AUTOFACT 4

Conference Proceedings

AUTOFACT® 4

Conference Proceedings

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in cooperation with:

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PREFACE

Faced with the most severe economic conditions and productivity challenges of the last 50 years, the United States and other major free world countries may be on the verge of a significant turnaround during the 1980's. The underlying computer and automated systems technology exists today for implementing dramatic changes and improvements in the ways we manufacture the products our society needs and wants.

Organized on the theme of integrated CAD/CAM systems, this AUTOFACT 4 Conference addresses the most significant topics that can help reverse declining productivity in the industrial sector. Almost all studies and qualified experts who have formally investigated the manufacturing productivity problems agree that properly planned investment in integrated manufacturing systems will probably yield more gain for the effort than other technology investment alternatives (not to say we can do without the others).

These Proceedings highlight the status, real experiences, and methods for implementing CIM systems.

Your Conference Steering Committee and CASA/SME staff very much appreciate the responses to the call for papers. Many excellent papers could not be selected for this program but will be considered for inclusion in other conferences. I thank the Steering Committee for their considerable thought in selecting the abstracts, guiding the speakers, and optimizing the program to achieve the objectives of this Conference. Dedicated to a new level of conference quality is an outstanding CASA/SME AUTOFACT staff. These people will continue during this conference to insure that you receive maximum value from your attendance.

Most important, we thank you for participating in this vital conference. The Committee and staff sincerely hope you find this to be the most worthwhile program you have ever attended!

Rex L. Nelson, Chairman
AUTOFACT 4 Conference

about CASA/SME

The Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME) was founded in 1975 to provide comprehensive and integrated coverage of the field of computers and automation for the advancement of manufacturing.

As an educational and scientific association, CASA/SME has become "home" for engineers, managers and other professionals involved in computer-based technologies and automated systems. CASA/SME is applications oriented and addresses all phases of research, design, installation, operation and maintenance of the total manufacturing enterprise. AUTOFACT 4 is one example of its wide-ranging activities.

Specific CASA/SME goals are to: (1) provide professionals with a focus for the many aspects of manufacturing which utilize computer systems automation, (2) provide liaison among industry, government and education in identifying areas for further technology development, and (3) encourage the development of the totally integrated manufacturing facility.

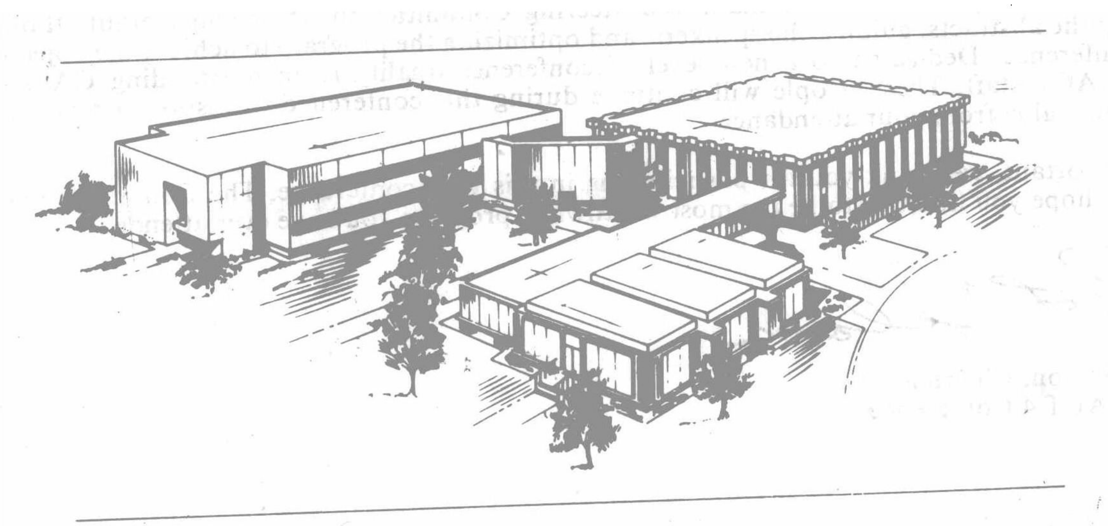

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TABLE OF CONTENTS

CHAPTERS

INTEGRATION SESSION (DAY 1)

1 Applications of Computer Graphics at General Motors
By *James F. Yevtich*
General Motors Corporation 1-1

The Strategic Management of Technology
By *Charles S. Skinner*
Booz, Allen & Hamilton Inc. 1-6

DOCUMENTATION SESSION

2 Basic Technical Illustration Techniques on a 3-D CAD/CAM System
By *John A. Cuozzo, Jr.*
Computervision Corp. 2-1

The Role of Solids Modeling in Engineering Documentation
By *Russell J. Doty*
Applicon 2-12

Computerized Wire Information and Release System
By *Robert M. Beers*
Boeing Commercial Airplane Company 2-23

Parts Lists Derived from Digitized Mechanical Drawings
By *A.J. Becampis, P.E. Niedercorn, J.W. Ross* and *C.R. Warburton*
IBM Corporation 2-30

Publishing a Computerized Technical Manual
By *T.J. Keane*
Boeing Commercial Airplane Company 2-47

ANALYSIS AND SIMULATION

3 Computer Integrated Approach to Design and
Simulation of Hydraulic Circuits
By *Don Riley, Fatih Kinoglu, Max Donath* and *Dennis Torok*
University of Minnesota 3-1

Response Animation of Finite Element Models
By *Burdett K. Stearns*
General Electric Company 3-15

Application of Advanced Computer-Aided Engineering Tools for Kinematic and Dynamic Analysis of Robot Systems
By *Imdad Imam* and *Samuel Levy*
General Electric Corporate Research & Development 3-28

Integration of Computer Aids for Digital Engineering
By *David F. Cahn, Peter Denyer* and *Charles A. Wilson*
Comsat General Integrated Systems 3-52

Finite Element Analysis for Managers
By *Jeffrey M. Steele*
Stress Technology Incorporated 3-69

DESIGN SESSION

4

An Integrated System Utilizing Solid Modeling Techniques for the Design and Manufacture of Mechanical Parts
By *Harry E. Davine*
General Electric Company 4-1

IGES Data Exchange Between Dissimilar CAD-CAM Systems
By *D.F. Theilen* and *J.F. Jones*
Bendix Corporation 4-20

CAD Applications for Sequence Controls and Programmable Controller Documentation
By *Les Spear*
Craft Line, Inc. 4-46

The Ford Graphics System: Local Processing, Central Control
By *Robert W. Parrott*
Ford Motor Company 4-56

Automation/Productivity—CADMAT
By *Floyd C. Bergsten*
General Electric Company 4-61

INTEGRATION SESSION (DAY 2)

5

The Systems Approach to Automation in the Modern Plant
By *B.J. Haupt*
IBM Corporation 5-1

SCHEDULING AND MATERIALS SESSION

6 Implications of Distributed Processing in Computer Integrated Manufacturing
By *Richard C. Winfrey*, Ph.D.
Digital Equipment Corporation 6-1

Integrating Design, Process Planning and Numerical Control Through the Use of Standard Programs and the Computer (CIM)
By *Willard Burge*
Eaton Corporation 6-12

Simulation for Design and Scheduling of Flexible Manufacturing Systems
By *Kenneth Fox*
Cincinnati Milacron Inc. 6-27

Unmanned Collection and Processing of Shop Floor Machining Data
By *Richard A. Mathias*
CAMTECH Inc. 6-37

PROCESS FACILITIES SESSION

7 DNC Evolution at Westinghouse Electric
By *James R. Finn, Jr.*
Westington Electric 7-1

Computer Managed Process Planning—A Bridge Between CAD and CAM
By *Charles F. Sack, Jr.*
United Technologies Research Center 7-15

An Approach to Control System Design for ICAM Flexible Sheet Metal Manufacturing Cells
By *Theodore M. Caridi* and *Kirk A. Gutmann*
Booz, Allen & Hamilton Inc. 7-32

A Rational Approach to Deburring for Flexible Manufacturing Systems
By *C. Andrew Wan*
National Bureau of Standards 7-54

Technology Modernization at Lockheed-Georgia
By *Joseph Tulkoff*
Lockheed-Georgia Company 7-72

MANAGING THE INTRODUCTION OF NEW MANUFACTURING TECHNOLOGY SESSION

8 Improving U.S. Industry's Competitive Position: Strategy for Success
By *Harry B. Thompson*
A.T. Kearney, Inc. 8-1

Integrated CAD/CAM: A Case History & Management Perspective
By *P.H. Ness* and *H. Jacobson*
Boeing Aerospace Company 8-9

Factory Simulation: Approach to Integration of Computer-based Factory Simulation with Conventional Factory Planning Techniques
By *J.B. Comly, P. Rao, B. Keramati* and *H. Jaster*
General Electric Corporate Research & Development 8-29

ECAM—Electronic Computer-Aided Manufacturing
By *Alfred C. Robinson* and *Carl R. Soltesz*
Battelle Columbus Laboratories 8-42

Managing Technological Change in Manufacturing
By *Jamshed D. Elavia*
Reed Rock Bit Company 8-53

Potentials and Limitations of Robotics: Guides to Managerial Evaluations
By *Bela Gold*
Case Western Reserve University 8-60

EDUCATIONAL FORUM

9 Fostering the Development and Growth of Manufacturing Engineering Research—A View from Academia
By *Albert B. Bishop*
Ohio State University 9-1

Integrating CAD/CAM in Drafting/Design Associates Degree Programs
By *Jack W. Thompson*
Macomb Community College 9-13

Innovative CAD/CAM Training
By *James A. Schretter*
Automation Strategies, Inc. 9-24

The College CAD/CAM Consortium—An Update
By *Larry G. Richards*
University of Virginia 9-40

Methods for Industry—Academia Interaction for Mutual Productivity
By *Timothy J. Greene*
Virginia Polytechnic Institute and State University 9-49

MATERIAL HANDLING SESSION

10 Automatic Storage and Retrieval in the Automated Factory
By *Darrell B. Searls*
Jervis B. Webb Company 10-1

AUTOMATED ASSEMBLY SESSION

11 Robotic Assembly and Computer Integrated Manufacturing Systems
By *Richard P. Chynoweth*
IBM Corporation 11-1

Robot Automated Temperature Check System
By *B. Seth, John G. Kourtesis* and *L.A. Sylvia*
Texas Instruments Incorporated 11-10

CAD Model Input for Robotic Sensory Systems
By *E.W. Baumann*
McDonnell Douglas Automation Company 11-25

Heirachical Control of Intelligent Robot and Vision Allows Plug-In System Integration
By *Gordon I. Robertson*
Control Automation, Inc. 11-35

Programmable Conformable Clamps
By *M.R. Cutkosky, E. Kurokawa* and *P.K. Wright*
Carnegie-Mellon University 11-51

A Robotic Wire Harnessing System
By *Brian R. Carlisle*
Unimation Inc. 11-59

QUALITY, INSPECTION AND TEST SESSION

12 CAD/CAM Applications in Quality Assurance Receiving Inspection
By *Geoffrey B. Wilson*
IBM Corporation 12-1

Machine Manufacturing Management and Quality System
By *Shirley S. Reilich*
Xerox Corporation 12-18

Paperless Quality Assurance Operations
By *Thomas H. Poyer* and *Thomas Nolan*
General Electric Company 12-33

ABSTRACTS

Abstracts of papers that were not submitted in time to be included in proceedings 13-1

AUTHOR'S INDEX 14-1

CHAPTER 1

INTEGRATION SESSION (DAY 1)

Applications of Computer Graphics at General Motors

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Abstract

Interactive Computer Graphics Systems, which was developed by General Motors to take automobile exterior surface data from the clay model through the design cycle into major tools, continues to be the most important computer-aided engineering tool used in the Corporation. Other computer graphics systems are in regular use throughout the Corporation for non-body automotive component product engineering and design activities. Although some mechanical component design is occurring at the component/supplier units, there is still a need for solving design/drafting and analytic problems on large cast components that are not handled well with the wire-frame technology afforded by most systems today. General Motors is now developing an in-house capability in solid geometry modeling called "GMSOLID" that will address these problems.

In the early 1960's, General Motors was faced with an ever-increasing work load due to the addition of a considerable number of new product programs. The new product programs were of such a number as to cause concern that the traditional method of acquiring data from the full-size clay model of the automobile via hand-cut and fitted templates and drawings could no longer keep pace with this higher level of work load. In searching out new ways to attempt to achieve these new assignments, computer-aided engineering and manufacturing techniques were explored.

In a joint effort between several General Motors technical staffs, divisions and IBM, a project was launched to provide a mathematical model of the full-size clay model that could then be converted to hard tools, including die models, stamping dies, checking fixtures, assembly and welding fixtures through computer-aided, numerically-controlled processes. This early attempt was a single console computer graphics system called DAC-I (Design Augmented by Computer). This was, for its time, a fairly sophisticated system utilizing an IBM 7094 processor and a jointly developed refresh console.

Subsequent development work and new hardware eventually caused this system to be replaced by two new systems called CADANCE (Computer-Aided Design and Numerical Control Effort) and Fisher Graphics. These two new systems have been running in a regular production environment since the early 1970's and have matured into systems that provide computer-aided engineering facilities for the design and manufacturing of internal structural body panels, as well as the exterior surface panels originally planned when these systems were developed. Both of these systems run on large IBM mainframe computers and utilize refresh design consoles furnished by IBM, Digital Equipment and Adage. The software for these systems was developed and is maintained by General Motors. These systems now support the external body surface panel and internal structural panel design at General Motors staffs and divisions, including Design Staff, Advanced Product and Manufacturing Engineering Staff, Research Laboratories, Fisher Body, Buick, Cadillac, Chevrolet, Oldsmobile, Pontiac, GMC Truck & Coach, AC Spark Plug, Guide, Inland, Harrison Radiator and one overseas unit -- Adam Opel in Russelsheim, West Germany. There are approximately 400 consoles running CADANCE and Fisher Graphics throughout the General Motors Corporation.

Let us now examine a typical body panel design from its creation in the Design Staff studio right through to the part delivery at the assembly operation. The quarter panel that we will study begins as part of a total vehicle concept with renderings and blackboard drawings, as well as reduced scale models in the design studio. After the vehicle concept is approved by management, a full-size clay model is developed in the same studio.

Upon completion and approval of the full-size clay model, a three-dimensional digitizer or point picker is employed to extract the three-dimensional raw data from the clay model. Through a series of programs developed at General Motors, this raw data is smoothed, refined and eventually passed on to the product designer who, through the use of both the CADANCE and Fisher Graphics systems, will complete the design of the panel, including attaching flanges, holes, reinforcements and adjacent panels. During the design process, this same data is also used to perform engineering analysis routines on the individual panel and on the panel as part of the total vehicle structure. Using the design graphics system CADANCE, a finite element model is built in an application program called SMUG (Structural Modeling Using Graphics) which is then input to a NASTRAN program for analysis. Both static and dynamic analysis can be accomplished using this same computer graphics data. The product design process is then completed, including the hardline design layout and details of the panel generated.

This product design computer graphics data is now ready to be passed on to several subsequent operations in the tool and die design process. One of the first operations to receive this data is the N/C group of the Die Engineering Activity, where by transferring the surface data from Fisher Graphics or the CADANCE system into another system developed at General Motors called the Network Station, end mill tool paths are developed for a three-axis mill to cut both hardwood die models and, in some cases, the steel dies to produce the stampings. Another group in the Die Engineering Activity also receives the same panel part geometry data via a computer graphics file transfer into a vendor-supplied turnkey system for the actual die design. The use of color in this die design function is of great benefit to the designer, since the product part geometry and standard die part geometry can be isolated using color, thus allowing the designer to concentrate on the new area to be designed.

The Product Engineering Activity also receives this same computer graphics product part geometry early on, since this operation is responsible for the major fabrication tool layouts. Such tools as welding fixtures, press welders, robotic welders, material handling and assembly checking fixtures are just some of the major tools employed in the production of subassemblies leading to the total assembly of an automobile that are designed on computer graphics systems at General Motors. Once again, the product part geometry is electronically transferred from the major GM graphic system into a vendor-supplied turnkey system, where the fabrication tool design is completed. The large number of standard components used in the major fabrication tool design is ideally suited for a computer graphics system. Such items as standard posts, clamps, weld guns and other components are easily recalled from the computer library and placed where required in the design. Color is playing an ever-increasing role in this activity also for the same positive results as in the Die Engineering business. Mainly, the ability to separate product part geometry, standard tool part geometry and newly designed tool geometry from one another improves designer productivity and eliminates costly errors.

The ability to use the same product part geometry for the design and detailing of the panel, as well as the other subsequent operations of engineering analysis, die design and major fabrication tool layout, has not only reduced the lead time to produce the part, but has improved the quality of the parts produced due to the elimination of the many stages of recreation of the geometry at the various operations. The production of body panels by the use of GM and vendor-supplied systems continues to be the most important set of computer-aided engineering problem-solving tools in use at General Motors today. While the body surface panel engineering and manufacturing may be the most important function using computer-aided engineering tools at General Motors, the use of computer-aided design tools in the design and detailing of automotive components at the component/supplier divisions of the Corporation is one of the most heavily penetrated. Every day, design and detailing of product components, such as starter motors, batteries, shock absorbers, radio antenna lift mechanisms, steering wheels, steering gears, power steering hydraulic pumps and automatic transmissions, are commonplace.

General Motors units utilize almost every major vendor system in this mainly mechanical design and drafting activity, with the leaders being the Lockheed/IBM CADAM System and the turnkey systems supplied y Applicon, Calma and Computervision. An example of this product design activity is this fuel tank that was designed on a vendor-supplied system. Not only was 100% of the design of the fuel tank accomplished using computer graphics, but the ability to extract part geometry from the design layout for detailing increases productivity on the detail up to a ratio of 20:1. Detailing can also be effective if the part geometry does not exist on a computer graphic system.

This inlet manifold was detailed directly from a conventionally produced design layout drawing at about a 2:1 productivity gain. However, the ability to use this geometry in other design activities, as well as other downstream operations, without having to recreate the product part definition far outstrips the productivity gain in the detailing function. Other details are produced utilizing more computer aids than merely line drawings. This power steering hose assembly is an example of an application where the detailer has only to input the three-dimensional coordinates of the pipe ends and bend intersections, select the style of hose couplings, hose and flared tube nuts, indicate where the views are to be placed, and the drawing is then generated and completed in one hour and fifteen minutes -- clearly a productivity gain in excess of 20:1.

While a good deal of product engineering work is still two-dimensional, such as this engine oil pan and power steering pump assembly, an ever-increasing number of engineering groups are realizing the benefits of three-dimensional models for design activities. Engine compartment packaging and clearance studies are immensely enhanced using a three-dimensional model of the engine general arrangement shown here. Similarly, the three-dimensional design of the engine accessory mounting brackets shown here can also be taken directly into the structural analysis modeling package and a NASTRAN file created for the actual analysis. Likewise, with a part such as this automatic transmission valve body completely modeled using three-dimensional modeling methods, all subsequent operations are made easier by being able to utilize this part geometry without having to recreate it at every operation. Again, lead time and errors are both reduced.

The overall productivity gain through the use of computer graphics systems at General Motors is approximately 3:1, of which you have seen some exciting exceptions. As our systems continue to expand and our people receive more training and experience, the productivity gains will also continue to increase.

Even though a great deal of mechanical component design is occurring at the component/supplier units, there is still a need for solving the design/drafting and analytic problems on components, such as engine cases, cylinder heads, inlet and exhaust manifolds, and other large cast parts that are not handled very well with the wire-frame technology available on most systems today. The confusion over the wire-frame model shown here is that where the opening exists is not clear -- top, end or side. Whereas, there is little doubt if viewing a solid object with part of the solid removed. General Motors is now developing an in-house capability in solid geometry modeling called "GMSOLID". This new tool may be the most significant addition to the General Motors computer-aided tool box since the introduction of the body surface systems CADANCE and Fisher Graphics.

Based on the premise of combining, removing or developing the intersection of solid primitives, such as blocks, cylinders, spheroids, cones and tori, simple parts are easily modeled. Complex parts, although requiring more time, are not much more difficult, although requiring considerably more computer resource. One of the benefits you can see on this example is hidden line removal. Those that are not as obvious are the ability to analyze the model more easily and completely. Volume and mass are immediately available from a solid model. Such specific analysis problems as combustion chamber volume, compression ratio and flame front travel are more accurately derived in far shorter cycle time than by using conventional methods. While this system is still in the development stage, several production design problems have already been processed using the power of "GMSOLID". This injector nozzle is one that demonstrates the capabilities of the "GMSOLID" system, including hidden line removal, the combination of the primitive elements and section cutting.

With the large number of divisions in the Corporation and the autonomy exercised by these units in selecting computer graphics equipment for engineering and manufacturing, coordination is not an easy task. Through the staff of Corporate Engineering Computer Coordination, centers of expertise have been established for various specific functions. Other units are participating in development centers, such as the Corporate Graphics System and Solid Modeling. These projects, although managed by Corporate Engineering Computer Coordination, are directed by the user community. Corporate Engineering Computer Coordination also provides seminars, conferences and task force activities to present new methods and techniques to the user community at General Motors.

It is our long-range goal that every job function that can be accomplished on a computer graphics system cost-effectively be put on that system just as soon as technically possible and cash-flow allowable in order to achieve a totally integrated computer-aided engineering system. This goal thereby expands the benefits realized in our CAD operations penetrated thus far into all of our product engineering activities and especially moving into the manufacturing area.