of the status of the latest release (June 1987) of NET-3.

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# PROGRAMMABLE LOGIC DEVICES*

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## ABSTRACT

Programmable Logic Devices (PLD's) are powerful, yet economic, digital devices. They offer digital designers a means to substantially reduce development time as well as reduce power and space requirements of digital electronics.

As a national laboratory, most of Sandia's projects require high density, low power hardware. In the past, we have met these requirements by designing and prototyping using 54/7400 level (TTL) logic, with the knowledge that the final package may require standard cell or gate array design. While adequate, this method has two distinct disadvantages. First, prototyping requires breadboarding/wire-wrapping, which is often extensive, especially when using 54/7400 level logic gates. Wire-wrapping is a time-consuming process and makes troubleshooting difficult. Simple design changes often require the wire-wrapping process to be completely repeated. Second, standard cell/gate array design is a costly and time-consuming process, especially when design changes are made after the chips go into production. Therefore, our goal is to reduce development time and eliminate the need for standard cell/gate array design whenever possible. With this in mind, we have begun to explore the use of PLD's.

In this presentation, I will discuss the use of the Altera Programmable Logic User System (A+PLUS) to design and implement digital circuits using Altera EPLD's (Erasable Programmable Logic Devices). Specifically, I will discuss the user interface to the PC-compatible A+PLUS as well as the EPLD architecture and performance. I will also include a design example.

* Work supported by the DOE.

# MECHANICAL SESSION 1
## CAD/CAE Integration

# DESIGN AND FABRICATION OF THE NSLS X-RAY SCRAPER: AN INTEGRATED APPROACH

*RUDY ALFORQUE, AND SUSHIL SHARMA*

NATIONAL SYNCHROTRON LIGHT SOURCE
BROOKHAVEN NATIONAL LABORATORY
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## ABSTRACT

The Phase-II project that is currently under construction at the National Synchrotron Light Source (NSLS) requires the installation of powerful insertion devices called wigglers into the X-ray Ring. These devices would allow the Facility to produce more powerful and intense synchrotron radiation that will greatly enhance the capability of the NSLS as the center of exciting research on this rapidly expanding field.

Preliminary calculations showed that a section of the vacuum chamber downstream of a wiggler would melt from the highly concentrated wiggler beam if this beam accidentally shifted in the vertical plane. It was, therefore, decided to flank each wiggler by a pair of vertical scrapers properly designed to withstand the expected thermal loads.

Initial engineering design concept of the scraper was laid out on the Computervision System. A preliminary design was agreed upon and then a thermal and structural analysis on the critical components was performed using the finite element method. This analysis was done using ANSYS which currently resides within BNL's VAX-Cluster. Hence, files were moved back and forth between the CV, and VAX systems until the final design was achieved.

Fabrication details were all prepared in the CDS 4000. Heavy emphasis was put on the use of nodal figures for the individual components. This technique has given us a taste of the more advanced and powerful features of the system.

When the job was submitted for fabrication to the Central Shops Division at BNL, critical components were identified for N.C. machining. Related files were activated by the N.C. group and fabrication tapes were generated. Finally, the parts were manufactured, inspected, assembled and installed. Thus, the cycle of an integrated approach to engineering design and manufacturing has been completed.

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# ROTARY SOLENOID DESIGN USING AOS/MAGNUM

Eugene A. Aronson

SANDIA NATIONAL LABORATORIES (SNLA)

Sandia has recently acquired the 3D, finite-element, electromagnetic code MAGNUM from CAD COMP of Milwaukee, WI, formerly A O Smith Data Systems. This code solves magnetostatic, magnetodynamic, thermal, electrostatic, electrodynamic, and electromagnetic problems with either linear or nonlinear materials in static cases and linear materials in dynamic cases. PATRAN is used to generate the MAGNUM input models and also to post-process the results. MAGNUM allows hexagonal, pentagonal, and tetrahedral three-dimensional elements.

Among other applications, MAGNUM is being used at Sandia in the design and analysis of cylindrical rotary solenoids. A FORTRAN code has been written to allow the designer to "easily" generate models of the "generic" rotary solenoids of interest, thus avoiding the relatively tedious PATRAN model generation. A similar code has also been written to easily model a class of linear (plunger) solenoids. A brief description of MAGNUM and these model generation codes will be given.

Of interest to the solenoid designer is the distribution of flux density to assess saturation regions in the solenoid, and of the torque (force in the plunger case) of the solenoid. Some sample results will be shown of the flux density distributions. The estimation of torque is not a simple matter. Presently, MAGNUM estimates torque by differencing the computed coenergy in two slightly different geometric models of the solenoid. We will present a torque estimation method which uses a material assignment method with a fixed geometry. Some torque results will be shown for these different method for various mesh refinements. These results indicate that the material assignment method yields better torque estimates for coarser models than the different geometric model method.

# DESIGNING SUPERCONDUCTING MAGNETS USING THE CAD/CAM SYSTEM

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Brookhaven National Laboratory

## ABSTRACT

Brookhaven National Laboratory is currently designing and manufacturing superconducting magnets for both the Relativistic Heavy Ion Collider (RHIC) and the Superconducting Super Collider (SSC) using commercially available computer aided design and manufacturing systems. The benefits and liabilities of CAD/CAM, based upon our experience, in terms of conceptual design production drawings, revisions and the functional integration with N/C will be discussed.

*Work performed under the auspices of the U. S. Department of Energy under Contract No. DE-AC02-76CH00016.

# Dynamic Analysis of Electromechanical Mechanisms

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The design and development process of complicated electromechanical devices can be significantly enhanced through the use of computer aided dynamic mechanism analysis. An overview of the steps performed in this analysis by the Electromechanical Subsystems Department at SNLA will be presented. From concept to prototype, this analysis assists in the design process by revealing failure modes and design margins.

This analysis starts with a CAD design definition of the mechanism's parts. Using this design definition, an input file describing the mechanism's geometry and part connectivity is semiautomatically created using the ANVIL-5000$^{TM}$/DRAM$^{TM}$ interface. This file is then input into DRAM$^{TM}$; a proprietary code which creates and solves the mechanism's differential equations of motion. Interactive graphic programs are used throughout this analysis for pre- and post-processing.

In this presentation, an overview of this analysis process will be discussed. In addition, several examples of how this analysis has contributed to our design process will be given.

# The Generation of Meshes for Finite Difference Analysis From a Solid Model Data Base

**Gary Laguna**
**Lawrence Livermore National Laboratory**

An issue of increasing importance to this nation's defense is the susceptibility of military and other critical systems to electromagnetic attack. One method that is used to determine the behavior of systems in such hostile environments is 3D finite-difference time-domain (FDTD) analysis. FDTD codes represent systems as collections of points on a uniform lattice or mesh. These points are then used to solve the differential equations describing the propagation of electromagnetic fields. Current and future problems require meshes having millions of points. Unfortunately, there are no satisfactory tools that automate the generation of such meshes for FDTD codes. Therefore, the Electronics Engineering Department at Lawrence Livermore National Laboratory initiated a research project to develop a mesh generator to provide meshes suitable for FDTD analysis.

Our approach to FDTD mesh generation is one of successive approximation. We start by defining the solid model of the object of interest. Next, the solid model is decomposed into equal sized cubes. Then we decompose the cubes into edges, resulting in the final mesh.

We are using our version of the solid modeler TIPS-1 to provide the geometric and topological data base necessary to decompose a part into cubes. This is accomplished by defining a rectilinear lattice over the part and then sampling the solid at each of the lattice node points. Each lattice node point defines a cube which is assigned the same material as the node point. The resulting cubic mesh is useful for mesh verification because it can be used with hidden surface graphics software, whereas the final mesh cannot. The cubic mesh must then be converted into a wire representation that can be used by our analysis codes. This is achieved by decomposing each cube into the twelve connected edges that define it. However, each edge is shared by four cubes, thus the edges of the final mesh are determined by examining the material value of each of the cubes sharing an edge and assigning the material value having the greatest priority to the edge.

Since the above technique will miss any detail that falls between lattice points, we are developing methods for detecting and meshing thin solids such as thin walls, thin slots and wires.

In summary, we have developed a preliminary mesh generator and have used it to create a mesh of an object of interest to the High-Power Microwave Program, namely an electrically detonatable land mine. We are continuing to develop features of the mesh generator to make it a more useful engineering tool.

# *AN UPDATE on SOLID/FEM INTEGRATION at SNLA **

*Patrick F. Chavez*
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*A previous talk described the benefits and difficulties associated with the integration of Solid and Finite Element Modeling (FEM) in 3-D. Also included in the talk was the current status in industry and academia on this effort. It was concluded because of the somewhat special requirements at Sandia National Labs, in particular the exclusive use of hexahedral elements for analysis, that an inhouse effort was required.*

*This presentation will describe the current status of the effort at SNLA with emphasis on the methodologies and techniques being used to generate strict hexahedral finite element meshes from a solid model. We utilize the functionality of the modeler to decompose the solid into a set of non-intersecting meshable finite element primitives. The description of the decomposition is exported, via a Boundary Representation format, to the actual meshing program which then uses the information to construct the finite element model. Particular features of the program will be discussed in some detail along with future plans for development which includes automation of the decomposition using artificial intelligence techniques.*

**This work performed at Sandia National Laboratories was supported by the U.S. Department of Energy under contract DE-AC04-76DP00789.*

# GENERAL INTEREST TOPICS

CAD/CAM NETWORKING - WHAT YOUR SALESMAN NEVER TOLD YOU

*A M. Peskin - BNL*

ENGINEERING DRAWINGS AND CHANGES: STORING AND CONTROLLING BY THE TENS OF TERRABYTES

*Jerry D. Stauffer - SNLA*

DESIGNING A SCIENTIFIC DATA SYSTEM: SOME SOFTWARE DEVELOPMENT PARADOXES

*Jonathan W. Lee - SNLA*

A MATRIX OF CAD/CAM APPLICATION REQUIREMENTS/DBMS CAPABILITIES

*M A. Ketabchi - University of Santa Clara*

THE EFFECTS OF CONSOLIDATION ON CAD/CAE IMPLEMENTATION AT HANFORD

*Bary D. Elison - BCS Richland, Inc.*

MECHANICAL COMPUTER AIDED ENGINEERING AT BENDIX KANSAS CITY

*William R. Freeman - Allied Bendix Aerospace*

ELECTRONIC CAD AT THE RUTHERFORD APPLETON LABORATORY

*D R.S. Boyd - Rutherford Appleton Laboratory U.K.*

SITE REPORT - CAE ACTIVITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

*Dale E. Evans - Idaho National Engineering Laboratory*

# CADCAM Networking - What Your Salesman Never Told You*

A. M. Peskin
Brookhaven National Laboratory


## Summary

The advantages of network based, distributed architectures for CADCAM systems are well understood. Networks of capable semi-autonomous workstations provide the advantages of independent user facilities, along with the ability to share major pieces of equipment, facilities, software and data bases as needed. Networking also fosters intergroup communications and promotes acceptance of standards. Brookhaven National Laboratory's CADCAM plans call for evolution to just such a distributed environment, typically using the Computervision/Sun workstation connected to an Ethernet, TCP/IP network.

There are, however, significant disadvantages to network based systems. Chief among them are the problems of increased system overhead, delays, utilization, security, reliability and maintainability. Network protocols introduce a degree of overhead that can deplete a medium of up to 90% of its bandwidth (in fact, with the popular "slotted aloha" ethernet scheme, a maximum of 36% efficiency is achievable). Furthermore, a network has all the properties of what mathematicians call an analytic queueing model which means, among other things, that there is an uncompromising tradeoff between resource utilization and user delay that must be delicately balanced. Security is at issue whenever data lines are strung and the problem is not limited to copper wire systems; recent research has recognized vulnerabilities with fiber optic media as well. Reliability and maintainability issues are fundamentally different for network based versus centralized systems and those differences must be dealt with.

The consensus is that the advantages of network based, distributed CADCAM systems outweigh the disadvantages. But in order to achieve successful implementation, the problems enumerated above have to be recognized, confronted, and ultimately overcome.


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# Engineering Drawings and Changes: Storing and Controlling by the Tens of Terrabytes.

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**Abstract:** Engineering drawings contain a lot of data. In the case of Sandia Albuquerque, we estimate that the engineering drawing film bank manages the equivalent of six terrabytes of data, including engineering drawings, engineering releases, and other engineering change paper. The ASCII text of seven million books would occupy the same storage. To store and access this data, the Design Information Management Department is planning a network of optical disk storage, image management workstations, compression and conversion software, and access and database software interfaces to traditional engineering data processing. There will be direct links into this "electronic film bank", access through the terminal switching network at Sandia Albuquerque, and task-to-task access by other software. In addition, the electronic film bank will allow electronic "wash-off" procession - e.g., drawing restoration, composites, and general editing - through satellite workstations networked to the central data repository. WORM (Write-Once, Ready-Many) optical disk storage is the medium of choice, with inability to erase data seen as a major desireable trait. Computer-aided design will be connected directly to the electronic film bank, and paper and microfilm documents will be entered through scanning. Documents will be stored in their original or scanned format, with conversion utilities available. Pilot workstations have already been acquired, with selection of the remainder of the hardware due in the next year.

# Designing a Scientific Data System: Some Software Development Paradoxes*

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The Product Test Data (PTD) System is a scientific data system for acquisition, storage, retrieval, and analysis of weapons and component test data which originates during component development/acceptance testing or from weapons quality assurance testing. A menu-driven system (MIRACLE) is designed for use by engineers in an interactive as-needed environment on a VAX cluster.

Three major components of such a system are the database, scientific functions, and end-user community. Characteristics of each lead to requirements which, when broadly summarized, reduce to versatility and friendliness. It can be easily demonstrated that these two requirements are diametrically opposed to each other. Consequently, design tradeoffs must be made in order to synthesize these requirements into a useful system

During the implementation of the initial version of MIRACLE, some paradoxes were discovered which had the effect of inhibiting rather than enhancing usefulness. Many common assumptions about user interfaces, top-down design, and utilization of 4th-generation software required rethinking. Specifically, is maximum friendliness an achievable constant? Are complex analytical tasks the most time-consuming? Is top-down design compatible with how end-users think? And are 4th-generation products as friendly as they claim to be? The resolution of these paradoxes and their implications in system design provide the foundation for future implementations of MIRACLE and other end-user systems.

* This work was performed at Sandia National Laboratories supported by the U. S. Department of Energy under Contract Number DE-AC04-76D00789.

## A MATRIX OF CAD/CAM APPLICATIONS REQUIREMENTS/DBMS CAPABILITIES

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**Abstract**

What kind of a DBMS can meet the data management requirements of CAD/CAM applications? A popular answer to this question is: object-oriented DBMS because CAD/CAM applications are object-oriented while conventional DBMSs have been designed to support set-oriented applications. Attempts to develop object-oriented DBMSs and objectify the conventional DBMSs reflect this fact.

But what is an object-oriented DBMS? There are significant differences among so called object-oriented DBMS which have been proposed so far. It seems that object-orientedness is not an absolute property. One can talk about the degree of object-orientedness or the level of object-orientation of a DBMS.

Rather than defining and classifying object-oriented DBMS and then arguing in favor of a certain class of them for CAD/CAM applications let us address the question directly. Let us define a matrix of DBMS capabilities by the data management requirements of CAD/CAM applications. We can then look at a given DBMS and decide which requirements of CAD/CAM applications are met by the system and which ones are not.

We will present and discuss such a matrix. We hope that the discussions at the workshop will lead to appropriate modifications of the matrix.

Assuming that the capabilities outlined in our matrix are exactly those needed in a DBMS intended to be used for CAD/CAM applications, the challenge is to provide them in an efficient, easy to use, coherent, and integral system, rather than as a loosely connected ad hoc collection of mechanisms. We will outline our approach to developing such a system.

# THE EFFECTS OF CONSOLIDATION ON CAD/CAE IMPLEMENTATION AT HANFORD

Bary D. Elison

**BCS RICHLAND, INC.**

A Subsidiary of the Boeing Company

## ABSTRACT

The consolidation of the contractors for The Department of Energy's Hanford Operations has provided an opportunity to redirect the focus and approach to the implementation of CAD/CAE technology at the facility. The various independent CAD/CAE operations previously run by each operating contractor in the preconsolidated environment are now part of a single operation. In this new environment increased emphasis is being placed on networking and data management. This report describes the near term plans for networking, data management, and the integration of existing and planned resources. Long range goals and plans for resource utilization are also discussed.

**Mechanical Computer Aided Engineering**

**at Bendix Kansas City**

William R. Freeman
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The Bendix Kansas City Division has been developing a Computer Aided Engineering/Finite Element Modeling (CAE/FEM) capability since the late 1970's. These analysis capabilities have been applied to production problems to improve quality, reduce scrap rates and minimize rework. A broad range of analysis types have been developed and are currently used to support weapon production programs.

Assembling the hardware, software and expertise to carry out CAE/FEM analyses has been the primary goal and has taken a great deal of effort, but the analysis capability itself has not been the only area of focus. One of the important goals of this program has been the development of analysis results presentation methods which are easily understood by the production engineers who have requested the analysis work. Color graphics has been used with great success in this area, and animation is currently being developed as a presentation tool for the near future.

Bendix CAE capabilities extend beyond the now commonplace linear stress and thermal analysis to include electrostatic and magnetostatic field analysis, 3D kinematics and dynamics, plastic injection molding simulation, plus simulation of highly non-linear behavior (geometric and material) such as metal forming and crimping processes. Examples of various analysis types will be presented, along with discussion of future directions for development.

# Electronic CAD at the Rutherford Appleton Laboratory

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Rutherford Appleton Laboratory (RAL), with a staff of about 1500, is the largest of four laboratories run by the Science and Engineering Research Council (SERC) in the United Kingdom. The principal role of RAL is to support the SERC-funded postgraduate research programme in the academic community by providing centrally a wide range of essential facilities in science and engineering. The laboratory also has extensive contacts with UK industry in many areas.

For the last 10 years, SERC has run a coordinated microelectronics programme providing facilities for electronic CAD, E-beam mask-making, silicon fabrication and IC testing. This presentation outlines the CAD activity at RAL established to support both research workers in universities and the laboratory's own in-house electronic designers. A wide range of electronic systems is designed at RAL. These range from multi-channel amplifiers linked to silicon detectors, to a set of digital image processing chips, to multi-board data acquisition systems for high energy physics and neutron scattering experiments. This work in turn requires access to a wide range of CAD tools for design, simulation, layout and test of analogue and digital ICs and circuit boards.

The strategy adopted in providing these tools has been to license established commercial CAD packages wherever possible. This frees valuable internal resource for the development of additional libraries, interfaces and utilities needed to weld these tools into an effective design system. An important factor in selecting commercial software has been its availability on more than one computer range. This has proved to be a sound criterion with today's rapid evolution of computer hardware.

The CAD software currently in use includes all the Silvar-Lisco software including DVP, HILO-3, ELLA, ISIS, GAELIC, REDCAD, SPICE, and a multi-sourceable 3 micron CMOS cell library. These provide access to a range of gate arrays and, using the cell library or full custom design techniques, to a number of commercial MOS or bipolar processes. This flexibility is important as the quantity of chips required for many of our projects is small. Other software developed in-house gives us access to a range of board technologies including wire-wrap, multiwire and PCBs. A number of other CAD tools are currently being evaluated on design projects including the SDA system and HSPICE. Work is just starting on the design of high frequency GaAs circuits.

The computing equipment available to designers comprises MICROVAX and SUN workstations, VAX and PRIME minicomputers and IBM and CRAY mainframes with appropriate network connections. Besides providing the software on internal machines, the CAD group distributes copies to university research groups under the terms of our licence agreements with the software vendors. An important aspect of the work of the group, both for internal users and university researchers, is the provision of a technical support service coupled with training courses and a user group.

Finally, the CAD group at RAL is involved in a collaborative R&D project on CAD for VLSI with a number of UK companies funded under the national Alvey Information Technology Programme. Links are also maintained with research laboratories in other European countries.

# SITE REPORT
# CAE ACTIVITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

by

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EG&G Idaho recently installed a CRAY X-MP/24 for the Department of Energy at the Idaho National Engineering Laboratory (INEL). The system is running UNICOS, version 3.0 which is CRAY's premier operating system. Front-ending the system are three SUN gateways as well as a CDC CYBER 176 running NOS, which are being networked to user locations via Ethernet and a local area network. Acceptance testing of the CRAY has just been completed, and was accomplished within the initial 30-day acceptance period.

The INEL has traditionally used mainframe computers for nuclear reactor simulation modeling and for supporting other scientific and engineering applications. There are currently about 1000 registered users, of which, approximately 200 are regular users, and 50 are daily users. Over the past few months, the Scientific Computing organization has served as the lead organization for software conversion to the UNICOS environment.

A major project which is currently underway is the acquisition of a Computer Aided Engineering system, to be used in engineering design, analysis and documentation, and which will be focused on mechanical and A-E (Architectural Engineering) mechanical applications. Over the next year, efforts will be directed toward the implementation of the new CAE system and toward placing the more complex engineering analysis codes onto the CRAY X-MP.

# ELECTRICAL SESSION 3
## Selected Topics in Electronic CAE

# GATE ARRAY CIRCUIT DESIGN AT LLNL

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A semi-custom integrated circuit (IC) system has been developed which enables designers to efficiently produce novel high speed, high density, digital designs with fast turnaround and low costs. Our evolving design system, which currently supports the RCA 2700-gate CMOS/SOS Variable Geometry Automated Universal Array (VGAUA), also affords designers low power, highly reliable circuits at a level of integration (VLSI) which is sufficient for producing systems integration on an IC. These design capabilities are being provided in the form of a nearly completed system which begins with schematic entry and simulation of a design and is concluded with in-house fabrication, packaging, and testing of parts.

The development of this technology provides many benefits for the Laboratory. One of the most attractive features of designing with gate arrays is that it allows fast prototyping of designs. This is of prime concern for designers responsible for developing complex, novel circuitry which is to be used in field experiments. The fast turnaround of prototypes made possible by gate arrays will permit designers to be more creative and to optimize their designs while staying on project/program schedule. The present degree of complexity of digital designs is such that bread boarding of prototypes is becoming much too costly and unreliable and is often impractical. Designs implemented using a gate array approach allows systems integration on a chip or chip set. This allows for reduction in size and weight of new or existing designs; thereby permitting the development of smaller instrumentation packages needed, for example, in down-hole testing and telemetry applications. Since the RCA gate array we are using is based on CMOS/SOS technology it offers the advantage of radiation hardened circuitry with good to excellent noise margins, and CMOS latchup immunity.

As a result of our efforts, we have attained a state-of-the-art design capability. While there are gate arrays available with higher gate counts than the RCA array, they are typically bulk CMOS arrays which are inherently and substantially slower. We feel we have exceeded the state-of-the-art in some measures by developing a system which allows our designers to essentially "realize" IC's from their desk top. In short, we have progressed in providing a design methodology which, through the use of advanced computer aids, allows LLNL designers to capture, simulate, manufacture and test new innovative circuits needed by the Programs. Specifics of our design system and methodology will be covered in this presentation with emphasis on computer aids.

*Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

# The Future of Computer Integrated Manufacturing in the Center for Radiation Hardened Microelectronics

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The Center for Radiation Hardened Microelectronics (CRM) has initiated a project which will provide a state-of-the-art computer-aided manufacturing system for integrated circuits. In the long term, the project will integrate design, manufacturing, and test data bases generated during the manufacture process.

The design system utilizes Apollo workstations running Mentor Graphics software. Product tracking is performed using Consilium COMETS software running on VAX mainframes. Test data is generated on a variety of integrated circuit testers, with data collection and storage occurring on a VAX computer. All computers in the system are tied together, utilizing a local area network. DECnet and Ethernet TCP/IP protocols are utilized in a cooperative fashion.

This talk will discuss the foundations which we have developed for providing a computer integrated manufacturing system for the CRM. The cooperation between Bendix (Albuquerque) operations and Sandia in developing this capability will be highlighted.

# Project WhiteStar: The Sandia National Laboratories Semiconductor Radiation Effects Database

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Sandia National Laboratories is developing and implementing a comprehensive database of semiconductor piece-part characteristics. The initial concept defined a modest database of radiation-effects test data on semiconductor devices, but was quickly expanded and has become Project WhiteStar. Project WhiteStar is a cooperative effort between specialists in semiconductor components, electronics design, radiation effects, CAD/CAE, information modeling, and computer programing. It will result in a database which will include electrical parameters, package description, radiation effects data, simulation (e.g., SPICE) models, and administrative information such as cost and stock quantity on all semiconductors qualified at Sandia for use in the design of radiation-tolerant systems.

Early in the program an information modeling tool was introduced as a means of optimizing the design of the database. The tool is based on Nijssen's Information Analysis Methodology (NIAM) and has resulted in a normalized, neutral schema for the database which is free of duplication of information and is flexible enough to accept the vastly diverse sets of parametric data which describe the many different semiconductor devices of interest. The neutral schema results in an adaptable database which easily accepts new classes of devices or device models. The modeling technique is flexible enough that portions of the model (sub-models) can be reused in implementing future applications, such as capacitor and connector databases.

We have succesfully used software pipes to directly implement a prototype model within a selected database management system. A test version of the database has been completed which operates on a PC with a minimal data set. This version is being used by electronics designers to evaluate the menus, screens, and output formats and develop a user-friendly interface. The semiconductors of interest have been identified, and available data are being collected. The production version of the model is presently under review.

The use of concise and easily understood models aided communication between the diverse groups participating in the database definition. The information modeling tools helped establish realistic project schedules and estimates of required manpower, allowing the project to remain on schedule and within budget.

Data Engineering: A New Challenge in the CAE Environment*

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The emergence of Computer Aided Engineering (CAE) has resulted in major developments in computer hardware and software. However, the consequent flood of machine-readable information has made it clear that specialized hardware and software are not enough; methodologies must be devised for coping with the information itself. Even if online storage capacity were unlimited and processing power infinite, the engineering information system exists to support human engineers, with human limitations on perceptual capabilities. For example, the use of computers for product test and evaluation has been beneficial but the resulting flood of data is enormous; we can easily provide an engineer with far more information than he or she can assimilate. Data Engineering can be defined as the application of information theory and related disciplines from an engineering point of view. Three IEEE sponsored international conferences on the subject in as many years are an indication of the growing interest in Data Engineering. Concerns which have been addressed include the use of computers for intelligent inference, the theory of database organization and design, data coding and transmission, and certain topics in information theory. However, there is very little, if any, literature available that addresses the practice of Data Engineering, especially Data Engineering in a scientific/engineering environment - i.e., is there such a professional as a Data Engineer and how does one practice Data Engineering? This paper is intended to

- define Data Engineering as a profession,

- illustrate the need for professional Data Engineers, and

- provide motivation for an engineering viewpoint toward the acquisition, transmission, storage, and use of data.

An example of the practice of Data Engineering will be given: the Data Engineering project associated with the Weapon Databases at Sandia Laboratories. The responsibility for formal determination of database contents, specification for data acquisition, communication, transformation, and storage, and the plan for computer analysis of test data for most Sandia-designed weapon components rests with this project.

* This work was performed at Sandia National Laboratories supported by the U. S. Department of Energy under Contract Number DE-AC04-76DO0789.

# An Engineering Data Management and Analysis System for Diagnostic Measurement Systems *

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This report identifies a problem area that is in need of research and development in CAE. Specifically, in designing, developing, installing, and utilizing the results of diagnostic measurement systems there is a need for an effective computer-based means for handling and analyzing the volumes of data that can now be collected using the modern data acquisition systems. This engineering data management and analysis system should incorporate the following features:

o Direct data paths from the DA systems to the EDM&A system providing the data for timely analysis and rapid turn-around in the engineering process

o Engineering databases composed of time, spatial and spectral signal data, and the associated support data which provides information about <u>what</u> are the essential characteristics of the signals, and <u>how</u>, <u>where</u>, <u>when</u>, and <u>why</u> were they collected.

o Support information entry with data type validation and database reconcilition so that the person indexing and storing the engineering data into the database need not be the person accessing this data.

o Signal data manipulation, processing and plotting capability integrated into the data management system so that the user can do both interactive and algorithmic signal data reduction and analysis

o Internal data model organized for fast retrieval which also provides the access points into the signal database for relevant retrieval

o External data views tailored to the needs of the various users; the operator, experimentalist, designer, etc.

o Archival so that the databases can be restored where subsequent analysis is necessary.

One approach to the general solution of this problem will be presented based on the needs of three engineering endeavors: high energy electromagnetic pulse effects on electronic systems, developing instrumentation for nuclear tests, and instrumentation of high explosive tests.

In this approach the physical structures for the internal data model is based on using a relational database management system; the support data entry and signal data retrieval capabilities are based on using a four generation nonprocedural language for this RDBMS; and the signal reduction and analysis capabilities are based on SIG, a signal processing code, which is being combined and integrated into the RDBMS.

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore Laboratory under contract No. W-7405-Eng-48.

# The Product Data Network:
# a Prototype Circuit to the QA System Test Lab*

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During 1983, we proposed an interactive computer network which could make weapon evaluation data available to Nuclear Weapon Complex engineers having the proper need to know. By 1985, an increasing DOE concern towards computer communications security put a hold on our efforts to extend the network then in place. Currently, we are pleased to report a resurgence in the effort to establish this network. An experimental link running full-function DECnet with Sandia's security enhancements is being set up to connect the Product Test Data and System Evaluation (PTD/SE) VAXcluster with Sandia's Quality Assurance System Test Laboratory in Amarillo, Texas.

## Environment

The existing environment is a data acquisition, storage, retrieval, and analysis system used to support engineering and system-evaluation applications of product test data. The computer support is provided by a VAXcluster consisting of three CPUs plus a large disk farm and tape drives centrally controlled through HSC mass-storage controllers. The operating system on the cluster is VAX/VMS Version 4.5 with security enhancements developed by Sandia. Full-function DECnet is also installed on each CPU within the secure partition of Sandia's Distributed Computing Network (DCN). Future applications may feature expanded office automation, data distribution, and remote analysis.

## Communications

In addition to local terminals, VAX DECnet and Remote Job Entry (RJE) links to Sandia's Central Computing Network (CCN) are connected over high speed computer links. Access to the ELSENET computers at other Nuclear Weapon Complex sites is provided by VAX Gateways within the CCN.

## Prototype Circuit

An encrypted, 56 Kb/s circuit has been installed using satellite communications to support a point-to-point connection with Sandia's Quality Assurance System Test Laboratory at the Pantex plant in Amarillo. The link is currently implemented as a prototype and is supported with MicroVAX computers. Ultimately, the circuit is planned to be incorporated directly into the VAXcluster as another DECnet link.

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**Networking Personal Computers**
**at**
**Sandia National Laboratories**

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This presentation consists of two major themes. First, for those contemplating the installation of a PC network, there will be a discussion of components and general design considerations for personal computer local area networks (PC LANs). Topics that will be covered include LAN technologies, media requirements, servers, work stations, applications, standards, interconnections, performance, and security.

The second portion of the presentation will constitute a case study of two PC LANs at Sandia National Laboratories. Here, each network will be examined, and the factors that influenced their design will be discussed. The first network is an Ethernet LAN supporting office automation and distributed communications functions in Sandia's Design Engineering Services Directorate. It includes 50 PCs, six minicomputers, five terminal servers, and internetwork gateways to integrate three separate locations. The second network is a document processing system for engineering specification writers. It is an Ethernet LAN supporting 25 users in three locations in an environment where security is a vital concern.

# MECHANICAL SESSION 3
## Selected Topics in Mechanical CAE

AN OVERVIEW OF ROBOTICS AT LOS ALAMOS NATIONAL LABORATORY
*W. Dan Powell - LANL*

PRODUCT DEFINITION MODELING AND SRAM II PROGRAM
*Donald L. Vickers and Derek Wapmam - LLNL*

STRUCTURAL ANALYSIS USING PATRAN AND ABAQUS-RESULTS FROM TWO RECENT PROBLEMS
*Steven P. Girrens and Peggy A. Goldman - LANL*

CPRF/ZTH TOROIDAL CONDUCTING SHELL FINITE ELEMENT STRESS ANALYSIS USING GFEM (GRAPHICS FINITE ELEMENT MODELING)
*C.L. Baker and G.D. Dransfield- LANL*

PROVIDING AN INTERFACE BETWEEN COMPUTER AIDED DESIGN (CAD) AND FINITE ELEMENT MESH GENERATION
*Vera D. Revelli - SNLL*

MATERIALS INFORMATION FOR SCIENCE AND TECHNOLOGY (MIST):
*John L. McCarthy - LBL*

# An Overview of Robotics At Los Alamos National Laboratory

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## Abstract

The Robotics Section of the Mechanical and Electronic Engineering Division has a programmatic effort to implement robotics and automation in a wide variety of applications at Los Alamos National Laboratory. The primary objective is to apply robotics and process automation technology to select areas of nuclear materials handling and processing operations. The overriding impetus is the reduction of low-level radiation exposure to operating personnel.

These goals are being realized by employing modern industrial and laboratory robots and developing unique automation and robotic systems to enhance processing of nuclear materials. Because the robotics industry focuses on major production markets, the nuclear-industry-related problems such as equipment sized for glovebox operation, construction materials that are radiation and corrosion resistant, and systems that will operate in corrosive and/or inert atmospheres need to be addressed.

The Robotics Section has realized several of these major goals in the nuclear material processing mission and is now beginning to apply the capabilities of robotic technology to other research efforts at Los Alamos. These new initiatives include the following: the design of a custom gantry robot; automation of molecular biology processes in support of the Human Genome Project; use of artificial intelligence and knowledge-based systems; automation and robotics for the planned Space Station mission; and other areas of research and development.

# Product Definition Modeling

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SRAM II Project
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For years the Nuclear Weapons Complex (NWC) within the Department of Energy (DOE) has taken an active role in pushing technology toward computer-integrated manufacturing (CIM) of mechanical product. They have demonstrated the ability to electronically transmit information, visually equivalent to an engineering drawing, between dissimilar systems. In addition, three-dimensional (3D) geometric information can be transmitted.

A necessary next step along the road to CIM is the development of a product definition that is complete, unambiguous and "computer-intelligible." Information modeling techniques provide the best approach for developing such a definition. Accordingly, an NWC project was initiated with the goal to: "(1) adopt, develop, and validate PDES models that contain information for product lifecycle support, enabling enhanced exchange and utilization with reduced human interpretation, and (2) recommend a path for production-worthy implementation." PDES (Product Data Exchange Specification) is a national effort to model and standardize mechanical product definition.

This presentation will contain an overview of the product definition project, a status report, and a discussion of information modeling.

1 July 1987

STRUCTURAL ANALYSIS USING PATRAN AND ABAQUS-RESULTS FROM TWO RECENT PROBLEMS

Steven P. Girrens and Peggy A. Goldman
Los Alamos National Laboratory

Recently, we have undertaken the structural analysis of two complicated systems using PATRAN for pre- and post-processing and ABAQUS for stress-displacement solution. The first problem considers a two-dimensional axi-symmetric model of a 90,000-psi pressure vessel illustrated in Fig. 1. The vessel consists primarily of a steel tube with threaded plugs inserted at both ends. The objective of the analysis was to investigate thread stresses developed in two design concepts. Problems overcome during the analysis to obtain the thread load comparison shown in Fig. 2 will be discussed.

The second problem is a three-dimensional analysis of representative equilibrium field and ohmic heating coils for the Los Alamos ZTH reverse-field pinch fusion machine to determine stresses developed due to Lorentz-force loading. Because of the complex coil configuration in cross section (copper conductors embedded in an epoxy insulating matrix), the study was performed in three phases consisting of a bulk orthotropic material property determination, a bulk material coil section analysis, and a detailed composite cross section of selected thickness analysis. The computational procedures developed to obtain stress-displacement results for complex field coils will be presented.

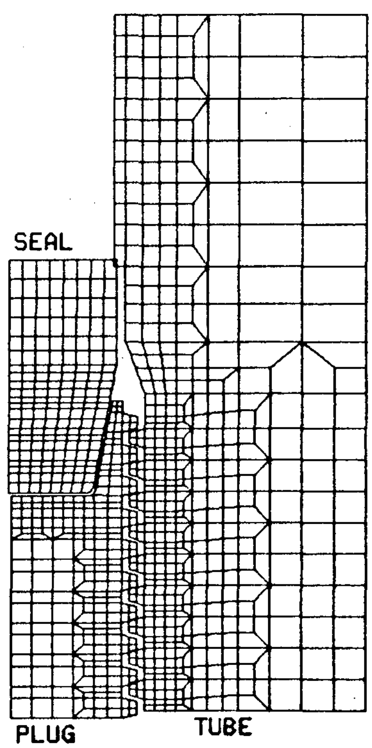


Fig. 1. Pressure vessel mesh.

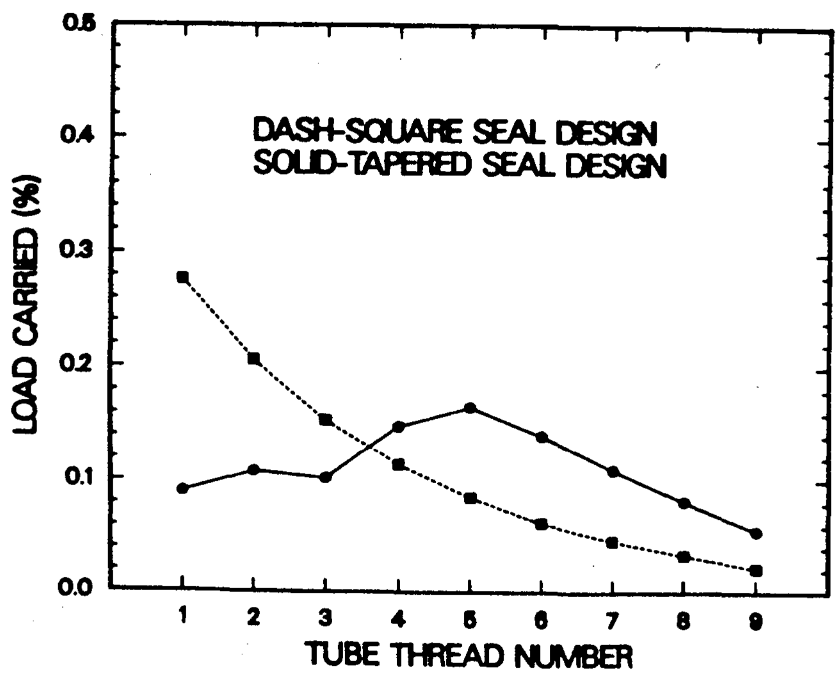


Fig. 2. Thread load comparison.

# CPRF/ZTH TOROIDAL CONDUCTING SHELL FINITE ELEMENT STRESS ANALYSIS USING GFEM (GRAPHICS FINITE ELEMENT MODELING)

C. L. Baker, MEE-12
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Design is in progress of a new generation reversed field pinch (RFP) machine to be fabricated and assembled at Los Alamos National Laboratory during FY86-92. The Confinement Physics Research Facility (CPRF) houses the front-end ZTH/Torus.

The finite element model was created directly from Unigraphis II geometry using the Graphics Finite Element Modeling software (GFEM). The geometry was taken from the actual layout of the shell assembly. A wire frame 3-D model was created from that layout. The wire frame model was then surfaced in preparation for the generation of elements. The flanges, channel sections and liner were modeled using 8-node elements that allow for curved surfaces. The asymmetric magnetic forces that act on the shell were introduced locally in the model using moments, point loads and pressure vectors. Due to the complex interaction of the magnetic loads from the inner vacuum liner to the shell, a second inner shell representating the liner was modeled.

Due to the complex interaction of the magnetic loads and the modeling of the toroidal shape, the present model is undergoing further development to assure that the correct approach is used to accurately describe the operating system.

# PROVIDING AN INTERFACE BETWEEN COMPUTER AIDED DESIGN (CAD) AND FINITE ELEMENT MESH GENERATION*

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Advances in Computer Aided Drafting (CAD)/Computer Aided Engineering (CAE) are getting closer to allowing stress and thermal analysts relatively easy access to the CAD database. In the past a significant portion of an analyst's effort was spent in manually entering geometric information from engineering drawings to form his model. The process of using CAD definitions completely eliminates this time consuming, tedious and inherently error prone task. Some of the time gained is lost to the new tasks of transmitting, translating, and revising the CAD data. It is unfortunate that at the current level of development these new tasks, though still expeditious compared to the old method, are fraught with their own problems - some procedural and some technical. The biggest obstacle to overcome is a way of limiting the data transmitted to that which is needed in the mesh generator. This can be easily accomplished at the CAD workstation but most engineers cringe at the thought of having to learn the CAD system, and turnaround may suffer if it is necessary to wait for an available CAD draftsman.

Some vendors are now incorporating analysis codes directly into their systems. However, since most DOE installations have specialty and established codes, this direct route is not really viable.

Four basic components are necessary to establish an efficient and effective link between CAD and Finite Element Modeling:

1. A convenient hardware link between the two systems. At Sandia, Livermore, this communication is done with Ethernet** protocol over a fiber-optics cable.
2. User friendly software for translating and limiting the CAD data. The user should be able to specify some basic requirements for the transferred geometry such as: removing all curves with radius less than r, or collapsing a three dimensional plate into a surface.
3. A CAD workstation set-up and a prepared instruction set so that the engineers can access and manipulate the CAD data essentially without prior "training". It is important to prepare a straightforward, self explanatory, instruction set of basic commands for simplifying the database. These should include: extraction of a layer, removing entities, extending lines, and translating entities.
4. A "system manager" to help infrequent or first-time users. No matter how well the first three items are done, there will will be questions and problems to be solved. This is an informal position and can best be filled by a frequent user of the system – perhaps one involved in its installation.

It is important to develop this link as a process rather than a single translation code so as not to overlook time consuming or problematic steps.

* *Work supported by the U.S. Department of Energy under Contract DE-AC04-76DP00789*
** *Ethernet is a trademark of Xerox*

# Materials Information for Science and Technology (MIST)

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MIST is a prototype demonstration system for information on material properties. It has been developed by the Lawrence Berkeley Laboratory for the U.S. Department of Energy, with additional support from the National Bureau of Standards and Sandia National Laboratories. The MIST Project is part of LBL's Scientific Information Management Research Program, which investigates how computer assisted information management can increase scientific research and development productivity; improve data quality; expedite dissemination of new results; reduce duplication of effort; decrease program delays; shorten the time between concepts and production; and identify significant gaps in current knowledge.

There are two generic types of queries for material properties databases. On the one hand, users want to retrieve property information for certain specified materials, much as they currently do using printed handbooks. On the other hand, they also want to find out what materials satisfy a specified set of property constraints (e.g., "find materials where tensile strength $>$ 40 ksi and resistivity $<$ 15E-06 ohm-cm and density $<$ 10 g/cc"). The latter type of question is very difficult to answer using conventional printed sources.

Initial data for MIST includes numeric tables and graphic representations on some 100 mechanical and structural properties for about 150 metallic materials, drawn from Military Handbook 5 and the Aerospace Structural Metals Handbook, plus a substantial amount of experimental data on pressure vessel steels from the Electric Power Research Institute. A central thesaurus on materials, properties, testing procedures, and related terminology supports automatic conversion between different nomenclatures, measurement units, etc.

MIST project participants are working closely with standards organizations such as the American Society for Testing and Materials and CODATA to harmonize naming conventions for materials, properties, independent variables, etc., as well as a materials data interchange format. Many of these groups are looking to MIST to provide some of the initial *de facto* standards regarding data elements, quality indicators, display formats, etc.

Initial MIST users include selected materials scientists and engineers from four of DOE's national laboratories plus sponsoring members of the Material Properties Data Network, Inc. -- a consortium of trade association and corporate members. Users can access MIST via computer networks (such as Telenet) as well as via direct dial telephone lines. They can search for materials that satisfy specified property constraints and retrieve fully documented information on results, including data source references and quality indicators. Results can be automatically linked to bibliographic citations and telephone numbers for organizations or individuals. Users can download selected subsets of data directly into their local systems for analysis, simulation, and CAD/CAM applications. Designated sites will be able to upload new experimental results for prompt peer review and addition to existing MIST databases.

If the initial system is successful, the next steps will be to make MIST a distributed system and extend its coverage to non-metallic materials. In the future, MIST's meta-data may also facilitate automatic access to various other material information systems.

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# ELECTRICAL SESSION 4
## CAE Systems for Electronic Engineering

# A UNIQUE APPROACH TO THE EVALUATION AND SELECTION OF AN ELECTRONICS COMPUTER-AIDED DESIGN AND DRAFTING SYSTEM

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Electronics Engineering Department
Lawrence Livermore National Laboratory

The Engineering Services Division of the Electronics Engineering Department recently acquired a workstation based computer-aided design and drafting system (CADD) for electronics schematic capture and printed wiring board (PWB) design applications. The systems were evaluated against a detailed set of requirements that covered the areas of 2-D drafting, PWB applications, and system operations. We used a unique approach to benchmark the final candidate systems which evaluated how each system performed at every phase of the electronics design cycle, from schematic capture to CAM output.

This presentation will address the process we went through in making our PWB design system selection. We will describe the process was used, beginning with requirements preparation and ending with the selection of the vendor who best met our requirements. We will discuss the unique series of benchmark tests that were used to evaluate the final candidates. We will also describe our requirements for communications with remote CAE systems and other CADD systems.

# BUILDING AN INTEGRATED ELECTRONIC CAD/CAE/CAM OPERATION USING SEVERAL SOFTWARE PACKAGES

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Starting in 1982 with very limited funds, Electronics Engineering at LBL has progressively built a fully integrated CAD/CAE/CAM facility. We recognized early the trends in CAD/CAE/CAM:

- Individual workstations
- Central database for parts' libraries
- Drawing backup and archival
- Open-ended software

Although it is clear that the benefits of integration warrant its pursuit, the dramatic evolution of hardware and software, lack of standards for archival and retrieval, as well as the need to spread CAD workstations in the engineering community, have constituted a serious challenge in a limited funding environment.

An essential feature of all the software we have chosen to use in this system is that the packages are either completely open-ended or a database access tool is provided by the vendor. In all cases, data can be extracted from the database and corrected for use by other programs. Data can also be formatted according to the database and retrieved as a drawing. The result is that data can be transported from the engineer's desk to simulation and/or fabrication with no manual data re-entry.

Despite this "Babel tower" approach, full database transfer, including graphics, has been established through the down-loading of parts specifications and the up-loading of drawings through the hierarchy of software. But the success of the system relies on a centralized library of schematic parts, printed circuit footprints and simulation models to facilitate the transfer of data from one software to another.

Archiving has been achieved under a unique format and files created on machines and softwares long obsolete are still retrievable. The ability to retrieve archived files is fundamental to the concept of the integrated system. Without it, previously archived data cannot be accessed.

The dramatic evolution of hardware and software has spawned specialization of workstations and software. We use IBM PC/AT class machines for entry level workstations for schematics at the engineer's desk; manual/semi-automatic entry for printed circuit board development and general drafting workstations is done by well-trained personnel using HP200/300 workstations at 2 Mips, and a limited number of powerful HP300 workstations, ranging from 2 to 4 Mips, are used for digital simulation, autoplacement, autorouting and linkage to testing, with appropriate exchange facilities between different soft -ware.

The development and operation of a facility with these capabilities requires substantial effort in programming and operations support. This includes the development of tools and utilities and proper training in their use to aid in steering daily system operation. Without such effort we feel that it will be extremely difficult for any institution to operate a successful CAD/CAE/CAM electronics' system.

*This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.*

# MANAGEMENT OF ELECTRONIC LIBRARIES IN A MULTI-SOFTWARE/HARDWARE CAD/CAE ENVIRONMENT

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The Electronics Engineering CAD/CAE facility at LBL operates in a multisoftware and hardware environment. Three different schematics entry packages are integrated with an autorouter/ autoplacer and linked to N.C. machines. The CASE TECHNOLOGY schematics package on the IBM PC/AT and compatibles and HP EGS on the HP9000 series 300 computers are used as entry points to the HILO3 simulator and the PCDS autoplacer/autorouter.

Full integration of the various databases relies on the unique representation of symbols throughout the entire operation. Components to be used on a printed circuit board are designed under EDS, with simulation models specified where applicable, including pointers to the autorouter database for footprints and functionality. Other parts are designed under HP EGS and downloaded to the CT2000 schematics entry package.

The task of managing libraries in a rapidly expanding world of devices and workstations faces a number of complex challenges, including:

- Synchronization of parts development between software packages
- Quality assurance for parts design and transfer
- Distribution and upgrades of parts on remote workstations
- Maintenance of a central and up-to-date library
- The ability to update drawings if parts are updated

Hewlett Packard provides only the transfer link between EDS and PCDS, the rest of the library management utilities and operating procedures must be written locally.

Although quality assurance of parts is essentially manual, utilities have been developed to decrease human intervention in parts transfer. In addition, procedures and software have been written to facilitate the comparison of parts lists by the automatic creation of a delta file between the different software packages. Similar utilities will be available shortly to synchronize remote sites with the central facility.

Using a central library is the most reliable method of avoiding the duplication of parts, creating quality parts, and expanding the range of library parts. However, strict procedures must be followed in order to maintain a smooth operation with remote sites. Thus, as libraries grow, very systematic methods must be employed to restrict write access to parts libraries, to distribute parts to remote sites and to keep library maintenance as a high priority on a CAD/CAE environment.

An integrated electronic CAD/CAE system can be very cost effective to operate, however, it relies entirely on the quality of its libraries and the development of procedures and utilities to insure a clean library operation.

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# Experience Using an IBM PC Based CAE Package for a Large Project *

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We report on our experiences using an IBM PC based CAE package to produce a large digital system. The system involved was the 3081/E microprocessor which consists of 5 processor boards averaging over 200 MSI circuits each. Using our system, three designers sharing one IBM PC were able to produce X-Y netlist tapes for Multiwire fabrication of three of the boards in only 6 weeks, including the time to learn the system. This report will outline the benefits of the system as well as its deficiencies and how we attempted to make up for them.

An important and time consuming task in carrying a large project is the schematic capture. However, at the time, to use the large centrally supported CAE system at SLAC required our designers to submit the circuit schematic on paper for CAE operators to enter it into the system. We found this unacceptable as not only did the designers not benefit from the time saving of doing his own design on a computer, but also even small boards came back from the operators with numerous errors that required several iterations between the designers and the operators before the schematic was correct. Thus instead of saving time by using a CAE system, it cost a lot more.

When the first PC based electronic CAE packages were introduced, we decided to purchase FutureNet's DASH-1, in order to put the schematic capture on the designer's desk. In terms of functionality, response time and cost effectiveness for schematic capture one can find little fault with the system. Our designers worked on the system from block diagrams which were only a little better than back of the envelope sketches. Learning to use the system was also very quick and easy. In a mere six weeks elaspsed time, three designers sharing one IBM PC were able to complete the design of 3 boards with over 200 MSI components each.

However, the DASH-1 schematic capture lacked other ingredients to carry the project from schematic to completed boards. Namely, we needed a board layout and a X-Y netlist for Multiwire fabrication. We found out that we could circumvent these deficiencies quite easily.

First of all we needed to have a graphic representation of the circuit board layout. We used a full screen text editor with cut and paste function, each component is represented by characters and the spaces between characters and lines represent a known distance, one tenth of an inch in this instance. Having done the layout, a simple program reads the layout file and the netlist file generated by the DASH-1 to generate a netlist in X-Y format suitable for the Multiwire services.

Another benefit of the X-Y netlist is the generation of a rat's nest which can be displayed using graphic utilities available. The layout can then be edited to minimize the areas with a high density of wires.

The Printed Circuit layout for the core of the Multiwire boards was done on SLAC's large CAE system. A program was written to convert data from the layout file to a format that could be uploaded to this system on which Gerber photoplotter compatible tapes were produced.

With an inexpensive system and a small amount of time spent in the development of software, we are now able to carry out a large project to completion with the benefits of a highly interactive PC based CAE system on the designer's desk.

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# LOW-COST CAD TOOLS CHALLENGE HIGH-PRICED SYSTEMS FOR ENGINEERING PRODUCTIVITY

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Low-cost CAD/CAE tools have often been regarded as toys to be used for amusement rather than as engineering tools. However, low-cost schematic capture and PCB design tools are capable of quickly generating production quality electronics on a personal computer platform. Added to these tools, a low-cost mechanical CAD package completes a construction package.

Present low-cost, PC-based schematic capture and PCB layout software tools can capture large flat file or hierarchical drawing structures, with the number of drawings limited only by the available mass-storage space. The complexity of the schematics is limited by libraries and by one's imagination in building them. Among the features available to easily generate multilayer boards are printer, plotter, and Gerber output capability, as well as the ability to generate power and ground planes, split planes, filled planes, and surface-mount designs.

An electronics project using two low-cost CAD software packages (Tango* & Orcad*) for schematic capture, netlist generation, autorouting, and PCB layout will be presented, with particular emphasis on problems and limitations and how those limitations were overcome. The project includes 9 schematics in hierarchical structure and 10 PCBs. These PCBs consist of 1 ground plane board, 2 six-layer boards, 1 mother board, and 6 two-layer boards. Seven of the ten boards have card edge connectors making for easier maintenance interchangeability in the future. Providing documentation and manuals for such projects are generally improved and considerably easier to generate. Given the trends in the last 2 to 3 years toward greater power and utility, even the few limitations experienced with CAD-CAE tools today may soon disappear.

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* Trademarks

# SCHEMATIC DESIGN TRANSFER USING NEUTRAL FILE FORMATS

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The need to transfer schematic design databases between CAE, CAD, and CAM systems is becoming ever more frequent with the introduction of schematic capture software packages running on PCs and local engineering workstations. Engineers are generating schematics on their local workstation, then testing their designs with simulators. Engineers want to send the completed schematics to the design and drafting group for documentation preparation and printed circuit board design. The environment consists of many heterogeneous workstations using many different software packages for schematic capture. Some of the workstations are connected to a laboratory–wide network. Complete reentry of the schematic is often the only way to get the schematic into the printed circuit design system. A transfer of the design database from the CAE system to the CAD system, through a neutral file format, would solve this problem.

This presentation will address the general problem of schematic design file transfer between heterogeneous systems. We will discuss how some of the common neutral formats, namely IGES 3.0, EDIF 2.0, and IPC–350, address the problem. We will also talk about some of our experiences in working with IGES and EDIF.

# INTEGRATING PRINTED WIRING BOARD CAM MACHINES INTO THE LABORATORY–WIDE NETWORK

Roland Portman

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The Lawrence Livermore National Laboratory (LLNL) Fabrication Special Processing Group had been using paper tape as the only medium of data transfer between PWB–CAD (Printed Wiring Board - Computer Aided Design) systems and their two PWB–NC (Numerical Control) machines. An alternative transfer medium was needed to provide continued and enhanced support for an increasing number of CAD and PWB workstations since many of the new workstations do not provide paper tape output.

A system has been designed which connects the NC machines to the network via a $\mu$VAX computer. Software running on $\mu$VAX gives the NC operators new capabilities previously not available on standalone NC machines. The system will meet the following objectives :

1. Replace paper tape as the principal medium of data transfer.
2. Provide a communications link between the network and the NC machines.
3. Provide archival and control of data.
4. Provide data editing capability.

This presentation will describe the motivation for change, the various alternatives, the benefits, our decisions, and the reasons behind those decisions.

# MECHANICAL SESSION 4
## CAD/CAM Applications

THE AUTOMATIC GENERATION OF PIN WIRING DIAGRAMS
*Cary B. Skidmore - LANL*

INTERCONNECTIONS 3-D ROUTING WITH SOLID MODELING
*Edwin D. Machin - SNLA*

INTEGRATION OF CAD INTO LOS ALAMOS LINEAR ACCELERATOR PROTOTYPE DESIGN
*T.O. McGill - LANL*

AUTOMATIC GENERATION OF UNIFORM GROUP TECHNOLOGY PART CODES FROM SOLID MODEL DATA
*Arlo L. Ames - SNLA*

AN INTELLIGENT CAD-CAM SYSTEM
*Alan H. Bond, Basuki Soetarman, Dong H. Kim, Ozia Ahmed, and Kang Chang - UCLA*

IGES EVALUATION AND SITE PRESENTATION
*H. Fulton, B. Kross, M. Leininger, F. Markley and J. Rauch - FNAL*

# THE AUTOMATIC GENERATION OF PIN WIRING DIAGRAMS

Cary B. Skidmore

Los Alamos National Laboratory

A three-dimensional array of electrical pin wires is commonly used as a diagnostic tool for testing implosion systems at Los Alamos National Laboratory. The pins are insulated piano wires charged to 300 volts. An electrical signal is discharged when contact is made with a grounded, imploding metal shell. The pin wires protrude radially through holes drilled in a phenolic pin dome which is placed inside the shell assembly. Typically there are 450 - 600 pin wires protruding from the spherical portion of a pin dome, 0.60 - 1.00 inches in diameter. A pin wiring diagram is automatically generated to serve as a visual aid to the drilling and wiring of the pin dome. The procedure for generating a diagram involves transferring information from a data file to a CAD system to be plotted. This procedure is described below.

Initially, a pin array is designed and the data are stored on a VAX computer. A FORTRAN program is employed to extract from the data file the location and size of the holes that need to be drilled in the pin dome. Location is specified by polar and azimuthal angles and size is designated by L (large) or S (small) diameter since only two sizes of wire are used. Each hole will have a single wire passing through it so a unique pin number serves as the hole identifier. Also extracted is the pin wire length designator or pin level number. There are a variety of hole locations which will have wires protruding the same radial distance from the center of the pin dome. Wires of the same radial length are grouped together as a level and the same color of wire insulation is used for all pins within a level. The FORTRAN program extracts the necessary information and uses it to write a Graphics Programming Language (GPL) program. The GPL command lines are written using FORMAT statements containing the appropriate text and parameter values.

The FORTRAN program outputs the GPL source code as a text file, which can be sent from the VAX to a CYBER CAD machine and compiled. The GPL program, executed inside ICEM DDN (Control Data's CAD System), draws circles corresponding to the location and size of each hole to be drilled. Each circle is labeled by pin number and colored to correspond with pin wire length or level. The circles and numbers are overlaid in the appropriate one of five views of a sphere. These pin dome views reside as a part file in ICEM DDN which is merged into a new part file before executing the GPL program. The completed pin wiring diagram is plotted at a magnified scale and used by the technician as a guide when drilling the holes and routing the colored pin wires through the dome. The automatic generation of such a diagram is a unique process of data transfer in a CAD application.

# INTERCONNECTIONS 3-D ROUTING WITH SOLID MODELING

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## SUMMARY

The Interconnections Division at Sandia National Laboratories is responsible for the design of cables for many weapon programs. A request for cables is first in the form of a request memo, followed by a material request schedule, (MRS). The MRS should be accompanied with a Control Drawing, (CD), which specifies the electrical, physical, and environmental requirements. The Interconnection Division completes the cable design based on the information provided by the CD.

Determining the routing of cables is usually required before the physical dimensions of the cable or cable branch can be found. Cable routing in the past has been determined by using string on wood mock-ups or by an educated guess using 2-D drawings. This has lead to the initial interconnection information to be incomplete and or inaccurate due in part to the lead time between the mock-up assembly and the design of the subcomponents.

The Interconnections Division, with the support of the Design Definition Department, 2850, has been exploring the use of solid modeling software to determine the routing of cables. The approach being explored uses the solid model of each subcomponent placed in an assembly of the weapon. This assembly is then used to determine the best route for the cables. As subcomponents are designed, the solid model of those components are placed into a library. These models can be withdrawn by designers to create assemblies pertinent to their area of interest. Should a database be opened that contains a subcomponent that has been modified since the last use of the database, the users are notified that changes have been made to that library component. The user then replaces the old component with the new one in the solid assembly. All users of that component can then determine if the component change affects their area of responsibility.

The CD drawing, the cable graphic drawing, (AY), and all associated mechanical assembly drawings are electronically generated from the assembly solid model.

Solid model vugraphs from a current program will be used to show the results of this exploration. The presentation will address the advantages, concerns, and possible problem areas of this method of determining cable routing and the generation of drawings.

# INTEGRATION OF CAD INTO LOS ALAMOS LINEAR ACCELERATOR PROTOTYPE DESIGN*

T. O. McGill
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Abstract

The Ground Test Accelerator is a prototype design for a space-based target discriminator. The Free Electron Laser is a ground-based prototype linear accelerator, wiggler and optical resonator for high power demonstration. These two projects are the first undertaken by Los Alamos Accelerator Division primarily using computer-aided design. The selection, acquisition, and implementation of CAD hardware, and training of personnel began concurrently with the start of the projects. This report includes methodologies, problems, solutions and observations in retrospect.

*Work performed under the auspices of the U.S. Department of Energy and supported by the U.S. Army Strategic Defense Command.

# Automatic Generation of Uniform Group Technology Part Codes from Solid Model Data

by
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Group technology part coding is a procedure for classifying parts based on design and manufacturing characteristics such as part shape, function, materials, and tolerances. In current practice, a human examines a drawing of a part according to the rules in a part coding specification in order to obtain a part code. This process is often nonuniform, due to misinterpretation or ambiguity of the part coding specification or drawing details. Identical parts can be coded differently based on any number of variables.

The boundary representation of a solid model is expressed in terms of low-level geometric entities, such as vertices, edges, and surfaces, while a part code specification is written in terms of higher-level entities, such as symmetries, holes, and diameters. Recognition of patterns in geometry and topology is required to locate higher-level entities within the low-level part description. This recognition process is called feature recognition.

At Sandia Labs, an expert system which uses feature recognition to automatically generate Multi M (OIR) part codes from solid model boundary representation data is being developed in the S.1 expert system shell. This software is expected to increase the uniformity of part coding by applying a single systematic algorithm to the task. The current status of this development will be presented.

# An Intelligent CAD-CAM System

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An integrated intelligent CAD system has been designed and implemented by combining VM/PROLOG and CADAM on an IBM 4341 mainframe. We discuss the system issues in integrating an artificial intelligence system like Prolog with a computer-aided design system like CADAM.

The end result is an integrated intelligent CAD system, called CADLOG, which allows the user to interact through one screen to
(i) work graphically in the conventional CADAM system
(ii) write application programs in Prolog, or a mixture of Prolog and Fortran
(iii) interact with his application program, setting Prolog goals and monitoring results in Prolog
(iv) produce modified drawings in Prolog and display them in CADAM

We have built up an intelligent CAD model The model provides 3D wireframe, surface and surface feature representations in both Prolog and Fortran, and higher level structures in Prolog which include volumes, manufacturing features and spatial relationships between faces.

The main application area is the design and manufacture of assemblies made of sheet metal and extrusions, as components of aircraft. The work is funded in part by a research collaboration with Lockheed Aircraft Company of Burbank, California.

We describe several CAD/CAM Expert System programs that we have designed and implemented using the CADLOG system. They include
(i) a design checker for sheet metal designs,
(ii) an automatic dimensioning program
(iii) an automatic 2D to 3D conversion program, and
(iv) a process planner for machined parts
Work in progress includes also (v) an intelligent simulation system for FMS systems, and (vi) a database for sheet metal assembly designs. (vii) a system for automatically generating GT codes for sheet metal parts.

# IGES Evaluation and Site Presentation

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Fermi National Accelerator Laboratory*

Fermilab is in the process of acquiring a new central computing engine as part of the implementation of a totally new central computing facility. A tactical decision has been made to use that central facility to support the mechanical design, analysis, manufacturing, inspection and surveying activities of the laboratory.

The current configuration includes a Cyber 875 and 3 175's supporting the design and NC activities using ICEM, a Control Data product. Finite element analysis is supported on a VAX Cluster using ANSYS and, recently, SDRC IDEAS. Inspection is centered around a Cordax coordinate measuring machine. The survey group uploads field data to the VAX Cluster for use by other groups. The current trained user base includes approximately 100 designers and drafters, 10 finite element analysts, 20 machinists, and 3 inspectors. The terminal hardware currently available to these individuals is the following Tektronix devices: 14-4105, 24-4107, 17-4207, 1-4109, 48-4209, 4-4111, 2-4125, 1-4128, 3-4114. These terminals are augmented by a variety of digitizing tablets, mice, HP Plotters and spooled Talaris Laser printers. Two main machine shops with NC equipment are supported on site.

In anticipation of the implementation of a new system, an evaluation process was begun in the spring of 1986 to allow selection of an appropriate software package by early 1988. An integral and parallel part of that evaluation process has been an internal evaluation of the applicability of using a solids based modeling approach for the entire design, analysis and manufacturing process. A special concern has been to integrate the data from the survey and alignment group into the design process and to ensure that the analysts, machine shop and inspection department can directly use the designs generated.

IGES may be the only economically feasible way to meet the requirements to transfer drawings. Existing drawings must be transferred to the new software; it is likely that more than one software solution will be required to meet our internal needs; most experiments involve participation by many institutions, all of whom have different systems; 95% of the lab's machining is done by local vendors who also have a variety of systems. The alternative to IGES, custom translators, is prohibitivley expensive given so many different combinations of systems. No attempt has been made to critique the IGES standard itself, but to simply document the results of (attempted) IGES transfers between ICEM and a number of different packages under evaluation.

* Operated by Universities Research Association, Inc. under contract with the U.S. Department of Energy

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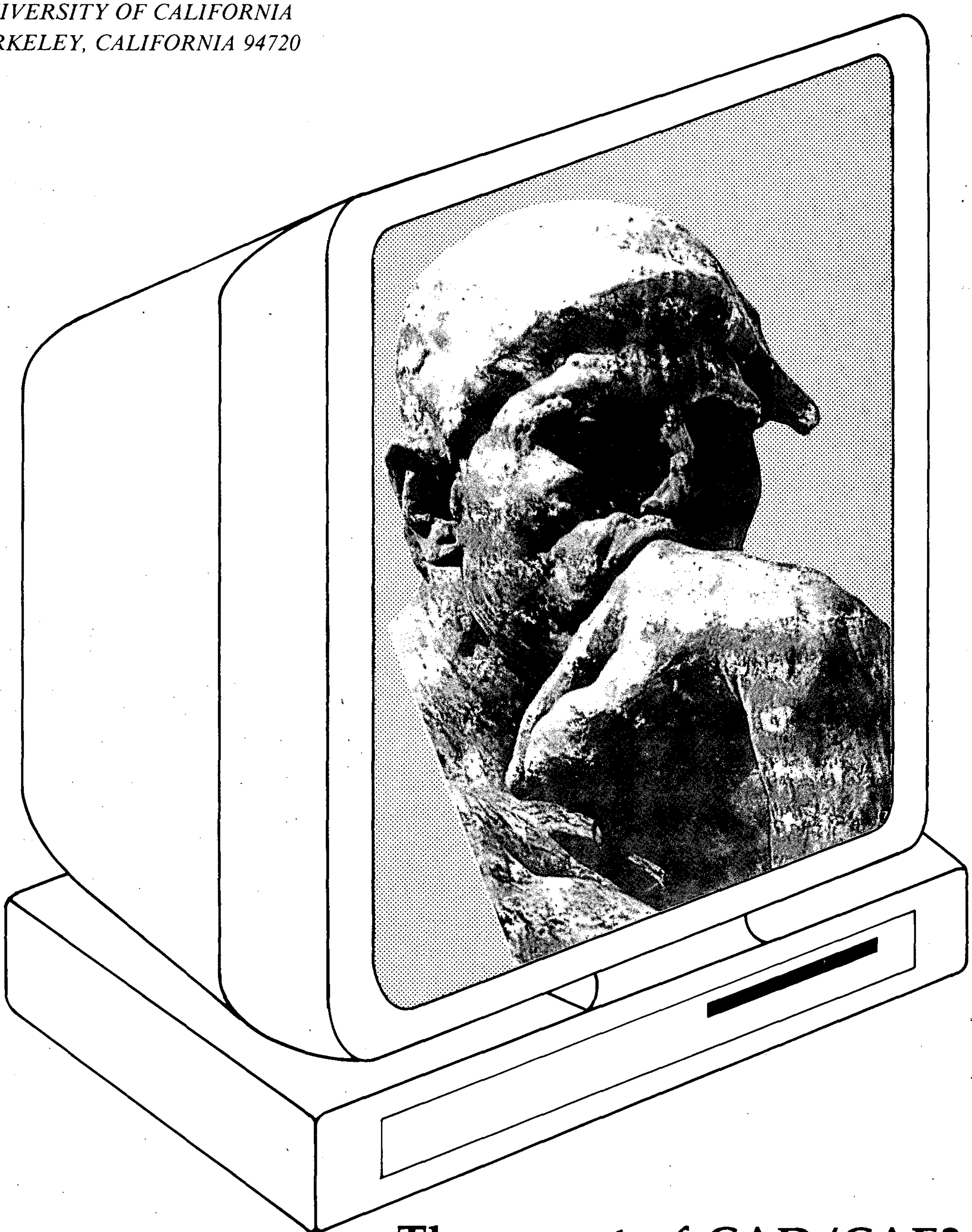

# The ascent of CAD/CAE?