

# RCA Engineer

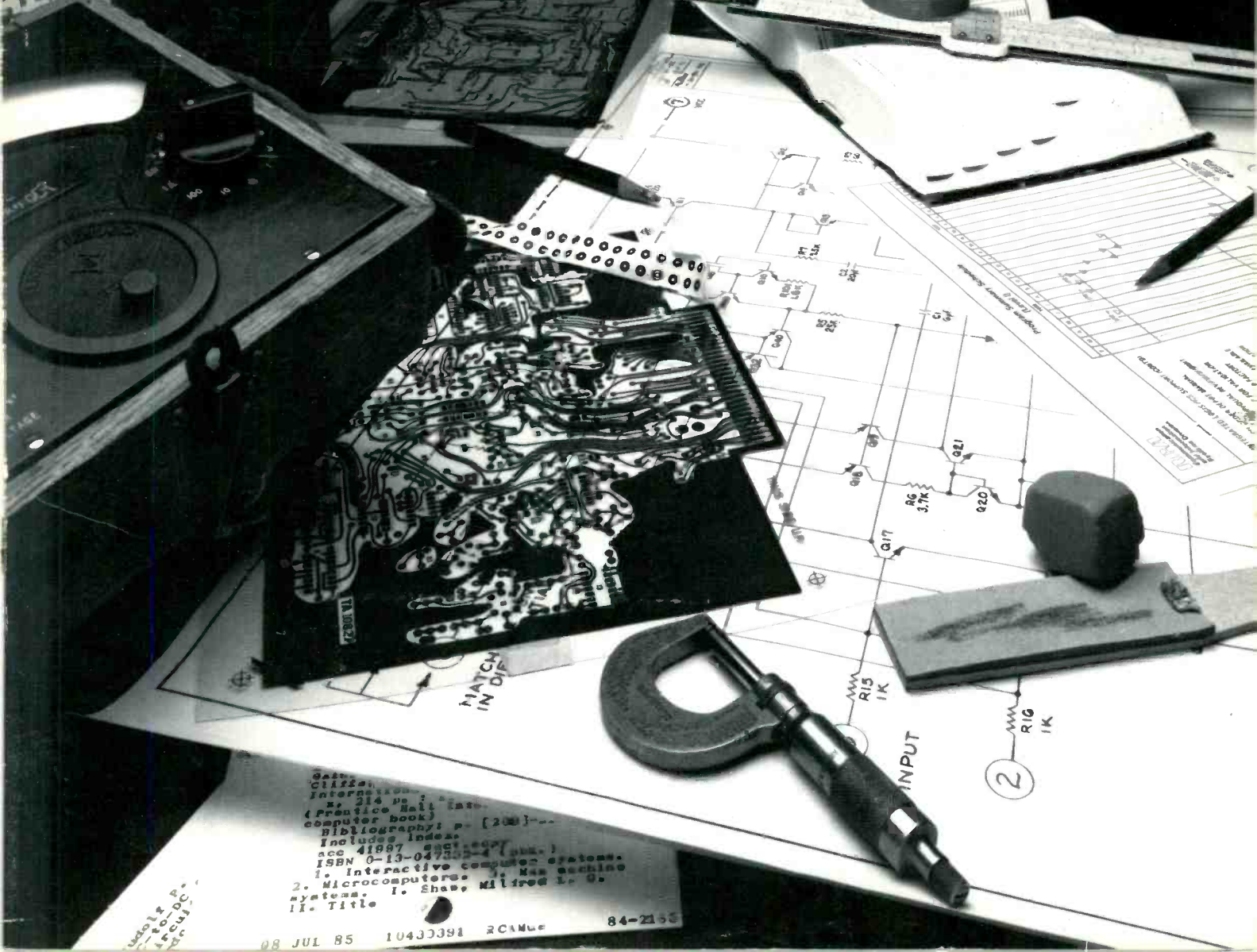
Vol. 31 No. 2 Mar. / Apr. 1986

## PCs & Engineering Workstations

Formulas  
for  
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strain

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RCA



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# RCA Engineer

A technical journal published by the  
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**About our cover:** the pervasive PC has become very much a part of the engineering workplace. With the proper software, PCs have successfully performed the functions of many traditional engineering tools.

In this issue we see some of the possible uses in engineering for the PC and its more sophisticated cousin, the engineering workstation. Of course, with each new application comes a new set of problems to solve, and this issue discusses a number of those, too.

Cover design by the RCA Engineer staff.

Cover photo by **James Pryor**, RCA Solid State Division

□ To serve as a medium of interchange of technical information among various groups at RCA □ To create a community of engineering interest within the company by stressing the interrelated nature of all contributions □ To disseminate to RCA engineers technical information of professional value □ To publish in an appropriate manner important technical developments at RCA, and the role of the engineer □ To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field □ To provide a convenient means by which the RCA engineer may review professional work before associates and engineering management □ To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.

computer model includes the effects of distributed parasitics. The model enabled Mr. Wignot to predict a parasitic oscillation mode and have a fix ready when the problem showed up during the factory pilot run. It also was used to solve a radiation problem. The work done is usable on all MTT units, and will be useful to future rf designers in reducing factory problems with tuners.

## Astro Employee of the Quarter Awards

Five engineers at RCA Astro-Electronics Division have been named Employee of the

Quarter for their exceptionally high level of personal commitment, sustained performances, and leadership.

**Mesut Ciceker** for providing the guidance, encouragement and initiative for his team during the integration and test of American Satellite Company's communications satellite, ASC-1.

**Michael Mihavetz** and a team from Astro's Management Information Systems (MIS), for making it possible for RCA to meet the contractual requirements of the Air Force on the DMSP 11-14 series of meteorological satellites.

**Roger B. Hogan, Michael Cummings, and Kenneth Ward** were selected by the American Institute of Aeronautics and Astronautics (AIAA) to receive the Haley Space Flight Award for their outstanding contributions to the advancement of astronautic technology. All three Astro employees were a part of the NOAA/NASA/RCA Recovery Team of the NOAA-8 satellite.

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## Professional activities

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### Hittinger receives IEEE award

**William C. Hittinger**, Executive Vice President (retired), has been named by the IEEE Board of Directors as the recipient of the 1986 Frederik Philips Award "for leadership in electronics research and development." Mr. Hittinger received the award at the International Solid State Circuits Conference in February. The Philips Award recognizes outstanding accomplishments in the management of research and development. Dr. William M. Webster received the same award in 1980.

### Nelson is ACS Chairman

**J. Roy Nelson**, RCA Laboratories, has been elected 1986 Chairman of the Central Jersey Section of the American Chemical Society.

### Bauer and Perlman elected IEEE Fellows

The Board of Directors of the Institute of Electrical and Electronic Engineers (IEEE) recently announced the election of **John A. Bauer**, Missile and Surface Radar Division, and **Dr. Barry S. Perlman**, RCA Laboratories, to the membership grade of Fellow. The grade of Fellow recognizes unusual distinction in the engineering profession and is conferred only by invitation of the Board of

Directors upon persons of outstanding and extraordinary qualifications and experience in IEEE-designated fields who have made important individual contributions to one or more of these fields.

John Bauer's citation is "for outstanding technical leadership in establishing leadless chip carrier technology and surface mounting packaging techniques as a viable approach to high-density, low-cost military and commercial packaging."

Dr. Perlman was honored "for contributions to microwave solid-state device and circuit design, and leadership in computer-aided methods for microwave engineering."

### Brown receives NAB award

**Dr. George H. Brown**, retired RCA engineering executive, has received the National Association of Broadcasters' 1986 Engineering Achievement Award. It was presented at the 40th annual Broadcast Engineering Conference luncheon on Tuesday, April 15 during NAB's annual convention at the Dallas Convention Center.

## Communication and Information Systems Division

**Donald Bussard** of RF and Microwave Engineering was chosen the Engineer of

the Month for the month of November. This award is recognition of Don's outstanding contribution on the GWEN and AF-FSP programs.

On the AF-FSP, Don was responsible for the successful design and development of a state-of-the-art solid-state power converter unit (PCU). He was instrumental in solving two major problems on the GWEN program. On the interface of the LFPA to the ATU, Don quickly diagnosed a problem and implemented a retrofitable fix to protect the PA and was able to diagnose reliability problems on the UPS manufactured by NOVA as a faulty control circuit design. Don redesigned the control circuit using the same components and furnished the design to the vendor for implementation. His performance on these two programs had a tremendous impact on cost and schedule.

**Marianne Nolan** was chosen Engineer of the Month for the month of December for her outstanding contribution on the GWEN program and the successful acceptance testing of the TRW HMI Computer program.

Her ability to analyze and solve problems was quite apparent in her efforts toward the finalization of the acceptance test and preliminary qualification test procedures. This dedication led to the successful acceptance test and PQT of HMI.

Engineering Excellence Award for his outstanding performance on the STC/DBS Attitude Control Subsystem test program. Without the benefit of experienced personnel and sufficient staffing, this very complex attitude control test was successfully completed as a result of his dedication, broad inherent capabilities, and long hours of work. Mr. Tracy performed as director and coordinator as well as customer liaison.

The Engineering Recognition Award has been presented to **Patrick Burkle** for his efforts in completing critical accelerated thermal balance testing, analysis, and design modifications for the thermal control system design for the ASCI spacecraft.

## Circleville presents first TEC Award

**Thomas H. Kirchgessner** of the VCDD Circleville plant has been awarded a Technical Excellence Award for the design and installation of a hot funnel glass code date process that has proved to be a virtually maintenance-free system since its installation.

## Fourth Quarter, 1985 MSRD TEC Awards

The following are winners of the Missile and Surface Radar Division's fourth-quarter Technical Excellence Awards:

**Geoffrey S. Edelson**, for major contributions to RCA's growing capabilities in advanced airborne lightweight surveillance radar technology. Mr. Edelson's contributions to the ground-based test bed proposal effort included a set of unique processing algorithms required for operation of the long-dwell radar system. His technical direction of the test bed effort resulted in an advanced processor that meets or exceeds performance requirements, delivered on time and under budget.

**Miles C. Johnson**, for outstanding analytical skills and technical leadership, demonstrated in the design implementation of the AEGIS antenna power supply. In addition to his direct responsibility for the input power section design, Mr. Johnson applied his circuit and mathematical skills to assist others in overcoming magnetic and stability problems. His efforts contributed significantly to the implementation of the technically complex multi-output switching power supply.

**Abraham E. Ruvin**, for innovative system design, performance analysis, and technical leadership on the lightweight surveillance radar program. His broad radar systems expertise was particularly effective in selecting waveforms and processing approaches for detecting stealth targets in heavy clutter. Mr. Ruvin established the feasibility of achiev-

ing the very high clutter cancellation required, and performed the antenna configuration tradeoff studies that resulted in a novel low-cost approach for the Naval Airship Radar.

**Thomas J. Sikos**, for significant contributions to the software system development for the lightweight surveillance radar test bed. As responsible software systems engineer and lead designer of the radar control computer, Mr. Sikos developed a control architecture fully compatible with both the array processor and the host computer operating systems. His modular top-level design and programming direction were major factors in the on-schedule, below-budget implementation.

## Ruvin named 1985 Annual TEC Award winner at MSRD

The Missile and Surface Radar Division's 1985 Annual Technical Excellence Award has been given to **Abe Ruvin** for special technical achievements directed toward establishing MSRD's credentials as a bona fide competitor in the field of lightweight airborne radar.

## Ten receive CE fourth-quarter awards

The fourth-quarter 1985 Consumer Electronics Operations Technical Excellence Awards were announced on February 20, 1986. They were:

**Jacob Sosniak** and **Leslie Avery**, for the development of structures on integrated circuits that protect the device from damage due to electrostatic discharges (ESD). Mr. Avery designed and developed structures for both bipolar and analog integrated circuits that protect each pad and the internal circuits from ESD damage. Mr. Sosniak designed and developed laboratory apparatus and techniques to evaluate and quantify the performance of ESD protection structures. He also coordinated the implementation of Mr. Avery's structures in several IC designs at CE. The structures, which provide protection to discharge levels of 4KV, offer ESD immunity levels two to three times greater than the competition.

**John Furrey**, for the initiation and design of a module (PWCPA) to provide cost-effective stereo in a leader model television receiver. The module combines a volume/tone control module and stereo power amplifier. Mr. Furrey worked to minimize the parts count and power requirements, and designed a system that resulted in a net savings of nearly \$8.00 at the instrument level. Although the design was started at GR-1, it was completed in time to meet the original instrument introduction date.

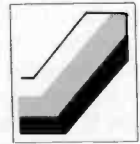
**Philip Morris** and **Thomas Sipher**, for the extensive and thorough evaluation of several candidate CAD/CAM systems, leading to identification and RCA corporate approval of a multi-million dollar, second-generation mechanical CAM system for CE. This evaluation focused on several key attributes (geometric modeling, programming environment, hardware platform, application software, and imaging capability) that provide a foundation for improved design quality and significant design cycle reductions. In addition to performing thorough evaluation and benchmark testing of several vendor's mechanical CAD systems, Mr. Morris and Mr. Sipher have developed an innovative parametric approach to remote transmitter and television cabinet/mask design.

**William Fitzgerald**, for the development of a new VIPUR (Variable Interval Pulse Regulator) power supply system. Utilizing a high-voltage power MOSFET operating in a non-synchronous mode, the VIPUR provides not only increased average power capability, but also higher peak power and transient handling capabilities. The unique use of the power MOSFET operating at increased frequency has permitted considerable reduction in ferrite size, space, and cost when compared to the chopper system as used in the CTC 131.

**Bill Testin** and **Juri Tufts**, for the development of the FS-III tuning system and its first successful application in the MTT1 used in the CTC 120 chassis. The system includes improved testability, automatic channel programming, extended cable tuning range, a new channel change muting algorithm, and on-screen display stabilization. The FS-III IC combines the functionality of four ICs from previous tuning systems. A new five-band op/switch replaces the previous system, which used a three-band switch and a discrete circuit. The FS-III was designed to be used across the line of digitally-tuned systems.

**G. Rene VanHoorde**, for the research and development of a reliability model for color television. Although established reliability models are well known, they are primarily designed for military applications and do not reflect the home television environment. Mr. VanHoorde's model predicts reliability using data from stress tests, past failure rates, vendor ratings, and component ratings. It is considered unique in the television industry. Field data has shown the results of the new model to be statistically twice as precise as the previous method. The model is used to evaluate each chassis go-round and highlight areas for improvement. It has been instrumental in the reduction of field failure rates since 1981.

**Leroy Wignot**, for the development and use of a computer model to design the oscillator circuits in the MTT-1 tuning system. The



## Technical excellence

### VCDD TEC Awards



Cooper



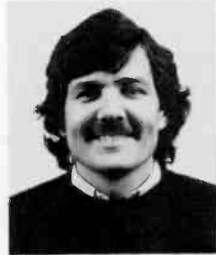
Opreko



Krufka



Mulholland



Thro



Lausman



Baker



Michielutti



Deal



Hsing



Benigni



Mitchell



Adams

RCA Video Component and Display Division (VCDD) recently honored thirteen employees for their outstanding contributions and achievements in engineering during 1985. **Charles A. Quinn**, Vice President and General Manager of the Video Component & Display Division, presented the awards to each of the quarterly winners and concluded by presenting the 1985 Engineer of the Year award to **John C. Cooper**. Mr. Cooper, who has five patents to his credit, was recognized for his design of the degaussing systems and evaluation of the magnetic charac-

teristics of RCA's complete family of COTY color picture tubes. Others honored were:

**Stephen T. Opreko**, for the implementation of a thermal/mechanical modeling capability for analyzing electron guns for color picture tubes.

**Frank S. Krufka**, for the design of concepts, circuits, and algorithms to measure opening size and other parameters of unphosphored display panels.

**Denis G. Mulholland**, for the development and implementation of vibratory finishing techniques for electron gun parts resulting in improved color picture tube performance.

**Dennis E. Thro**, for the development of a universal yoke holder to support deflection yokes in test sets.

**Thomas C. Lausman**, for the design and development of an electron gun for use in high-resolution data display tubes having state-of-the-art resolution and convergence performance.

**Paul D. Baker**, for the evaluation of the performance and establishment of potential productivity gains of iron oxide working plates in making 19V100 aperture masks in the Barceloneta production environment.

**Thomas J. Michielutti**, for the evaluation of the performance and establishment of potential productivity gains of iron oxide working plates in making 19V100 aperture masks in the Barceloneta production environment.

**Samuel B. Deal**, for the successful coordination, development, and implementation of the automated ADP materials and processes for the 27V SP color picture tube.

**Hsing-Yao Chen**, for the design and development of an electron gun for use in high-resolution data display tubes having state-of-the-art resolution and convergence performance.

**Samuel P. Benigni**, for the development and implementation of vibratory finishing techniques for electron gun parts resulting in improved color picture tube performance.

**Michael E. Mitchell**, for his contributions to the design and installation of automatic load and unload equipment for color picture tubes in the Subjective Color Automatic Test System.

**John L. Adams**, for this contributions to the design and installation of automatic load and unload equipment for color picture tubes in the Subjective Color Automatic Test System.

### Astro TEC Awards

**P. Bruschi, D. Corrington, D. Sable, A. Spitz, and T. Young** received the Astro-Electronics Engineering Excellence Award for the Message Authentication Device concept and design implemented on the ASC Communication Satellite.

The RCA Astro Engineering Excellence Committee presented the Engineering Excellence Award to **Chirasak Thasanatorn** for his development of an in-house analysis capability to perform Coupled Transient Loads Analysis for payloads launched by the Shuttle. This new in-house analysis capability is essential for accurately predicting the dynamic loads for all Shuttle launched payloads.

**Terry Tracy**, member of the Attitude Control Systems group, has been awarded the

**Istvan Gorog**, Director, Manufacturing Technology Research Laboratory, announces his organization as follows: **David P. Borteld**, Head, Control Systems Research; **Phillip M. Heyman**, Head, Advanced Technology Research; and **Saman Hong**, Head, Modeling and Analysis Research.

**Fred Sterzer**, Director, Microwave Technology Center, announces his organization as follows: **Erwin F. Belohoubek**, Head, Microwave Circuit Technology; **Raymond L. Camisa**, Head Microwave Components Technology; **S. Yegna Narayan**, Head, Microwave Device Technology; **Markus Nowogrodzki**, Head, Subsystems and Special Projects; **Barry S. Perlman**, Head, Design Automation Technology; **Herbert J. Wolkstein**, Head, Space and Counter Measures Program.

## Communication and Information Systems Division

**Charles A. Schmidt**, Acting Division Vice President and General Manager, Communication and Information Systems Division, announces the appointment of **Donald J. Parker** as Division Vice President, Digital Communications and Recording Systems; **Joseph Pane** as Director, Special Programs; and **Joseph B. Christopher** as Director, Plant Operations.

## Microelectronics Center

**David S. Jacobson**, Director, IC Product Operations, announces his organization as follows: **Richard H. Bergman**, Manager, Test Operations; **Robert A. Donnelly**, Manager, Product Engineering and Production Control; **Peter P. Idell**, Manager, Wafer Fabrication Operations; and **Richard H. Zeien**, Manager, Package and Assembly Operations.

## Missile and Surface Radar Division

**William V. Goodwin**, Division Vice President and General Manager, Missile and Surface Radar Division, announces the appointment of **Bryce D. Inman** as Director, Submarine Combat Systems.

## NBC

**Michael Sherlock**, Executive Vice President, Operations & Technical Services, an-

nounces his organization as follows: **James M. Overman**, Director, Broadcast Control and Communications; **Joseph M. Rohr**, Director, Program Production; **Sharon R. Johnston**, Manager, Capital and Project Implementation; **Theodore O'Karma**, Director, Communications and Support Services; **Thomas C. Nollie**, Manager, Screening Rooms; **Joseph A. Ralston, Jr.**, Technical Manager, Studio Technical Operations; **Warren Allgyer**, Managing Director, Long Range Space Plan, Engineering; **S. Merrill Weiss**, Managing Director, Systems Engineering; **Charles Jablonski**, Director, Technical Strategic Planning; **David Rabinowitz**, Director, Computer Imaging & Automation Software; **Peter Haas**, Manager, Engineering Operations and Services; **Louis Libin**, Manager, Allocations Engineering; and **Alan J. Wechsler**, Project Manager, BSE.

## Solid State Division

RCA and Sharp have entered into a strategic alliance with WaferScale Integration, Inc. The agreements provide for licensing and joint development of WSI's CMOS macrocell library, non-volatile memories and bit-slice products. WSI is a privately held California based corporation.

**Carl R. Turner**, Division Vice President and General Manager, Solid State Division, announces the appointment of **Larry J. Gallace** as Division Vice President, Product Assurance, MIS and Materials.

**Carl R. Turner**, Division Vice President and General Manager, Solid State Division, announces the appointment of **Richard A. Santilli** as Division Vice President, Strategic Planning.

As part of the agreement, RCA/Sharp Microelectronics, Inc. has acquired 7 percent of WSI's outstanding stock. **Richard Santilli**, Division Vice President, Strategic Planning will represent RCA, Sharp and RSM on the WSI board of directors.

**Heshmat Khajezadeh**, Division Vice President, Integrated Circuit Products, announces his organization as follows: **Stephen C. Ahrens**, Director, Product Marketing—Standard IC Products; **John R. Kowalak**, Administrator, IC Administration; **James L. Magos**, Director, Government & High Reliability—IC Products; **Charles J. Nuese**, Division Vice President, Manufacturing—ICs; **H. Gene Patterson**, Director, Application Specific IC Products; and **Bruno J. Walmsley**, Director, Engineering—Standard IC Products.

**Bruno J. Walmsley**, Director, Engineering—Standard IC Products, announces his organization as follows: **Kenneth W. Brizel**, Manager, Engineering—Logic, Memory & Microprocessor Products; **Charles Engelberg**, Manager, Test Engineering; **Lewis A. Jacobus, Jr.**, Manager, Engineering—Automotive & Consumer Products; **Sterling H. Middings**, Section Manager, Layout Services; and **Bruno J. Walmsley**, Acting Manager, Engineering—Computer, Telecommunications & Industrial Products.

**H. Gene Patterson**, Director, Application Specific IC Products, announces his organization as follows: **R. Adrian Bishop**, Manager, Product Marketing—Application Specific ICs; **James E. Gillberg**, Director, Engineering—Application Specific ICs; and **Henry S. Miller**, Manager, Design Centers.

**Charles J. Nuese**, Division Vice President, Manufacturing—ICs, announces his organization as follows: **Frank F. Cocozza**, Manager, Plant Operations—Palm Beach Gardens; **Raymond T. Ford**, Manager, Wafer Fabrication—Palm Beach Gardens; **Charles J. Nuese**, Acting Manager, Operations Support; and **John R. Steiner**, Director, Environmental & Plant Engineering—SSD.

**James L. Magos**, Director, Government & High Reliability—IC Products, announces his organization as follows: **Joseph A. Augusta**, Administrator, Government and High Reliability IC Administration; **William F. Allen**, Manager, Design Engineering Government and High Reliability IC Products; **Jack Handen**, Manager, Product Marketing—Government and High Reliability IC Products; **Donald R. Carley**, Manager, Applications & Product Engineering—Government and High Reliability IC Products; and **James L. Magos**, Acting Manager, Operations Support.

**Stephen C. Ahrens**, Director, Product Marketing—Standard IC Products, announces his organization as follows: **Donald L. Beech**, Manager, Product Marketing—Telecommunications & High Speed Logic Products; **Edmund J. Blickle**, Manager, Product Marketing—Microprocessor Products; **Richard E. Funk**, Manager, Applications Engineering—Linear & Logic Products; **Ralph S. Hartz**, Manager, Memory & Microprocessor Applications Engineering and RSM Product Definition; **Thomas J. McNerney**, Manager, Product Marketing—Distribution & Memory Products; and **Jack Yellin**, Manager, Product Marketing—Linear Products.

Manager, PRICE Model Operations; and **William W. Kuhn**, Manager, PRICE System Projects.

**Mark H. Burmeister**, Director, PRICE Systems, announces his organization as follows: **Mark H. Burmeister**, Acting, PRICE Marketing; **John J. Procaccino**, Manager, PRICE Business Operations; **William E. Rapp**, Staff Engineer, PRICE Systems; and **Roy M. Summers**, Manager, PRICE Operations and System Projects.

## Americom

**John Christopher**, Vice President, Technical Operations, announces his organization as follows: **Joseph F. Elko**, Manager, Spacecraft Engineering and Operations; **Murray Fruchter**, Director, Terrestrial Systems, Technical Operations; **Joseph J. Schwarze**, Director, Quality Management and Advanced Space Programs; and **Carlton N. Thomas**, Manager, Business Operations.

**Joseph F. Elko**, Manager, Spacecraft Engineering and Operations, announces his organization as follows: **Jacob Levin**, Manager, Mission Operations; **Archie T. Miller**, Manager, Spacecraft Operations; and **Joseph F. Elko**, Acting Manager, Spacecraft Engineering.

**Joseph J. Schwarze**, Director, Quality Management and Advanced Space Programs, announces his organization as follows: **Lindy W. Morgan**, Manager, Procurement Quality Assurance; **Albert E. Schmidt**, Manager, Reliability and Quality Engineering; **William R. Palme**, Manager, Advanced Space Programs; and **Rodney A. Stevens**, Manager, Configuration Management, Product Safety, and Drafting.

## Automated Systems Division

**Eugene M. Stockton**, Division Vice President and General Manager, Automated Systems Division, announces his organization as follows: **Duane M. Belden**, Director, Plant Operations; **Glenn W. Coleman**, Division Vice President, Marketing and Advanced Planning; **Emilio W. Dusio**, Division Vice President, Engineering; **Thomas E. Fitzpatrick**, Division Vice President, Vehicle Test Systems; **James E. Kupec**, Director, Employee Relations; **Kenneth I. Pressman**, Director, Finance; **David M. Priestley**, Division Vice President, Automatic Test Systems; **Murray D. Radlo**, Director, Materials; and **Eugene M. Stockton**, Acting, C3I Systems.

**David M. Priestley**, Division Vice President, Automatic Test Systems, announces his organization as follows: **Donald R. Bartlett**, Manager, Program Operations; **John H.**

**Groff**, Manager, Program Operations; **John Hallal**, Manager, Program Operations; and **Walter R. Wadden**, Staff Scientist, Software Systems.

**Eugene M. Stockton**, Acting, C3I Systems, announces his organization as follows: **John J. Morris**, Manager, Program Operations; **Gerard T. Ross**, Manager, Program Operations; **Allan R. Stern**, Manager, Program Operations; **Chris A. Wargo**, Manager, Program Operations, and **James C. Williams**, Manager, Program Operations.

## Astro-Electronics Division

**Jack A. Frohbieter**, Division Vice President and General Manager, Astro-Electronics Division, announces the appointment of **Frank A. Boyer** as Director, Plant Operations.

## Consumer Electronics Operations

**Jack K. Sauter**, Group Vice President, Consumer Electronics and Video Components, announces that effective immediately, the **Video Display Monitor Products Division** name will be changed to **Display Systems Division**. The organization will continue to report to the Group Vice President, Consumer Electronics and Video Components.

**Richard A. Sunshine**, Director Mechanical Design Engineering, announces the appointment of **Roger D. Sandefer**, as Manager, Product Protection Engineering.

**Bruce M. Allan**, Vice President, Strategic Planning, announces his organization as follows: **Theodore L. Allen**, Manager, Product Operations; **James O. Early**, Manager, Quality Systems and Procedures; **R. Eugene Eddy**, Vice President, Warranty Programs and Training; **Reginald J. McKinstry, Jr.**, Director, Entertainment Tubes and Parts Product Management, Distributor and Special Products Division; **Denzil R. Miller**, Director, Business Analysis; **William H. Needham**, Manager, Finished Goods Procurement; **Gilbert M. Ravelette**, Manager, Video Cassette Recorder Merchandising; **Alfred J. Schick**, Manager, Video Products Technical Support; and **Brian K. Smith**, Manager, Television Product Systems Development.

**Jack K. Sauter**, Group Vice President, announces that **Bruce M. Allan** will assume responsibility for the Direct Broadcast Satellite Program. These responsibilities include the interdivisional coordination of product design, development and market introduction. Mr. Allen will continue to report administratively to his functional superior

in his current position, Vice President, Strategic Planning.

**Larry J. Byers**, Manager, Test Technology, announces the appointment of **James M. Keeth**, Manager, Direct Broadcast Satellite Test Systems.

## Earth Observation Satellite Company

An Executive Committee has been named for the Earth Observation Satellite Company (EOSAT), which has taken over operation of the Landsat satellite program. Members of the committee from RCA are Charles A. Schmidt, RCA Group Vice President, Government Communications Systems, and Robert A. Amadio, Director, Finance, for RCA Astro-Electronics Division, East Windsor, N.J. Names from Hughes Aircraft Company's Santa Barbara Research Center, Goleta, Calif., were Dr. Robert Talley, President, and Warren Nichols, Vice President. The executive committee is responsible for EOSAT policy and executive management and overview. EOSAT, a joint venture/partnership formed by Hughes and RCA Corporation, is headed by C. P. Williams, President and Chief Operating Officer. The federal government, which formerly operated the Landsat satellites, transferred the program to EOSAT last September. Landsat involves the remote sensing of the Earth's resources by satellite and the dissemination of the collected data to users around the world.

## Government Volume Production

**Charles A. Schmidt**, Group Vice President, Government Communications Systems, announces the appointment of **Joseph L. Mackin** as Division Vice President, Government Volume Production.

The Division Vice President and General Manager, Government Volume Production, announces the appointment of **Victor C. Scarpello** as Manager, Manufacturing.

## RCA Laboratories

**James J. Tietjen**, Vice President, RCA Laboratories, announced that effective March 1, 1986, **Jay J. Brandinger** was appointed Staff Vice President, Manufacturing and Materials Research, replacing **James L. Miller** who retired on April 1, 1986. Additionally, Dr. Brandinger will continue his present responsibility as Staff Vice President, Engineering, and in this capacity will report to the Executive Vice President, Electronic Products and Technology.

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# Engineering News and Highlights

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## Frohbieter is head Astro-Electronics



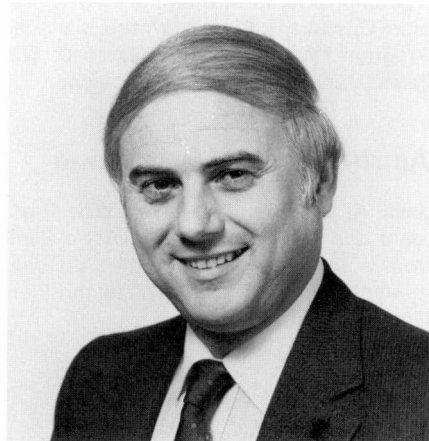
**John D. Rittenhouse**, Executive Vice President, Aerospace and Defense, has announced the appointment of **Jack A. Frohbieter** as Division Vice President and General Manager, RCA Astro-Electronics Division. He succeeds Charles A. Schmidt, who has been named an RCA Group Vice President.

Prior to his current appointment, Mr. Frohbieter served as Division Vice President, Communication Satellite Programs. His responsibilities included Video Distribution Satellites, General Purpose Communications Satellites, and the NASA Advanced Communications Technology Satellite (ACTS) program. Previously, as Director, Satellite Programs, he was responsible for management of Astro's fixed-service communications satellite programs.

Mr. Frohbieter received the BS in Electrical Engineering from the University of Evansville. He also attended Purdue University and is a graduate of the Harvard Business School Advanced Management Program.

## deBastos named Division VP at Astro

**Jack A. Frohbieter**, Division Vice President and General Manager, RCA Astro-Electronics has announced the appointment of **Ricardo deBastos** as Division Vice President, Communications Satellite Programs. Mr. deBastos is responsible for management of all Astro communications satellite activities, including Video Distribution Satellites



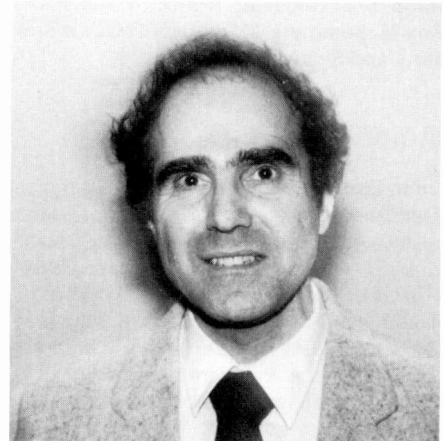
and General Purpose Communications Satellites. He was previously Manager, General Purpose Communications Satellites, responsible for all aspects of each program's delivery, performance, and cost. In 1971, he became a Systems Manager for the Atmosphere Explorer Program and later served as the Program Manager for other Astro programs such as the Dynamics Explorer, TIROS and GSTAR satellite systems.

Mr. deBastos received the BS and MS degrees in Mechanical Engineering from Oklahoma State University. He is a member of Pi Tau Sigma, Theta Chi and the American Geophysical Union, and is an Associate Fellow of the AIAA. He is also an assistant professor, adjunct staff and Chairman of the Mechanical Advisory Commission at Mercer County College in Trenton, N.J.

## Bedrosian is named NPD TPA and Ed Rep

**Peter G. Bedrosian** has been named the Technical Publications Administrator and the *RCA Engineer* Editorial Representative for the Lancaster plant of the New Products Division. He is a Member, Technical Staff in the Communications Department of the Closed-Circuit Video Equipment activity, and is responsible for the establishment of data sheets, brochures, and product guides for all products manufactured or marketed by the New Products Division in Lancaster, Pa. and Vaudreuil, Quebec.

Mr. Bedrosian joined RCA in 1953 as a specialized trainee in the Color Kinescope Production Development group of the Lancaster plant. After a leave of absence to



serve in the Armed Forces, he returned to Lancaster as a production engineer in Power Tube manufacturing. He has held various engineering positions including Manager, Engineering Standards. He has also served on several military ad hoc and JEDEC committees. Mr. Bedrosian received the BS in Electrical Engineering from the University of New Hampshire in 1953.

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## Staff announcements

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### Aerospace and Defense

**Leonard V. Fox**, Staff Vice President, Finance, announces his organization as follows: **Arthur J. Barrett**, Manager, Facilities and Special Programs; **Mark H. Burmeister**, Director, PRICE Systems; **John R. Lee**, Director, Operations/Contract Review and Operations Analysis; and **Peter J. Pernice**, Director, Financial Planning and Operations.

**John D. Procaccino**, Manager, PRICE Business Operations, announces his organization as follows: **Benjamin Chackman**, Manager, PRICE Timeshare Services; **Geraldine C. Devlin**, Administrator, Contracts; **Richard E. Moyer**, Administrator, PRICE Business Operations; and **Susan Steinberg**, Administrator, PRICE Systems.

**Roy M. Summers**, Manager, PRICE Operations and System Projects, announces his organization as follows: **Francis B. Barnett**, Manager, PRICE operations; **Peter B. Korda**,



## Communication and Information Systems Division

T. Anastasia | D.G. Herzog | D.W. Donze  
**Hardware Implementation of a Two-Axis, Three-Tapped, Finite-Impulse Response (FIR) Digital Filter**—Presented at the Society of Photographic Scientists & Engineers (SPSE), 25th Fall Symposium—Imaging, Arlington, Va. Nov. 17-22, 1985 and published in *Symposium Brochure*

H.R. Barton, Jr.  
**Unit Production Cost Tracking Model UPCT6**—Presented at the Electronic Industries Association (EIA) G-47 Meeting, Washington, D.C., October 2, 1985 and published in *EIA Engineering Design Integration Bulletin* No. 1-B

O.E. Bessette  
**High Data Rate, High Capacity, Severe Environment Optical Disk Recording Equipment**—Presented at the 21st Annual International Telemetry Conference, Las Vegas, Nevada, Oct. 28-31, 1985 and published in *ITC-85 Proceedings*

S.L. Corsover | W.L. Vaughan  
**Frequency Response of an Image Recorder Using Repeat Scan**—Presented at the Society of Photographic Scientists and Engineers (SPSE), 25th Fall Symposium—Imaging, Arlington, Va., Nov. 17-22, 1985 and published in the *Symposium Brochure*

D.A. Ellengold | M.H. Merkert Oddo | J.J. Salerno  
**Simplified Voice Tracking Model Simulation**—Presented at the IEEE Globcom '85 New Orleans, La., Dec. 2-5, 1985, and published in the *Proceedings*

H. Holcombe  
**Project Development Using Design and Development Tools**—Presented at the 1985 Fall Digital Equipment Computer Users Society (DECUS) U.S. Symposium, Anaheim, Cal., Dec. 9-13, 1985

H.P. Miller  
**A Comparison of the Flux-Corrected Transport Method with Other Low-Dispersive Schemes for 2-D Incompressible Convection Dominated Flows with Steep Gradients**—Presented at the American Society of Mechanical Engineers (ASME) Winter Annual Meeting, Miami, Fla., Nov. 17-21, 1985 and published in *ASME Journal of Fluids Engineering*

H.P. Miller  
**A Comparison of High Resolution Schemes for the Two-Dimensional Linear Advection Equation**—Presented at the 38th Annual Meeting, American Physical Society, Division of Fluid Dynamics, Tucson, Ariz., Nov. 24-27, 1985

D.P. O'Rourke | R.O. Yeager | J.I. Pridgen | A.L. Bramble  
**Agile, Low Power CMOS/SOS Frequency Synthesizer**—Presented at the GOMAC '85 Conference, Orlando, Fla., Nov. 7, 1985, and published in the *GOMAC Conference Proceedings*

M.H. Riddle | P.F. Muraco  
**Rotary Digital Recording—Addressing the Storage Needs of the Future**—Presented at the 21st Annual 1985 International Telemetry Conference, Las Vegas, Nev., Oct. 28-31, 1985, and published in the *ITC-85 Proceedings*

T.E. Sasena  
**Applications Specific Chip Set for Microprocessor I/O**—Presented at the GOMAS '85 Conference, Orlando, Fla., Nov. 6, 1985, and published in the *GOMAC Conference Digest*

J.D. Whalen  
**Trends in Personal Computing Technology**—*Auerbach Data Processing Management Periodical*, December 1985

## RCA Laboratories

W.F. Kosonocky | F.V. Shallcross | T.S. Villani | J.V. Groppe  
**160x224 Element PtSi Schottky-Barrier IR-CCD Image Sensor**—*IEEE Transactions on Electron Devices*, Vol. ED-32, No. 8, August 1985

P.A. Levine  
**Low-Noise CCD Signal Recovery**—*IEEE Transactions on Electron Devices*, Vol. ED-32, No. 8, August 1985

E.S. Nartowitz | A.M. Goodman  
**Evaluation of Silicon Optical Absorption Data for use in Minority-Carrier-Diffusion-Length Measurements by the SPV Method**—*Journal of the Electrochemical Society*, Vol. 132, No. 12, December 1985

J.R. Nelson  
**Electromagnetic Interference Shielding of Plastics**—Presented at the University of Toledo (11/7/85)

D. Raychaudhuri  
**Stability and Optimal Retransmission Control of Announced Retransmission Random Access Systems**—IEEE Communications Society, IEEE International Conference on Communications, June 23-26, 1985, Chicago, Ill.

L.K. White  
**A Modeling Study of Superficial Topography for Improved Lithography**—*Journal of the Electrochemical Society*, Vol. 132, No. 12, December 1985

## Missile and Surface Radar Division

F.J. Buckley  
**The Search for Software Quality, or One More Trip Down the Yellow Brick Road**—*ACM Software Engineering Notes*, Vol. 11, No. 1, January 1986

T.A. Dorsay  
**Command-Activated Diagnosis and Test (CADET) on the DDG and CG 65 Class Ship**—AN/UYS-44 Users' Technical Conference, Monterey, Cal., November 6-7, 1985

R.J. Felbinger | H.G. Rouland  
**Improved system engineering support of instruction modes, technical manuals, and training courses**—*RCA Engineer*, Vol. 30, No. 6 (Nov/Dec 1985)

D.R. Higgs  
**Engineering Documentation in the Computer Age—Are We Using the Tools Wisely?**—IEEE Philadelphia Section, Joint PCS/EM Meeting, Philadelphia, Pa., January 27, 1986

W.K. Holden  
**Mechanical design problems associated with glass-reinforced polytetrafluorethylene printed-wiring boards**—*RCA Engineer*, Vol. 30, No. 6 (Nov/Dec 1985)

F.E. Oliveto  
**Reliability for the '80s**—Productivity and Technological Innovation Symposium, The Engineers' Club of Philadelphia, January 23, 1986

H.R. Weiss  
**A new peripheral computer interface for the AEGIS weapon system**—*RCA Engineer*, Vol. 30, No. 6 (Nov/Dec 1985)

# Pen and Podium

Recent RCA technical papers and presentations

To obtain copies of papers, check your library or contact the author or divisional Technical Publications Administrator (listed on back cover) for a reprint.

## Advanced Technology Laboratories

J.A. Adams | J.W. Dempsey | M. Gale | G.W. Kaizar | N. Straguzzi

**Artificial intelligence applications—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

E. Alexander | R. McClain | C. Tsikos | B. Siryj | R.M. Carrell

**Advanced technology for mail processing in the 1990s—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

W. P. Altman | G. M. Claffie | M. L. Levene

**Optical storage for high performance applications in the late 1980s and beyond—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

D.E. Britton

**Verlangu: formally verifying system designs—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

E.J. Conklin

**Leonardo: design environment of the 1990s—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

R.J. Dick | W.A. Helbig | W.D. Moyers

**A High-Level Systolic Architecture for GaAs—Presented at the 19th Annual HICSS, January 8-10, 1986 and published in the Proceedings, Vol. 1.**

A. Feller

**A New design methodology reduces design time for very large applications-specific integrated circuits (ASICs)—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

W.A. Helbig | W.F. Heagerty | R.M. Zieger

**Design Issues in GaAs Computer Systems for Efficient Execution of HLL Programs—Presented at the 19th Annual HICSS, January 8-10, 1986 and published in the Proceedings, Vol. 1, pp. 238-245.**

W.A. Helbig | R.H. Schellack | R.M. Zieger

**The design and construction of a GaAs technology demonstration microprocessor—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

W.A. Helbig

**RISC vs. CISC, GaAs vs. Silicon, and Hardware vs. Software—Presented at the**

joint meeting of the IEEE MTT/ED Societies and the Computer Society, January 23, 1986

F.C. Luce | W.B. Schaming

**Automatic classification of ship targets—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

T.E. Lynch | D.E. Graff

**Acoustic phonetic techniques for automatic speech recognition systems—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

G.W. Mebus | J.B. Shields | L.T.

Armstrong | H. Rosenthal  
**Ada software development tools—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

P.B. Pierson

**Advanced robotics projects at ATL for remote servicing—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

F.B. Warren

**Advanced technology for future imaging sensors—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

D.A. Wille | A. Rosen

**Laser development and applications—RCA Engineer**, Vol. 31, No. 1 (Jan/Feb 1986)

## Automated Systems Division

J.E. Greenup | S.H. Ward | E.G. Zablocki

**Non-Contact Sensors for Automotive Testing—SAE International Congress and Exposition, Detroit, Mich., February 26, 1986**

S.C. Hadden

**A Design Manager's View at RCA—Corporate Window Session, Cornell University, Ithaca, N.Y., February 6, 1986**

S.C. Hadden

**Engineering and Physics Roles in Industry—Aeronautics and Engineering Physics Address at Cornell University, Ithaca, N.Y., February 26, 1986**

M.E. Petty | K.J. St. Pierre | J.R. Wilkinson

**Multiple Fault Diagnosis with Portable ATE Utilizing a Knowledge-Based System**

**Architecture—SAE International Congress and Exposition, Detroit, Mich., February 26, 1986**

A.J. Silva

**Reconstruction of Undersampled Periodic Signals—Thesis Toward Masters Degree in EE and CS at MIT, Department of EE and CS, Cambridge, Mass., January 1986**

## Astro-Electronics Division

D.R. Chalmers | J.J. Pustay

**Advanced Communication Satellite Thermal Design Using Variable East/West Radiators—24th AIAA Aerospace Sciences Conference, Reno, Nev., January 6-8, 1986.**

G.F. Chilson, Jr. | D.F. Chu | C. Trundle

**Comparison of Predicted and Measured Acoustic Response of Components-Mounted Sandwich Panel—4th Int'l Modal Analysis Conference, Los Angeles, Cal., Feb. 3-6, 1986**

D.R. Chu | B.P. Wang

**On Changing Boundary Conditions in Structural Dynamics—4th International Modal Analysis Conference, Los Angeles, Cal., Feb. 3-6, 1986**

D. Chu | B.P. Wang | T.Y. Chen

**Model Refinement Using Test Data—4th International Modal Analysis Conference, Los Angeles, Cal., Feb. 3-6, 1986**

J.P. Layton

**Multi-Mode Nuclear Space Power Systems—3rd Symposium on Space Nuclear Power Systems, Albuquerque, N.M., Jan. 13-16, 1986**

V.J. Mancino | V.R. Monshaw | W.J. Slusark

**Reliability Considerations for Communications Satellites—Reliability Symposium, Las Vegas, Nev., Jan. 29, 1986**

T. Tracy | R. Hogan | K. Ward

**The Reactivation of Attitude Control on NOAA-8—Rocky Mountain Guidance and Control Conf., Keystone, Col., Feb. 1-5, 1986**

# Patents

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Knop, K.H.

**Solid-state color-encoding television camera—4546380**

Kosonocky, W.F. | Elabd, H.

**Schottky-barrier diode radiant energy detector with extended longer wavelength response—4544939**

Kosonocky, W.F. | Shallcross, F. V.

**Method of making a charge-coupled device imager which includes an array of Schottky-barrier detectors—4548671**

Kumar, M.

**Broadband adjustable phase modulation circuit—4549152**

Levine, P.A.

**Low noise black-level reference for CCD imagers—4549215**

Levine, P.A.

**Dark-current level regulation in solid-state devices—4551762**

Lewis, H.G., Jr. | Stiller, T.M.

**Logarithmic color matrix for a digital television receiver—4544945**

Lewis, H.G., Jr. | Stiller, T.M.

**Digital signal processing system employing logarithms to multiply and divide—4555768**

Longeway, P.A.

**Apparatus for mounting crystal—4547648**

Maa, J. | Halon, B.

**Anisotropic etching of aluminum—4547261**

Martinez, M.R. | Mitchell, W.J., Jr.

**Press workpiece thickness measuring system and method—4548066**

Nicholson, W.H. | Pritchard, D.H.

**Apparatus for frame-to-frame comb filtering composite TV signal—4550340**

Palmer, R.C. | Plotnick, M.A.

**Video disc encoding and decoding system providing intra-field track error correction—4551770**

Pankov, J.I.

**Method of making p-type hydrogenated amorphous silicon—4551352**

Powers, K.H.

**Compatible and hierarchical digital television system standard—4550335**

Pritchard, D.H.

**Apparatus for reducing motion induced distortion in a frame combed chrominance signal—4555723**

Rao, S.T. | Trager, L.L.

**Bath and process for the electrodeposition of micromachinable copper and additive for said bath—4551212**

Reichert, W.F.

**Method of making a gallium arsenide field effect transistor—4545109**

Russell, J.P. | Goodman, A.M.

**Power switching circuitry—4551643**

Schiff, L.N.

**Noise reduction system for a single sideband multiplex signal—4554679**

Sepp, W.E.

**Progressive scan speed-up processor—4550336**

Southgate, P.D.

**Thermally isolated imager—4547809**

Wagner, T.M.

**Complementary color splitting filters used in a color camera—4555163**

Whartenby, J.C. | Kumar, M.

**Predistortion circuit with feedback—4554514**

White, A.E.

**Panel seal and support structure for fiber optic cable—4548465**

Wine, C.M.

**Apparatus for synchronizing a source of computer controlled video to another video source—4554582**

Woodward, O.M.

**Cross-polarization corrector for circular waveguide—4549310**

## Microelectronics Center

Dingwall, A.G. | Zazzu, V.

**Apparatus for matching FET switches as for a video digital-to-analog converter—4553132**

## Patent Operations

Meise, W.H. | Dischert, R.A.

**Compatible wide-screen color television system—4551754**

## Solid State Division

Chandrasekhar, H.S.

**Method of making integrated PNP and NPN bipolar transistors and junction field effect transistor—4553318**

Dackow, P.N.

**Auto ranging counter—4546487**

Faulkner, R.D. | Rhoads, J.L.

**Electron discharge device having a ceramic member with means for reducing luminescence therein—4554481**

Harwood, L.A. | Shanley, R.L., 2nd

**Tri-level sandcastle pulse decoder—4555722**

Rodgers, R.L., 3rd

**Feedback kinescope driver—4547799**

Savoye, E.D. | Tomasetti, C.M.

**Imaging device having improved high temperature performance—4547957**

## Video Component and Display Division

Opresko, S.T.

**Cathode-ray tube having a low power cathode assembly—4554479**

Schlack, R.E.

**Cathode-ray tube having an electron gun assembly with emissivity modifying means—4554480**

license fee. Traditional methods of pricing relate to product cost, are based on historical data, or are established through market sampling and testing. The nature of the product combined with the by-product approach to marketing makes it impractical to apply these traditional approaches. Our method is to establish a fee in accordance with the utility value of the software to the customer. Through accurate quantification of this value is not always possible, a reasonable approximation can be made.

Promotional methods depend upon the size of the market and the method of distribution. When third party distribution is used, the prime licensee assumes the responsibility for distribution. For very small markets and to locate a suitable third party, promotion consists of direct contact with the potential licensee. In the case of large markets, the established business-to-business methods of direct mail, promotional articles in trade journals and papers, advertising, presentations at technical meetings, and trade shows are used.

All software is released under a licensing agreement that protects RCA's rights to the software and limits RCA's obligations and liabilities. Preparation and administration of the agreements is performed by the Contracts Administration activity.

The Software Marketing activity, though part of RCA Laboratories, markets software for any RCA organization having need of its service. In such cases, an agreement is reached

between the MOU originating the software and RCA Laboratories in which RCA Laboratories takes responsibility for all marketing, licensing, and administrative functions. A significant aspect of the relationship is that all revenues are shared by the MOU and RCA Laboratories.

In addition to the marketing functions just described, Software Marketing prepares and distributes the RCA Software Catalog, which contains a listing of RCA proprietary software. The catalog is distributed to all libraries and updated periodically to promote greater use of existing software and to prevent duplication of effort.

### **Summary**

The increased use of computers in the performance of engineering and manufacturing tasks, coupled with a deficiency of existing software, has resulted in greater amounts of engineering time to develop software. Much of this software is unique and has value to others both inside and outside RCA. This situation presents RCA with an excellent opportunity to realize additional gain from the engineering dollars spent in developing software. Addressing that opportunity is the task of the Software Marketing activity.

## Software, a valuable by-product at RCA

A.J. Stranix  
RCA Laboratories  
Princeton, N.J.

Software is the new driving force in the world of computing. As recently as 1981, it was still considered a cottage industry, in spite of annual sales of 2.7 billion dollars. By 1984, annual sales exceeded 10 billion dollars, and are expected to more than triple in the next five years. To put this in perspective, 1984 television sales totaled six billion dollars.

Prospects of a rapidly expanding market have enticed not only dozens of small entrepreneurs, but also have prompted the traditional hardware manufacturers (IBM, Hewlett-Packard, DEC, etc.) to establish new software units or to enter into joint ventures with existing software suppliers. Even unlikely players such as communication companies and publishers—including CBS, Dow Jones, Dun & Bradstreet, McGraw Hill and Simon & Schuster—are licensing programs that are then marketed through their distribution channels.

RCA develops more software than many companies in the software business. Our programs are usually of the applications type and scientific in nature. As our engineers and scientists perform their tasks, they continually advance the leading edge of technology. Ever increasing percentages of technology advancements are being accomplished with the use of computers and sophisticated software. The necessary software, in all too many cases, does not exist and is developed as one would create a tool needed to perform an engineering task. The expense of this development is considered part of the cost of designing or manufacturing the product, and is recovered through the sale of that product.

Software, however, is an intellectual property that has value beyond its direct utility to RCA. As such, it can be copyrighted and licensed to others for a fee. Thus through the marketing of software, RCA has the opportunity to realize a greater return on its software investment dollars. It was to address this business opportunity that the Software Marketing activity was established.

The software marketing concept is to take what is developed to solve RCA's software needs and market this "by-product" to others with similar needs. RCA offers a license to interested parties for an appropriate license fee. Our licensees receive a copy of the RCA software, appropriate documentation, and the right to use the software. Being a by-product, the software is usually licensed "as is" with no warranties. Since the marketing of software is beyond the objectives of the RCA activity that generated it, involvement of the designers is kept to a minimum.

The tasks performed by the Software Marketing activity include:

- Determining product availability
- Determining product marketability
- Establishing a distribution method
- Establishing appropriate licensing fees

- Developing promotion programs
- Negotiating licenses
- Administration of product

These tasks, described briefly below, are those faced by a small entrepreneur.

Candidate programs are located from several sources, including RCA Technical Reports, programs submitted to the Patent Department for copyright, or programs that are submitted directly to Software Marketing by the software authors. In addition, incentive programs have been proposed that should aid in increasing software author participation.

Determining marketability includes the obvious decision regarding market size, value, expected return, competition, etc. But in addition, it entails:

- Determining the existence of and the resolution of any legal obstructions.
- Establishing whether it is in RCA's best interest to license or to retain the software as company-private.
- Ensuring that RCA has copyright ownership.

The Software Marketing activity is responsible for assuring that the marketing decisions are made in compliance with RCA Corporate Policy, and that all affected MOUs have the opportunity to evaluate the decision to license a particular program and to comment on any effects a decision to license would have on their business activity. The decision to market a software package is made jointly by the Patent Department, Legal Department, the MOU originating the software, any user MOU, and the Marketing Department. In special instances, the review will also include the Licensing Department.

Methods of distribution include direct licensing to the end user as well as marketing through a third party. In keeping with the criteria to minimize RCA manpower involvement, the most desirable distribution method is through a third party, preferably one whose product/service is complemented by the licensed software package. An ideal third-party candidate is the manufacturer of the equipment controlled by the software, because his sales force is in place and his customers are potential licensees. The software package enhances the value of his product, therefore making it more appealing to his customers. In such a scenario, the third party becomes a prime licensee with the right to grant sublicenses to his customers. He takes full responsibility for the sales, installation, and servicing of the software. In return, he receives a greater market acceptance for his product as well as a portion of the license fee, with the balance of the fee going to RCA.

When the third party approach is not possible, direct licensing to the end user is considered. This approach is used when the customer base is small and the required support is minimal and available.

One of the more difficult tasks is establishing an appropriate

slowed down by the need to move data in and out eight bits at a time, instead of 16 bits at a time. A related processor, the Intel 8086, is a true 16-bit machine, and has the full 16-bit data path to the outside world. Unfortunately, the two processors are not pin-compatible, so you just can't pull out your 8088 and replace it with an 8086. There are, however, some measures you can take to speed up your IBM PC by adding a co-processor. The co-processor is a device that takes over certain functions that the main processor would otherwise perform, and does them more rapidly. There are two types of co-processors available for the PC. One of these is specifically designed to take over the floating point mathematics operations from the 8088, and the other takes over the bulk of the computing tasks from the 8088 and leaves the 8088 just doing input-output and memory management.

The first of these, the math co-processor, is an Intel 8087 processor. It was designed by Intel specifically to perform floating point math functions, and works along with the 8088 processor, taking over when certain machine instructions direct it to do so. Since the 8087 has 80-bit-wide registers, as compared to the 16-bit registers of the 8088, it can perform arithmetic operations with much greater precision and much faster than the 8088. Typically, the addition of an 8087 co-processor to a system may result in as much as a five-hundred-fold increase in processing speed for certain operations. A typical overall average speed increase is from five to seven times for a computational task that performs a mix of floating point operations. It should also be noted, however, that NO speed increase will be realized unless the software being run is written in such a manner as to utilize the co-processor, because it relies entirely on the execution of a special extension of the processor instruction set in order to perform its work. Thus, you won't see a speed increase for tasks such as running an interpreted BASIC program, which doesn't use the co-processor.

A second type of co-processor is an auxiliary processor board that fits in one of the expansion slots in the machine, and plugs into the processor socket on the motherboard. This type of processor essentially replaces the 8088 processor with an 8086, 80186, or 80286 processor, which are newer, more sophisticated members of the same processor family as the 8088. These are capable of higher performance levels than the 8088, but as noted earlier, are not plug-compatible with the 8088, and thus require the extra hardware on the expansion board to operate. Examples of this type of board are the PC-Turbo from Orchid Technologies, and the Quad Sprint board from Quadram. These boards will give the PC some of the operating properties of the new PC AT, which uses the 80286 processor, but they are really no substitute for the PC AT.

Also perhaps worth mentioning is the QuadLink board from Quadram Corporation. This is a co-processor board that allows the use of Apple II software on the IBM PC, by taking over control of the disk drives and display. This might be useful if you have a heavy investment in Apple software, but the user should be aware that it will not run all Apple software, because some is copy protected.

There is one other type of processor that is available for the IBM PC. Nippon Electric Corporation makes a processor that is designed to replace the 8088 processor in the IBM PC

entirely. This chip, called the V20, is designed to implement many of the functions of the 8088 in hardware instead of software. What this means is that operations which might take several machine cycles for the 8088 processor to complete are performed in fewer cycles by the V20 processor. This results in greater speed, for although the clock time is not changed, the number of clock cycles needed to perform a task may be reduced, depending on the task. Although some advertisements claim as much as a 50 percent increase in speed, a more realistic number is 10 to 12 percent, based on a mixture of tasks to be performed. This chip also does not require special software to effect a speed increase, as does the 8087. While this chip is said to be 100 percent hardware and software upward compatible, I have not tested it, and thus cannot vouch for that claim.

### **Printer buffers**

Generally, it is true that a machine such as the IBM PC can only do one thing at a time. However, by offloading some of the work to another processor, you can gain an effective speed increase. One of the ways to do this is with a printer buffer. Essentially, the way a printer buffer works is to provide the computer with a place to dump the data to be printed, accept the data as fast as the computer can output it, then store the data and feed it to the printer at the rate that the printer can accept it. Typically, an IBM PC can output data from the parallel port at a speed several times greater than even the fastest printer can accept it. Thus, if you put a buffer on the line to the printer, the IBM PC will be done "printing" the data long before the printer is actually finished, and thus will be free to move on to the next task. The PC does its printing as a background process anyway, stealing CPU cycles from whatever process is going on when they won't be noticed. By using the buffer, the PC is making optimum use of the machine cycles that it dedicates to the printing. It may be noted that there are software programs that dedicate a portion of memory to be set aside as a printer buffer. While these are better than having no printer buffer at all, they suffer from two drawbacks. First of all, they take up part of the random access memory space that would otherwise be usable as program or data storage space. This is not too much of a problem if you have the machine configured with 640 kbytes of memory, because very few programs can make use of all that memory anyway. The second problem is that these programs also take up machine cycles, and can therefore actually slow down the execution of programs, since they are essentially another task for the processor to manage.

### **What if it doesn't say IBM on the front?**

Many of the upgrades mentioned here also will work on IBM clones as well. Generally, if the machine to be upgraded has full-length expansion slots, is slot interface-compatible with the IBM PC, and uses the same processor and operating system, at least some of the upgrades mentioned in this article should work.

floppy drives to be mounted. Larger drives are available as full-height units. If an expansion chassis is used, the fixed-disk drives can be put in it, and four half-height floppy drives can be mounted in the main chassis.

The addition of a fixed-disk drive also requires the use of a fixed-disk controller card, which will use up one of the expansion slots in the PC. The standard fixed-disk controller used by IBM supports drives up to only 10 Mbytes in size, but there are many aftermarket controllers produced by companies such as Xebec, Western Digital, and Data Technologies Corporation that may be outfitted with firmware to support the larger drives. If you are short of expansion slots within the PC, there is even a controller card available from Xebec with the capacity to handle two hard drives and two floppy drives at the same time.

Another option available for updating an IBM PC is to add external mass storage. One of the most popular choices is the IOMEGA Bernoulli Box. The Bernoulli Box uses removable cartridges as the storage medium. A single Bernoulli cartridge may contain up to 20 Mbytes of data, and any number of cartridges may be swapped in and out of the drives in a similar fashion to the way diskettes may be swapped in and out of a diskette drive. In addition to allowing virtually unlimited offline storage, this has the additional advantage of allowing a user to remove the cartridge for the purpose of locking up sensitive data in a secure area if so desired. With the installation of the proper ROM in the PC, you can even start-up the machine from the Bernoulli Box instead of a floppy disk, in a similar manner to the way you would start up from a fixed disk. The Bernoulli Box, in addition to being used as an alternative mass storage device, is also often used as a backup device for fixed-disk drives.

### Backup for the masses

Fixed disks, because they can hold so much data, hold within them the potential for disaster as well. Anyone who has ever had a fixed disk crash, and has lost valuable data because of it, can describe in great detail the value of backing up your disk.

Fixed-disk backups may be performed in either of two basic ways; either file-by-file, or image. In a file-by-file process, individual files are copied to another medium, one at a time. In an image backup, an image of the entire disk, including unused sectors, is copied to the backup medium. There are advantages to both methods; file-by-file backup offers a convenient means of restoring damaged files one by one. Image backup, on the other hand, is usually faster and, since it backs up unused sectors as well, can usually back up a fixed disk containing copy-protected software, and later restore it without making a re-installation of the software necessary.

In Versions 2.1 and later of DOS, IBM provides a system utility to allow a file-by-file backup of a fixed disk, using floppy disks as a backup medium. The capacity of a floppy disk is 360 kbytes, while the capacity of the IBM fixed disk is 10.6 Mbytes. A little arithmetic shows that it takes 31 diskettes to back up one fixed disk. In addition to taking a fair-sized pile of diskettes to back up even a small fixed disk, it also takes a fair amount of time. Both the expenditure of time and the number of diskettes required rises linearly with the size of the hard drive to be

backed up. Thus, a pair of 32-Mbyte hard drives could easily take 200 diskettes and several hours to back up. This lack of a convenient means of backing up the data on a fixed disk has led many users to ignore this vital function until it is too late. In order to remedy this situation, an easy to use means of backup (that would also be inexpensive to use) was needed. The answer to this requirement came first in the form of the Bernoulli Box. The original 10-Mbyte Bernoulli Box has a capacity of slightly less than that of a 10-Mbyte (actually 10.6-Mbyte) hard drive; thus, in order to do an image backup of the disk, two cartridges are needed. This unfortunately wastes about 94 percent of the capacity of the second cartridge. In order to back up a 10-Mbyte drive on a single Bernoulli cartridge, a file-by-file backup can be done.

Another backup medium that is gaining popularity is the quarter-inch tape drive. A drive of this type can back up from 10 to 60 Mbytes on a single tape, can do either image or file-by-file backups, and can often restore a single file from an image backup. Some of the tape drives on the market, such as the Archive Scorpion, use their own controllers, while others, such as the Irwin Magnetics, can use the connector on the back of the floppy drive controller, which is normally used for the connection of a third and fourth drive. The obvious advantage to the type that uses the floppy drive controller is that it does not take up a slot for the tape controller. However, if you are using more than two floppy drives, or if you have a disk controller that can only handle two floppy drives, such as the Xebec 1220 combination controller or the controller in the Compaq or Corona IBM lookalikes, you can't use this type of drive. There are usually separate controllers available for operating this type of drive, but they are often designed only for the PC AT, and may or may not work with the PC XT and regular PC.

### Power to run it all

The standard IBM PC has a power supply capable of providing 63.5 watts of power to run the motherboard and all the expansion cards and disk drives within the machine. This power supply is insufficient to power a fixed disk, and may also be insufficient to power all of the expansion memory and other devices that may be stuffed into the chassis by using expansion cards. Both the IBM PC XT and the IBM Expansion Chassis, on the other hand, are equipped with 135-watt power supplies, which are sufficient to power one or two fixed disks and just about anything else one might wish to put in the machine. Such a supply, which will fit in the space occupied by the original PC power supply, is now available from many sources as a replacement part, for those who might wish to upgrade the PC with a fixed disk. For those who fear overloading even such a heavy duty supply, 150- and 175-watt supplies are available as aftermarket add-ons from a few suppliers, as well.

### More processing power

The PC family, as noted, is based on the Intel 8088 micro-processor. While it uses 16 data bits in all its calculations, it has only an 8-bit data path to the outside world. Thus, it often is

in either the enhanced color mode or the monochrome graphics mode.

There are other display options to consider as well. IBM also produces a Professional Graphics Adapter, which provides even nicer text and higher-resolution graphics display. Princeton Graphics Systems has produced a high-resolution monitor, called the SR-12, which has finer horizontal resolution, and twice the number of scan lines for increased vertical resolution. This monitor is normally used with a card that doubles the scan rate of the signal going to the monitor, thus eliminating the "dot-matrix" look of the text characters displayed. Cards such as the Tseng Laboratories ColorPak and UltraPak allow such things as more color flexibility in graphics and 132-column displays on the monochrome display. Special software drivers are needed to take advantage of these enhancements, however.

### Thanks for the memories

As mentioned earlier, the original IBM PC was limited to 64k of memory on the motherboard, and the later models of the PC, including the PC XT, are limited to 256k of memory on the motherboard. This limitation in memory size was intended by IBM to be overcome by adding additional memory on plug-in boards placed in expansion slots on the motherboard. The original IBM memory expansion boards held only 256k, so that in order to increase the memory of the machine past 512k, two of the available expansion slots would be used. This could present a problem for the owner of a five-slot PC, or even an eight-slot PC XT. You could run out of slots rather quickly that way. Companies such as AST research and Quadram soon solved this problem by providing multifunction cards that provide more than one function on a card, thus vastly increasing the array of options you can put in one machine. Typically, a multifunction card might contain up to 512k of memory, one or two serial ports, an on-board clock, a parallel port, and perhaps even a game port. This is as much equipment as could be contained on seven of IBM's boards; two for the memory, two more for the serial ports, and one each for the clock, the parallel port, and game port. When you count the fact that the IBM PC requires a monitor interface card and a disk drive controller card, you might need a nine-slot motherboard to configure a system that could be built using a multifunction board and only three slots. Of course, IBM also thought of a way to get around the lack of slots in the PC. They have produced an expansion chassis for the PC and the PC XT. The expansion chassis has eight expansion slots, one of which is taken up by a transceiver card. A matching card takes up one slot in the main chassis, providing a total of four slots in the main chassis, and seven in the expansion chassis.

The expansion chassis also contains a full-height, 10-Mbyte hard disk. While this is fine if you want to add a 10-Mbyte hard disk, as you will see later in this article, the 10-Mbyte full-height disk is no longer exactly the state of the art. In my opinion, it would have been much more useful had IBM sold the expansion chassis without the hard disk, although as we have seen, the need for an expansion chassis can often be eliminated altogether with multifunction cards. There are other companies that sell an expansion chassis without any disk

drives at all, so if that is really what is required, it should be easy enough to find.

### Mass storage devices

The IBM PC, like any other computer, loses the contents of its memory when the power is turned off. Therefore, in order to save programs and data, some sort of non-volatile storage is needed. The original IBM PC could be equipped with a cassette recorder for program and data storage, but this was very slow and inefficient, and did not allow for much flexibility in storage. IBM also equipped the original PC with full-height, single-sided diskette drives, each of which held up to 160k of storage. Beginning with the introduction of Version 1.1 of the Disk Operating System (DOS), double-sided drives, which held 320k, were supported. Version 2.0 of DOS provided two more advances in disk storage. One of these was an increase in the amount of data one could store on a drive by increasing the number of sectors in a disk track from eight to nine. This provided a capacity of 180k for single-sided drives, and 360k for double-sided drives. A far more significant advance, however, was the introduction of a 10-Mbyte fixed-disk drive. This drive stores as much data as 31 floppy disks, but the storage medium is not removable. In order to equip the PC-1 and some very early models of the PC-2 with a fixed-disk drive, the BIOS ROM in the machine must be updated to the one that supports the hard disk drive. The 10-Mbyte hard disk was originally offered as standard equipment on the PC XT, but it has since been made an option. The same disk drive was also available installed in an expansion chassis, should one desire to add it to the standard PC.

The IBM PC can accommodate up to two full-height floppy disk drives within its main chassis. There are, however, any number of half-height disk drives available that may be installed in the PC or PC XT; thus it is possible to install up to four disk drives in the PC or PC XT. As a matter of fact, the standard IBM diskette drive controller is capable of supporting four floppy disk drives through an external 37-pin connector on the back of the drive. Those interested in the technical details of this connection are referred to an article called "The Third Drive" in the June 1985 issue of *PC Tech Journal* (Vol. 3, No. 6), written by Jack Wright and David Zarodnansky of RCA Laboratories.

Of course, the disk drive mounting bays in the PC can just as easily be used to mount fixed-disk drives. The original PC XT contained one full-height floppy disk drive and one full-height 10-Mbyte fixed-disk drive. It is just as possible to outfit the PC or PC XT with a pair of half-height floppy drives and one or two half-height fixed-disk drives as well. Machines using version 2.0 or 2.1 of DOS support fixed-disk drives up to 16 Mbytes in size. Versions 3.0 and 3.1 of DOS support drives of up to 32 Mbytes each without special software device drivers, and it is possible to install drives as large as 140 Mbytes each by using special software device drivers supplied by the vendors of the drives. Ten, twenty, and even forty-Mbyte fixed-disk drives are now readily available in half-height form factors. This makes it possible to fit an IBM PC with up to 80 Mbytes of online storage within the chassis, while still allowing one or two



## Dressing your PC for success

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It's been five years since the IBM PC first appeared on the scene, and there has been a host of newer and shinier machines introduced, but just because there are some fancier machines around doesn't mean that you should relegate your PC to the scrap heap yet. There are plenty of items that can be added to the PC to make it perform nearly as well as the newer models, often at a fraction of the cost of trading up to a newer machine.

The IBM PC series includes the original IBM PC, which will be referred to herein as the PC-1, the later models of the IBM PC, which will be referred to as the PC-2, and the IBM PC XT.

The series is based on an Intel 8088 microprocessor. The PC-1 had up to 64 kilobytes (kbytes) of memory on the motherboard, and used 4116 memory chips. The PC-2 and PC XT have up to 256 kbytes of memory on the motherboard, and use 4164 memory chips. The two types of memory chips are not interchangeable. Additional memory is available with add-on memory boards, which are inserted into one of five expansion slots within the machine. Other slots can be used for a floppy disk drive interface board, a color or monochrome video interface board, serial ports, parallel ports, and so on. The original PC-1 was equipped with BIOS (Basic Input Output System) firmware (the BIOS ROM), which allowed a maximum of 544 kbytes of memory to be installed in the system. This BIOS ROM made no provision for a hard disk. The PC-2 and the PC XT are equipped with a BIOS ROM that supports up to 640 kbytes of memory and other devices that require a BIOS-callable firmware, such as a hard disk.

The PC-1 and the PC-2 each have five expansion slots. The PC XT has eight expansion slots, although two of these are so-called "short" slots; that is, they will not accommodate a full-length expansion card. This is usually not a problem, however, because many manufacturers produce short cards to go in these slots.

### Monitor options

IBM's original idea with regard to monitors was to allow two options; either a monochrome monitor or a color monitor could be purchased and used with the appropriate monitor interface card. The advantage to the monochrome monitor and interface is that the text quality is excellent—however, there was no graphics capability. A color monitor system could be purchased, which allowed for graphics capability, but the text quality was not nearly as good, and this was felt by many to be a definite disadvantage. If one desired both high-quality text display and graphics, the only option open was to equip the system with two monitors and two monitor interface cards.

One of the first aftermarket vendors to attempt to remedy this situation was Hercules Computer Technology, which produced a monochrome monitor interface card that also had the

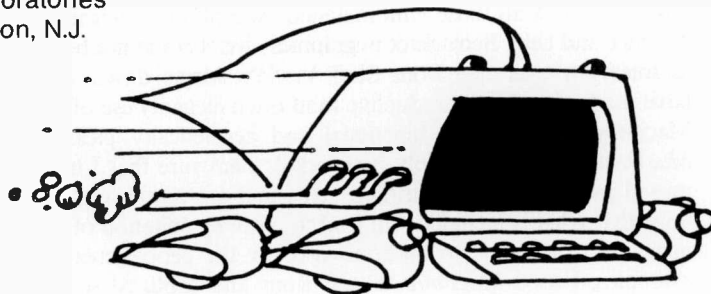


Illustration by Joseph McGarrity

capability of displaying bit-mapped graphics. The Hercules card is supported by most, but not all, major software packages that use graphics, so you have to be careful to note whether the software you plan to run supports the Hercules card. Due to memory addressing conflicts, the earliest Hercules cards could not co-exist with a color graphics card in the same system. The newer versions of the Hercules Monochrome Card may be turned off and on at will to allow the use of a color card in the same system, although they will not give access to both graphics pages if the color card in the system is not also made by Hercules.

A disadvantage of the IBM color card was the lack of a printer port on the card. The monochrome card from IBM, in addition to serving as a monitor interface, also contained a parallel port for use with a printer. If one used a color card instead, a printer interface card was also required if a printer was to be used. Recognizing the need for a color interface card with a printer port built in, Hercules also has produced a color interface card that provides one. In addition, as mentioned above, the Hercules Color Card has a software switch that allows it to be used with a Hercules Monochrome Card. Another advantage is the fact that the Hercules Color Card is a short card, so it can be placed in one of the short slots in a PC XT with no problems.

IBM's monochrome monitor comes in only one color, green. Other companies, such as Princeton Graphics Systems (PGS) and Amdek, have produced monochrome monitors in amber and white, which many users feel are much easier on the eyes for long term use. PGS and Sony have also produced color monitors with a finer dot-pitch than that of the IBM color monitor, thus providing a sharper image, although with no further increase in resolution due to the fact that they are still used with the standard color monitor interfaces. Thus the text display on even these higher-quality color monitors is relatively poor when compared to that on the monochrome monitor.

If you really want to go first class with respect to display options, you can outfit your PC with IBM's Enhanced Graphics Adapter and Display. This adapter is the only unit presently sold by IBM that will allow graphics display on the monochrome monitor. When used with the Enhanced Color Display, the text quality is superior to that of the standard IBM color monitor, and higher graphics resolution is possible. Unfortunately, there is also a scarcity of software that supports this display and card

professional-looking results. We present the included examples as evidence.

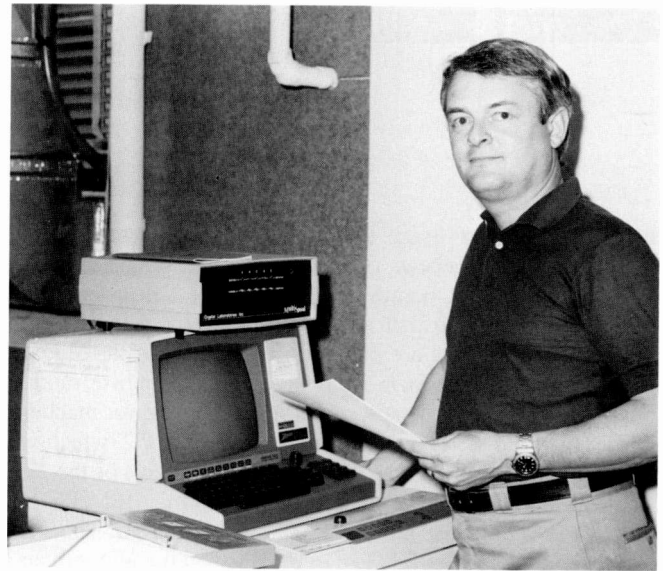
### Acknowledgments

I wish to thank all those with included examples for their time, patience and help. Because of time limitations, I could not begin to interview everyone from Staff Vice-Presidents down who have made significant productive (and often elegant) use of the Macintosh. A stack of functional and aesthetically pleasing *MacDrawings* would simply be overkill. I am sure that I have missed packages and application areas that are significant, but hope that what is included will lead to more exploitation of the machine. In addition to the tools used by the people creating examples, I used *MacPaint* to edit icons and captured screen images, *MacDraw* to integrate and create figures, *MacWrite* to write the text (*MacSpell+* to check it), and *PageMaker* to lay out and integrate the entire document.

**Table II. Comparison of software for the Macintosh.**

Program	Text Terminal	Graphics Terminal	Spread Sheet	Graphics	Data Base	Word Process	Drafting	Painting	Layout	Outline	Statistics	Price Approx	Comments
MacTerminal	x											85	VT-100 emulator
Tekalike	x	x										250	Supports plotters
VersaTerm	x	x										100*	Better VT 100 & 4014
Multiplan			x									110	Replaced by Excel
Excel			x	x	x							225	More power than Jazz
Chart			x									75	Replaced by Excel
OverVue				x	x							150	Fast, easy
Helix					x							220	Stores pictures
MacWrite						x						85	Easy
Word						x						115	More power than Write
Jazz	x		x	x	x	x						350	Does everything easily
MacDraw							x					140	Easy, powerful
MacDraft							x					140	Rotates 1 degree
MacPaint								x				85	Easy
PageMaker									x			360	More power than RSG
Ready Set Go									x			65	Inexpensive
ThinkTank										x		125	To organize projects
Statview											x	100	With ANOVA

\* + \$80 for TekPrint to pan, zoom, and print graphics on the LaserWriter.



Prior to receiving his MS in Operations Research (with a minor in systems design) from Rutgers University, **Don Barton** worked for nine years as a field engineer on U.S. Air Force flight simulators, mostly in Japan. After receiving his degree, he worked as a hardware design engineer in data communications and computer peripherals, and later he worked for RCA Camden on a distributed computing system. He joined RCA Laboratories in 1980, where he developed a testing information system for VideoDisc research using a database and graphics on an IBM mainframe. He joined the Information Systems Planning and Computer Services Group in 1983, and now supports scientific computing for RCA Laboratories. His primary interests are computer graphics and the use of the computer as a tool for the researcher. Don is a member of ACM and a cofounder and Chairman of Grafuse.

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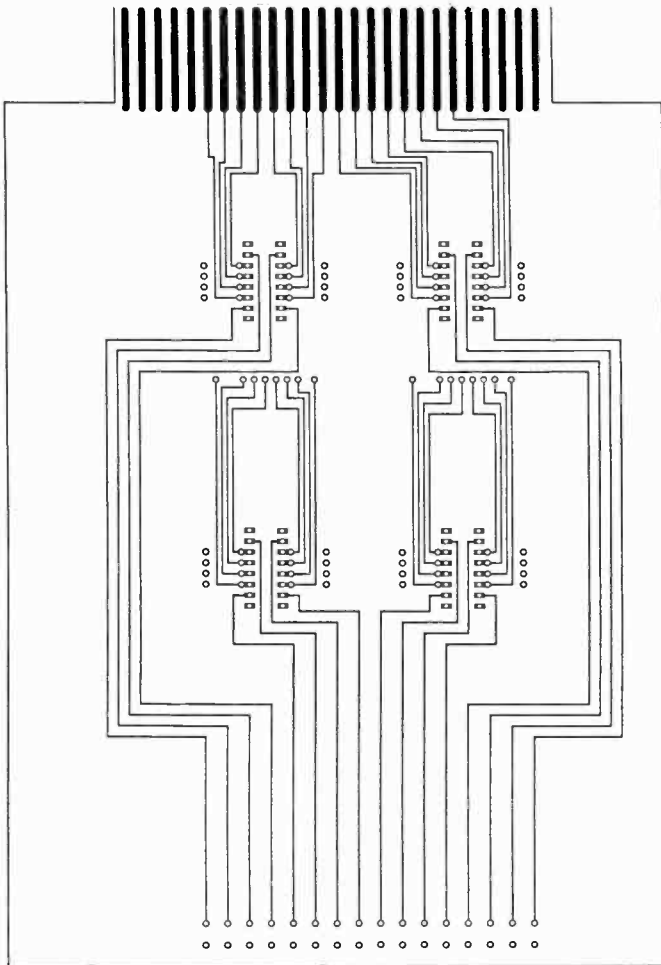


Fig. 5. Printed-circuit board laid out using MacCad.

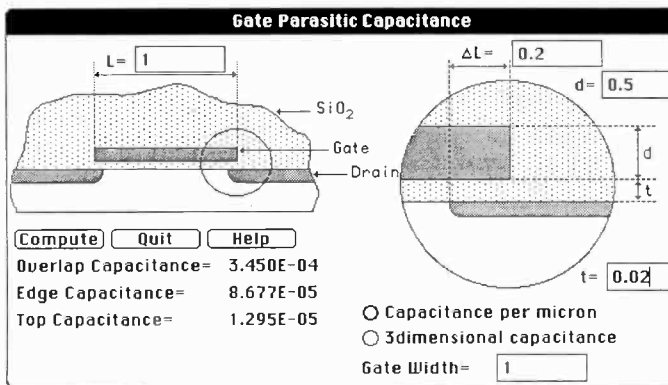


Fig. 6. Output of a program designed to calculate capacitive fringing capacitance.

A second example of Dr. Amantea's work is a graphical process editor under development. In Fig. 7, the program gives users palettes for objects (process steps), and actions (erase, select, etc.). With the mouse, users can place process step icons in order in the process window. If they double-click on a step icon, the program displays a window showing the default parameters for the step. Users can edit these with the mouse.

Figure 8 shows a parameter window for a step that is graphical. The user draws the "curve" by positioning the mouse at the first data point on the graph and pressing the button, repeating the process for each subsequent point, double-clicking

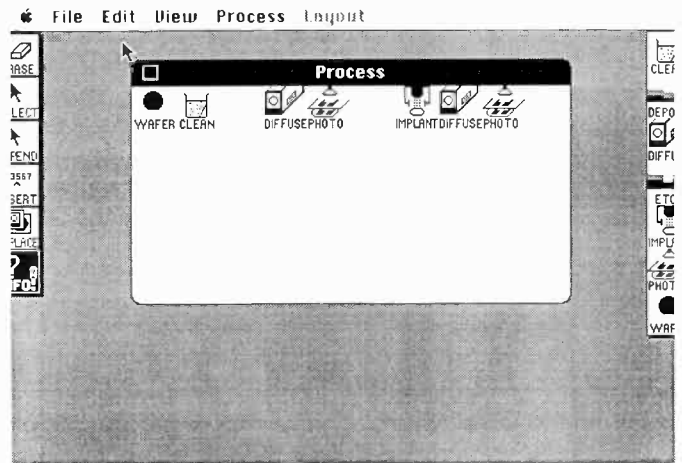


Fig. 7. Screen from a custom-made graphical process editor.

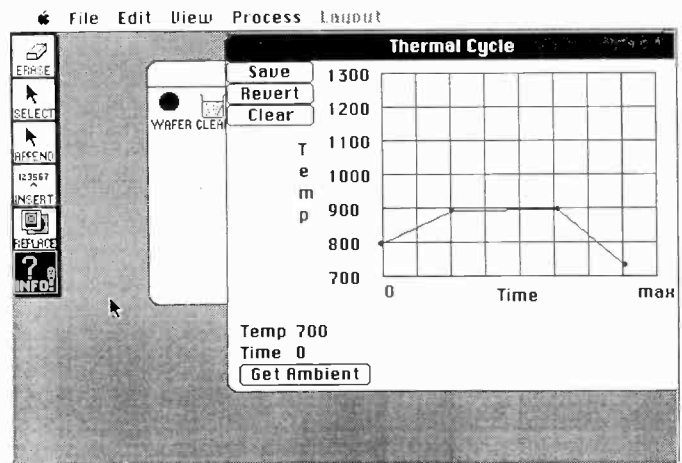
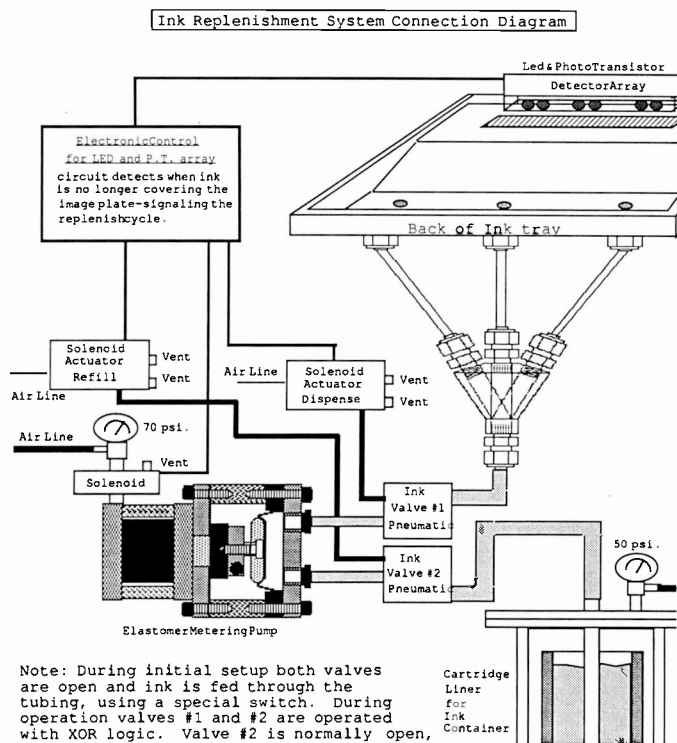


Fig. 8. Parameter window for a step in the graphical process editor.

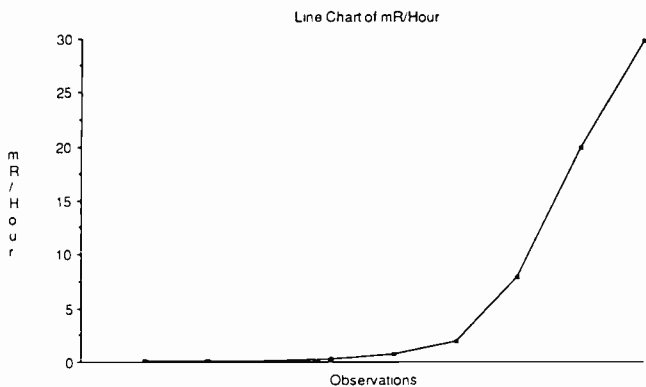
to set the last one. The program creates an EDIF (standardized format for design data) file, which users can send to a mainframe running on CMS by means of the *Kermit* file transfer protocol. Users will then be able to select regions for simulation, capturing data back into the Macintosh for manipulation and/or plotting later, including the results in a report. Dr. Amantea has programmed the same function on an Apollo workstation using Apollo's *Dialog Manager*. Since the *Dialog Manager* functions at a more primitive level than the Macintosh's *QuickDraw*, the program is larger on the Apollo and is much simpler graphically. The Macintosh *Resource Editor* allows one to modify objects such as windows, dialog boxes, and icons directly with the mouse, while the user must specify the parameters of such objects in a text file for the Apollo *Dialog Manager*. Expect a paper by Dr. Amantea on his programs.

## Summary

We believe that the Macintosh can serve as a welcome alternative to traditional personal computers as an engineering workstation. Its user-friendly graphics interface (developed first for the Lisa at a cost of 200 man-years of programming), combined with internal, publication-quality laser printing, make it a tool that can get many an engineering job done easily and quickly with

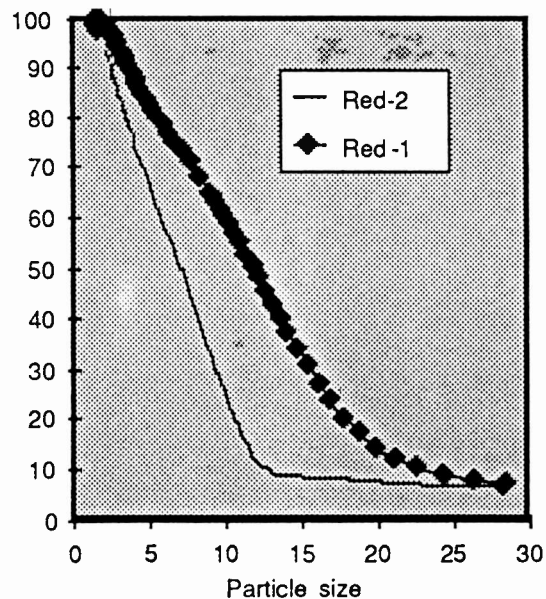


**Fig. 2.** An example of documentation used for the transfer of bar code technology from the Labs to Video Component and Display Division.



**Fig. 3.** A sample plot of experimental data using Multiplan, Chart, and Statview.

**Dr. Roy Nelson** of the Display Systems Materials and Processing Research Laboratory uses a Macintosh with *MacTerminal* to collect data from a porosimeter, an instrument that measures particle sizes by mercury intrusion (this is the only installation in North America with such a device). The instrument is useful for measuring the size distribution of fine particles in the dry state, and can measure particle size and aggregate size. After he captures the data with *MacTerminal* (the porosimeter thinks it is sending data to a serial printer), he pastes it into *Multiplan* for a significant amount of manipulation and then to *Chart* for plotting (see Fig. 4). He expects to replace *Multiplan* and *Chart* with *Excel* for this purpose. He also uses *StatView* for statistical manipulation, *MacDraw* for data presentations and model work, and *MacWrite* augmented with *MacSpell+* for word processing. He says that since he acquired his Macintosh, his output of



**Fig. 4.** Statistical data in graph form. The data was captured with *MacTerminal*, pasted into *Multiplan* for manipulation, and plotted by *Chart*.

technical papers has climbed dramatically (he formerly did his computation on a mainframe).

**John T. Zurich** of the Television Research Laboratory uses *MacCad* (Vamp, Inc.) to lay out non-dense printed circuits. He operates the package as if he were taping the board on a light table, but instead of tape he uses the mouse, instead of the table, the Macintosh screen. While the operation is manual, the ease of change makes it easy to use for small prototype boards. Vamp has announced additional packages for autorouting, schematic capture, surface-mount technology, and circuit simulation. Figure 5 is the only case in which we have been forced to manually cut and paste, since *MacCad* is designed to produce circuit-board layouts and not figures in papers.

**Dr. Robert Amantea** of the Integrated Circuit Research Laboratory is one of the few people, if not the only person, at RCA Laboratories developing custom programs for the Macintosh. He uses a compiled Pascal. He is interested in using the Macintosh for:

1. Development of programs that are not CPU-or I/O-intensive, and that can benefit from a Mac-like user interface.
2. A user-friendly frontend to batch programs.
3. A terminal connected to a more expensive workstation.

He also uses the Macintosh in the more usual way, for word processing, diagraming, etc.

A first example of Dr. Amantea's work is a program designed to calculate capacitive fringing in an MOS transistor. By filling in the blanks for a textbook-like example diagram, the user can calculate fringing capacitance (see Fig. 6). Help dialogue boxes explain such things as the theory underlying the calculations. This is an example of taking advantage of the Macintosh's user interface facilities to create a program tailored to the problem and that speaks in the Mac's language. This program makes the Macintosh appear to be a custom calculator designed to solve just this type of problem.

enough for ram disk operation in a 512k Macintosh. *MacMemory Disk* lists at only \$29.95.

**Switcher** (Apple Computer, Inc.) allows you to partition random access memory to run more than one program at a time, switching between them with a mouse click. It is especially convenient for repeated copying and pasting operations between different kinds of documents (terminal emulation and word processing or spreadsheet, for instance), or for programs designed to be used together (*VersaTerm* and *TekPrint*, for instance). It allows what appears to the user as a limited amount of multi-tasking.

**Dubl-Click** (Dubl-Click Software) is a calculator construction kit that allows you to create your own calculator desk accessory (desk accessories are available from within Macintosh programs), with choices from a wide variety of mathematical and simple statistical functions (as well as business math functions). You select the keys you want and position them as you want (as if you were drawing the calculator). The tape can go to the printer or to a disk file if you want. Dr. Robert Amantea has evaluated this product and found that it provides functions missing from the Macintosh's built-in calculator.

**MacSpell+** (Creighton Development, Inc.) is a spelling checker that installs in the menu of a word processor (*MacWrite* or *Word*) as a desk accessory (so that you can check spelling in the middle of writing a document), and features a thesaurus, word hyphenation, and the ability to add to the dictionary. It searches for the right spelling phonetically. We used it to spell-check this paper. Spelling errors are now a thing of the passed.

### Languages

At this point, most of the major programming languages are available for the Macintosh. Two are in use at RCA Laboratories. A number of users have used Microsoft BASIC to port simple programs from other machines to the Macintosh, and all have reported success. One user uses Softech Microsystems Pascal to program engineering applications in such a way as to take advantage of the user interface. While the results can be remarkable, you should be warned that for the latter, learning time to get started can be months. The Macintosh user interface includes about 480 ROM calls. We have, and are evaluating Microsoft FORTRAN, Aztec C, ExperLisp, and ExperOps-5 (this rule-based expert systems tool is really somewhere between an applications package and a language). Our natural inclination is to suggest that before you write anything for the Macintosh, you should see if there is an applications package that will do the job for you. (This is wise for any computer, but doubly so for the Macintosh). If you want to develop a specialized application whose user interface is of primary importance, the Macintosh is a fine tool, but be prepared to commit a considerable amount of effort to learning how to use it.

### Macintosh users

**Dr. Alvin Goodman** of the Integrated Circuit Research Laboratory uses the Macintosh in his research on MOSFETs (Metal Oxide Silicon Field-Effect Transistors) and COMFETs (Complementary Field-Effect Transistors): *MacWrite* for word processing, *MacDraw* for viewgraphs, *Multiplan* and *Chart* to calculate

statistics (mean and standard deviation, for instance) and plot experimental data.

**Dr. Marvin Leedom**, Director of the Manufacturing Systems Research Laboratory uses *MacDraw* for presentations, etc. He has also programmed the RCA salary guidelines into *Excel* and uses it to track the salaries of approximately 150 people. He had previously done this on an IBM PC using *Lotus 1-2-3*, and on the Macintosh using *Jazz*. The changes in spreadsheet used have provided faster programming and execution time as well as much greater ease of use. He also tracks capital requirements and manpower planning for Manufacturing and Materials Research.

**Walter Marz** of the Advanced Video Systems Research Laboratory has been investigating the possibilities of using the Macintosh as a workstation for the electrical engineer, concentrating on documentation (he field tested *MacDraft*), and on CAD/CAE. He has used and recommends the printed circuit layout package *MacCad* as well as the schematic capture package *ParaGenesis* (Advanced Engineering Solutions). He plans to link schematic capture by the Macintosh into the more powerful Cadnetix workstations. Expect a paper from him on the results of his investigations.

**L. Dimarco** of the Optoelectronics Research Laboratory uses the Macintosh to collect data from a die attachment evaluator, which measures thermal resistance characteristics of laser diode mounts. He modified a BASIC program written for the HP-85A to run on the Macintosh, collecting the data over an RS-232c data communications link. He passes the data (via the clipboard) on to the Microsoft *Excel* spreadsheet for manipulation and graphing. He also uses the Macintosh to produce reports.

**Kenneth Hang** of the Optical Systems and Display Materials Research Laboratory uses *MacWrite*, *MacPaint*, and *MacDraw*. Figure 2 is an example from transferring bar code technology to the VCDD for processes developed at RCA Laboratories. He finds himself updating such documentation frequently, and the Macintosh makes this easy. He also does research in other areas, including thick film multi-layer copper circuits. He finds that the Macintosh can speed his preparation for meetings to the point that it is faster to use it than to delegate the job. He is using *MacPascal* to learn programming.

**Dietrich Meyerhofer** of the Materials and Processing Research Laboratory uses the Macintosh in his research in resists for microlithography. He uses *MacTerminal* and *Tekalike* to make the Macintosh emulate text and graphics terminals for his CMS account, where he is able to run mainframe simulations, viewing text and graphical output on his Macintosh screen. He also uses it for word processing for report preparation, printing the reports on the LaserWriter. He has transferred CP/M BASIC programs from an older Apple II into the Macintosh.

**Dr. James R. Matey** of the Materials and Processing Research Laboratory uses *MacWrite* for Purchase Order templates, letters, and patent disclosures. He uses *MacDraw* to sketch experimental apparatus, and for viewgraph presentations. He uses *MacTerminal* and *VersaTerm* to communicate with other computers. He uses *Multiplan*, *Chart* and *Statview* (see Fig. 3) to plot experimental data. He also uses *Kermit* to exchange files with an IBM PC AT.

We recommend *Ready.Set.Go* as an inexpensive way to overcome the layout limitations of *MacWrite*. Carol Irwin of Information Systems Planning and Computer Services at RCA Laboratories uses it to lay out a monthly newsletter. It does not follow the Apple interface guidelines as exactly as some other programs do, but once you master moving and resizing blocks without the Apple top bars and resizing boxes, it is easy to use. You can move and size blocks with the mouse or type actual positions and sizes (to 1/10,000th inch) into a dialog window. *Ready.Set.Go's* major limitation is speed (you must leave it and enter other programs, such as *MacWrite*, to copy information to be pasted). The latest version can import text files directly, but not graphic ones. *Swicher* (see Utilities) could provide some help, provided the memory is available to run all those programs simultaneously. Starting and stopping programs does take time. *Ready.Set.Go* should be fine for the small newsletter or occasional technical report.

*PageMaker* (Aldus Corp.), a layout program costing several times as much as *Ready.Set.Go*, provides comprehensive facilities for laying out documents. I used *PageMaker* to lay out the draft of this paper, and any deficiencies were a result of human limitations and the wish to conform to technical report format requirements. From within *PageMaker* you can bring in text and graphics from external files and place them arbitrarily (this is a speed feature as much as a convenience one). You can create master pages for numbering, running heads, etc. You can crop graphics, edit text with full control over attributes, etc. It conforms well to the Apple interface guidelines.

### Spreadsheets/graphics

*Excel* (Microsoft Corp.) includes the features of *Multiplan* and *Chart*, and builds on them, adding the ability to format the spreadsheet for printing or inclusion in another (bold, etc.), database functions to sort, select, and report material stored in the spreadsheet, to graph directly from the spreadsheet, and to create macros. While you create macros on a conventional personal computer by typing in command sequences, in *Excel* you turn on a macro recorder and then perform the actions. These are recorded, and placed in a window of macro commands (which you may edit if you want to learn the command language), and you name the macro. Any time you select the named macro (with the mouse) for execution, *Excel* will repeat the steps involved. It is as if by simply turning on and off a cassette recorder, you could request a computer to watch what you did and to write a program to repeat it. We recommend *Excel* for sophisticated spreadsheet users. Much of what engineers used to program in BASIC or FORTRAN (with graphics enhancements) can now be done with *Excel*.

### Integrated office

*Jazz* (Lotus Development Corp.) is a program combining text terminal emulation, spreadsheet, database (including forms and mail merge), graphics, and word processing. Since it is a single program, moving from one function to another is fast and easy. It does as good a job of adhering to the Apple interface guidelines as any program we have seen, and as a result, is exceptionally easy to use, even more so than most Macintosh programs. Its limitations are a result of having to cram all those functions into a single program capable of running on a 512k Macintosh. It does not have macros. You cannot create plots

with logarithmic axes (you could take logarithms of the data first using the spreadsheet, but it is not the same thing). It has limited capabilities for annotating plots (which could, of course, be pasted into *MacDraw*). It does have more word processing power than *MacWrite*. For someone whose requirements do not exceed its capabilities, it is a remarkably easy way to make use of a Macintosh. I captured the information for the Grafuse (RCA Corporate Graphics Users' Group) mailing list (over 250 people) from a mainframe database (terminal emulation), created a *Jazz* database, loaded it, created a form for updating information (database), and created mailing labels (database and word processing) in half a day, all with no previous experience with *Jazz's* database functions.

### Outline programs

*ThinkTank 512k* (Living Videotext, Inc.) is an outline program that allows you to create an outline, indenting and un-indenting with the mouse, expanding to view information at lower levels, contracting to hide it. Moving a contracted topic moves indented information under it. At first, *ThinkTank 512k* might seem pleasant, but perhaps not worth its cost. It can, however, store an entire *MacWrite* or *MacDraw* document, for instance, as a topic. With those capabilities, it starts to look more like an ad hoc mixed text and graphics data management system. You can print a table of contents created by *ThinkTank 512k* and/or the actual complete contents themselves. You can create documents of this sort in *MacWrite* (mixed text and graphics, outlined and indented), but you cannot collapse them to examine only high-level information. *ThinkTank 512k* can be of use in organizing projects.

### Statistics

*StatView* (BrainPower Inc.) is a statistics program with spreadsheet-like tables for data to be analyzed, and graphical as well as tabular output. In late 1985, Joseph Blanc and Dr. James R. Matey were kind enough to compare a number of statistics packages for the Macintosh, and *StatView* proved to be the first choice. It can calculate the usual descriptive statistics and tests, one and two-way analysis of variance, nonparametric statistics and regressions. For diagnostics, it will plot residuals as well as the regression model. Tables may be pasted from terminal emulators, spreadsheets and databases, and graphic output may be copied and pasted to *MacDraw*. We recommend *StatView* for analyzing experimental data in a Macintosh.

### Utilities

*MacMemory Disk* (Assimilation, Inc.) allows you to create what appears to be a disk in random access memory. RAM can be accessed much faster than any disk drive, so programs stored in ram disk can run faster. Whatever is stored in the ram disk disappears when the computer is turned off (or suffers a power interruption), and data must be copied to a real disk to preserve it, but you can control when disk updates take place rather than having the computer do it while you are kept waiting. *MacTerminal*, *MacDraw*, *MacWrite* and *Chart* are examples of programs that run much faster in ram disk. RAM dedicated to ram disk is not available for program execution, and programs that use much of the 512k RAM (*Jazz*, for example), don't leave

provides easy to use tabs, it will not allow multiple columns of text, as in a newspaper. Along with this, although it will allow you to paste a *MacDraw* or *MacPaint* graphic in the middle of text (how many word processors do you know of that permit integration of text and graphics?), it will not allow you to place text alongside the figure (only above and below it). It does, of course, allow you to select blocks of text with the mouse for cutting and pasting, allow multiple fonts with attributes, and allow searches and replacements of whole or partial words with or without case sensitivity. Many Macintosh users will need to overcome *MacWrite*'s limitations, either through the use of a more powerful word processor or by means of a page layout program. We have taken the latter approach with this paper.

**Word** (Microsoft Corp.) is the first word processor providing features omitted from *MacWrite*. It provides more keyboard-oriented commands. It lets you print closer to the margins than *MacWrite*. It will allow multiple columns of text, as in a newspaper. Along with this, it will not allow you to place text alongside a figure. For the accomplished typist with a heavy word processing load, concerned with speed, this is probably the solution of choice to *MacWrite*'s limitations. You could also add a page layout program for even greater capability.

### Spreadsheets

**Multiplan** (Microsoft Corp.) was the first spreadsheet available for the Macintosh. Users of spreadsheets on other computers might be surprised by its ability to adjust the width of a column by grabbing the dividing line with the mouse and dragging it to the desired location (who wants to count characters: I want it that wide!). Many of the things that engineers used to do with BASIC or FORTRAN programs can now be done more productively with a spreadsheet! You can construct formulae with transcendental functions, conditions, etc. You can paste information captured from a remote computer as a table by a terminal emulator into *Multiplan*. For our purposes, *Multiplan* has been replaced (along with *Chart*) by Microsoft's *Excel* (which combines their functions and adds more in one package).

### Databases

**OverVUE** (ProVUE Development Corp.) is a database program for the Macintosh. You can paste in tables or text from a terminal emulator or a spreadsheet, for instance (capturing information from other computers, when it is available, rather than typing it in). Known for its speed and ease of learning, *OverVUE* lets you create tabular and graphical reports.

**Helix** (Odesta Corp.) is a relational database program for the Macintosh. You can paste tables, text, objects or bit-maps into *Helix*. A graphic or even a *MacWrite* document can be a data field to be retrieved by a query. (Consider a relational database of plots of experimental data, which lets you retrieve all the runs made before lunch with a query, or of integrated circuit base diagrams, which lets you retrieve the pin-outs of all the 16k dynamic RAM chips with an access time less than 50 nanoseconds with a query). *Helix* uses icons for everything, including queries (multi-user *Helix* has been announced). *Helix* appears to require more learning than *OverVue*, but to provide more features.

### Graphics

**Chart** (Microsoft Corp.) was the first graphics package available for the Macintosh. It plots tables (typed in or brought in from spreadsheets, terminal emulators, databases, etc.) as line, scatter, bar, etc. It provides logarithmic axes. For our purposes, it has been replaced (along with *Multiplan*) by Microsoft's *Excel*.

### Drafting programs

The drafting programs we describe below have the familiar Macintosh interface.

**MacDraw** (Apple Computer, Inc.) was the first drafting program supplied for the Macintosh. You can draw lines (with or without arrowheads), boxes (with or without rounded corners), circles and ellipses, arcs, polygons and free-form figures, all with selectable line widths, line patterns, and (where appropriate) fill patterns. You can determine dimensions of objects to within a hundredth of an inch. The maximum multi-page drawing size is 48×96 inches. *MacDraw* provides a complete variety of text placement and insertion. With the exception of the icons included (distinguished by their bit-mapped jagged appearance), I could have produced this entire paper in *MacDraw*. Since it produces objects that are represented internally as a line of width  $w$  and pattern  $p$  between points  $(x_0, y_0)$  and  $(x_1, y_1)$ , for example, the quality of output produced is limited only by the hardware (300 dots per inch for the Apple LaserWriter, 2500+ dots per inch for an Allied Linotype phototypesetter). I produced the figures for this paper using *MacDraw*, electronically pasting in bit-maps from *MacPaint* for icons and screen examples.

**MacDraft** (Innovative Data Design, Inc.) is similar to *MacDraw*, but provides additional features such as automatic dimensioning lines, the ability to rotate objects at 1° intervals (*MacDraw* can only rotate objects at 90° intervals), and others aimed at making it a more professional two-dimensional drafting program. Our users have reported problems using *MacDraft* with *Switcher* (see Utilities), and *MacTutor* magazine (November 1985) reported problems using *MacDraft* with *PageMaker*.

### Painting

The painting program we describe below has the familiar Macintosh interface.

**MacPaint** (Apple Computer, Inc.) was the first painting program written for the Macintosh. While it can draw lines, boxes, etc., the 72 dots per inch bit-map limits the quality severely if you are printing on a LaserWriter. We recommend *MacPaint* only for those tasks not possible with *MacDraw* (editing saved example screens, creating bit-map objects, spray painting, etc.), at which point we recommend copying and pasting those bit-maps into *MacDraw* for the addition of objects created in *MacDraw*.

### Page layout

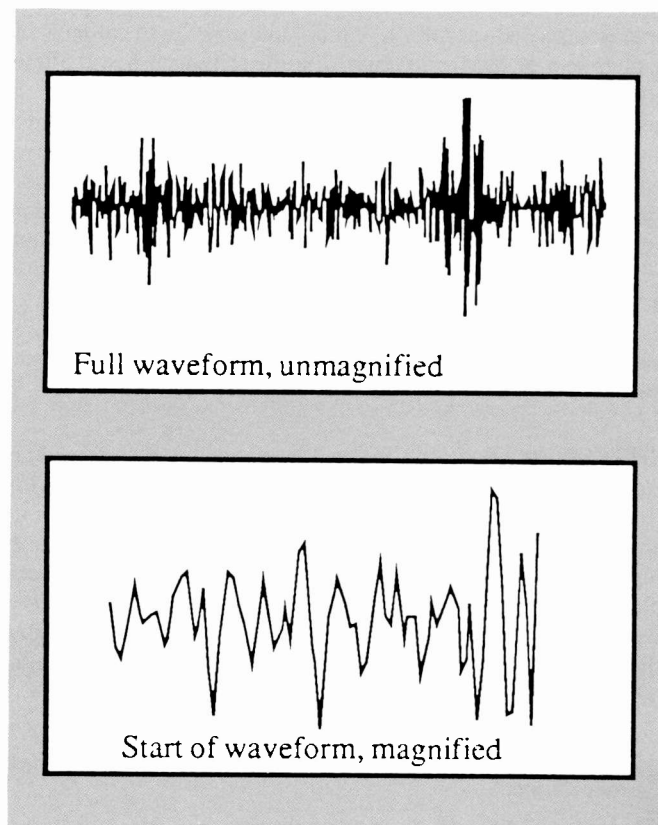
The layout programs we describe below can place text and graphics in arbitrary positions on a page using the mouse.

**Ready.Set.Go** (Manhattan Graphics Corp.) is a page layout program for the Macintosh. You can copy blocks of text and graphics into *Ready.Set.Go*. You can save page layouts (as opposed to the contents) so that you can establish a given type of format for a document, and repeat the look page after page.

ulation with programs such as *MacWrite* as well as tables for transfer to Macintosh spreadsheet, database, or graphics programs. We have sent text to other computers using *MacTerminal*, but not to the IBM mainframe. *MacTerminal* provides for file transfer to and using the *Xmodem* protocol, and from other computers in ASCII (American Standard Code for Information Interchange) text (files can be pasted to other computers, but only a clipboard-full at a time. Its latest version allows the BACKSPACE key to be programmed to be a DELETE key (a menu selection), a convenience for DEC users.

*Tekalike* (Mesa Graphics) is the earliest graphics terminal emulator we used on the Macintosh. It emulates the Tektronix 4010, 4012, 4014 and 4016 graphics terminals (a later version we have not yet tested adds VT-100 and VT-640). It also provides the ability to pan and zoom on areas selected by the mouse and to save plots for *MacPaint* or *MacDraw* for full 300 dots-per-inch LaserWriter resolution. It was this program that first enabled us to consider the Macintosh as a replacement for graphics terminals. The Macintosh could not only view plots at its 512×342 resolution, but thanks to the pan and zoom, could view parts of plots at full 4014 (4096×3072) resolution, a feature then available only on much more expensive graphics terminals (some other personal computers now have programs for Tektronix 4010/4014 emulation, but the best known to me at this time zooms in 4× and only provides 1024×768 resolution at zoom; 4010, not 4014 resolution). The plots could also, of course, be printed and stored in on a Macintosh disk for later viewing, avoiding the cost of recreating them. *Tekalike* also enables emulation of the Tektronix 4662 8-pen color plotter, connecting to low-cost Apple, Hewlett-Packard, and Houston Instrument plotters for color output (plotting graphics stored on disk, enabling you to have panned and zoomed plots). The ability to paste into *MacPaint* or *MacDraw* enables you to include all sorts of plots from other computers into technical reports such as this one, and to edit the plots.

*VersaTerm* (Peripherals Computers and Supplies, Inc.) provides text (more complete DEC VT-100 emulation than *Tekalike*, DG Dasher) and graphics (Tektronix 4014) emulation. It allows the BACKSPACE key to be reprogrammed to be a DELETE key (a menu selection), a convenience for DEC users. It also allows the mouse-controlled cursor to transmit appropriate sequences wherever the remote for either *EMACS* or *vi* editors. It allows whatever appears on the screen to be simultaneously directed into a disk file or to the printer, convenient for capturing long passages (text or graphics) from a remote computer. Screens may be printed at any time. Its Tektronix 4014 emulation provides simulation of the four sizes of 4014 hardware characters. Remote computer-issued commands to print the Tektronix 4014 screen do so (on either ImageWriter, the Apple dot-matrix printer, or LaserWriter). It provides file transfer as plain ASCII text, *Xmodem* and *Kermit* (the public-domain file transfer protocol provided on most RCA Laboratories computers). *Kermit* is available for the Macintosh as a separate public-domain program, but there are obvious advantages to having it built into your terminal emulation program. A companion program *TekPrint* (also from Peripherals Computers and Supplies, Inc.) displays plots saved by *VersaTerm* and provides panning and zooming, rotation (vertical or horizontal page), direct printing (ImageWriter or LaserWriter), and saving (*MacPaint*). Laser-



Writer printing, either from *TekPrint* or *MacDraw*, provides a full 300 dots-per-inch, much finer quality than that provided by an actual 4014 with attached copier. We captured the following wave form plot from Issco's *Tellagraf* running under CMS on a CISS mainframe (data courtesy of Dr. James Matey of RCA Laboratories), passed it to *TekPrint*, saved it for *MacDraw*, where we annotated it, zoomed in with the mouse, saved it again, annotating in *MacDraw*, naturally, we could annotate more, adding arrows to points of interest, with boxed explanations, etc.

#### Word processors

The word processors we describe below have the familiar Macintosh interface.

*MacWrite* (Apple Computer, Inc.) was the first word processor written for the Macintosh (This paragraph was written with *MacWrite*). *MacWrite* is limited in its capabilities, but not in its ease of use. It appears that Apple concluded they had made a mistake in providing a comprehensive selection of integrated software for the Lisa (virtually no one wrote software for the Lisa, since the major functions appeared in the original release of the Lisa Office System). They did not repeat the mistake with the Macintosh—features apparently omitted from Apple packages such as *MacWrite*, *MacPaint*, etc. appeared in third-party packages. *MacWrite* permits both mouse-oriented operation and keyboard-oriented operation (COMMAND-b = bold, etc.). More keyboard operation could speed things up for accomplished typists oriented toward more traditional word processors. *MacWrite* refuses to let you print farther to the left than the 1-inch mark or farther to the right than the 8-inch mark, even if you are printing a horizontal page rather than a vertical one. While it



## PostScript—words and pictures

When Apple Computer introduced the Lisa and Macintosh computers, they not only were selling new computing hardware, they were selling a radically different environment in which text and graphics could be created and edited via a graphical icon-based user interface. With all this emphasis placed on graphics, Apple needed a way of generating high-quality printed output. One year after the introduction of the Macintosh computer, the Apple LaserWriter was introduced.

Apple was one of the first companies to adopt a graphic output protocol named *PostScript* (Adobe Systems, Inc.). *PostScript* is a programming language that generates text and graphics on a printed page. Its programs only work on "PostScript-equipped" printers.

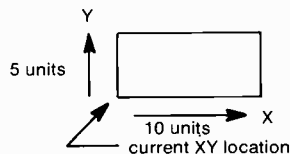
*PostScript* is a complete programming language. In addition to text and graphic operators, the language offers mathematical functions, string manipulation, and file I/O operations. *PostScript* is similar to the FORTH language in that it uses the notion of a "stack" to pass arguments and data. The "stack" is a reserved portion of memory where items are placed and manipulated. Hewlett-Packard calculators operate on a similar principal.

*PostScript* offers many data types such as integers, reals numbers, arrays, and strings. "Objects" such as dictionaries can also be created and manipulated on the stack.

*PostScript* programs are readable 7-bit ASCII text files. Usually, these programs are generated by a given application program running on a computer, such as *MacWrite* on the Macintosh. However, most *PostScript*-equipped printers can operate in a mode where *PostScript* commands are fed to the printer interactively by any host that can create ASCII files.

Variables and procedures can be defined and placed into dictionaries. For example, the following procedure would define and create a rectangle:

```
/RECTANGLE
10 0 rlineto
0 5 rlineto
-10 0 rlineto
closepath def
```



This procedure will generate a rectangle that is 10 default units in X and 5 default units in Y.

The operator "rlineto" is short for relative line to, indicating that the rectangle will be placed relative to the current X,Y location. The "def" operator places the procedure into a dictionary so that future instances of rectangle can be created by simply calling the procedure name.

Much of *PostScript*'s power is in its ability to handle textual operations. Text is denoted by any sequence of characters enclosed in parentheses. The following program creates the text string "Text

Sample" in 24-point Helvetica typeface, 50 default units up and over on the page.

```
/Helvetica findfont
24 scalefont
setfont
50 50 moveto
(Text Sample) show
showpage
```

## Text Sample

Frequently, other systems store type fonts in bit-map form. A separate bit map is required for every character in every size. Because different printers have varying degrees of resolution, bit-map encoding of characters is usually optimized for a specific output device.

In place of bit-map encoding, *PostScript* "builds" a one-point typefont "template" from a set of mathematical instructions stored in the printer's memory. When a program invokes a particular font and size, *PostScript* scales the original one-point template and then stores this scaled image in bit-map form in cache memory. This technique allows the resolution to be independent of the point size. Memory resource use is kept to a minimum as well because only a single template is required for all sizes.

At the present time, the majority of *PostScript*-equipped printers are 300-dot-per-inch (dpi) laser printers. Printers that offer resolution between 200 and 1000 dpi are considered "near-typeset" quality. However, for many printing tasks this resolution is more than adequate. For those jobs requiring higher resolution there are *PostScript* typesetters with 2540 dpi resolution.

Manufacturers supporting the *PostScript* protocol are Apple Computer, Inc., QMS, Inc., Dataproducts Corporation, Prime Computer, and the Allied Linotype Company. Recently, Digital Equipment Corporation announced that they would be using the *PostScript* protocol for certain models of their laser printer line.

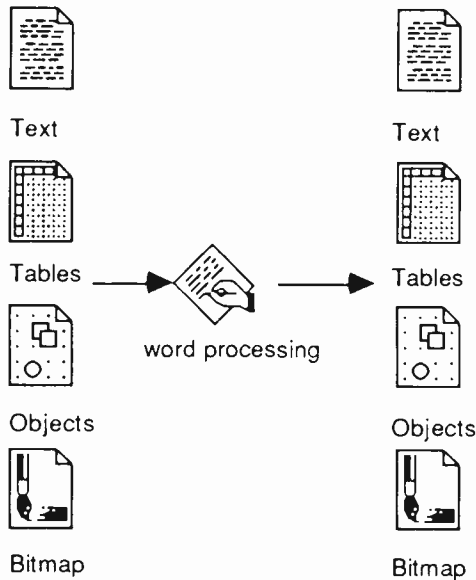
*PostScript* has already had an significant impact on the printing industry. One of the new "buzz-words" in the computing industry is "desktop publishing." This whole new industry is due mostly to the availability of low-cost laser printing and the success of *PostScript*.

The promise of *PostScript* is that unlike other proprietary graphic protocols, *PostScript* is truly device-independent.

—James K. Anders  
Missile and Surface Radar Division

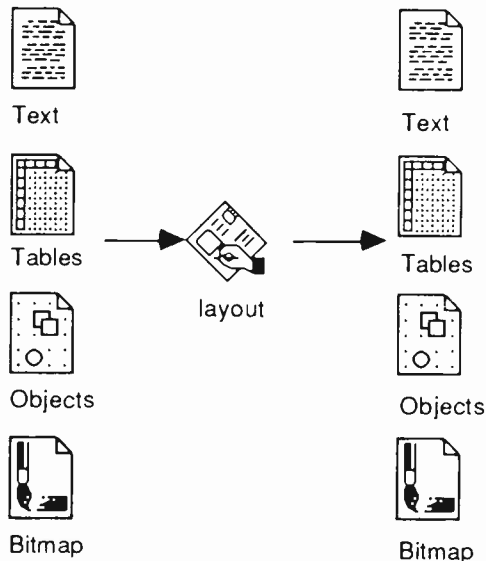
## Word processing

Word processing programs for the Macintosh create text files and can accept text, objects, or bit-maps from the clipboard. They can thus include graphics in a text document, although they will not place text alongside a figure (only above or below it). They allow you to change fonts and their attributes and display the effect on the Macintosh's bit-mapped screen.



## Layout

Page layout programs for the Macintosh permit the arbitrary placement of graphics and text on a page. They permit multiple columns, text alongside figures, etc. This is true, complete integration of text and graphics. It is generally possible to store page formats as templates, thus creating standard document types.



## Specific programs

The table on the next page shows Macintosh programs we have tried and found useful. It does not include languages and utilities, described in later sections, but shows applications that communicate with each other well and are useful for getting a job done. It shows the kinds of inputs and outputs possible. Arrows pointing to the left show inputs to the program, while ones to the right show outputs. Also shown are generic functions (as covered previously) supported by the particular program.

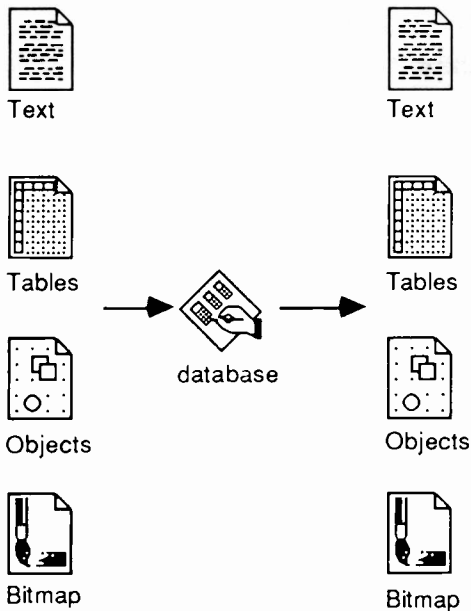
### Terminal emulators

All of the terminal emulators we describe here have the familiar Macintosh interface with radio buttons, and check boxes to select communications settings such as baud rate, parity, etc. We have successfully used them with our Ungermann-Bass local-area network, and with modems.

**MacTerminal** (Apple Computer, Inc.) is the earliest text terminal emulator we used on the Macintosh. Since it emulates the DEC (Digital Equipment Corp.) VT-100 terminal, we have found it compatible with our Decmail electronic mail system. It works successfully with the DEC full screen applications we have tried, as well as with line mode applications on a variety of computers. We have also used it successfully with our *Data-stream* protocol converters for full screen operation on an RCA CISS (Computer Information Systems and Services) IBM mainframe running the CMS operating system in Cherry Hill. We can capture text from other computers for Macintosh manip-

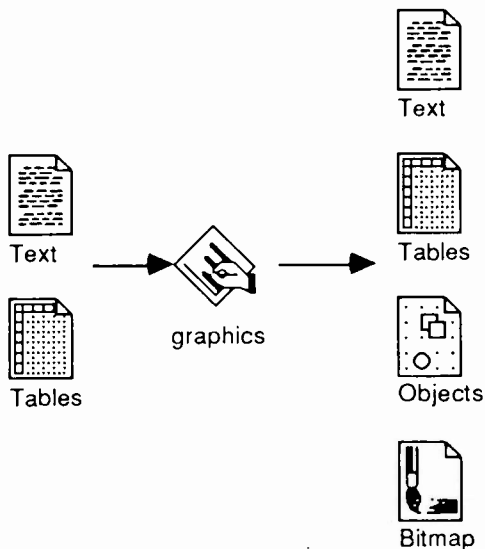
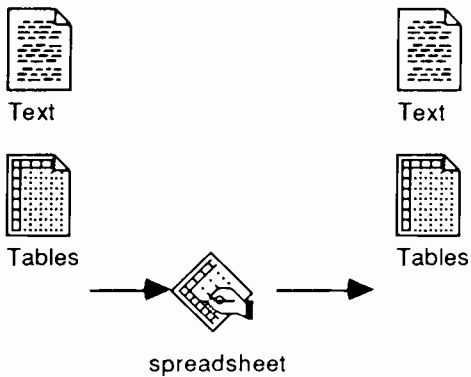
**Table I. Communications among Macintosh software packages.**

Category Program	Remote text	Remote graphics	Text	Tables	Objects	Bitmap	Functions
<b>terminal emulator</b>							
MacTerminal	↔		↔	↔			text (DEC VT-100) terminal
Tekalike	↔	←			→	→	text (DEC VT-100) & graphics (Tek 4010/14) terminal
Versaterm	↔	←	↔	↔	→	→	text (DEC VT-100, DG D200) & graphics (Tek 4010/14) terminal
<b>word processing</b>							
MacWrite			↔	↔	←	←	word processing
Word			↔	↔	←	←	word processing
<b>spreadsheet</b>							
Multiplan				↔			spreadsheet
<b>database</b>							
OverVue			↔	↔	→	→	database & graphics
Helix			↔	↔	↔	↔	database & graphics
<b>graphics</b>							
Chart			↔	↔	→	→	graphics
<b>drafting</b>							
MacDraw			↔	↔	←		drafting
MacDraft			↔	↔	←		drafting
<b>painting</b>							
MacPaint			←		←	↔	painting
<b>layout</b>							
PageMaker			←		←	←	page layout
Ready, Set, Go			←		←	←	page layout
<b>spreadsheet/graphics</b>							
Excel				↔	→	→	spreadsheet, graphics, macros
<b>miscellaneous</b>							
Jazz	←		←	↔	→	→	text terminal, spreadsheet, database, graphics, word processing
<b>outlining</b>							
Thinktank 512k			↔	↔	↔	↔	outline, including text & graphics
<b>statistics</b>							
Statview			↔	↔	→	→	spreadsheet/graphics statistics



### Spreadsheets

Spreadsheet programs allow you to manipulate tables of information, calculating parts from other parts. A surprising amount of technical computation can be programmed into spreadsheets.

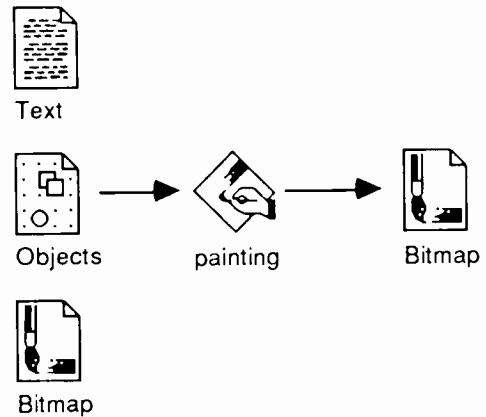


### Graphics

Graphics programs make plots from tables of information.

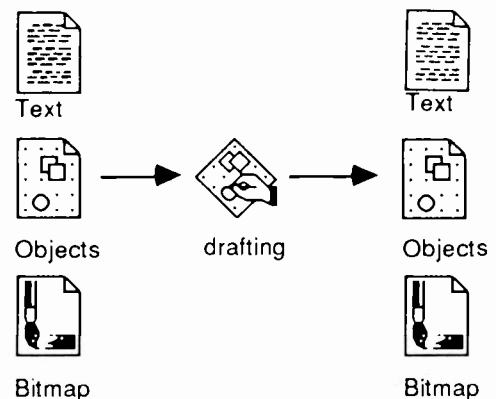
### Painting

Paint programs create bit-maps and can accept text, objects, or bit-maps from the clipboard (which they then turn into bit-maps). They are extraordinarily flexible in manipulating graphics information, but very limited in the amount of detail (72 dots per inch) that they can display.



### Drafting

Drafting programs create objects and can accept text, objects, or bit-maps from the clipboard (which they then turn into objects). They are less flexible in manipulating graphics information, but limited only by hardware in the amount of detail (300 dots per inch on the LaserWriter) that they can display. To eliminate part of an object (you cannot erase part of an object in a drafting program), you cover the part with an appropriately-shaped white object with a white border.



## Text, tables, objects and bit-maps

There are four primary types of information passed around and manipulated within a Macintosh:

1. Text: letters, numbers, spaces, punctuation, carriage returns; may include attributes—bold, underline, italics, outline, shadow, superscript, subscript, font, size; attributes may be passed from one program to another or may not; text is one-dimensional—first character, next character, . . . , last character.
2. Tables: two-dimensional (rows and columns) of text (usually numbers and labels).
3. Objects: straight lines, circles and ellipses, rectangles, polygons, free-form lines, arcs, etc., with attributes including width and pattern for boundary, pattern for interior, and so on. Some programs may stretch, squash, distort, or rotate. An object is an entity, so part of it may not be altered or erased separately.
4. Bit-maps: patterns of dots (at 72 dots per inch in the Macintosh) to produce the appearance of objects. Some programs (MacPaint, for instance) may manipulate individual dots.

## Clipboard, notepad, scrapbook

There are three primary paths for passing information around within a Macintosh:

1. The clipboard: you cut or copy to and paste from the clipboard; it may contain text, tables, objects, or bit-maps; if they fit, the operating system keeps them in random access memory (RAM), otherwise it keeps them in a clipboard file on disk; each copy or cut replaces the previous contents of the clipboard.
2. The notepad: available at any time, even from within a program; will accept up to eight pages of pasted or typed text; the operating system keeps the notepad contents in a disk file; also useful for jotting down notes.
3. The scrapbook: available at any time, even from within a program; will accept pasted objects, bit-maps, and text; the operating system keeps its contents in a disk file.

## Software integration

Figure 1 shows the most commonly used paths among different types of application software. Note that some programs include multiple functions (Lotus *Jazz* includes terminal emulation, word processing, spreadsheet, database, and graphing, for instance), and others are generically equivalent to one or more of these functions (*StatView* uses spreadsheet and graphics functions to provide statistical computations and graphs).

The following diagrams each show an application in the middle, the types of inputs common on the left, and the types of outputs common on the right. Except for terminal emulation, the inputs on the left can be pasted in from other programs, and the outputs on the right copied to other programs.

## Terminal emulation

Terminal emulation allows the Macintosh to appear to be a text and/or graphics terminal. Although this allows a Macintosh to be used in place of a terminal, its real value lies in its ability to capture information from other computers (and paste it to other programs) without entering it into the Mac by hand. Terminal

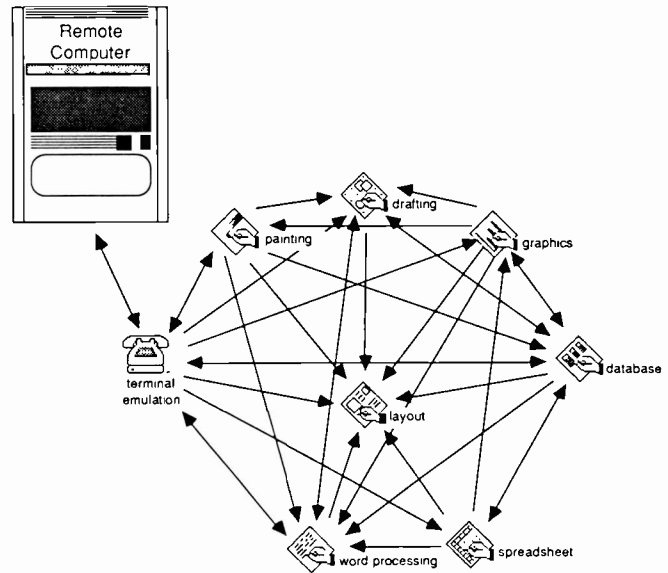
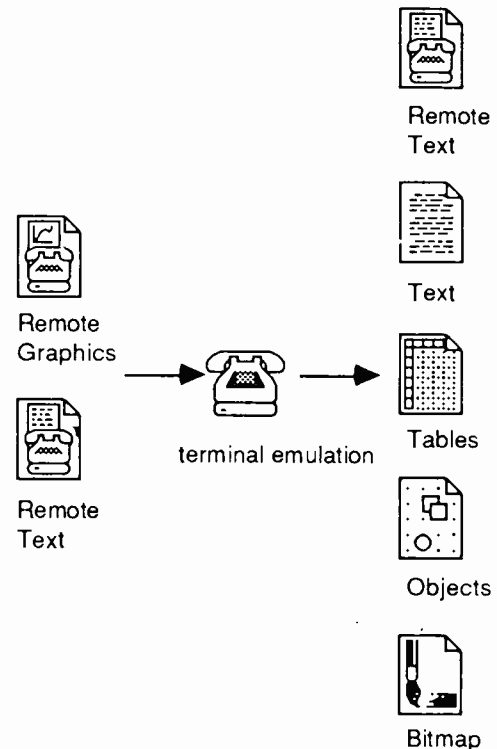


Fig. 1. The most commonly used paths among different types of application software.



emulators may allow text and tables to be sent to a remote computer, depending upon the emulator and the computer.

## Databases

Database programs allow you to store information, retrieving parts of it based on some selection criteria. The primary method of storage is the table, although some databases will even store pictures.

# Using the Macintosh as an engineering workstation

*It may not be all things to all people, but at RCA Laboratories the Macintosh is an Apple with quite a shine.*

Since November 1983, when the first Apple Lisas arrived at RCA Laboratories, Information Systems Planning and Computer Services has had an ongoing evaluation of the window and mouse technology for personal workstations. After the introduction of the less expensive and more popular Macintosh, focus shifted in its direction. For some time we have been recommending the Macintosh as a low-end graphics terminal. This paper describes the Macintosh, its hardware, software, some of its applications at RCA Laboratories, and additional possibilities for taking advantage of its capabilities.

## Hardware features

The Macintosh has a number of hardware features not common among microcomputers in its price class:

---

**Abstract:** *Before automation, engineers and scientists described their work graphically, stressing the use of diagrams, graphs and formulae (with these considered the "meat" of both technical reports and presentations). While they would include text (spoken or written) for guidance, they used blackboards and drawing boards far more than typewriters. Engineering workstations with high-resolution, bit-mapped displays, graphic input devices and direct manipulation software automated many engineering tasks, but at a cost too high to provide every engineer with one. When Apple introduced the Macintosh, many engineers and scientists noticed the presence of workstation attributes, as well as consistent, friendly user interfaces and ease of integration of programs, all this at prices comparable with graphics terminals. This article describes examples of how engineers and scientists at RCA Laboratories use Macintoshes in their work, as well as how they might use them.*

---

1. A high-resolution (for microcomputers) 512×342 bit-mapped screen;
2. A graphic input device (the mouse);
3. Operating system commands to allow applications programs to communicate with both;
4. A high-quality (300 dots per inch) black-and-white graphics laser printer (LaserWriter), available separately.

## Software features

The Macintosh software has a style unlike that of conventional microcomputers.

It is not command-driven (it does not display a prompt and wait for you to tell it what to do).

It is not menu-driven, although it has menus (it does not display a list of choices and wait for you to tell it which you want it to do).

It works by direct manipulation. You may select an object at any time by pointing at it (using the mouse to move an arrow around the screen) and pressing the mouse button (if you did not want to manipulate that object, point elsewhere and click the button). Any time an object is selected, you may point at one of several action categories at the top of the screen and press the mouse button to see a menu of actions for the category. If you keep the button pressed, point at an action, and release the button, it will take that action against the object selected.

Since this type of operation is built into the machines, and Apple has provided guidelines for how the man-machine interface should appear to the Macintosh user, applications written for the Macintosh tend to be quite consistent, and as a result require less time to learn. Common operations become second nature, and the user can concentrate on the problem at hand rather than the tool.

In addition, Apple has provided standard formats for developers to use for data, making it easy for data to be passed from one program to another. They have also provided built-in facilities for passing information around.

DETAIL EVALUATION: CRITERIA AND RULES SCORE WEIGHT

AN/ZZZ-77	839	920
PROCESSOR BBB	737	

Criteria	Processor BBB Score	AN/ZZZ-77 Score	Weight
SIZE	75	80	100
NUCL HARD.	100	100	100
SECURE OS	100	100	100
WEIGHT	90	90	100
OS LEVEL	75	15	75
ADA SUPPORT	75	75	75
AVAIL DEV SUPT	75	75	75
S/W SUPPORT	75	75	75
MAX. KOPS	15	18	50
NUMBER OF PROC	50	50	50
LANGUAGE	50	50	50
OS LEVEL	50	0	50
MEMORY CAP.	8	8	10
# I/O CHANNELS	1	1	10
SECURE OS	Passed	Passed	

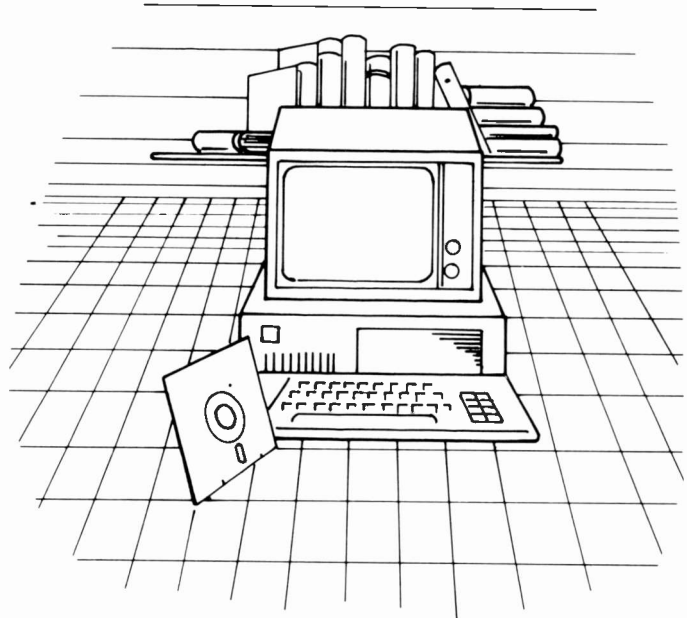
Fig. 6. The major difference between Processor BBB and the AN/ZZZ-77 is the OS level (criteria and rule). Processor BBB is ranked over 100 points lower based on this single factor.

## Help is at hand

Whether you need a few facts or a literature search, or you want to know how other engineers have solved the same problems you face, your RCA Libraries are ready to help.

Ready access to statistical data or research articles is available online at many of RCA's libraries. Online literature searching of hundreds of databases and access to the collections of RCA, public, and academic libraries expand your information gathering possibilities.

Check with the librarian or information specialist at your location for assistance. If you don't have a library, contact **Technical Information Systems, Tacnet: 226-2410**, for assistance and information.



DETAIL EVALUATION: CRITERIA AND RULES	SCORE	WEIGHT
PROCESSOR BBB	737	920

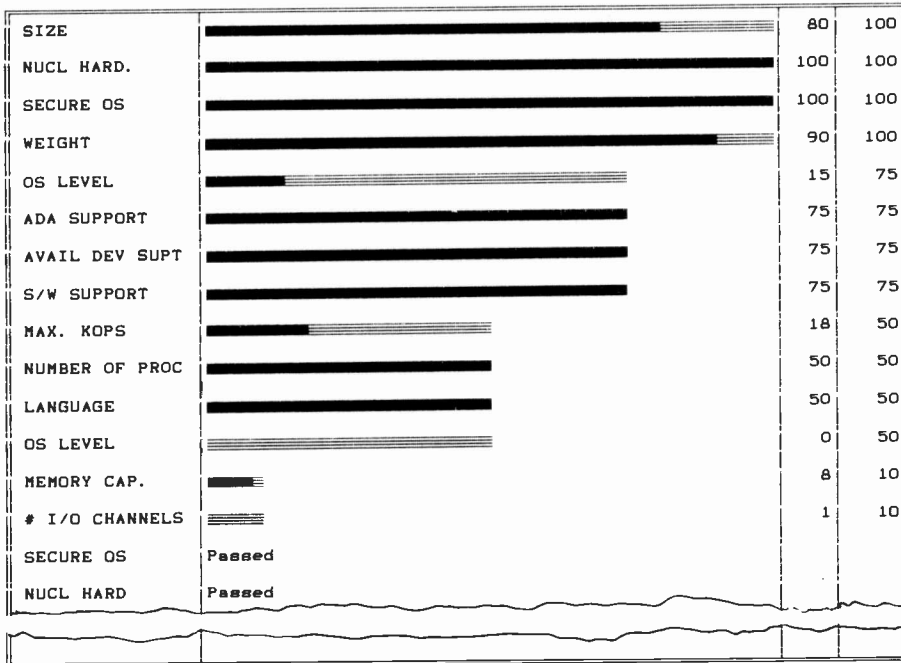


Fig. 5. The detailed evaluation of any alternative can be displayed with a single keystroke. Processor BBB scored 737 out of a possible 920 points.

shines. Figure 1 shows the summary output of an evaluation, but consider now that a detailed evaluation of Processor BBB is wanted. In a single key stroke a detailed evaluation is displayed (Fig. 5). In this figure the horizontal bars represent the maximum score for any criterion. The darkened portion shows the score for this particular candidate. A second question is often asked as to why a particular alternative was ranked higher than another. *Lightyear* addresses this question by "locking" an alternative and selecting a second for a detailed analysis. Any pair of alternatives can be analyzed in this way (Fig. 6).

But what if the score for a particular criterion was changed to a new value—would that have changed that results? With a few simple key strokes any criterion for any alternative can be changed and the resulting ranking can be recalculated.

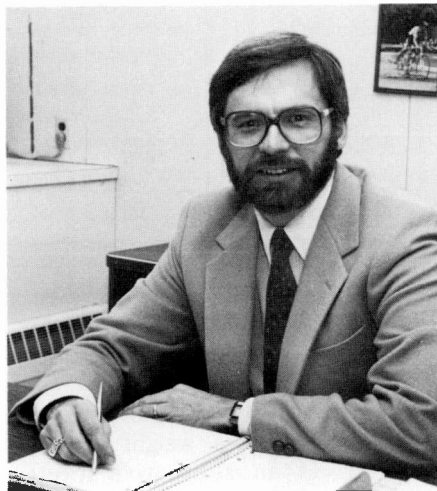
### Summary

The *Lightyear* decision support program provides a key analysis tool that belongs on the software shelf of any engineering PC workstation. It provides a more timely and consistent approach to tradeoff analyses that are either not done or involve tedious pencil and paper efforts. Though the example discussed addresses an engineering application, *Lightyear* has proven value in many business situations.

### References

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## Lightyear hardware requirements:

192k of random access memory  
MS/DOS 2.00 or higher  
At least one double-sided floppy disk drive  
A printer is desirable

is expressed in values from A1 to C1. The verbal criteria are used for including this factor in the model. *Lightyear* comes preconfigured with several verbal criteria categories such as quality, yes/no, frequency, and risk. Each of these can be used to describe a particular criterion. In addition, a vocabulary may be easily customized for such factors as security. In any of these cases the weights assigned to each verbal criterion are under control of the user and may be rapidly tailored.

Once the weights are assigned, however, the user of the model is unaware of their values. Only the appropriate vocabulary selections are shown during an evaluation session. Figure 3 illustrates the verbal criteria.

The third type of criterion uses a graphical representation in *Lightyear* and provides an effective method to deal with subject criteria that cannot easily be expressed in words or with numerical values. Often an evaluator can determine that one alternative is better than another, but has difficulty in translating these feelings into concrete values. For graphical criteria *Lightyear* presents a bar with an "X" located on the line. The evaluator simply has to move the X along the line from most desirable to least. *Lightyear* automatically computes the relative position of the X, translates the position to a score, and computes a weighted result. The example analysis did not use any graphical criteria.

The ability to create and evaluate rules in a weighted-criteria model is the final step in the model creation, and one of the most powerful and useful capabilities of *Lightyear*. In general, a rule is a statement of the relationship of the values of one or two criteria in a model. There are two types of rules that may be written for a *Lightyear* model; elimination or weighted. The elimination rules are those rules that represent pass/fail criteria for an alternative under consid-

Lightyear

SUBJECT: PROCESSOR EVAL  
VERSION: 7 JANUARY 1986

CRITERIA: OS LEVEL

SECURE OS	
A1	*
B3	
B2	
B1	
C2	
C1	
NONE	

ALTERNATIVE	WORD	ALTERNATIVE	WORD
AN/XXX-99	NONE	AN/YYY-88	NONE
PROCESSOR AAA	B3	PROCESSOR BBB	C2
PROCESSOR CCC	A1	PROCESSOR DDD	NONE
AN/ZZZ-77	A1	PROCESSOR EEE	A1
PROCESSOR FFF	NONE	PROCESSOR GGG	NONE
PROCESSOR HHH	B3	PROCESSOR III	NONE

Fig. 3. The operating system security level is a custom verbal criterion based on DoD security standards. The most desirable value (A1) is indicated with an asterisk in the upper right corner.

Lightyear

SUBJECT: PROCESSOR EVAL  
VERSION: 7 JANUARY 1986

RULE NAME	RULE
SECURE OS	SECURE OS MUST BE EQUAL TO Yes (ELIMINATION RULE)
NUCL HARD	NUCL HARD. MUST BE EQUAL TO Yes (ELIMINATION RULE)
LANGUAGE	ADA SUPPORT SHOULD BE EQUAL TO Yes (WEIGHT = 50)
OS LEVEL	OS LEVEL SHOULD BE GREATER THAN B1 (WEIGHT = 50)
S/W SUPPORT	IF ADA SUPPORT EQUAL TO Yes THEN AVAIL DEV SUPT SHOULD BE EQUAL TO Yes (WEIGHT = 75)

Fig. 4. Design considerations concerning the value or relationship of design criteria may be expressed as rules and evaluated in a *Lightyear* model.

eration. A weighted rule is one that has a numerical score or weight associated with it. If an alternative meets a weighted rule requirement, additional points are added to its respective score. In addition, these two types of rules may be either simple or compound (if-then). A simple rule (elimination or weighted) addresses the requirement for a single criterion. A compound rule addresses a requirement for a criterion "if" a second criterion meets a specific condition.

Examples of each of these types of rules are shown in Fig. 4. Of particular note in the use of *Lightyear* is the simplicity built into the program for the

construction of these rules. The user is not required to remember any of the syntax for the rules. All the possibilities are displayed as menu options during each stage of the rule building process, and the user simply makes selections.

Once the alternatives, criteria, and rules have been entered into the *Lightyear* program the model is ready for evaluation. Models can be evaluated in three ways; criteria only, rules only, or criteria and rules. The first two provide a method for evaluating portions of the total model. The last (criteria and rules) is the final goal. It is in this final stage of model evaluation that *Lightyear* really



**Table I.** Evaluation criteria are listed with their modes (numerical, verbal) and their assigned weights (0-100).

Lightyear

SUBJECT: PROCESSOR EVAL  
VERSION: 7 JANUARY 1986

CRITERIA	MODE	WEIGHT	CRITERIA	MODE	WEIGHT
MAX. KOPS	N	50	MEMORY CAP.	N	10
# I/O CHANNELS	N	10	SIZE	N	100
NUCL HARD.	V	100	SECURE OS	V	100
OS LEVEL	V	75	NUMBER OF PROC	N	50
ADA SUPPORT	V	75	WEIGHT	V	100
AVAIL DEV SUPT	V	75			

Lightyear

SUBJECT: PROCESSOR EVAL  
VERSION: 7 JANUARY 1986

CRITERIA: SIZE

VALUE RANGE
MOST DESIRABLE: 0
LEAST DESIRABLE: 100

ALTERNATIVE	VALUE	ALTERNATIVE	VALUE
AN/XXX-99	50	AN/YYY-88	80
PROCESSOR AAA	20	PROCESSOR BBB	20
PROCESSOR CCC	50	PROCESSOR DDD	40
AN/ZZZ-77	25	PROCESSOR EEE	80
PROCESSOR FFF	20	PROCESSOR GGG	20
PROCESSOR HHH	25	PROCESSOR III	12

**Fig. 2.** Size is a numerical criterion expressed in vertical inches of rack space, from 0 to 100.

Ada programming support was desirable, and light weight and small size were important because this was an airborne application. As with most computer applications, maximum throughput and memory capacity were an advantage. Finally, the equipment had to operate in a military airborne environment, with consideration given to nuclear effects. In addition to determining requirements, engineering collected data on potential equipment candidates. The candidates included a large variety of computers ranging from multiple parallel microprocessors to large minicomputers. Computers in government inventory as well as those commercially available were included. Even with some culling of the potential candidates, more than a dozen remained for analysis.

With these basic requirements (and others) and the list of candidates in

hand, systems engineering turned to *Lightyear* for assistance in organizing the analysis and selection of the best candidate.

Creating a model starts with defining the alternatives to be analyzed. For our example of processor evaluation, a large number of computer manufacturers were solicited for prospective hardware. The field was initially narrowed to approximately 12 models. These remaining alternatives were entered into the *Lightyear* program by selecting alternatives from the main menu and listing the name of each model in turn. The names may be up to 15 characters in length. The next step in using the *Lightyear* program is the selection of the criteria to be used. This portion of the model construction is the most time-consuming; not because of the *Lightyear* program but because of the thought that must go into a well-

constructed, accurate model. In addition to simply deciding which criteria to use, their relative importance (weight) must be estimated and their type (numerical, verbal, etc.) must be specified.

The processor evaluation used 11 numerical, verbal, and graphical criteria as a basis. They are listed in Table I.

The most common criterion for engineering evaluations is numerical data. Such factors as size, weight, processor speed, memory speed, and available growth are expressed in quantitative terms. *Lightyear* accepts numerical criteria by defining the most desirable value and least desirable value and linearly scaling values in between. The most desirable value is given a maximum score (maximum weight assigned to the criteria) and least desirable the minimum (0).

Figure 2 shows the numerical criteria used for processor size in inches of rack height for each alternative.

The ability of *Lightyear* to use verbal criteria is one of its most powerful features. One particularly useful aspect of the verbal criteria is the ability to create nonlinear evaluation factors. For example, consider the situation where such a factor as equipment weight is being used as a criterion. Normally this type of factor would be expressed numerically, with values ranging from heaviest to lightest in linear progression. However, there are cases when this approach distorts the appropriate model. This kind of case can occur if only the extremes of weight are important. In our example, computer weights between 100 and 200 lb are considered equally acceptable. Weights above 200 lb are increasingly undesirable. Weights below 100 lb are nice but should not control the model. With a verbal criterion this condition can be handled quite easily, as shown below:

Verbal criteria	Weight
Under 100 lb	100
100 to 200 lb	90
200 to 350 lb	50
350 to 500 lb	20
Over 500 lb	0

The more common use of a verbal criterion is for the scoring of design factors that can not readily be expressed in terms of numerical quantities. Common examples of this are quality, effectiveness, and other factors involving a specialized vocabulary. In our example the security level of the operating system

# Lightyear—an engineering analysis tool

Lightyear is a tool for the most common type of systems engineering analysis—the weighted-criteria alternative-selection analysis.

All systems engineering involves the analysis of design alternatives and selection of the optimum design solution. Examples of such analyses include the selection of computers, peripheral equipment, and software. The list is endless. In a large system, the number of analyses and alternatives requiring evaluation may number in the hundreds. A PC workstation provides an excellent basis for supporting the myriad system tradeoffs, when coupled with appropriate software.

Lightyear, a product of Thoughtware Inc., is a software package that provides an effective tool to aid engineers in analysis of design alternatives. With a superbly engineered man-machine interface and a singular focus on a weighted-criteria analysis, Lightyear is a unique engineering tool. It is clear that Lightyear was developed with a rare insight into user needs. Figure 1 illustrates the

**Abstract:** One of the newest uses for the PC is in the area of decision support. Lightyear is a program based on the weighted-criteria method for ranking decision alternatives. The program has wide engineering application for tradeoff analyses. Its advantages include ease of operation and the ability to use non-numeric evaluation criteria.

Lightyear is a trademark of LIGHTYEAR, Inc.

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Reprint RE-31-2-10

key output from a Lightyear analysis of several candidate computers.

### An example

A recent contract will illustrate the power and usefulness of Lightyear. The contract required that the RCA Communication and Information Systems Division (CISD) study design alternatives for an advanced airborne communications system. Little guidance was provided by the customer except for overall requirements for the system. Of

primary importance to the customer was the selection of comprehensive analyses and clear and complete supporting rationale. A team of approximately ten engineers performed the analyses. An example of the type of tradeoff performed during the contract was the selection of the primary computer used for controlling the system. From the guidance provided by the customer and standard military specifications, basic requirements were determined. For example, the system had to support a B1 computer security level,

Lightyear

SUBJECT: PROCESSOR EVAL  
VERSION: 7 JANUARY 1986

RANK	SUMMARY EVALUATION: CRITERIA AND RULES	SCORE
1	AN/ZZZ-77	839
2	PROCESSOR AAA	838
3	PROCESSOR HHH	743
4	PROCESSOR BBB	737
5	PROCESSOR CCC	610
6	PROCESSOR III	587
7	PROCESSOR EEE	461
8	AN/XXX-99	389
9	PROCESSOR DDD	376
10	PROCESSOR GGG	374
11	PROCESSOR FFF	370
12	AN/YYY-88	191

POSSIBLE = 920

Fig. 1. Even alternatives that fail elimination rules (lighter bars) are ranked in the summary evaluation output.

Box (a 10-Mb cartridge data storage system), a 360 kb floppy disk drive, and a modem. The software is *PMW*, *dBASE III*, and *Relay* communications software (published by VM Personal Computing). The processing sequence (shown in Fig. 1) is:

1. Create an ASCII export file for each related *PMW* project file (*PMW* operation).
2. Process *PMW* export file(s) with customized *dBASE III* program. This creates a data file of information required to set up a *PAC III* project (*dBASE III* operation).
3. Generate local reports using the combined capability of *PMW* and *dBASE III* for audit prior to upload to the mainframe (*dBASE III* operation).
4. Transfer processed *dBASE III/PMW* file(s) to a mainframe file (*Relay/modem* operation).
5. Run *PAC III* (IBM mainframe operation using either a terminal or a PC as a terminal).

The input requirements of *PAC III* include resource (primarily people rates) and actual cost data. Both types of data reside in routine CISD operating systems. These sources are tapped to provide continually-updated data to *PAC III* on a periodic (monthly) basis.

#### **In general**

Considerations of the man/machine interface are probably the single most important parts of a system. They can

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make or break any new systems approach to project planning and management. An assessment of the general level of expertise of the planned user community in both basic project management theory and computer literacy is essential before setting up such programs. The more experienced members of a user group may have a good practical grasp of project management techniques but only minimal acquaintance with computer-assisted planning. Entry-level technical personnel, on the other hand, will characteristically be strong in the computer area and have little background in project management. This diversity makes a user training program an essential part of an automated project management implementation plan.

A major training investment was made by CISD to bring all technical managers up to a level of understanding that is essential for successful introduction of automated project management.

A combination of seminars by an outside consultant, in-house hands-on training with PC software, and lecture sessions and workshops aimed at the mainframe system were used. The courses were open to all technical managers. Easy access to terminals and PCs is another key factor in the acceptance of automated project management.

The era of automated project management is here. Those individuals who are equipped to use automated systems as part of their management techniques will have a competitive edge. The key is attitude and adaptability—the manager who is waiting for the perfect system will still be waiting years from now. Those resourceful individuals who can take advantage of the best elements of a combination of systems to attain a marriage of strengths will make significant contributions to successful project management at RCA.

quickly evaluated. *PMW* has become an accepted standard for planning and controlling engineering projects within CISD.

The ABT attitude toward customer relations and philosophy of keeping their programs abreast of PC technology has strengthened user confidence in their product. They have also been very receptive to requests for *PMW* feature enhancement and minor operational modifications. ABT's future plans for expanding the utility of *PMW* track well with RCA needs for continually improving resource and project management efficiency.

Following a survey of mainframe systems, *PAC III* by AGS Management Systems, Inc. was chosen for evaluation of a mainframe project management software program for overall project and resource integration. It is a typical, versatile mainframe program that is capable of processing and analyzing a large database, and it generates both tabular and graphic management reports. This includes calculation and presentation of financial data and the capability of "earned value" reporting.

CISD's experimentation has been limited to two specific program management software packages. However, the general scheme of uploading data from a PC system could be adapted to many combinations of PC and mainframe software. The prime requirement is that the PC system have the capability of creating "export" files. Then a commercially available, programmable database system such as *dBASE III* (published by Ashton-Tate) can be used to translate the data to a form compatible with the mainframe project management program requirements.

A translation program has been written that facilitates electronic transfer of data from *PMW* to *PAC III*. This is a major breakthrough that will allow exploitation of the strongest elements of both systems in preparing integrated project plans. Figure 1 shows the relationship between the PC and mainframe systems.

Establishing the degree of compatibility between the PC and mainframe is key to preparing an interface program.

### System differences

Detailed analysis of the specific form and content of the PC export file and absolute knowledge of the mainframe

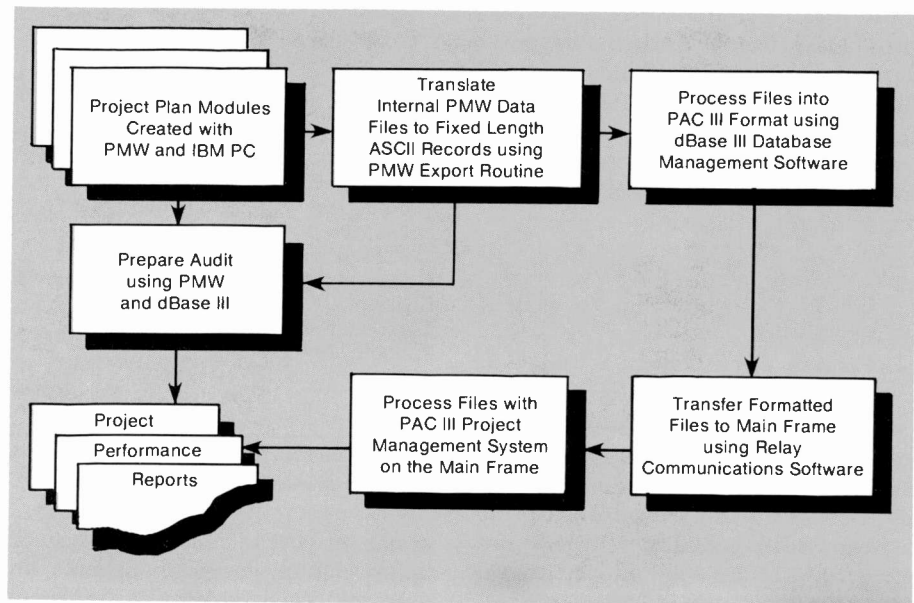


Fig. 1. Relationship between the PC and mainframe systems.

system data input requirements is essential. A few examples of differences that had to be resolved to accomplish the *PMW* to *PAC III* transfer were:

1. Task ID: *PMW* uses a five-digit numerical scheme assigned internally by the program, outside of user control. *PAC III* uses a four-character alphanumeric ID, user entered.

*Solution:* Translate the *PMW* five numeric digits to three alphanumeric characters, using a translation algorithm. The fourth *PAC III* character position was reserved for the assignment of an alphanumeric prefix, unique to each file transferred. This avoids the danger of duplicate task IDs.

2. Logic network connections: *PMW* allows greater than 60 dependencies. *PAC III* has a limit of 10 dependencies per input record, and an absolute limit of 14 per task.

*Solution:* Edit *PMW* files by putting in dummy tasks as collection points for every multiple of 10 dependencies. Put error trapping code in the *dBASE III* translation program to stop processing if the limit of 10 dependencies is violated.

3. Privileged characters: *PAC III* uses the left parenthesis at the beginning of a task description to indicate that the record is a dependency record.

*Solution:* Code *dBASE III* to test for a leading left parenthesis in the task

description field, and if present, substitute an asterisk.

4. Work days: *PMW* allows three digits for work days. *PAC III* allows two digits for either work days or work weeks.

*Solution:* Code *dBASE III* to translate any work day durations of more than 99 to work weeks.

5. Task description: *PMW* allows 60 characters as a task description. *PAC III* has a maximum of 22 characters.

*Solution:* Edit *PMW* files to abbreviate task descriptions. Code *dBASE III* transfer program to truncate any description longer than 22 characters.

6. Task/phase hierarchy: *PMW* has a four-tiered hierarchy—project/phase/activity/task. *PAC III* uses three tiers—project/phase/activity.

*Solution:* Edit *PMW* files to transfer meaningful phase information to the activity level. Code *dBASE III* transfer program to eliminate phase data.

### System operation

The system for transfer of project planning data from *PMW* to *PAC III* is a multiphase process. An IBM PC is used with well-established, commercially-available software. Use of available PC database management and communications programs as building blocks minimizes the custom programming task. The PC is configured with 640 kb of memory, an IOmega Corp. Bernoulli

## Automated project management with PCs and a mainframe

*PCs can't do the job alone, and mainframes can be unfriendly. Put the two together with the right software, and project management stops being the chore it once was.*

RCA's Communication and Information Systems Division (CISD) designs and builds communications and information processing systems for myriad government agencies. Typically, hundreds of contracts, ranging in value from \$100,000 to over \$100,000,000, are in process concurrently. The desire for improved scheduling and resource management focused attention on the need for state-of-the-art automated project management systems.

A system specification was written for an automated planning system that would improve the management efficiency while meeting the stringent reporting and control requirements of RCA/CISD customers. Among other requirements, the ease of data entry, interactive on-screen planning capabil-

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**Abstract:** *CISD wrote a system specification for an automated planning system that would improve the management efficiency while meeting the stringent reporting and control requirements of customers. Among other requirements, the ease of data entry, interactive on-screen planning capability, and large-scale multiproject integration were prime requirements. This article discusses the system tested at CISD. It uses PCs as frontend devices and a mainframe for data "crunching." The software is also discussed.*

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ity, and large-scale multiproject integration were prime requirements. The facility to allow for personal and private analysis during the conceptual phases of planning a project was also high on the priority list of desired features. The often overlooked importance of the man/machine interface was given major consideration in the rating scheme devised for evaluation of project management systems.

Review of the capabilities of both personal computer-(PC)-based and large mainframe project management software systems showed that, when used alone, neither the PC nor the mainframe-type system could meet the total requirements for operation within a large and diverse business and cultural environment.

The better PC packages offer excellent screen interactive facilities, with varying degrees of reporting and analysis capability. However, PC systems are limited when it comes to handling integration of resource data and subsequent rescheduling of 100,000-plus tasks across multiple projects. Repeated attempts to stretch PC-based systems to plan multiple large projects were only partially successful.

Mainframe planning systems are well suited to "crunching" masses of data and providing good multiproject analysis. However, the data input requirements are characteristically "unfriendly" to the point of hostility to the casual computer user.

The concept of using a PC system as a frontend planning and data entry device

and a mainframe system for data integration appeared to be the right answer. An implementation team was established to design and install such a hybrid system. PC software was used for initial planning and optimization of project modules, a PC database system was used to customize and upload data, and the mainframe system was used for final processing and reporting. The resulting combination of resources embodies the strength of both PC and mainframe systems while avoiding the weaknesses that lead to non-acceptance by the user community.

After a literature search for suitable PC systems, several copies of *Program Manager Workbench (PMW)* by Applied Business Technology Corporation (ABT) were purchased for evaluation. The ease of use, innovative screen graphics, and the live interaction features of the program made it a good candidate for consideration. In particular, the speed of the in-memory processing keeps pace with the user's thought process without the delays characteristic of "batch"-oriented systems.

During the first year of availability, many first-level engineering managers have adopted *PMW* as a prime management tool. The use of *PMW* has spread through the engineering organization due to user enthusiasm as opposed to management edict. During a *PMW* session, the manager is in intimate and dynamic contact with his project. The drudgery of using paper, pencil, and eraser is truly eliminated, and the impact of alternate scenarios can be

expertise yielding the foundation of the Digicube.

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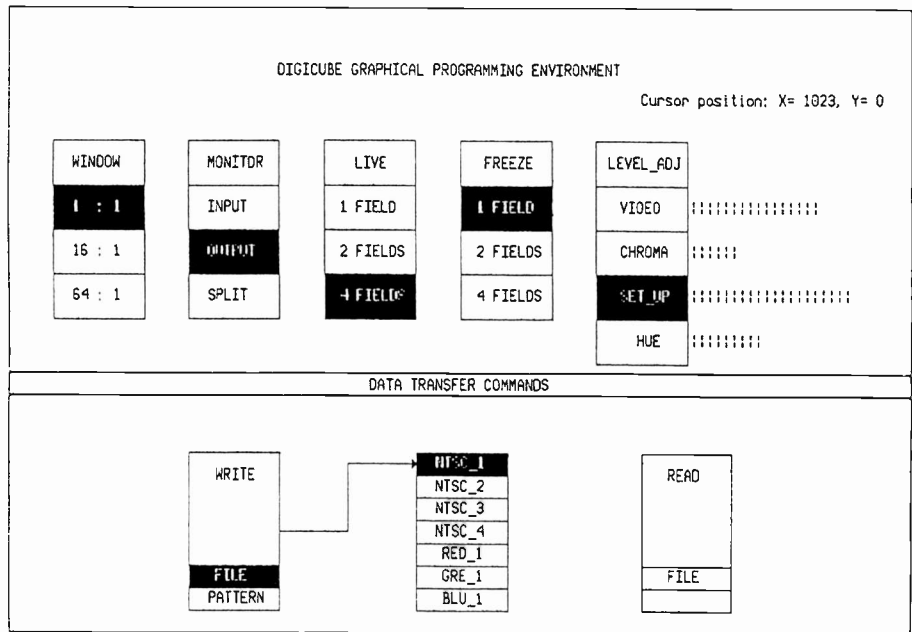


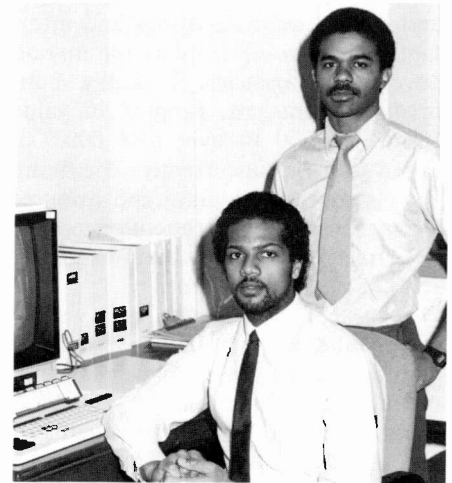
Fig. 6. Illustration of the graphical control environment for the Digicube.

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Law (seated) and Bernard.

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Mr. Bernard joined RCA Laboratories in 1984 as an Associate Member of the Technical Staff in the Digital Signal Processing Research group. Prior to joining the Laboratories, Mr. Bernard also worked on the initial details of interfacing the Fortel Digicube system to the MENTOR engineering workstation. Mr. Bernard holds one U.S. patent, and is a member of IEEE and Audio Engineering Society.

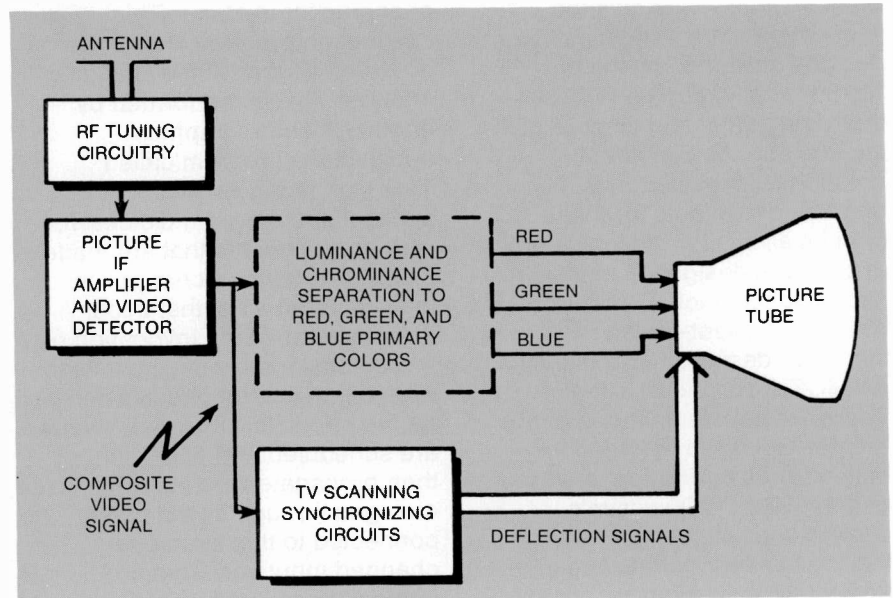
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## A brief description of a digital television receiver

The block diagram for a typical TV system is shown in the accompanying figure. The dashed line represents the block for which the main article is concerned.

This block diagram would be representative of an analog or digital TV. In the case of DTV, the location of the analog-to-digital (A/D) converter might be at the output of the picture IF amplifier. The input to the TV scanning synchronization circuits could be analog or digital. The digital-to-analog (D/A) conversion is assumed to be located at the output of the luminance (luma) and chrominance (chroma) separation circuit. Therefore, there will be a D/A for each output R, G, and B. For the purpose of this article it is assumed that the sampling frequency of the A/D converter is 14.32 MHz, or four times the 3.58-MHz color subcarrier, and the sample phasing of the A/D converter is such that the quadrature components I and Q of the chroma signal are extracted from the composite video signal (CVS).

The Fortel Digicube performs the A/D conversion, initial storage of video, and D/A conversion operations. The Multibus interface between the Digicube and an EWS or DSP unit allows for data transfer into and out of the Apollo DOMAIN System. The Digicube employs the use of video frame



Block diagram of a typical TV system.

synchronizing circuitry. Therefore, input video to the Digicube is analyzed and stripped of its horizontal synchronizing (sync) signal and its color burst reference signal of 3.58 MHz so that new generated horizontal sync and color burst signals can be put in their places. These new signals generated by the Digicube will be free from the nonstandard deviations in horizontal line frequency experienced in such signals as video output from a video tape recorder (VTR). Because of this stripping of the horizontal sync and burst, the video data we can access from the memory of the Digicube is

that of the active video scene only. This consists of the part of the video line after the sync and burst and between the occurrences of the vertical synchronization (vertical sync) periods. The simulation program can take this into account.

In a DTV, the actual separation of the luma and chroma signals can be performed using various processing schemes. The literature<sup>9</sup> discusses the visual improvements noted through the use of line-comb filtering, which is filtering of the CVS in the vertical resolution direction, over the standard practice of luminance and chrominance separation.

with the Digicube using various user-friendly features. These communication programs have included control through menus consisting of textual prompting and even high-resolution graphics symbols that represent command choices. These graphics symbols can be selected via a graphic cursor (using a mouse, for instance). Figure 6 is an EWS screen hardcopy illustrating the Digicube's graphical programming environment. Shown are the symbols for the various function choices: "WINDOW," the digitizing window size; "MONITOR," the viewing choice at the monitor; "LIVE,"

which allows the user to view the input video according to the chosen time base corrector/frame synchronizer mode; "FREEZE," the number of fields to digitize; "LEVEL?ADJ," which allows various level adjustments for the incoming video to the Digicube; and "DATA TRANSFER COMMANDS," the data transfer choices between the EWS and the Digicube.

### Acknowledgments

We would like to acknowledge those who have given us their support and given

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Appreciation is extended to Fortel Corporation for providing their engineering

## Mentor Quicksim

Mentor Quicksim allows the verification of the functionality of designs produced by the other Mentor applications programs that yield schematic capture of circuits as well as symbol creation for these circuits. The creation of symbols for these circuits allows for the inclusion of previous designs in other circuit schematics. Quicksim is a nine-state, event-driven simulator designed specifically for MOS, TTL, and ECL logic. There are several features of the Mentor Quicksim that tend to maximize its performance. Three of these are: (1) Quicksim's oscilloscope-type logic level tracing of network data line (net) activity; (2) its interactive control allowing the user the choice of signals to monitor, list or trace how the circuit is to be stimulated, and any probes or breakpoints to be set; and (3) the possibility of saving the circuit's input stimuli, history, and the particular state of the simulation.

Quicksim is a fairly efficient simulator because it only examines components with

changing input states. This application program is not, however, a worst-case timing analyzer. This is performed by another Mentor Graphics applications program called TVER, or timing verifier. The applications program Quicksim, is driven by events that are made up of transitions or changes in logic state on a net that occur through time. At the invocation of the Quicksim program, no values exist on any of the circuit's nets. As the circuit is simulated, events are scheduled and Quicksim then propagates the state changes through all the nets connected to this circuit. Any changed inputs on what are termed "primitives" or behavior language models (BLMs) are evaluated to see if any changes are occurring at their outputs. If any outputs of the elements are changing, then more events are scheduled.

The term primitive, used above, refers to Mentor's use of "modeling primitives" or built-in simulation models whose functional behavior Quicksim

understands. Examples of some Mentor primitives include:

Simple logic gates: INVERTOR, AND, OR, NOT-OR, EXCLUSIVE-OR, and EXCLUSIVE-NOT-OR gates;  
Memory devices: RAM, ROM, and PLA;  
Registers and latches.

When Quicksim attempts to evaluate the inputs to an element in a circuit schematic so as to determine if an output is to be generated, it references a property of the element known as MODEL. If the MODEL property of this element corresponds to a Mentor-defined primitive, like one of those listed above, it refers to its own built-in functional description when determining an output value from the input stimuli. If Quicksim does not find correspondence between the MODEL property found and its list of possible primitives, it looks at the underlying schematic sheet or sheets of that element until it finds a set of modeling primitives by which it can determine the part's functional behavior.

In the functional modeling of a video processing system, such as the DTV, it is desirable to observe the effects of motion on the signal processing methods chosen. The Digidube's windowing mode provides a means to store long sequential sequences of video. In windowing mode the Digidube is able to store a portion of each field of the incoming video in the NTSC main memory block. This main memory block is capable of storing up to four full video fields (each full video field being 768 pixels by 240 video lines). The window sizes available allow the storage of up to 16 fields (384 pixels by 120 video lines per field) or 64 fields (192 pixels by 60 video lines per field) of incoming video. For example, a reduced picture area (window), which contains 1/4 of the maximum number of video lines (height) and 1/4 of the maximum number of video pixels (width) of each field is stored rather than a full field of video.

An illustration of the various window sizes (1:1, 4:1, and 16:1) is given in Fig.

5, along with the partitioning of the incoming reduced active video area fields within the main NTSC memory block of the Digidube.

In the display of TV video image data, the conventional method is a 525-video line 2:1 interlacing format.<sup>7</sup> Another method suggested for the display of TV signal data uses a 525-line non-interlace format. This reduces the visual artifact known as line-flicker and raster line structure.

The Digidube allows one to display in either the 525-video line 2:1 interlace format or to create the impression of a 525-video line non-interlaced format. This feature allows the subjective evaluation of both display formats. The latter display format is achievable through the use of various processing techniques such as line- or field-progressive scanning.

Non-interlaced displays can be achieved through the display of a single field of video data where the number of horizontal line synchronization pulses is forced to be

262 instead of 262.5. This causes the video to be rewritten over the same spatial locations on the display monitor. The monitor's vertical scanning height is then decreased to half its standard height. This method implies being able to simulate the display of a noninterlaced format for only half of the original image. Through software, for example, to generate a field-progressive scan simulation, one would write a line of video data from field 1 followed by a line of video data from field 2 into the output field to be displayed. Obviously, the output field becomes full at the point halfway through fields 1 and 2. The resulting image is half the size of the original. Pertinent information characteristic of the display format chosen can be discerned without additional hardware.

In summary, the Digidube has become a very useful and versatile peripheral for the investigation of video signal processing problems. Also, because of the peripheral interface and graphics capabilities of the EWS, we are able to communicate



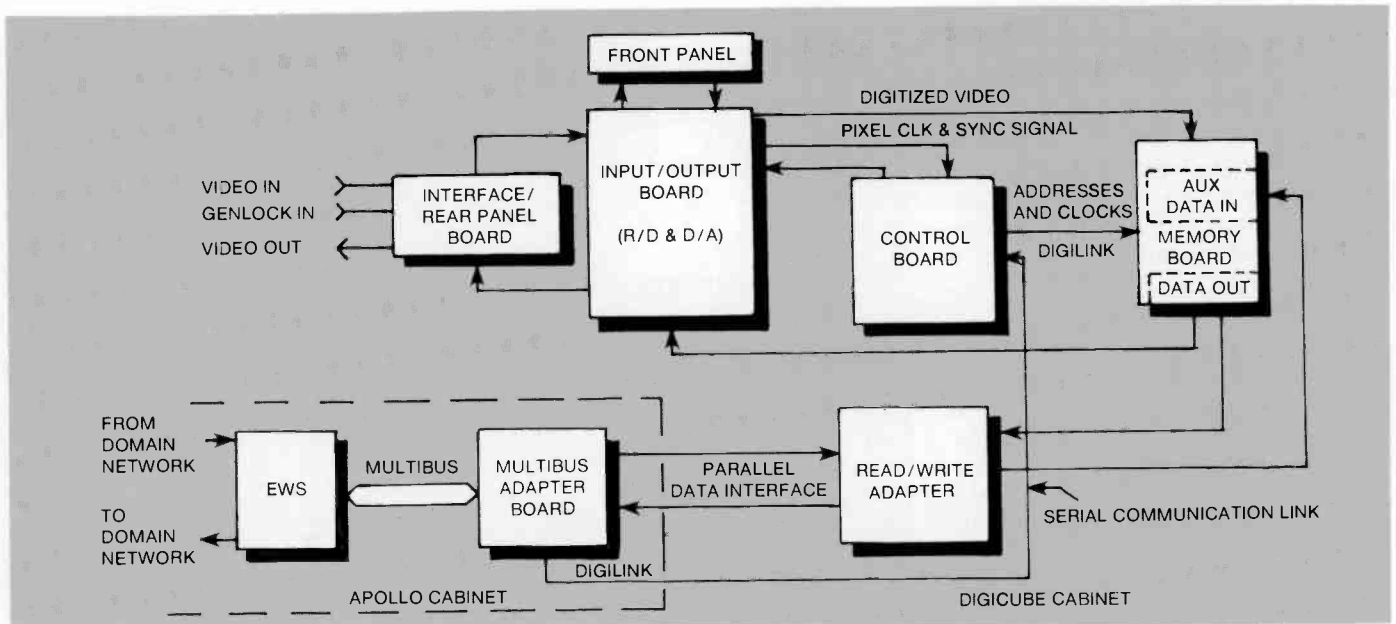


Fig. 4. Digicube block diagram.

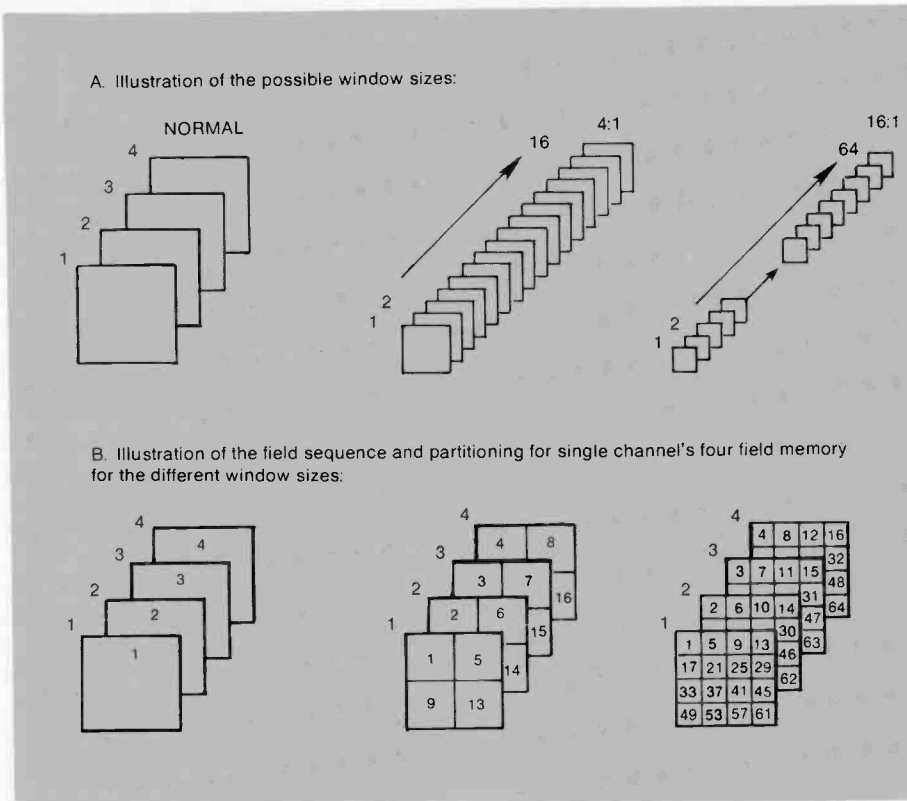


Fig. 5. Relationship of window size and memory storage partitioning.

and routes this information to the Digicube's control board for subsequent execution. The read/write adapter board permits direct memory accessing of the Digicube's video storage memory to allow transfer of data to and from the EWS. The Multibus adapter board is located in one of the EWS Multibus card cage slots. As shown in the figure, the input/output board con-

tains the A/D and the D/A converters along with circuitry that performs video signal conditioning. The front panel offers manual control of various functions and displays the Digicube's status.

The video data is stored in a memory composed of an array of 64k dynamic RAMs (DRAMs). There are actually four blocks of main memory, each one capable

of storing four video fields. The four blocks are denoted as NTSC, R, G, and B. They are used as follows. When the Digicube is used as a viewing device for RGB data, the R, G, and B main memory blocks are used. An incoming video sequence, which is in an NTSC composite video signal (CVS) format, is written into the NTSC memory when requested. If the user has an NTSC CVS stored on the EWS and desires to view the video data on the Digicube, he or she would transfer this video data into the NTSC main memory block. When the video data is read from the NTSC video memory block a color burst reference signal is added to the signal along with the horizontal sync signal, and other associated chroma processing is performed before the data is displayed. Note that the designation of the video memory blocks as NTSC, R, G, and B is to signify that the R, G, and B memory blocks do not perform any insertion of color burst reference or associated chroma processing, but do insert the required horizontal sync timing signals.

The Digicube samples the incoming CVS at the sample positions corresponding to the chroma quadrature positions of I and Q. This convention is assumed for the display of composite video placed in the NTSC memory block also. Thus, if one loads the NTSC memory block with composite video, it will assume that the samples are located at the quadrature positions of I and Q. If the data to be viewed was sampled differently from this convention, one will see a chroma hue error in the displayed video signal.

per color. This yields over 16 million possible colors.

This latter feature is used by the authors and allows the viewing of decoded composite video pictures (RGB) using data digitized by the Fortel Digicube and subsequent processing by the functional modeling software emulating a digital TV.

3. The DOMAIN network—The DOMAIN network is a high-speed, token-passing local-area network that gives each user a dedicated computational node based on a 32-bit computer architecture. This network uses a 12 megabit-per-second token passing ring. Apollo claims that a network is maintainable even with nodes separated by as much as 1000 meters (over 1/2 mile). This token passing protocol insures that all workstations and DOMAIN server processor units (basically workstations with no display hardware that can be used to run non-viewable processes to service peripherals) on the network have guaranteed access to the network, and allows a large number of workstations to share a single network without collision detection schemes.

By the end of 1986 there will be approximately 50 nodes (EWSs and DOMAIN server processing units) at RCA Laboratories, and about 50 elsewhere in the corporation. The total amount of disk space is expected to be around ten gigabytes. Since the DOMAIN system appears to all users as a single file structure, and even though the actual data may be physically located on various system nodes, the disk resources are available to all users in the network.

Gateways allow access to other DOMAIN local-area networks, to remote mainframes and superminicomputers, and to public long-haul packet-switching (X.25) networks. Communication with IBM systems is supported by gateway software that emulates several RJE (Remote Job Entry) subsystems—IBM's HASP and the standard 2780 and 3780 environments. An Ethernet gateway provides DOMAIN system users shared access to Ethernet transport facilities. The TCP/IP (Transmission Control Protocol/Internetworking Protocol) provides easy access to DEC VAXs and other systems.

All DOMAIN system workstations and servers have RS-232C ports and provide for VT100 terminal emulation. In addition, some models of the EWS and all DO-

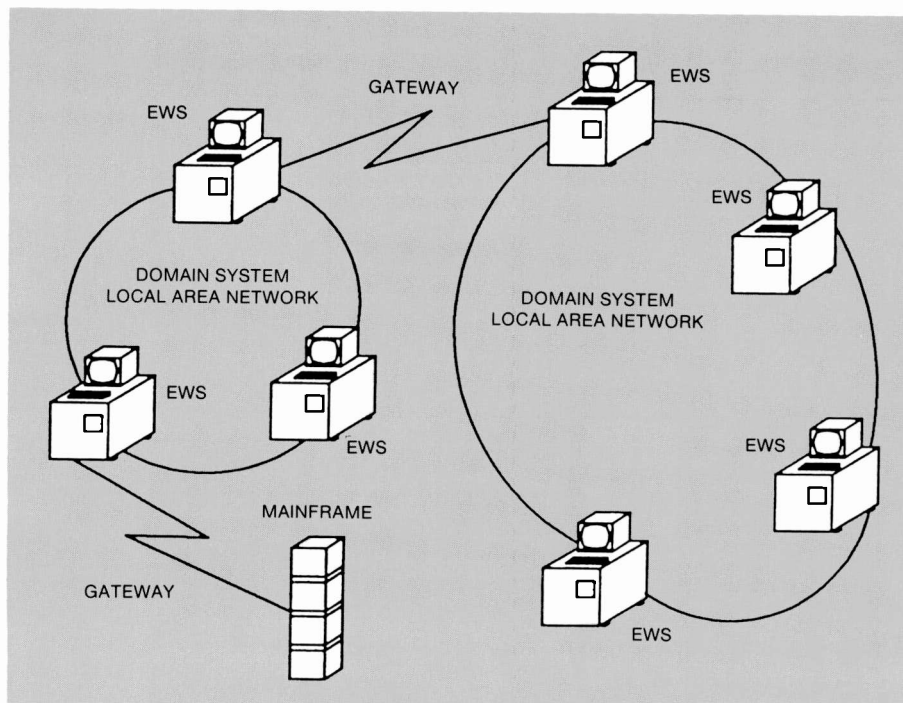


Fig. 3. Illustration of a possible DOMAIN networking scheme.

MAIN server processor units contain Multibus Interfacing hardware. Apollo gives the user the capability of defining the peripheral interfacing environment through the use of general-purpose input/output (GPIO) software.<sup>4</sup>

Figure 3 is an illustration of two DOMAIN local-area networks, one with three and the other with four engineering workstations. These two local-area networks are linked by a communications gateway. The drawing also shows a gateway to a mainframe.

It must be pointed out that one of the advantages that we saw in using this particular workstation was that in addition to the offerings discussed above, it allows for straightforward interfacing of user-defined peripherals. In our case this was the Fortel Digicube digital frame store device.

#### Video frame storage device

We chose the Fortel Digicube as our workstation video multiframe storage device. This system is useful for subjectively testing digital signal processing algorithms that operate on NTSC video pictures. This frame store is built around a Pictel frame synchronizer. It is capable of capturing up to 64 fields of video, and the user can choose from three digitizing window size formats. Once this video data has been captured the digitized video can be accessed by any node on the DOMAIN network via the Multibus interface. Software run-

ning on an EWS can now access and manipulate this digitized NTSC video data. For example, the results could be decoded using a DTV simulation program, and the resulting RGB components could be transferred back into the RGB memories of the Digicube for viewing. The video stored in the RGB memories will then be read out at a rate of 14.32 MHz, converted to an analog signal, and displayed in one of the window size formats on a display monitor. Because the Digicube is a frame synchronizer/time base corrector (FS/TBC),<sup>5,6</sup> non-standard signals from a videotape recorder (VTR) or videodisk player could be captured for analysis also.

The Digicube's windowing option allows a reduced area of the active video field to be digitized and stored. This enables longer time sequences of video storage for the same amount of the Digicube's memory. Thus, one can digitize a video sequence of up to one second in duration. NTSC decoding algorithms can use this feature to show (and allow the study of) motion artifacts due to temporal type processing such as frame combing and frame recursive filtering.

The Digicube allows freeze-field, freeze-frame, hue, chroma, setup, and video levels to be altered under remote control via the Fortel Digilink serial communication link. This is shown in Fig. 4 in an illustration of the main blocks of the Digicube. The Digilink interface interprets commands from the EWS (via the Multibus interface)

## A functional software simulation scheme for digital television

The simulation of a digital signal processing (DSP) system can take many forms. Mentor software packages allow a designer to simulate digital circuits in such a way as to extract the timing and logical correctness of the circuit design. With a good understanding of the DSP algorithm being implemented in simulated hardware components, a designer can relate the logical correctness to the particulars of the algorithm. For complex algorithms, however, the implementation in logic circuitry becomes so complicated that extracting algorithm particulars becomes a burdensome task at the logic gate level. Simulating the DSP algorithm while still at the mathematical expression level offers easier modification and parameter

variation testing. The mathematical expression level of simulation can be done using higher-level programming languages such as Pascal, Fortran, or C. At this level, blocks of programming code that correspond to blocks of logic circuitry can be denoted and optimized with special attention given to such effects as finite word length (FWL) processing.

Mentor allows functional representations of logic-gate-interfaceable circuit elements using Pascal. These elements are referred to as behavior language models (BLMs). Through the use of BLMs a designer can model various functions in Pascal and have these functions be executable in an event-controlled environment known as Mentor Quicksim®

(interactive simulator—see the sidebar on Mentor Quicksim) applications program.

BLMs can be used with other elements whose functional description is defined by a set of logical primitives. Because the BLM also operates in a timing-controlled environment, timing and logical verification of the system can be obtained using Quicksim. This BLM capability becomes advantageous when algorithms require complex logic circuitry to implement. One advantage is the reduction of the time required for total system simulation. Another is the capability to provide designers with a means of testing the algorithmic equivalence of their logical primitive-derived circuits against a verified functional description, the BLM.

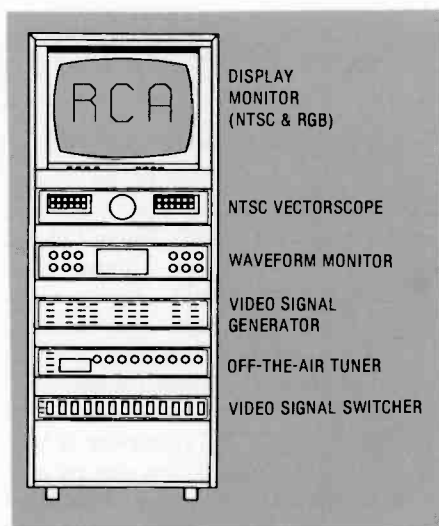


Fig. 2. Illustration of VFMS component rack used by the authors.

features in actual televisions. The off-the-air tuner allows for the digitizing of live video signals, and the video signal switcher is used for routing the choice of input video to the Digicube.

### The Mentor engineering workstation

In the early 1960s, data processing meant dealing with large mainframes in batch

processing terminology. In the mid-1960s more alternatives became available as computer technology grew. These alternatives included time-sharing and dedicated minicomputers. Some pitfalls of the two computing schemes were limited performance due to shared computing power, delays due to time-sharing, and lack of readily available program, file, and peripheral sharing in minicomputers.

Apollo Computer (the computing hardware used by Mentor) developed the DOMAIN operating system, which combines the favorable aspects of the computing schemes mentioned above. There are three basic principles behind the DOMAIN system architecture:

1. Mainframe-style dedicated computing, which entails virtual memory, large address space, and an assortment of software.
2. Tightly integrated high-resolution graphics features.
3. A distributed system linked by a high-speed local-area network. This offers users the responsiveness of a single-user system with the centralized file access of a time-sharing system.

These principles are illustrated by Apollo in the following manner:

1. Operating system—The DOMAIN sys-

tem architecture provides the user with a computer workstation (node) integrated into a transparent local area network. Each EWS features a 32-bit processor. There are two operating environments: AEGIS and AUX (AUX is Apollo's implementation of UNIX software).

The operating system of the Apollo computer workstation used by the authors was AEGIS. Apollo makes the point that the software engineering results and/or application packages of one operating system are compatible with the other. All Apollo system software runs under either operating system, and in fact AEGIS and AUX could be run concurrently in different processes.

2. High-resolution graphics—The DOMAIN workstations employ high-resolution, bit-mapped, raster graphics technology. Resolution ranges from 1024×800 (monochromatic or color) to 1024×1024 (color). The presence of a dedicated graphics processor allows for the display of graphical information such as fast vector generation, area fills, and bit block transfers. On some Apollo workstations, one can purchase extra display memory that allows viewing of pictures using red, green, and blue (RGB) data with eight bits of resolution

on a monitor, or it can be routed to typical video analysis tools such as a waveform monitor and/or vectorscope.

One could use the high-resolution display capabilities of the EWS to view the processed video data. The EWS allows 8-bit-resolution red, green, and blue signal components to be viewed on its high-resolution monitor. Also, the digital data can be plotted in the form of a waveform analyzer curve. Because of the high-resolution graphics available on the EWS, a user could generate other graphical representations of the video data (multidimensional plotting).

Via the EWS network gateways, an interface to other computer systems is possible. One such system offering some similar video signal processing modeling capabilities is the Digital Video Facility (DVF)<sup>2</sup> at RCA Laboratories. The ability to transfer video data between the DVF and VFMS implies that one can process or view the information that has been digitized on either system. Since both systems have the ability to digitize a video signal, the versatility of each is enhanced by their interaction.

The VFMS is different from the DVF in the sense that the former offers a designer a dedicated desktop computer, while the latter is composed of a time-shared computer system with a user's display room. The DVF does allow for processing of the video data from remote terminals and in batch mode, but the viewing must be done in the display room. The high-resolution graphics features of the workstation are more flexible than those offered by the DVF. One advantage of the DVF is its video storage capacity. It can store a longer video time sequence than the VFMS. Since data transfer between the two systems exists, it is possible to digitize a long video time sequence on the DVF and transfer it to the VFMS for processing. The VFMS could be used to view parts of this digitized sequence or parts of the processed sequence. For viewing the total sequence the transfer of this data back to the DVF would be required.

The EWS that was used as the hub for the development of this functional simulation environment is the Mentor Graphics Workstation. The Mentor Graphics EWS is composed of an Apollo Computer engineering workstation combined with Mentor Graphics software.

Note that the majority of illustrations and original text entry of this paper were done using Mentor Graphics software tools. Highlights of the workstation will be dis-

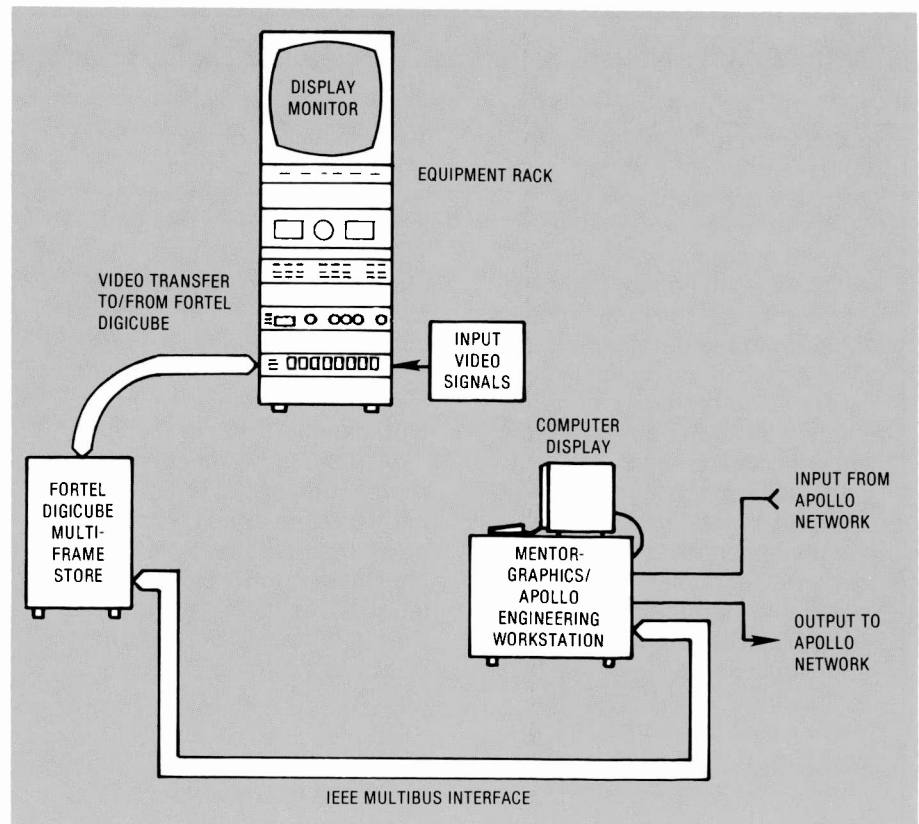


Fig. 1. Configuration of a video functional modeling system (VFMS).

cussed later, and will center around the actual features of the Apollo Computer EWS.

The sidebar contains a brief discussion of Behavior Language Models (BLMs). BLMs are a feature of the Mentor Graphics software logic simulator which gives a user the ability to model complex logic circuitry through a descriptive algorithm written in Pascal<sup>3</sup>. These BLMs can be used in circuits containing other BLMs or formal logic elements. An example of a BLM's value becomes evident when one desires to include intensive logic devices such as microprocessors in the circuit design. If this logic element is not present in the library of components available to the designer, he/she can model the functional description of the device in a Pascal structure instead of in its logic gate equivalent.

The basic simulation system to be discussed herein is illustrated in Fig. 1. In it there are references to an Apollo Network. The Apollo Computer System allows for database sharing among other nodes (or EWS) by placing the nodes in a rings architecture referred to as the Apollo DOMAIN (Distributed Operating Multi-Access Interactive Network) System. The Apollo is able to communicate with peripheral devices such as high-resolution printers and other plotting devices, tape drives,

and user-defined peripherals (such as Fortel Digicube) through its Multibus Interface.

### Component options for a VFMS

Here we will briefly describe the components that made up our video functional modeling system (VFMS). Figure 1 shows a basic VFMS, and Fig. 2 shows some additional components in a rack configuration. These components were found to be useful in the analysis of both the video input and output signals used in functional simulations. The monitor is capable of displaying both NTSC composite as well as RGB-format signals. For the purpose of analyzing DTV results as if from an actual TV, one might also want a monitor with a picture tube characteristic of a possible DTV product. The Fortel Digicube is capable of outputting data in NTSC composite or in the RGB format.

The vectorscope and waveform monitor shown in the figure are standard video measurement tools and have been quite useful in video signal analysis and characterization. The video signal generator allows standard test signals to be digitized by the Digicube for use as input to a simulation. This has proven effective for comparing the performance of simulated DTV features with the performance of

# Simulation of digital TV signal processing with an engineering workstation

*In this article, which is a shortened version of one that will appear in the March issue of RCA Review, the authors propose a technique for modeling and evaluating digital TV signal processing schemes at the algorithmic level, rather than at the complex logic circuit level.*

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**Abstract:** *This paper describes a video functional modeling system (VFMS) developed to simulate digital video signal processing. The VFMS comprises a Mentor Graphics engineering workstation, a video data multiframe storage device, and software generated by the authors. The VFMS functions as a node in a networking system that permits communication with other engineering workstations and mainframes. Software developed by the authors for use with this system is briefly described. A digital television chrominance/luminance processing system is presented as an example of a typical modeling system. The storage/playback device in the system permits digital frame or multiframe storage. It includes means to synchronize the incoming video signal, digitally sample this information, and store the data on a disk file located in the engineering workstation. The data is processed with a user-developed functional modeling program of a digital video processor, and the results are sent back to the frame store for viewing and subjective evaluation. This system concept could easily be used in the development of a speech and/or music processing system, as well as for a digital image processing system.*

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Much attention has been focused on the applications of engineering workstations (EWS) to integrated circuit (IC) and/or hardware logic design. In some application software packages the intent is to give designers a way to enter schematics, verify logic, verify timing, and document results. This paper will discuss a scenario for modeling and testing digital video processing systems at the algorithmic level as opposed to dealing with the details of such a system in the form of very complex logic circuitry. This paper will also describe how input data for an algorithm is obtained through the use of hardware interfaced to the EWS.

The need for video processing functional modeling was seen in the development of digital television (DTV). In particular, the number of digital signal processing features that the design engineers want to evaluate for this product makes a functional simulation tool a necessity. The functional models of many of the DTV features have been or are being simulated, and have greatly reduced the amount of time that would have been needed for initial evaluation of the feature. Note that once an actual feature algorithm has been identified, without the functional simulation capability, the building of these features on breadboards would have been required. It could take days or months instead of hours or days to implement such features as luminance/chrominance decoding schemes, automatic horizontal luminance peaking schemes, luminance vertical detail peaking

schemes, finite word length effects in digital filtering,<sup>1</sup> etc. As one might expect, because of time deadlines on product designs, some algorithms may be overlooked because of hardware breadboarding time and complexity. These overlooked algorithms may actually offer better performance for the implementation of a specific feature. Suffice it to say that software functional modeling has allowed the evaluation of many approaches and their perturbations for DTV and its many features.

In order to evaluate the effects of DTV features on true video information, it was necessary to capture and display video signals. This need to perform data capture through digitization from signal sources such as signal generators and off-the-air programs and eventual display of processed results was met by a multiframe storage device—the Fortel Digidcube. The combination of the EWS, multiframe storage device, and associated software will be referred to as the video functional modeling system, or VFMS.

The multiframe storage device will digitize video at the rate of 14.32 MHz (four times the NTSC color subcarrier frequency) and store it internally until transfer to the EWS. After the data has been processed by the functional modeling software, it can be analyzed by the user in one of several ways. The processed video could be transferred back to the Digidcube, which can convert the digital data back to an analog signal and allow it to be viewed

As a graphics emulator *Reflection 3* has allowed almost all of our two-terminal workstations to be converted to single IBM PC workstations. When the 2623 is used to preview graphics for final output on a plotter, the terminal can be replaced with this emulator; however, if a 2623 is being used for final output from a remote mainframe, the resolution of the PC monitor or of the print-out may not be high enough to suit the needs of the application. Figure 6 shows a graphic image displayed on a standard HP 2623A terminal. The quality of this image can be compared with that of the same image produced by *Reflection 3* on various IBM PC displays. In Fig. 7 the image is reproduced on a standard IBM PC color display. In Fig. 8 the image is shown on an IBM monochrome display with a Hercules driver board, and in Fig. 9 the image is shown on an Enhanced Graphics Display. Both the monochrome and the EGAD displays produce image quality similar to the HP terminal. The resolution of these monitors when used with *Reflection 3* is listed in Table I.

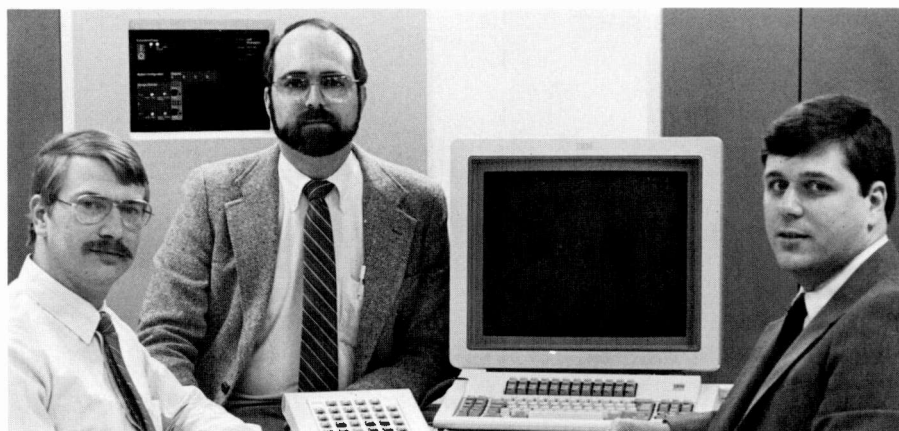
#### Advantages:

1. Ability to display HP graphics on an IBM personal computer.
2. Much more terminal memory than 2623.

#### Disadvantages:

1. None of the supported monitors is pixel-for-pixel compatible with the 2623, which causes some aliasing in the display.
2. Printout is not high resolution.

*Reflection 3* requires an IBM PC, PC XT, or PC AT with at least 256k of RAM. At least one floppy disk drive is required as well as a serial port for asynchronous communication. Version 2.0 or higher of DOS is needed. There are also versions of *Reflection 3* available for the AT&T personal computer and the HP Vectra personal computer, although we have not tested these. *Reflection 3* is a new product and is in the process of being enhanced. The main enhancements being pursued are support of color graphics on the Enhanced Display, support of plotters attached to the PC, and higher resolution for graphics printouts.



Authors, left to right: Miller, Renfro, Kunz.

**Peter J. Kunz** received the BSME with a minor in Materials Science from the University of Connecticut in 1979. He joined RCA in 1979 and his initial work centered on machine design of production equipment for the electron gun, including cathode problems and the quick-heat bimetal cathode process. He received his first patent in 1983 and has several patents pending. In 1983, Mr. Kunz was promoted to Member, Technical Staff and joined the VCAD project. In this capacity, he was responsible for implementation and support of the CADAM computer-aided design system including training, database management, finite-element modeling, productivity measurement, and systems support. In March 1986, Mr. Kunz became leader of the VCAD group.

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**Richard H. Miller** received a BSEE from Lehigh University in 1978. He joined the RCA Engineering Rotational Program in 1978 and accepted a permanent assignment with Lancaster Applications Engineering. His initial work involved automated testing equipment for picture tubes and equipment support for YAMMED entertainment product for the European market. In 1982 he was promoted to Leader, Technical Staff of Test Methods and Systems in Applications. His current responsibilities center around picture tube

testing and include development of display tube YAMMING systems, laboratory test equipment and the associated data analysis systems, picture tube setup equipment for the customer, and support for production testing. He has represented Applications Engineering on the VCAD Task Force since its inception in 1983.

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**G. Mike Renfro** is the Manager of Applications Engineering at VCDD in Lancaster, Pa. He earned the BS, MS and PhD in Physics from the University of Oklahoma. He is a member of Sigma Pi Sigma and Phi Beta Kappa. He came to RCA in 1980 as a Member of the Technical Staff in the Tube Development department of VCDD. His initial work involved electron trajectory studies for the COTY picture tube project. Between 1983 and 1985 he served as leader of the deflection components group of Product Design. During that time he also represented Product Design on the VCAD task force. His current interests include the development and implementation of a computer-integrated manufacturing strategy for the Division.

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## Conclusion

Despite the fact that IBM entered into the engineering graphics arena rather late by most standards, VCDD has successfully achieved a marked increase in design and drafting productivity through the use of IBM products. We have avoided some of the potential problems with this decision by choosing not to write our own graphics software. We have made great strides in engineering automation by simply using commercially available software. In its 24 months of operation, the VCAD engineering computer system has become an integral part of our Division.

## References

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2. J.C. Miller, W.T. Kelley, "Personal computers, an engineering productivity tool," *RCA Engineer*, 29-3, pp. 10-14 (May/June 1984).
3. J.C. Miller, P.J. Kunz, "CADAM, an engineering productivity tool," *RCA Engineer*, 29-3, pp. 15-19 (May/June 1984).
4. T.V. Hoffmann, "Graphic Enhancement," *PC Tech Journal*, 3, pp. 58-71 (April 1985).
5. K. Koessel, D. DiNucci, "Clearly Resolved," *PC World*, pp. 256-261 (June 1985).
6. D. McCune, "The Myth of the Virtual Device," *PC World*, pp. 178-187 (April 1985).
7. *Reflection 3*, copyright 1985 by Walker, Richer and Quinn, Inc., Seattle, Wash.

**Table I. Monitor resolution.**

	Graphics			Text			
	Pixel Count		Rows	Horizontal		Vertical	
	Columns			Lines	Char	Lines	Char
<i>HP 2623</i>	512	x	390	39	73	51	55
<i>Standard Color Graphics</i>	640	x	200	33	74	53	40
<i>Enhanced Graphics Adapter</i>	640	x	350	43	74	74	43
<i>Hercules Board</i>	720	x	348	38	74	53	58

4. Preset function keys for initial values.
5. File transfer with HP 3000 system.
6. Optional hard disk backup program to HP 3000 system.

*Disadvantages:*

1. Not all screen attributes are supported (e.g., underline and inverse features simultaneously)
2. Edit functions must be relearned (e.g. insert line, delete line, etc.).
3. Only one line of user key labels available with 24- line screen (two lines available with enhanced graphics adaptor).

**A CADAM lookalike from ADAGE**

It would be desirable to have a standalone graphics workstation capable of running CAE/CAD/CAM software without the need for a host computer. Such a workstation should be fast enough to provide sub-second response time for CAD/CAM software. To conform to the VCAD philosophy of integration, a trained CADAM user should be able to use the software on this workstation without additional training. Such a device could be used to provide CAD/CAM capabilities at a remote site without the added cost of high-speed data communication lines. It could also be used locally to increase the number of users without increasing the load on the host.

For this purpose we evaluated a CADAM look-alike product from ADAGE.. The name of this product is CADRA, and we found it to be almost exactly like 2-D CADAM in speed and function. To the user, CADRA presents menu screens that are very similar to CADAM and so fulfills the requirement for no additional user training. Despite this fact, however, the internal software and file formats are not CADAM. The unit is able to perform data transfers with a host-based CADAM system via CADAM's geometry interface module.

Since CADRA has the ability to perform data transfer over low speed phone lines, it is potentially a key product for the support of remote sites. It also has local E-size pen plotter capability and can store

**Table II. Feature comparison of IBM and ADAGE workstations.**

FEATURE	IBM 5080	ADAGE 6080
<i>Refresh Rate</i> Non-Interlaced	60 Hz Non-Interlaced	60 Hz
<i>Resolution</i>	1024 x 1024	1024 x 1024
<i>Pixel Writing Rate</i>	100 nanosec	50 nanosec
<i>Lightpen</i>	No	No
<i>Data Tablet</i>	Yes	Yes
<i>Transformation Dials</i>	Yes	Yes
<i>Element Highlighting</i>	Changes color	Intensifies element
<i>Number of Terminals per Display Controller</i>	1	1
<i>Data Transfer Rates</i>	2 MBPS	3 MBPS
<i>PRANCE Compatible</i>	Yes	Yes
<i>CBDS Compatible</i>	Yes	Yes
<i>IBM 327X Compatible</i>	Yes	Yes
<i>Coax/Microwave/Fiber-optics/Telephone</i>	Yes/Yes/Yes/Yes	Yes/Yes/Yes/Yes

This information was compiled from vendor data sheets and from *CADCORRESPONDENCE* (CADCOR, Inc.) Vol 1.2, p. 8, Nov./Dec. 1984.

data locally on diskettes. Our only reservation is our uncertainty about whether the third party CADRA software will remain compatible

with all future releases of CADAM. Table II gives a feature comparison between the IBM and ADAGE workstations.

Apparently, few software vendors have elected to follow the Graphics Kernel Standard in supporting the high-resolution displays. None of the software tested at VCDD would run on the Professional Display after being configured for the Enhanced Display. This probably means that these programs access the EGAD adapter directly rather than as a virtual device through calls to the GKS. The high-resolution features of the Enhanced and the Professional displays are not accessible from BASIC 3.0, which is supplied with the personal computer; however, they are accessible through IBM's Professional Fortran.

At the fall meeting of the CADAM User's Exchange in Chicago, CADAM, Inc. announced that early in 1986 they would market a 2-D version of CADAM that will run on the IBM PC AT. This CAD/CAM software will be able to take advantage of the high resolution and multiple color capabilities of the Professional Graphics Display. A version of this software—called Micro-CADAM—has been available in Japan for some time. In VCDD we see this product as a potential solution for our need to support CADAM at remote sites.

#### HP graphics terminal emulation on the IBM PC

Not all users of IBM PCs work strictly with IBM PC graphics or IBM main-frame graphics. Within VCDD there are a number of IBM PC users who need to be able to display graphics intended for Hewlett-Packard terminals. Until recently, these users had workstations consisting of two terminals; an IBM PC and an HP 2623 or 2393 graphics terminal.

During the Fall of 1985 the solution to this graphics problem became available. Walker, Richer, and Quinn, a software firm in Seattle that had been selling a PC software package that emulates the HP 2622/4 alphanumeric terminal, introduced *Reflection 3*, an HP 2623 graphics terminal emulator for the PC.<sup>7</sup> This package will permit the IBM PC, PC XT, or PC AT to display graphics that were intended for the HP 2623 terminal.

As an alphanumeric emulator, *Reflection 3* is highly compatible with software written for Hewlett-Packard terminals. No bugs have been uncovered in the emulator to date at VCDD.

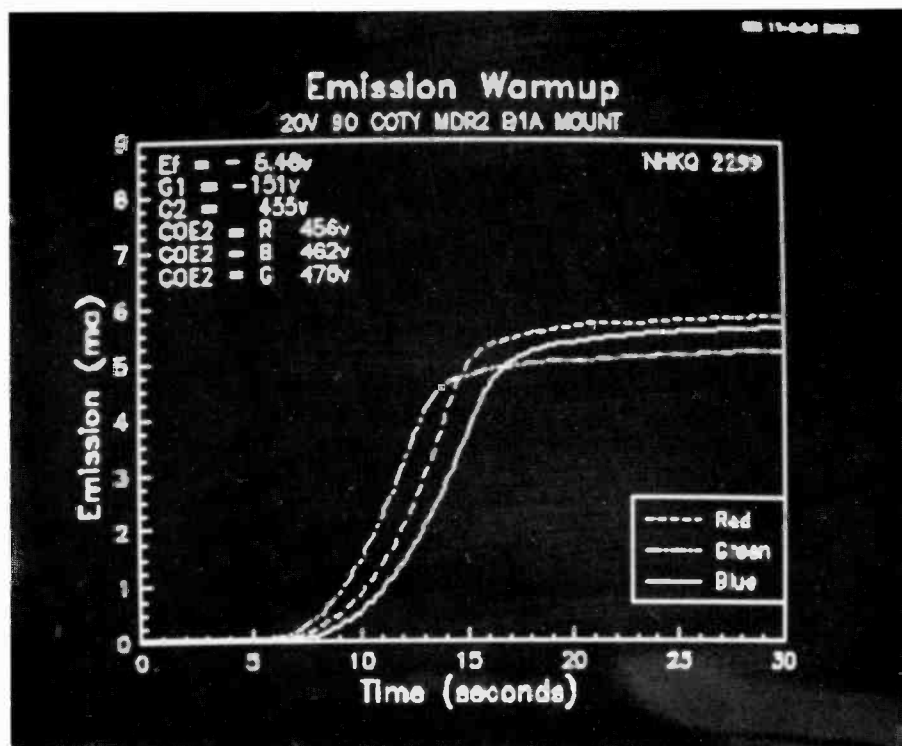


Fig. 8. A graphics image produced by *Reflection 3* on an IBM PC with a monochrome display and Hercules card.

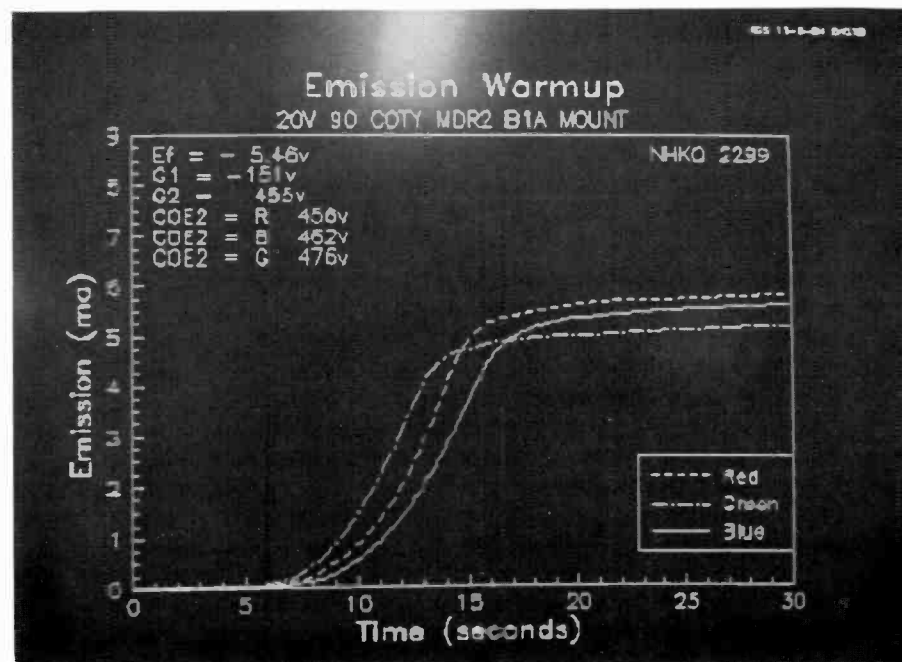


Fig. 9. A graphics image produced by *Reflection 3* on an IBM PC with Enhanced Graphics Adapter and Display.

The disadvantages listed can cause problems in certain applications; however, in general, they do not cause any serious limitations.

#### Advantages:

1. Terminal memory is limited only by

PC memory. 640k PC memory gives more than 2000 lines of terminal memory.

2. Provides spooled local printouts using the PC printer.

3. Easy storage of ASCII data to PC disk.



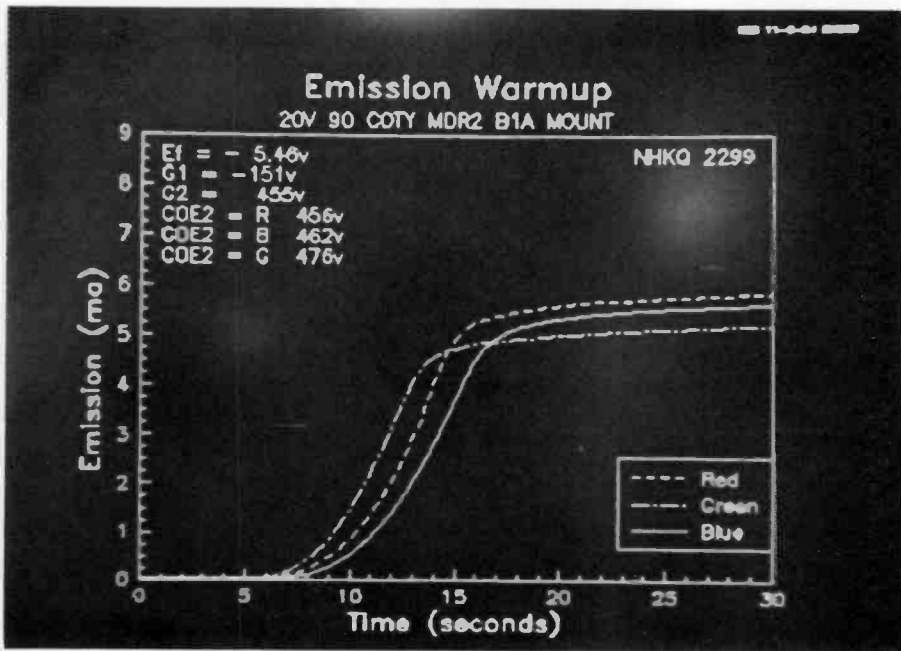


Fig. 6. A sample graphics image on a Hewlett-Packard 2623A terminal.

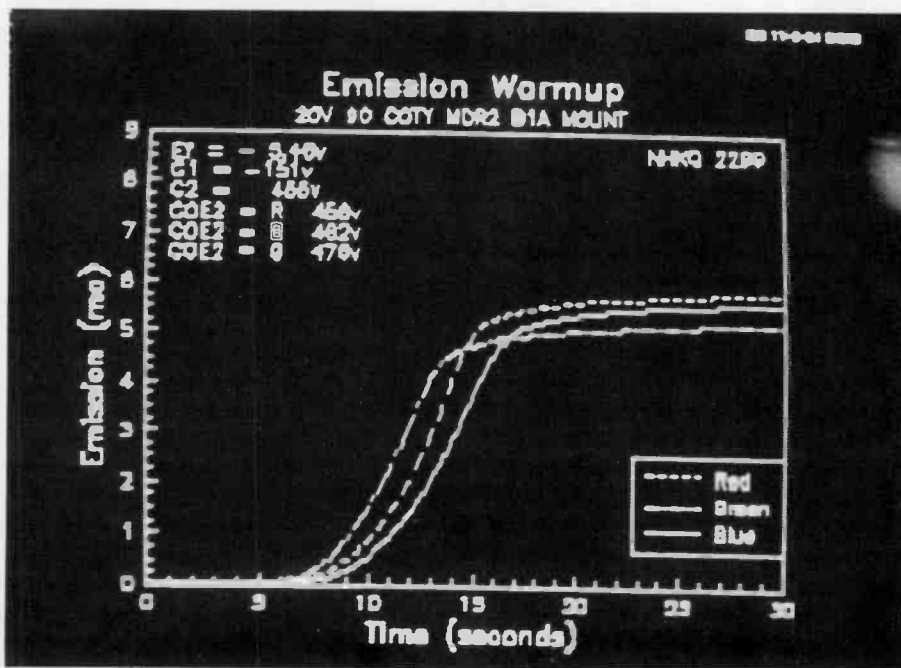


Fig. 7. A graphics image produced by Reflection 3 on an IBM PC with standard color display.

quality graphics requiring a wider range of colors, *Video Show* was selected. It also supports the dual monitor workstations, but provides a special piece of hardware to drive the color monitor. This driver allows up to 1000 different colors to be displayed on a standard color monitor.

Color is also needed to distinguish information contained in very dense engineering graphics. Engineers quickly discovered that both *Lotus* and *Stat-*

*graphics* support this dual monitor configuration. The tables of numeric information being analyzed are presented on the monochrome display, and the graphic summary of this information is simultaneously presented on the color display.

#### Enhanced graphics display

Late in 1984 IBM announced the Enhanced Graphics Adapter and Dis-

play (EGAD). This display produces alphanumeric characters in an 8×14 dot matrix rather than the 8×8 dot matrix of the standard color display. Its resolution is sufficient to present reasonably crisp characters in 80-column by 25-line format. In addition, it can support 16 colors with a graphics resolution of 640×350 pixels compared to only two colors at 640×200 pixel resolution for the standard color display. In order to support the full 16 colors the EGAD must be fitted with an optional Graphics Memory Expansion Card and have a total of 128k of display memory.<sup>4,5</sup> In 1985 we decided that all IBM PC ATs purchased would have enhanced displays installed.

Most third party software vendors were somewhat slow in supporting the EGAD; however, by about the third quarter of 1985 many of the major vendors had drivers available. Software that does not explicitly support the EGAD board can still be run because the board is capable of emulating the standard color display driver. DIP switches accessible through an opening at the rear of the card are used to select the desired display mode.

#### Professional graphics display

Also in late 1984, the Professional Graphics Adapter and Display were announced. It can support 245 simultaneous colors from a palette of 4096. It has a graphics resolution of 640×480 pixels and uses an 8×16 dot matrix for characters. The Professional Graphics Adapter automatically emulates the standard color display without the need to set DIP switches. It is switched into high resolution mode via software. Few application programs are available to date that take advantage of the capabilities of this display, despite the fact that it has been on the market for over a year.

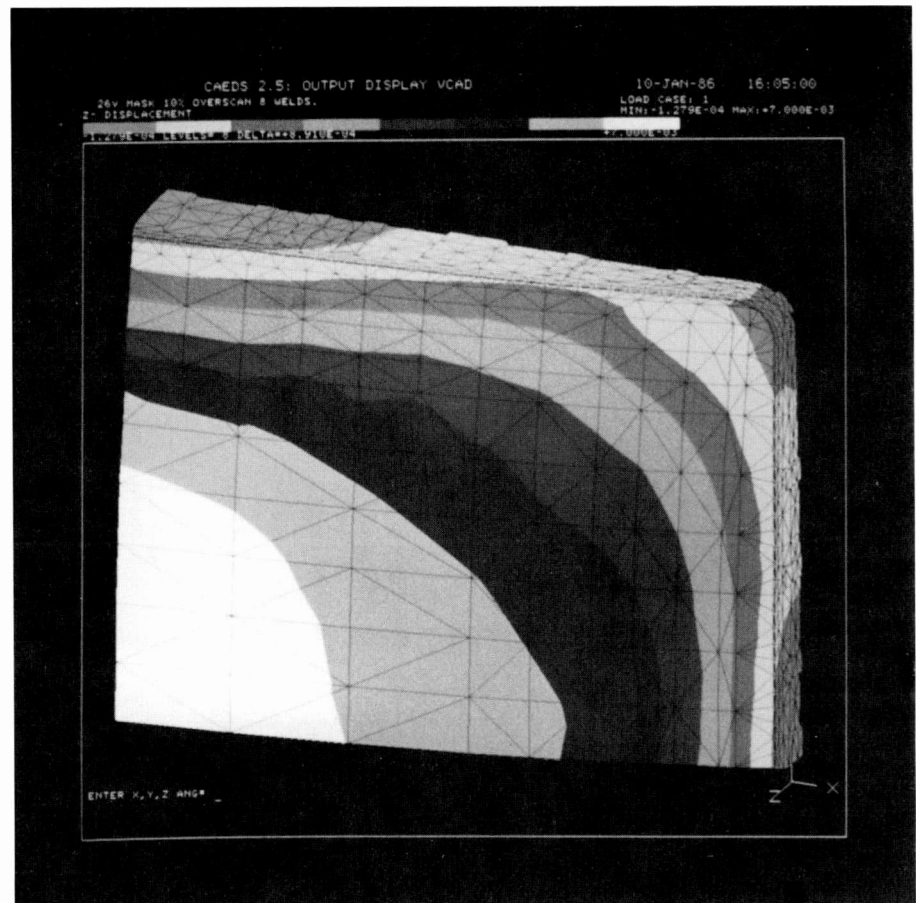
Both the Enhanced and the Professional displays were intended to be addressed as "virtual devices" by applications software. IBM markets a development package for programmers wishing to write applications for these displays. The Graphics Kernel System (GKS) provides a large set of graphics subroutines callable from high-level languages such as Pascal and Fortran. GKS takes care of accessing the device drivers required to execute the desired graphics commands on most popular peripherals.<sup>6</sup>

little firsthand experience with writing host graphics programs. However, for those who must write their own graphics applications, IBM has designed their 5080 workstation to be compatible with the Programmer's Hierarchical Interactive Graphics Standard (PHIGS). PHIGS is a proposed standard for 3-D graphics programming. It allows the applications programmer to interface with the peripheral graphics device through high-level commands without the need to provide a customized device driver.

It is only necessary to list the wide range of application software that is supported to see the impact that this single workstation has on the engineering community. Of course, the main design tool used at VCDD is CADAM. The value of CADAM has been dramatically demonstrated by the fact that in only 24 months of operation we have achieved a 5:1 increase in drafting productivity—surpassing our original goal. In addition to this productivity gain, CADAM has enabled us to model our production equipment to a level not previously attainable. Figure 3 shows an isometric view of a picture tube, conveyor, and carrier assembly. It represents a section of a large assembly drawing showing an automated work cell. The CADAM information panel is visible at the top of the screen, and the task menu is visible at the bottom. Isometrics of this complexity could not be feasibly attempted by manual methods.

We have extended our use of the system to include the area of finite element modeling with other software products such as CAEDS and ANSYS. Figure 4 shows a 3-D wire frame model of a 26V COTY picture tube. This model was constructed using CAEDS. Models such as this can be overlaid with information about material properties and external forces, and then submitted to a finite element solver—such as ANSYS—for analysis. Figure 5 is a CAEDS display of the results of such an analysis. It shows a false-color contour plot of a picture tube mask-frame assembly. The colors represent the amount of displacement along the z-axis that this mask will experience under a given set of thermal conditions.

PRANCE, a printed circuit board design module, is being installed to replace our Applicon system. PRANCE will be used for schematic capture of machine control ladder diagrams as



**Fig. 5.** False-color contour plot of a picture tube mask-frame assembly. Colors represent z-axis displacements of the assembly resulting from a given thermal distribution. See the color photograph on the back cover.

well. Other applications covered by CADAM are numerical control machining, 3-D wire frame models, surfaces, solids, 3-D piping, and facilities design and management. The Standard Library has proven to increase drawing speed, accuracy and uniformity. We are moving toward the increased use of macros for parametric design. Other advanced features available include hidden line removal, silhouettes, kinematics, and shading.

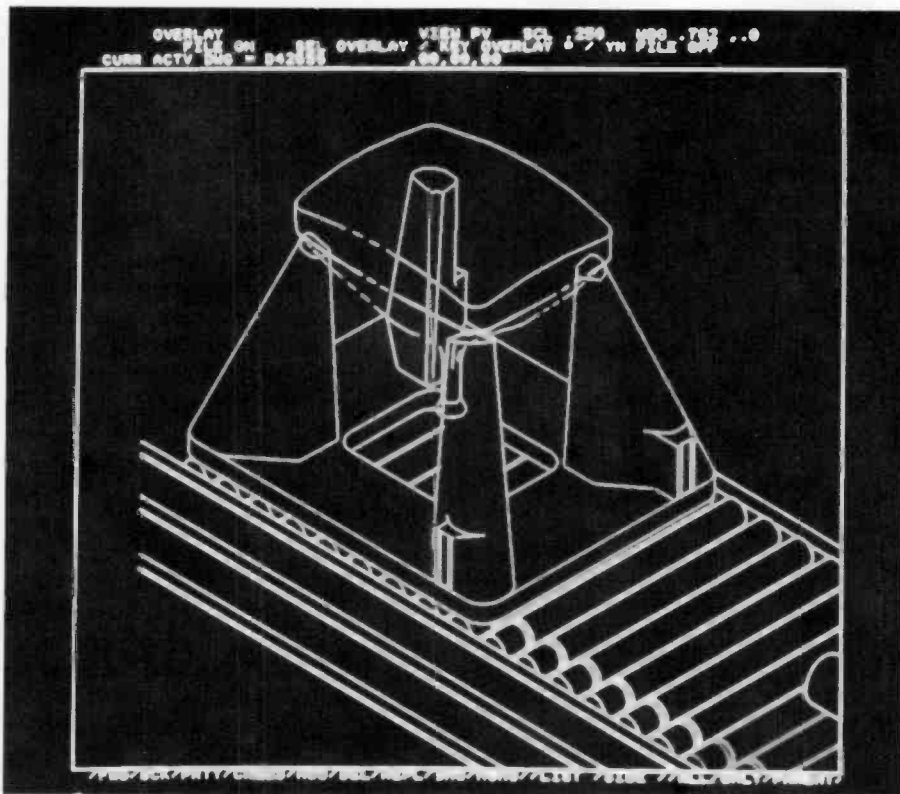
## Personal computer graphics

### Monochrome and color displays

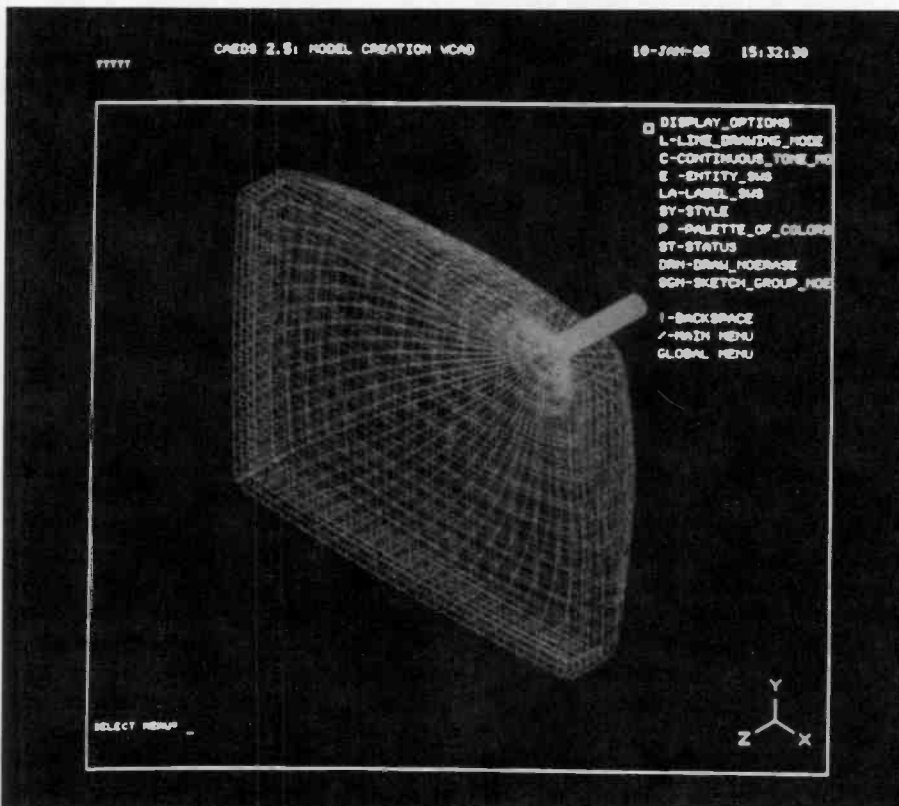
The VCAD philosophy of purchasing rather than writing graphics software applies to personal computers as well as to the mainframe. PC graphics packages in use in VCDD include *Lotus 1-2-3*, *Statgraphics*, *Graph Writer*, *Chart Master*, *Sign Master*, *Reflection 3* and *Video Show*. Before our initial purchases we came to the conclusion that most of our

PCs would be heavily used for manipulation of alphanumeric data, and that the standard color monitors available in 1983 did not have adequate resolution to justify their cost for this purpose. Therefore, we decided to purchase mostly monochrome displays and to add Hercules cards for those users needing monochrome graphics capabilities.

As the number of PCs increased, however, it became clear that users need a facility for producing high quality presentation graphics on their PCs and that color capabilities were necessary. Each engineering department was provided with one personal computer having both a monochrome and a color monitor as well as a multi-pen plotter. Copies of *Graph Writer* were provided with this workstation. *Graph Writer* has the ability to support two monitors simultaneously. As the user constructs his graphic image, the alphanumeric data and system commands are displayed on the monochrome screen while the graphic image being constructed can be viewed on the color screen. For high



**Fig. 3.** Complex CADAM isometric. This is a portion of a large assembly drawing of an automated work cell. Isometrics of this complexity cannot feasibly be constructed by manual methods. See the color photograph on the back cover.



**Fig. 4.** 3-D wire frame model of a 26V COTY picture tube. This model was constructed using CAEDS software. CAEDS serves as a pre- and post-processor for finite element solvers such as ANSYS. See the color photograph on the back cover.

Another major difference between the 3250 and 5080 workstations is in the terminal controller. In the 5080 system, each display has its own controller with a 32k buffer, so flicker is eliminated. In addition, the 5085 display controller can be configured in a variety of ways to meet the needs of the user and the applications. Installable features include expansion video pixel memory for up to 256 colors, local memory of up to 1.1 megabytes, clipping and transformation cards for fast local display processing, 3270 emulation to allow the graphics terminal to operate as an alphanumeric terminal, RS-232C to support locally attached pen plotters, and dials to control local zoom, pan, and rotate. The device can also perform as a remote node with a V.35 attachment; however, due to the high information content of video images, rapid data communication speeds are required. The minimum communication rate recommended for remote operation is 56 kbps.

This wide range of options would seem to complicate the system design problems, but instead it is the key to the workstation's versatility and future growth. A diskette drive in the 5085 unit provides a means to configure the workstation and to collect error statistics. The terminal controller is attached by coax to the IBM 5088 channel controller up to three miles away, or alternatively, the 5085s can be daisy-chained to that same length with up to sixteen terminals in the string.

The 5088 is channel-attached to the CPU and comes in three models. There are two locally attached models capable of supporting 16 terminals or 32 terminals and a remote model with the V.35 communication option. The remote option allows the configuration of a single remote 5085 or a remote cluster of up to 16 terminals. The controller has a dual address range to accommodate the graphics devices, and it acts like a 3274 to handle the 3270 addresses. This allows a single controller to contain 64 system addresses. I/O contention can occur on a heavily populated 5088 even though the CPU-to-5088 data exchange rate is 2.5 Mbps and the 5088-to-5085 rate is 2.0 Mbps.

#### Graphics software

As a result of our decision to purchase as much software as possible, we have

chrome, local vs. host transformations, and data transfer rates are all important considerations. However, we were willing to sacrifice, if necessary, some specific features in order to achieve a high level of integration. A key factor in building an integrated system, one that is easily overlooked in the quest for ever more powerful features, is whether the graphics software driving the device will present a consistent user interface for a wide variety of solver algorithms. The user should not have to learn many different sets of commands and menus in order to use different tools such as 2-D drafting, 3-D drafting, FEM, electrical design, etc. It should be easy to use any of the devices on the system to retrieve graphics data without learning a completely new set of commands and interfaces. This allows the managers, engineers, and designers to concentrate on their task rather than on operating the computer. By adhering to these principles, VCAD has been responsible for a marked improvement in the communication of engineering information and for an 80-percent decrease in the time required to produce an engineering drawing.

Our selection of graphics workstations was artificially limited by our decision to purchase an integrated system. Although several IBM plug-compatible devices existed on the market, we initially chose the IBM 3250 as our graphics terminal. This decision gave us a single vendor to rely on for both software and hardware, and opened the door to other goals as well. These workstations filled our needs for fast response time, significant increases in productivity, and the ability to access a wide range of software tools from a single terminal. As is common in the rapidly changing computer market, the 3250 terminal became obsolete within the first year of the VCAD project with the announcement of the IBM 5080 workstations. All subsequent purchases consisted of 5080 devices.

#### IBM 3250 terminals

Currently, two families of terminals are supported by CADAM. The original system was configured with six IBM 3251 terminals, which are monochrome and use vector display technology. Three terminals are attached to a single IBM 3255 terminal controller. These terminals must be within fifty feet of the

controller. Two such clusters of three are connected to a single IBM 3258 channel controller by coaxial cable at a distance of 1000 feet. Finally, the 3258 controller is channel-attached to the CPU.

At each 3251 workstation the user has a program function keyboard, an alphanumeric keyboard, and a light pen to interact with the display. The display has excellent resolution but is prone to flicker due to the I/O contention caused by having three displays on the same controller and a 16k limitation on display buffer size. Despite the flicker problem, many users prefer to use these devices because they believe the interactive response achievable from a light pen is faster than that of the 5080 tablet.

#### IBM 5080 terminals

The remaining 29 terminals are 5081 displays. The configuration is similar to the 3250 model, but with many additional features (see Figs. 1 and 2.). The CADAM software is capable of handling any of the many hardware configurations available, even interchanging the devices across controllers if necessary. The major difference is that the 5081 is a non-interlaced raster refresh device rather than a vector device. It is

available in a 50-Hz monochrome model or a 60-Hz color version. We have found that the majority of our users who perform standard 2-D drafting tasks prefer the monochrome monitor for this purpose. This choice allows us to pay less for the display, use less CPU resource per terminal, and support more devices.

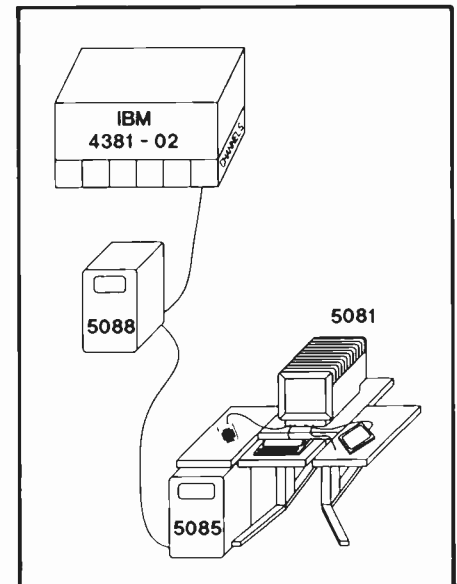


Fig. 1. IBM 5080 graphics workstation configuration.



Fig. 2. IBM 5080 graphics workstation. The workstation consists of a 5081 CRT display, a typewriter keyboard (left), a cursor tablet (center), a lighted function key pad (right), and a 5085 graphics processor (right, on the floor).

# IBM graphics workstations at Video Component and Display Division

*In 1983 there was a graphics revolution at VCDD. They decided they wanted to encourage engineers and designers to concentrate on the product rather than on the computer, so they developed the VCAD system.*

In 1983 a graphics revolution started in the Video Component and Display Division. An IBM computer system running CADAM software was installed to provide CAE/CAD/CAM graphics tools to the engineering community. This computer system became known by the acronym VCAD—video computer-aided design. The primary goals of VCAD were to increase engineering and design productivity and to integrate existing engineering hardware and software within the division. To achieve these goals the VCAD system included

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**Abstract:** *There are many types of graphics workstations available to the engineering community, and because there are so many choices, most engineering organizations eventually find themselves with several different systems that are not compatible. In 1983 the Video Component and Display Division adopted a divisional strategy for future purchases of CAE/CAD/CAM tools. This article describes our experience with IBM workstations in engineering. Two generations of graphics are discussed, and four PC displays available from IBM are compared. We are successfully using the IBM PC as a graphics terminal communicating with a Hewlett-Packard host.*

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not only host-based graphics, but also a large number of personal computers linked by a local area network. The network serves the role of hardware integrator, allowing existing minicomputer systems as well as different types of microcomputers to successfully communicate. Details of the VCAD system architecture and implementation philosophy were published in a series of articles in the May/June 1984 issue of *RCA Engineer*.<sup>1,2,3</sup>

From the beginning IBM was selected as the prime vendor of hardware and software. At the time many engineers did not consider IBM to be a leader in CAD/CAM graphics. Nevertheless, they offered a proven mainframe-based system, a long-term strategy for engineering automation, and the range of products necessary to achieve the desired integration. This integrated approach allowed us to build a system that is reliable, has fast response times, supports a large number of users, and is easily taught to new users.

The initial target for design automation was the equipment development organization. This department contains our largest number of designers and draftsmen. The ease with which this system could be expanded allowed us to start simple and to rapidly expand into product design, adding tools such as finite-element modeling (FEM), 3-D design, and printed circuit board design. Solids and NC machining modules are also available from CADAM, Inc. An organized and intense training program

brought to each user the graphics skills necessary to successfully improve productivity.

## Host graphics

### System configuration

The VCAD host is an IBM 4381-02 with 16 megabytes of real memory, 12 I/O channels, and a processing speed of 2.7 MIPS. This very stable CPU runs 24 hours a day, seven days a week. Peripherals consist of 10 gigabytes of fixed disk storage, two tape drives, two 3274 terminal controllers, HYDRA protocol converters, and 5088 graphic workstation controllers. As many as 166 users can be locally attached to the system. Of this 166, up to 35 can be 3250 or 5080 graphics workstations. An IBM 3725 communications controller was recently added to allow data communications to the corporate computer center.

From the beginning our intention was to purchase as much engineering software as possible and to avoid writing custom routines. We wanted to encourage our engineers and designers to concentrate on the product rather than on the computer. We chose CADAM for design and drafting, CAEDS as a pre- and post-processor for finite element analysis, and PRANCE for printed circuit board design.

There are several key elements in selecting a graphics workstation. Display size, resolution, color vs. mono-

the analytical equations to accommodate changing hardware configurations. By running on our own PC instead of a mainframe, we have kept costs low. Along the way, we have certainly demonstrated that there is a place for the PC in hardware reliability calculations. We also found we had to sacrifice speed for lower costs. A simulation run of 10,000 simulated missions used to take a few minutes (elapsed time, not CPU time) on the mainframe; on the PC, it can take eight hours. However, once the PC has been purchased, whatever use you make of it is free. The combination of an owned PC, the APL programming language, and graphics hardware and software has proved to be extremely cost-effective for RCA Astro-Electronics.

## References

1. Solomon, J.G., "APL and engineering productivity," *RCA Engineer*, Vol. 28, No. 1 (Jan./Feb. 1983).

**Table I.** Current library of simulation programs.

Program	Configuration for which designed
<i>MCSIM01</i>	Identical groups of identical units—e.g., 2G8X6. Any spare can be switched to replace any active in the same group.
<i>MCSIM02</i>	2G11X8 with special switching restriction: all 3 units at the same end.
<i>MCSIM03</i>	2G11X8 with special switching restriction: any 3 of 5 at the same end.
<i>MCSIM04</i>	Groups of identical units, but the groups need not be of the same length.
<i>MCSIM05</i>	Two sets of different units, connected in series and switchable.
<i>MCSIM06</i>	All the units in any one group have the same failure rate, but different groups may have different rates, and the groups may be of different lengths.
<i>MCSIM07</i>	Two sets of units, connected in series and switchable. The units in each set need not be identical.
<i>MCSIM08</i>	Two sets of units, connected in series, and switchable according to a defined pattern. Each set consists of identical units.
<i>MCSIM09</i>	Identical groups of identical units, but some channels are premium, and some are pre-emptable.
<i>MCSIM10</i>	One ring-redundant group of identical units.
<i>MCSIM11</i>	Identical groups of identical units, but the failure rate varies with time.
<i>MCSIM12</i>	One broken-ring-redundant group of identical units.
<i>MCSIM13</i>	Identical groups of identical units, but with a spare satellite to be launched when any group runs out of spares.
<i>MCSIM14</i>	Identical groups of identical units, but with a spare satellite to be launched at a preset time.
<i>MCSIM15</i>	Identical groups of identical units. Any spare can be switched to replace any active in the same group, but there is a prescribed sequence for using the spares, and the program keeps track of the switching history of each channel.
<i>MCSIM16</i>	Groups of identical units, but the groups need not be of the same length. Under specified conditions, a spare can be switched to replace a failed unit in another group.

## The Statgraphics package

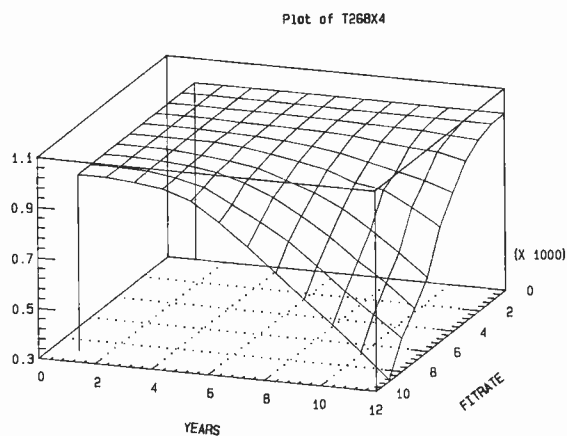


Fig. 1

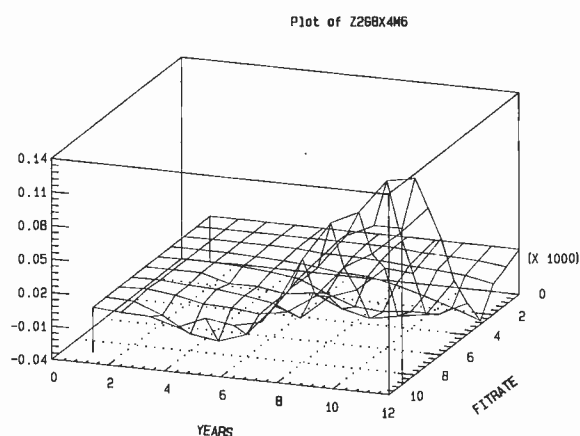


Fig. 2

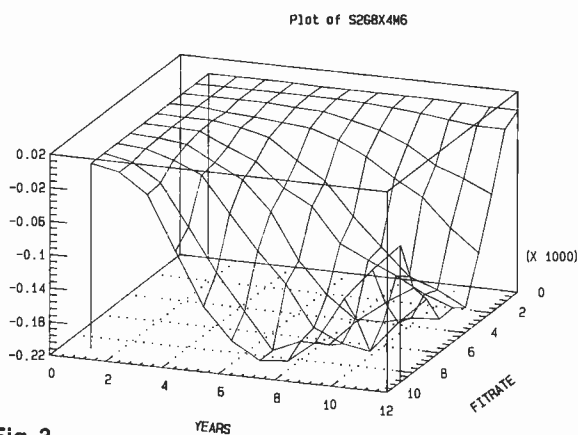


Fig. 3

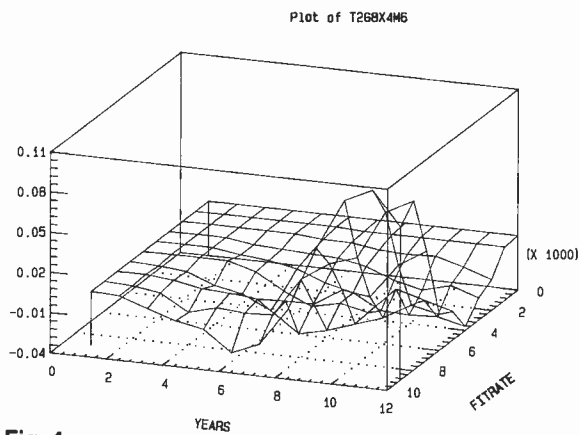


Fig. 4

In probing the "anomaly" mentioned in the accompanying article, I generated an enormous amount of data. Many people have noted that it is difficult to read tables of numbers and comprehend their significance—and it is. On the other hand, I was most reluctant to plot several dozen graphs, each of which had 120 points. It so happened, however, that Reliability Engineering bought a graphics package and a color monitor—and, later, a five-pen plotter. The graphics package is called Statgraphics, and was written by Dr. Neil Polhemus, then of Princeton University. As its name implies, it is actually a statistical and graphics package—and a very powerful one. It is also inexpensive—even though we have used only about ten percent of its capability, we have more than gotten our money's worth from it. Stat-

graphics is written in APL, which makes it even more convenient to use with our library of programs. Statgraphics is menu-driven, is very easy to use, and does not require any knowledge of APL. It is available from Statistical Graphics Company, 2 Wall Street, Princeton, NJ 08540, or from STSC Inc., 2115 E. Jefferson St., Rockville, MD 20852. In order to run Statgraphics, you must have the APL interpreter APL\*PLUS, which is available from STSC at the above address.

The accompanying contour graphs, drawn by Statgraphics, use as data the probability of survival of eight groups, generated by MCSIM01 under different assumptions. Figure 1 shows the probability of survival of eight groups in a 2G8X4 configuration. This probability is denoted  $P_8(2G8X4)$ , and is shown over each year of a twelve-

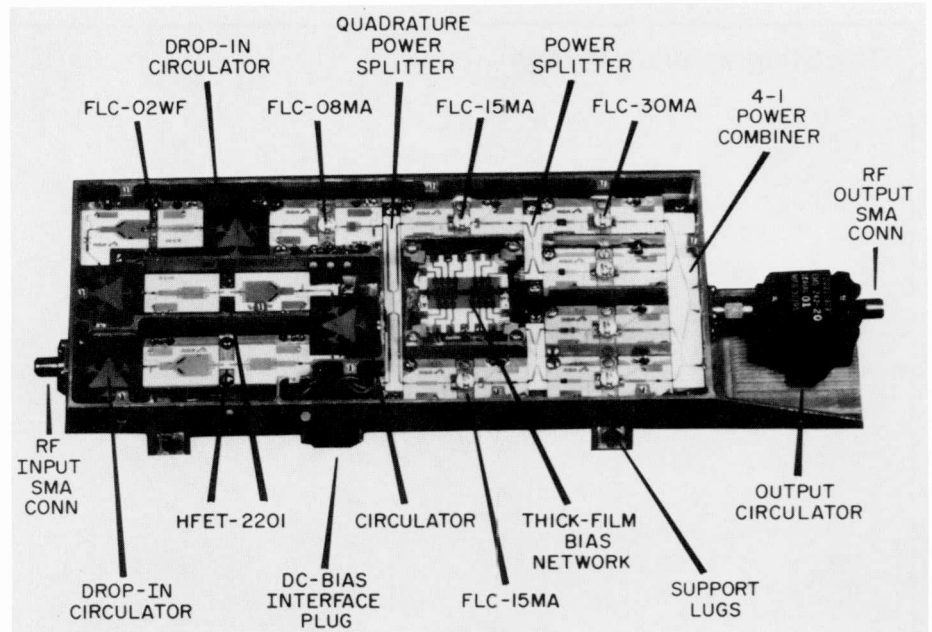
year mission. SFMAIL, the failure rate for standbys, is  $0.1 \times \text{AFMAIL}$ , the failure-rate for actives. AFMAIL ranges from 1000 to 10,000 FITS (failures in  $10^{10}$  hours). The other three graphs show the difference in survival probability,  $P_8(2G8X4) - P_8(2G8X6)$ , for each year of a twelve-year mission, and the same range of AFMAIL. Figure 2 shows the difference when SFMAIL is  $0.1 \times \text{AFMAIL}$ . Figure 3 shows the difference when SFMAIL = AFMAIL. Figure 4 shows the difference when SFMAIL = 0. As explained in the article, when SFMAIL = AFMAIL, there is no penalty for the "pseudo-spares" in 2G8X6, and  $P_8(2G8X6)$  remains higher than  $P_8(2G8X4)$  for all values of AFMAIL. When SFMAIL = 0, the penalty is maximized—over the course of the mission,  $P_8(2G8X6)$  drops below  $P_8(2G8X4)$ , and remains below.

2G8X4 configuration to have eight amplifiers operating. Each group must have four amplifiers operating. If one group loses five of its eight amplifiers, it doesn't matter how many amplifiers in the other group are *capable* of operating—the total number of amplifiers actually operating for both groups will be less than eight. On the other hand, the 2G8X6 configuration has the flexibility that one group can lose as many as six of its eight amplifiers, and the configuration will still have eight amplifiers operating until the other group has lost three of its eight. This was not exactly obvious—although it is now.

One way of looking at the 2G8X6 configuration is that it has two extra "pseudo-spare" in each group, as compared with the 2G8X4 configuration. However, these "pseudo-spare" are really in use, and therefore they will fail at the active rate, rather than at the (lower) standby rate. One would expect, then, that 2G8X4 would "catch up" with 2G8X6 over the course of a long mission—especially if the failure rate is high. And so it was: If the failure-rate was as high as 7000 FITS (failures in one billion hours), the cross-over point was reached about eight years into a mission. After that,  $P_8(2G8X6)$ —the probability of survival of 8 channels in a 2G8X6 configuration—was less than  $P_8(2G8X4)$ , and decreased more rapidly with time than did  $P_8(2G8X4)$ . This effect was even more pronounced with higher failure rates.

In our simulation runs, we usually assume that the failure rate for standby amplifiers is 0.1 times the failure rate for operating amplifiers; that is, the shelf life is ten times as long as the operating life. If the explanation suggested above is correct, changing this ratio should significantly change the relationship between the calculated reliabilities. In particular, if the failure-rate is the same for standbys as for actives, then there is no penalty for having the pseudo-spare, and 2G8X6 should maintain the higher reliability for the entire mission. On the other hand, if the failure rate for standbys is 0, then the penalty for having the pseudo-spare is maximized. One can predict that the crossover effect would be even more pronounced. As the graphs in the sidebar show, all these predictions were verified.

As the design groups at Astro-Electronics requested reliability predic-



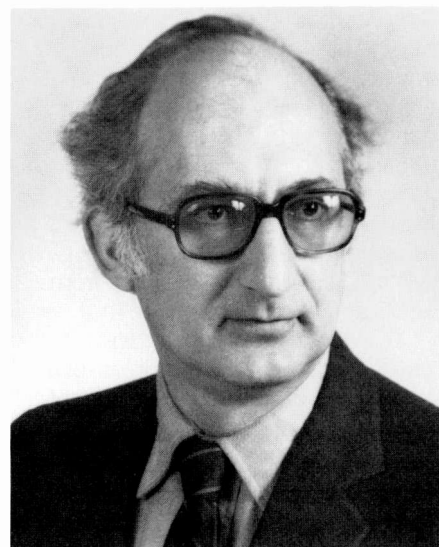
*Solid state power amplifier.*

tions for different kinds of configurations, it became necessary for us to write more simulation programs. These programs had the same basic structure, but reflected the different selection rules or different linkages of the different configurations. Some of the changes were minor, but some were drastic. Even so, making the changes usually required only a minimal effort, because all the programs are designed and implemented in APL. To give an idea of the

scope of the current library of simulation programs, Table I shows the list of programs and the configurations they were designed to handle.

### Conclusion

Our experience has shown that reliability calculations can be done using Monte Carlo simulations instead of analytical solutions. Also, it is easier to change the simulation programs than



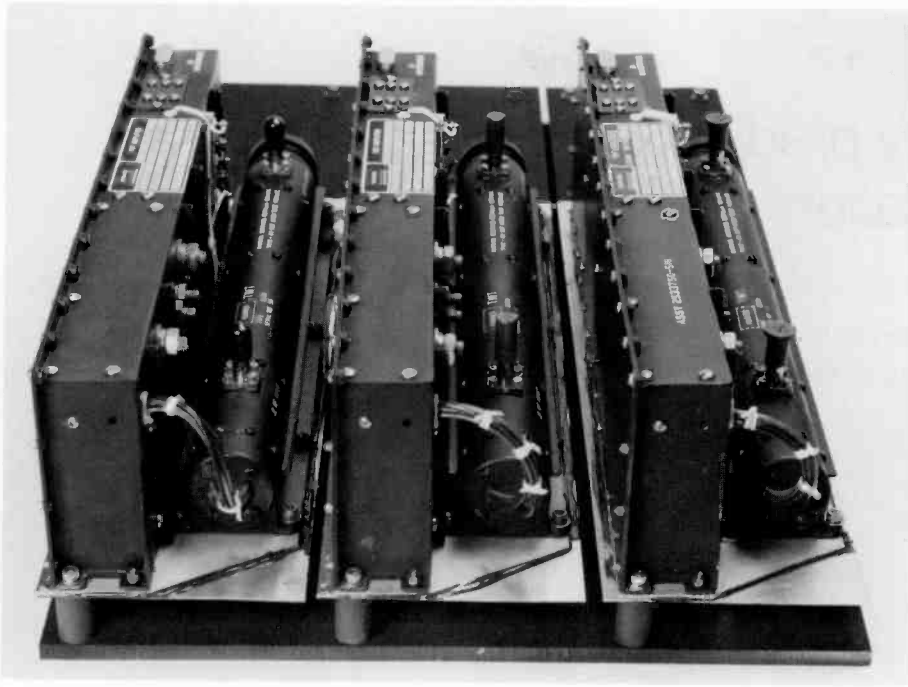
Josef G. Solomon was awarded a BS degree in Mathematics from the University of Oklahoma while on active duty with the United

States Air Force. He first joined RCA in 1959, working on BMEWS at the Missile and Surface Radar Division. He was awarded the MA degree in Physics from Temple University in 1963. After two years of research in high-energy physics at the University of Pennsylvania, he returned to RCA in 1966, joining the Systems Programming group of the Information Systems Division in Cherry Hill, where he participated in the implementation of the FORTRAN compiler for RCA's Spectra series of computers.

Mr. Solomon became an independent software consultant in 1971. He joined the Systems Engineering group of Government Communications Systems in March 1982, and worked in digital signal processing, propagation of measurement errors, and network vulnerability. In 1983 he transferred to Astro-Electronics, where he has worked in hardware reliability predictions, orbital rendezvous, satellite eclipses, and space-based radar.

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Traveling wave tube amplifier.

replace the failed unit. The program kept a cumulative total of how many amplifiers were still operating at the end of each year of each mission. Dividing that set of numbers by the total number of missions gave the fraction of missions in which that many amplifiers survived—and, hence, the probability of survival. These probabilities were then compared with probabilities generated by solving the coupled differential equations.

This comparison showed that the Monte Carlo simulation method gave essentially the same answers as the exact analytical solution. Our experience has shown that simulation is indeed faster and cheaper than the analytical solution. In addition, using simulation makes it much easier to accommodate changes in the hardware configuration.

### Rewriting the program in APL

The original program was written for the Reliability Engineering group by an outside consultant who had departed before my arrival on the scene. It was designed for a configuration in which any spare could be switched to replace any failed active amplifier in the same group; it was not possible to switch amplifiers from one group to another. Any configuration with those characteristics could be simulated by that program. The program was written in

Apple BASIC, and simulation runs had been made on the consultant's computer. The size of the configuration was built into the program. This meant that several lines of the program had to be changed each time the program was run. Also, the consultant had not supplied any program documentation. Finally, the program did not work on the Apple computers at Astro-Electronics, and making it work was my first assignment. In order to be able to debug the program, it was first necessary to understand it. Because APL is the language I prefer, my explanatory notes (to myself) on the program were written in APL. The interesting result of this effort was that, by the time I understood the BASIC program, a replacement APL program had thus been brought into existence. Results obtained from the new APL program agreed closely with results previously obtained from the BASIC program—keeping in mind that the results will never agree precisely, because of the statistical nature of the Monte Carlo method.

The fact that the operational program was in APL, rather than BASIC or some other conventional language, conferred unanticipated benefits almost immediately. Very soon after the demonstrated success of that program, we were confronted with configurations that the program could not handle: different switching restrictions within a

group, groups with different numbers of amplifiers, groups composed of different types of amplifiers, etc. To respond to these new challenges, new simulation programs were designed and implemented. At present, the simulation library contains over a dozen programs, each designed to handle a different type of hardware configuration. As the "traffic" became quite heavy, the cost of running these programs on a mainframe became prohibitive. We therefore purchased a PC (and then several more), and have been running the library on PCs for the past two and a half years. In addition, we have purchased a graphics package, and we can now plot graphs of the results from individual simulation runs, or contour graphs from a collection of runs.

### PC or mainframe?

The specific event that triggered the decision to purchase a PC instead of continuing to rent time on the in-house mainframe arose from an apparent "anomaly" in our simulation results. Comparing the results for two different hardware configurations showed that the simulation program predicted a lower reliability for the configuration that seemingly should have had a higher reliability. Attempts to resolve the anomaly consumed a great amount of money on the mainframe, and yet it was essential to resolve it, because the reliability numbers generated by the simulation programs are a critically important input in the design process. If those numbers are wrong, we have to know it *now*, and correct them. So we continued on our new PC, and resolved the problem. Here is a description of the problem and its resolution.

If you compare reliabilities for a configuration described as 2G8X6 and one described as 2G8X4, which configuration has the higher probability that eight amplifiers will still be operating after, say, 10 years? It certainly seems that the 2G8X4 configuration, which has four spares in each group, should have a higher reliability than the 2G8X6, which has only two spares in each group—and yet 2G8X6 consistently came out higher than 2G8X4. Does one *increase* reliability by *decreasing* the number of spares? Varying the parameters at our disposal began to show a pattern, and the answer emerged. The apparent anomaly arises because there is only one way for the

# Spacecraft reliability predictions by computer simulation

*Satellite hardware reliability simulations are being run on PCs at Astro-Electronics, and the payoffs are reduced costs and increased flexibility.*

The Reliability Engineering Department at Astro-Electronics is charged with the responsibility for predicting the reliability and survival probability, of complex satellite hardware. It is essential to know the probability of survival of electronic circuits over the entire lifetime of a satellite. This information is then used, for example, in deciding how much redundancy to build into a particular section of the circuitry. Because of

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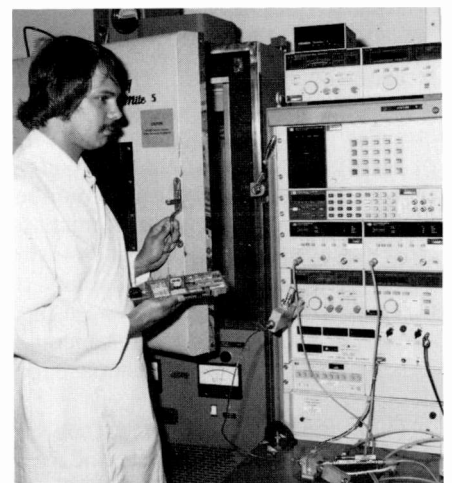
**Abstract:** *The equations used for determining the reliability of satellite electronic circuits are a set of coupled differential equations, and solving them can be very expensive in both time and money. Accordingly, engineers at Astro-Electronics wrote a Monte Carlo simulation program in APL for a particular electronic circuit and switching configuration. Very soon after the demonstrated success of that program, configurations were designed that the program could not handle. To respond to these new challenges, new simulation programs were designed and implemented. As the "traffic" became quite heavy, the cost of running these programs on a mainframe became prohibitive. Therefore, several PCs were purchased, and the library of programs has been running on them for two and a half years.*

---

the great cost of a failed mission, RCA wants to build in "enough" redundancy. But because of the great cost of putting any weight into space, it is also important not to build in more redundancy than is necessary to meet the mission reliability specifications. For a given set of performance criteria, then, the problem is to calculate how much redundancy should be employed. In the context of this paper, however, the problem is a different one. Solving the set of coupled differential equations used to determine the reliability of electronic circuits can be very expensive in both time and money. Accordingly, we had to find an alternative method of determining the reliability of complex systems one that is faster and cheaper than direct solution of the differential equations, and acceptably accurate. Inasmuch as our attention had already been drawn to computer simulation methods, our problem was even more specific: Can computer-simulation satisfy the above criteria?


## Monte Carlo simulation

A Monte Carlo simulation program was written for a particular—and particularly simple—electronic circuit and switching configuration. The results agreed closely with results obtained by "brute-force" methods. The configuration was an array of identical traveling-wave-tube amplifiers, arranged into groups that were physically and elec-



*Solid state power amplifier.*

tronically separated. Each group contained the same total number of amplifiers, the same number of active amplifiers, and (of course) the same number of spares. A typical configuration might be described as "2G11X8", meaning that there are two groups in the configuration, and that each group has 11 amplifiers, of which eight are active. Given the failure rate for active amplifiers and the failure rate for spares, the program simulated a large number of missions in which amplifiers failed at random times in accordance with those failure rates. When an active amplifier failed, the program attempted to find an available spare in the same group; if there was one, it was switched in to

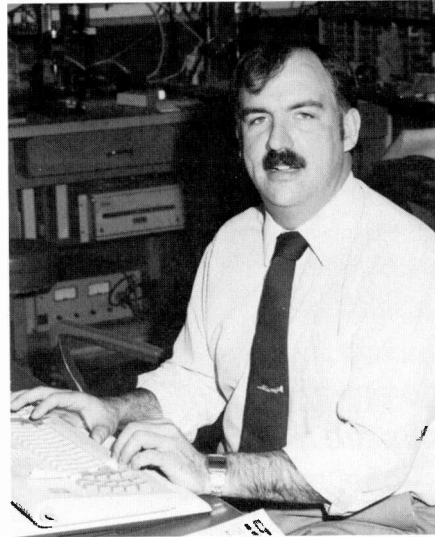


**RCA Astro-Electronics must determine the reliability and survival probability of complex hardware to be installed on satellites. The equations used to predict the reliability of electronic circuits are a set of coupled differential equations, and solving them can be very expensive in both time and money. Accordingly, a Monte Carlo simulation program was written for a particular electronic circuit and switching configuration. The program was written in APL, of course.<sup>1</sup> The results agreed closely with results obtained by “brute-force” methods. Very soon after the demonstrated success of that program, we were confronted with configurations that the program could not handle. To respond to these new challenges, new simulation programs were designed and implemented. At present, the simulation library contains over a dozen programs, each designed to handle a different type of hardware configuration. As the “traffic” became**

**quite heavy, the cost of running these programs on a mainframe became prohibitive. We therefore purchased a PC (and then several more), and have been running the library on PCs for the past two and a half years. In addition, we have purchased a graphics package, and we can now plot graphs of the results of individual simulation runs, or contour graphs from a collection of runs.**

**Our experience has shown that reliability predictions can be done using Monte Carlo simulations instead of analytical solutions. Also, it is easier to change the simulation programs than the analytical equations to accommodate changing hardware configurations. By running the programs on our own PC instead of a mainframe, we have kept costs low. Along the way, we have certainly demonstrated that there is a place for APL and the PC in predictions of hardware reliability.**

designer the capability to place and route circuit components using a relatively inexpensive personal computer. The ability to use any path width and polygon shape, to combine paths and polygons to make cells, and then to combine cells to make circuits reduces the layout time and the time it takes to redo circuits. Once you find that the first board isn't quite what you wanted, the task of changing the circuit is simple. Figure 3 was drawn by Robert M. Evans of the Signal Conversion Group at RCA Laboratories. Bob has had no real previous experience with circuit board layout systems other than a graphics routing he wrote for our HP 1000. He was able to pick up the system after a few hours work with me, and over the past three months developed this working board.



**Tom Marett** is an Associate Member, Technical Staff in the Television Research Laboratory at RCA Laboratories. He previously worked in the Picture Tube Systems Research Laboratory at RCA Laboratories, and in the Technology Transfer Laboratory, Magnetic Deflection Group, Lancaster, Pa. His professional interests include rf, magnets, CAD and CAM. He has a BS from Spring Garden College, Philadelphia, Pa.

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I wish to acknowledge the assistance of Sue Handman of CISS in Cherry Hill for the help she has given our group in evaluating CAD packages, and for finding this one. I would also like to thank Bernie Wiegand of the Design Automa-

tion group at Missile and Surface Radar Division for giving us a demonstration of *PERSONAL870*, and for his help in ordering the hardware needed; Phil Deem of the New Product Laboratories for his assistance in getting us started with the software; Bill Kimble of RCA

Laboratories for first teaching me the Applicon 4000 system, and then interfacing it with the *PERSONAL870*; and Ed Cuomo and Greg Zak, Process Technology, RCA Laboratories for their help with PREP on the Cherry Hill CMS system.

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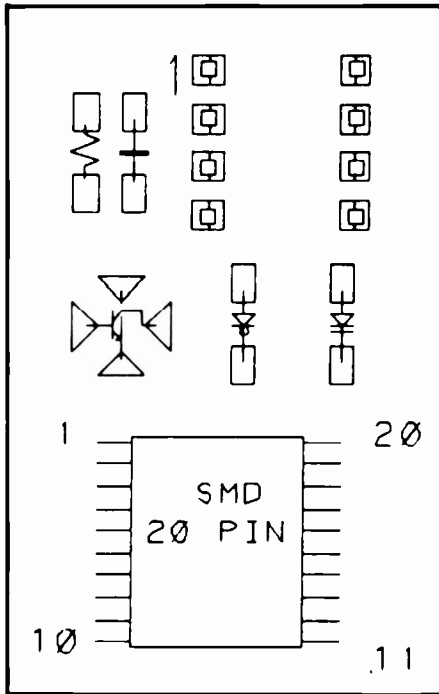


Fig. 1. Example of a component cell.

to another. This allows many designers to work on individual circuits and then assemble the pieces into one working file for a final board.

### Board design

Our group is using two sets of the software, one on an IBM PC AT and one on an IBM PC XT. The PC is not permanently changed, so it can still be used for other tasks (writing this paper, for example). The sidebar on this page lists the hardware requirements for PERSONAL870.

Three methods are used for creating PC Boards from the drawing files in our IBM PC AT. The first two methods use the IBM mainframe in Cherry Hill (CMS). The first of these gives us fast turnaround time because it produces an immediate print on a thermal printer. Resolution is low, 300 dots-per-inch, and we have a size limit of 3.5 inches by 3.5 inches with this method.

The second method uses a Gerber plotter driven by software on CMS, and gives us 1000 dots-per-inch accuracy. This software, called PREP, creates a standard Gerber-formatted tape from plot files created by PERSONAL870 software.

The third method is to transfer the drawing file from the IBM PC AT to an Applicon system. We use the Applicon 4000 system in the Microwave Technology Center at RCA Laboratories, which also has a resolution of 1000 dots-per-inch.

Software has been written to check for design problems in drawing files such as unclosed polygons. It highlights problem areas so they can be moved off to the side of the page, corrected, and moved back in place.

Most components used in our group are surface-mount, so we create cells consisting of polygons or pads for attachment to the board. One such cell is shown in Fig. 1. Active devices used at 40 MHz and up do not normally have standard packages, so we create whatever pad configuration is needed for the individual device. These cells are put together to make developmental circuits like the one in Fig. 2. Figure 3 is an example of a complete circuit that was recently developed.

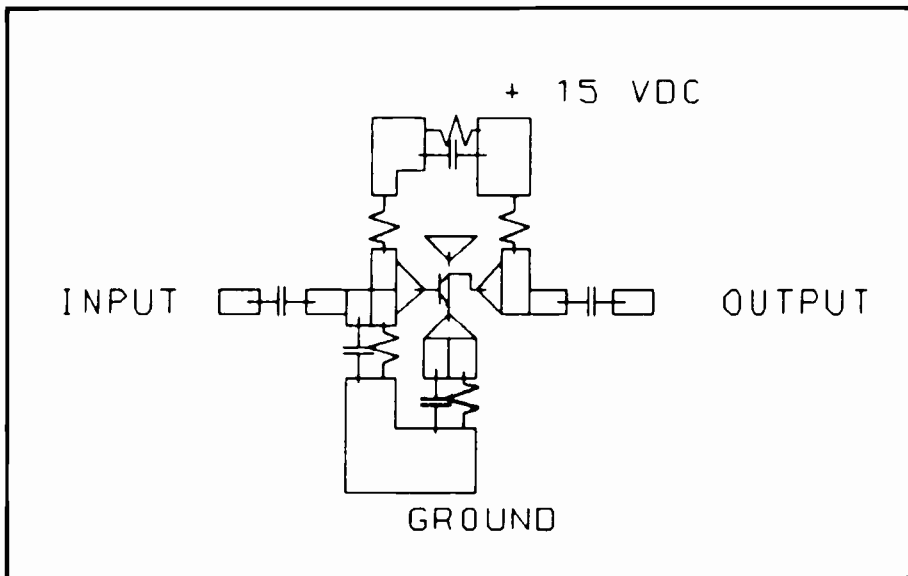


Fig. 2. Developmental circuit drawn using cells.

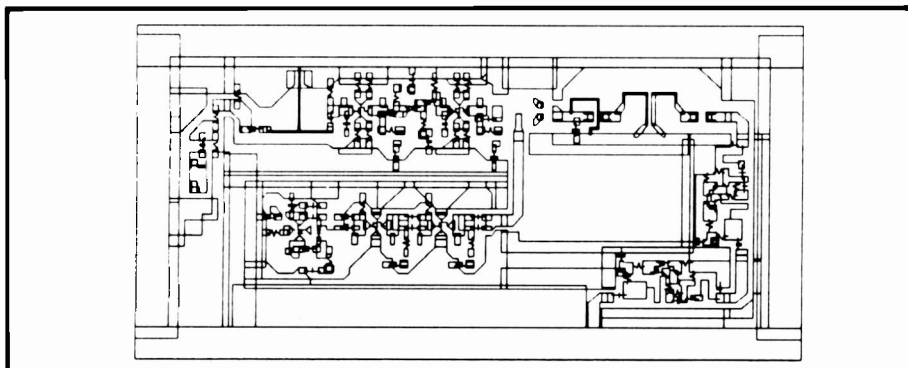


Fig. 3. Completed circuit.

### Conclusion

The powerful (yet inexpensive) computer-aided design software used by the Signal Conversion Group at RCA Laboratories gives the analog circuit

#### The following is a list of the hardware necessary to run PERSONAL870:

1. IBM PC AT or XT (or compatible)
2. At least 640k of memory
3. Two serial ports
4. Printer port
5. Display controller
6. Display (color or monochrome, high-resolution preferable)
7. Pen tablet

## Analog printed-circuit board design using an IBM PC AT

*A group at RCA Laboratories has found a software package that is specifically intended for the computer-aided design of analog printed-circuit boards.*

Digital printed-circuit board design systems, with their elaborate schematic capture, placement, and routing routines, are of no real use to the analog circuit designer without heavy modification of the algorithms controlling the placement of components.

Analog circuits used in television tuners, for example, operate at frequencies above 40 MHz with low-level signals. These circuits amplify and change the frequency of the incoming signals so that they may be displayed by the TV

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**Abstract:** *Analog circuits operating at frequencies above 40 MHz cannot take advantage of the elaborate placement and routing routines that have been developed for low-frequency circuitry. The powerful and expensive printed-circuit board design packages that need a medium to large computer are therefore wasted, since the design demands all of the circuit designer's attention. The placement of each component and the routing of each path between components is critical to the performance of the circuit. The Computer-aided design software used by the Signal Conversion Group at RCA Laboratories allows the designer the freedom of individually placing the components while operating with an IBM PC AT, keeping the cost of the system down below \$20,000. This software will also run in an IBM PC XT and many IBM compatibles.*

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set. This signal amplification and conversion must be done in a small area free from interaction with the rest of the TV set. The placement of the individual components of the tuner is critical. Lead length of components such as capacitors, inductors, resistors, and active devices will determine the frequency response of the overall tuner. Extra lead length will also act as an antenna, radiating unwanted signals throughout the TV set. The exact placement of each component so as to minimize lead length and unwanted radiated signals between circuits is left up to the designer. The actual width and length of each trace, the shape of the pads connecting the components to the board, and any ground plane used in and around the circuit will determine the characteristics of the tuner as much as the components themselves.

The Computer-aided design software used by the Signal Conversion Group at RCA Laboratories is a simple two-dimensional system capable of describing multilayer printed-circuit boards with any shape polygons and paths on each layer. It also can output to several types of high-resolution printer/plotters for fabrication of the board.

The software used by the Signal Conversion Group at RCA Laboratories is called *PERSONAL870*, and can be purchased from Automated Images Inc., Woburn, Ma. *PERSONAL870* emulates the Applicon 870 and the Applicon 4000 2-D printed-circuit board layout systems. The limits for the physical size of the boards are the same as those for the Applicon systems, and you can work

in mils or millimeters. This software is also used by New Product Laboratories in Indianapolis and Missile and Surface Radar Division in Moorestown, which makes it possible to transfer drawing files to and from these locations. If you are familiar with these systems you will be able to use this software with little assistance. I am familiar with the Applicon 4000 system, and was able to use *PERSONAL870* system after a few hours of reviewing documentation obtained with the software. Three other people in the group have picked up the use of the system in a short period of time.

Most of the commands of *PERSONAL870* are the same as those used by the Applicon software. Commands are communicated to the computer by pen strokes or with a pen table. We have added the IBM PC AT function keys to supplement the pen strokes and tablet menus. The user sets up an account with a start file consisting of personalized pen stroke commands, menu, and command set. There is also a definitions section that has a group of cells used to create a new board. These cells are capacitors, resistors, inductors, active devices, and combinations of cells that have been drawn to the correct physical size. A group of cells making up a working circuit can also be set up as a cell. This is how most of our circuits are developed—small sections are made, and the cells are then connected together. Individual cells, whole libraries, whole drawings, pen stroke libraries, and individual or whole commands can be copied from one drawing



Authors, left to right: Piazza, Miller, Butt, Hoke.

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**Harvey P. Miller** received his BS in Mechanical Engineering from Rensselaer Polytechnic Institute, an MS in Mechanical Engineering from Massachusetts Institute of Technology, a M. Phil in Plasma Physics from Columbia University, and will complete his PhD in Applied Physics from Columbia University in the spring of 1986. He joined RCA Government Communications Systems in 1984 as a Senior Member of the Engineering Staff. Mr. Miller has been responsible for computer-aided thermal design involving computational heat transfer and fluid dynamics.

He has developed a front-ended computer-aided design general purpose heat-transfer program for use on the RCA CISD Auto-trol engineering workstation to allow interactive graphics for 3-D model generation and transient thermal analysis.

Mr. Miller is a member of the American Society of Mechanical Engineers, American Physical Society, Society for Industrial and Applied Mathematics, American Nuclear Society, and Tau Beta Pi and Pi Tau Sigma Honor Societies. Mr. Miller was a Raytheon Fellow from 1966 to 1967 while attending MIT, and has been elected to Who's Who in Frontiers of Science and Technology for the past two years. He has numerous technical publications in Computational Fluid Dynamics and Heat Transfer, and is a registered Professional Engineer in New Jersey and Pennsylvania.

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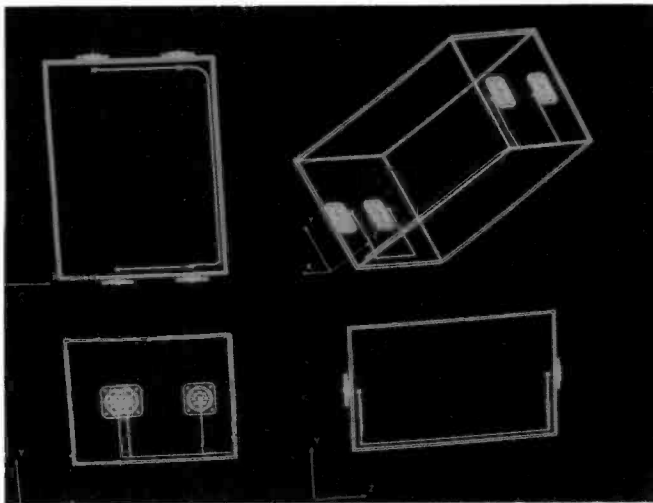
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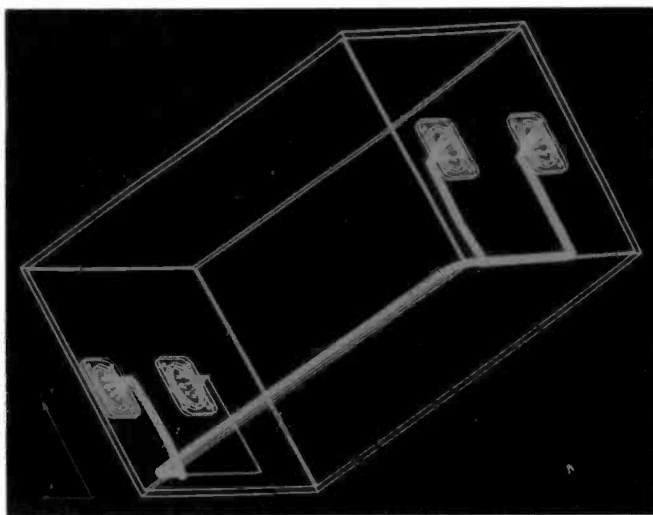
**David N. Hoke** is Senior Member, Engineering Staff, Design Automation. He received a BS in Industrial Management from Georgia Institute of Technology. He joined RCA CISD in 1984, and has been responsible for the CAD/CAM integration effort within engineering and specifically for initiating the cable harness automation effort. Mr. Hoke is also an associate member of the IEEE.

Contact him at:

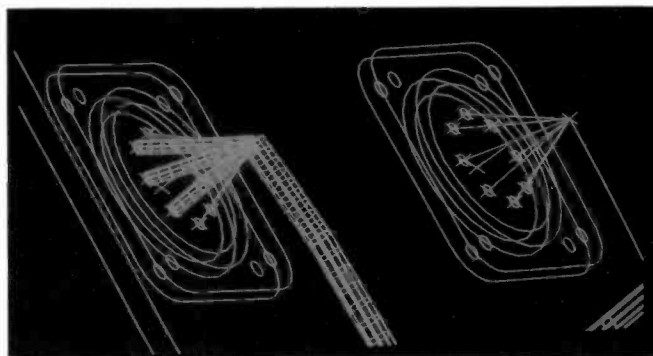
**Communication & Systems Division  
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(a)



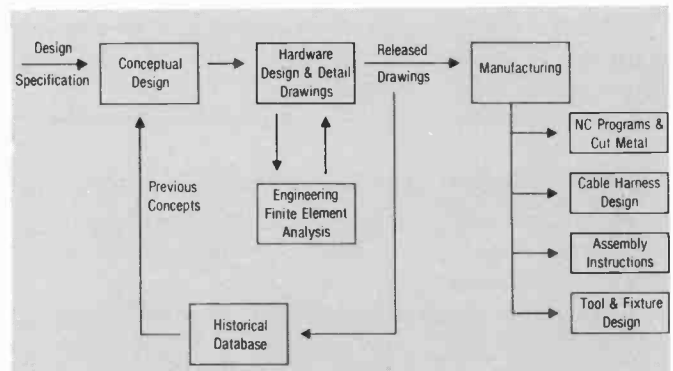
(b)



(c)

**Fig. 5.** The designer constructs cable harness routes through the 3-D model (a), then forms and displays the cable harness (b and c).

locally on a floppy disc and transferred to the VAX 11/750 where it will be accessible to those users specified and controlled by Engineering Documentation. In addition, software was completed for the transfer and reformatting of these same files for manufacturing engineering, where editing may take place. This information may then be used by the factory in the manufacture of the cable harness.



**Fig. 6.** The information flow in the mechanical design process. Each transition represented different utilization of the CAD database.

Software to aid in the automation of cable harness design has been developed and implemented on the Auto-Trol CAD system. This software interfaces with Auto-Trol's CAD system, which allows the design of a 3-D assembly. The model of the assembly sets the stage for the automation of cable harness manufacture. The designer can readily see possible paths or positive routes for the main trunk of the cable harness, and then constructs these paths via the Auto-Trol CAD system within the 3-D model illustrated in Fig. 5a. At this point, the designer executes the option for "visual inspection," and the cable harness bundle is formed and displayed as shown in Figs. 5b and 5c. Here each signal is routed between connector pins as well as the wire radii accumulated for cable bundling. Next, the "report generator" option may be selected in order to calculate lengths, resistances, and weight for each wire. Further development is required for the implementation of the flattening of the 3-D model for manufacturing and for the assessment of connector and tooling data.

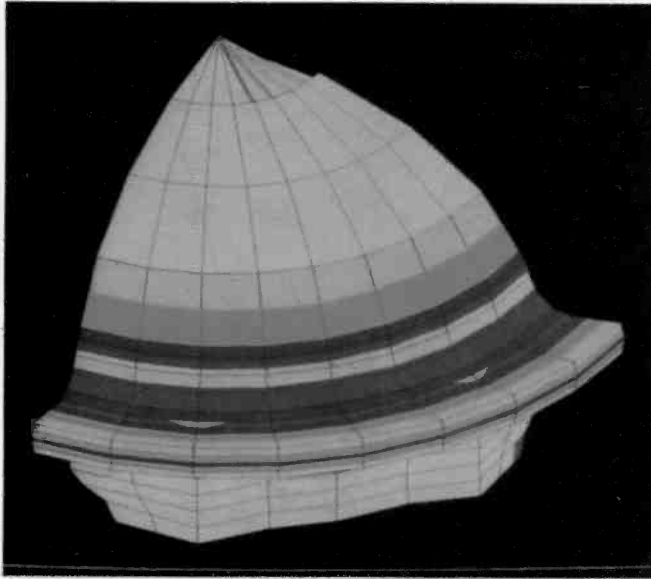
## Conclusion

To realize the benefits of a CAD system, information must be available from all the areas that would normally interface with the using activity (Fig. 6). At CIRD, the original purchase of mechanical design CAD equipment was implemented in a Design Engineering/Drafting group. As our system evolved, we soon realized that in addition to creating production hardware drawings in an efficient manner, the system enhances communication between various departments involved in the mechanical design process. By using a shared 3-D database, we are eliminating the regeneration of geometric data, which reduces the possibility of error and therefore improves the design cycle. This approach will improve RCA's competitive position in the communications and information systems field.

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2. MIL-HDBK-217, "The Reliability Stress and Failure Data for Electronic Equipment," U.S. Department of Defense.
3. "SINDA—Systems Improved Numerical Differencing Analyzer," National Aeronautics and Space Administration, Houston, Tex., 1980.
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**Fig. 4.** An iso-stress plot from a finite-element model of a structure.

another graphics input system. There is also a wide range of automatic mesh generation routines embedded in the software that provide such features as linear or controlled logarithmic volume fills of elements between defined surfaces. All of these features provide the ability to create a complex finite-element model for input to ANSYS.

With the model complete in Series 7000, a menu is selected to produce a finite-element file. This file is converted into ANSYS format using an ANSYS module (AUX15), and the engineer enters ANSYS with an intact geometry model. Once in ANSYS, the stress-behavior environment must be specified. The type of analysis is chosen (static, modal, linear dynamic, etc.); the applied forces, pressures or constraints are entered; and any physical or material properties associated with the elements are specified. The ANSYS solution phase is then executed and produces superimposed displacement plots, color stress contour plots (Fig. 4), and tabulated displacements and stresses (at numbered nodes and elements). Sorts can be done to list critical values exceeded in the model. With this tool an engineer can "tweak" a design to achieve optimum behavior and raise the level of confidence by subjecting more designs to a greater detail level of analysis in a shorter period of time.

### Manufacturing applications

The next phase in the development of mechanical designs is to have the parts fabricated and assembled. Again, the 3-D database can be used by a number of manufacturing engineering functions. For fabricated parts, the CAD software contains modules for flat pattern and punching as well as NC machining.

### Numerical control

The majority of the hardware designed and manufactured at CISD is for the packaging of electronic communications equipment. The types of packaging fall into two categories; sheet metal chassis and machined casting housings. The sheet

metal chassis designs are generally folded box structures with numerous cut-outs for connectors, purchased electrical components, and assorted mechanical mounting hardware. Manufacturing engineers can use the flat pattern software to generate a flat pattern layout of a part simply by indicating where the bend lines are and entering the bend radius and material thickness. This layout is generated with all of the cut-outs in their proper locations. The punching software can then be used to create a command file to drive an NC punch to "knock out" the part. Time is saved by eliminating redundancy (the manual entry of geometry from drawings) and reducing chances for error.

In the "cast chassis" area of design, tooling changes are expensive, and extensive checking is needed to eliminate design mistakes. With the NC software, there is a relatively short turnaround time for mechanical fit verification model production. Here, an NC programmer can generate toolpaths in an interactive session on the CAD workstation (using the part that is already in the database) in one tenth the time of manual toolpath programming methods. This procedure can also be applied when schedule crunches on a program cannot tolerate the long lead times involved in the purchase of castings.

Process and assembly engineers also benefit from the design information in a CAD database. In our assembly area, process engineers routinely make copies of production drawings, cut and paste parts of these drawings and add text to direct the assembly operation. Redisplay and formatting functions that exist in the CAD software are already tailored to accomplish this easily.

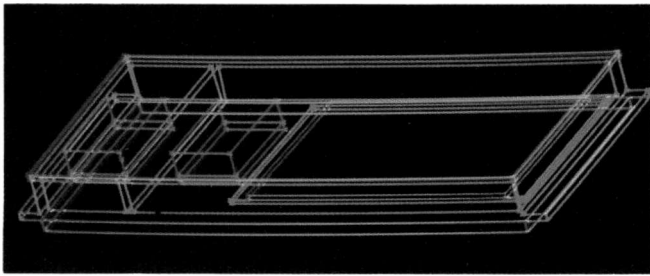
### Cable harness

The cable harness design process is labor intensive, complex, and detailed. It is for this reason that CISD has pursued this CAD application.

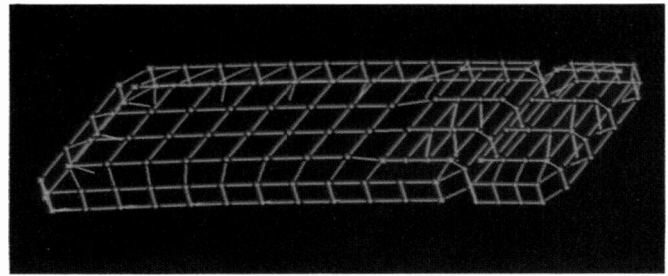
In the past the electrical engineer, with the assistance of a mechanical engineer, produced a sketch that defined critical paths for the cable bundles and connector locations. This sketch was then delivered to drafting, which produced a wire list for the pin connections and a detailed schematic. All cable harness pin connections and cable routing information were then manually typed and reviewed by engineering for accuracy. The schematics were distributed to manufacturing engineering along with a wire connection list. Here the flat pattern is developed. In some cases this is accomplished by fitting the cable harness to the rack cabinet. This process is labor intensive and would best be solved through engineering via a CAD system rather than through manufacturing by hand.

After manually reformatting all of the above information, it was then sent to MIS to be entered into their materials inventory system and a final hardcopy was returned for use by manufacturing engineering. The process described was lengthy and, because of human intervention, the error rate was high.

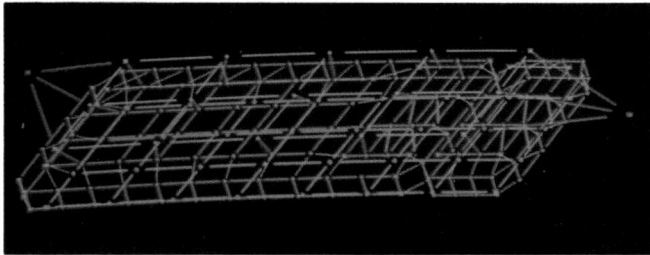
We first concentrated our efforts on establishing a link between engineering and manufacturing. This became possible with the installation of the Ungermann-Bass local area network. Also, software was designed to assist the draftsman in entering the wire connection list and formatting the information for the customer. Upon completion, the list is stored



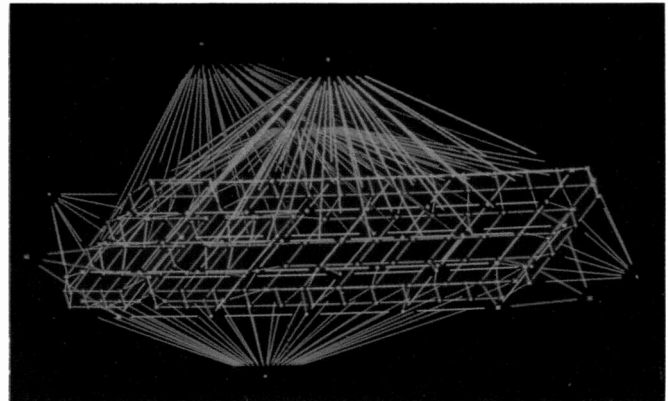
(a)



(b)



(c)



(d)

**Fig. 3.** (a) Shows the wireframe outline of a fiber-optic transceiver; (b) is a preliminary RC thermal model of 3-D internal grid conduction; (c) is an evolved RC thermal model of 3-D conduction including the transceiver lid and base coldplate; and (d) is the complete RC thermal model of a fiber-optic transceiver.

CHTC convection resistors (for convection in fluids that are not presently in PROPTY);

6. "Nodal" calculation of free and forced convection from respective grid nodes to ambient nodes, and internal convection;
7. "Nodal" calculation of direct radiation from respective grid nodes to ambient nodes, and re-radiation to adjacent grid nodes.

The operation of GCSMOTHA involves:

1. Construction of a physical model in 3-D (so-called "wireframe");
2. Execution of the Finite-Element Modeler for creating nodes and elements;
3. Response to menu-driven screen prompts for creating the input data file in Auto-Trol's graphics system Series 7000;
4. Running GCSMOTHA using the graphics-generated data file;
5. Providing transient and steady-state temperature output in matrix format.

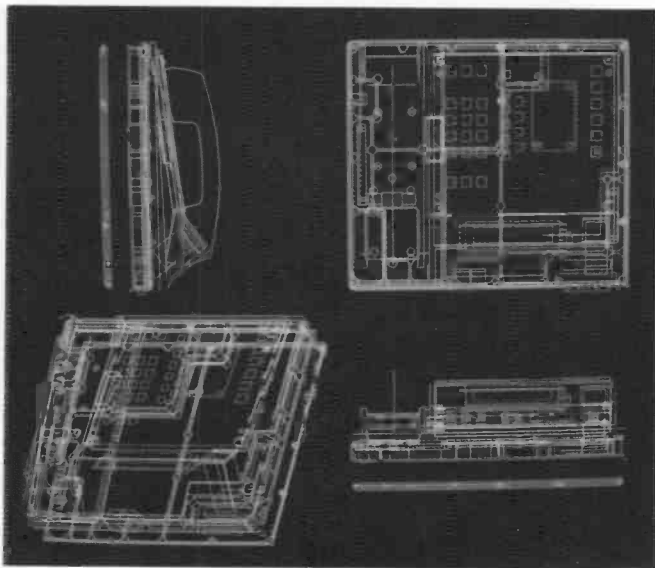
A thermal problem recently solved by GCSMOTHA involved a high-resolution discretization of a fiber-optic transceiver. Figure 3a illustrates the wireframe of the proposed package design. A wireframe is first constructed so that all surfaces are visible for executing the Finite-Element Modeler. The thermal model is constructed employing the vitally important techniques of "color coding" and level management, so that resistor elements corresponding to various modes of heat transfer can be effectively differentiated. Figure 3b shows the FEM-constructed thermal model that accounts for 3-D internal conduction on the grid surfaces. The linear conduction coupling in this high-resolution ther-

mal model can be readily observed. Note that heat-dissipating electronic components were carefully distributed in three separate circuit modules. Figure 3c illustrates the thermal model evolved one step further, accounting for conduction to the transceiver lid and to a base coldplate. Figure 3d shows the complete RC thermal model including the effects of internal and external convection, ambient radiation, and the use of special thermal resistors accounting for perpendicular conduction (through several different materials) and lateral boundary conduction from the coldplate to the chassis.

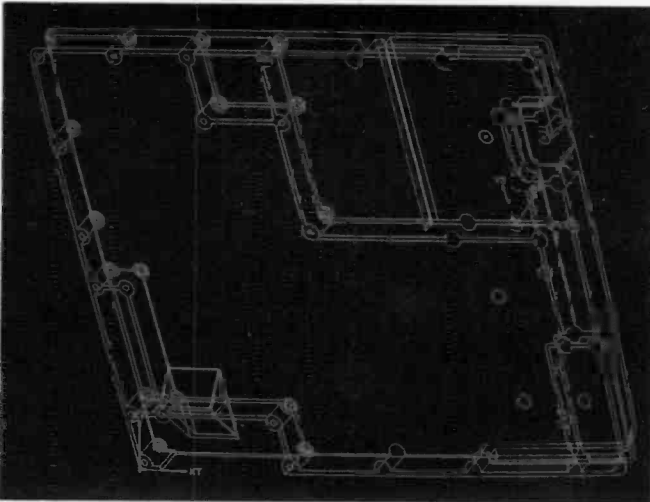
The fiber-optic transceiver model was successfully run with GCSMOTHA, and a design change was modeled and analyzed within hours using this CISD CAD tool on an Auto-Trol engineering workstation. It should be noted that the complete thermal model used over 200 nodes and approximately 700 thermal resistors. The GCSMOTHA input data file was created by direct console prompting within one hour. It is expected that this CISD CAD tool will yield both much higher resolution RC thermal models, when deemed necessary, and significantly reduce thermal design turnaround time.

### Structural analysis—ANSYS

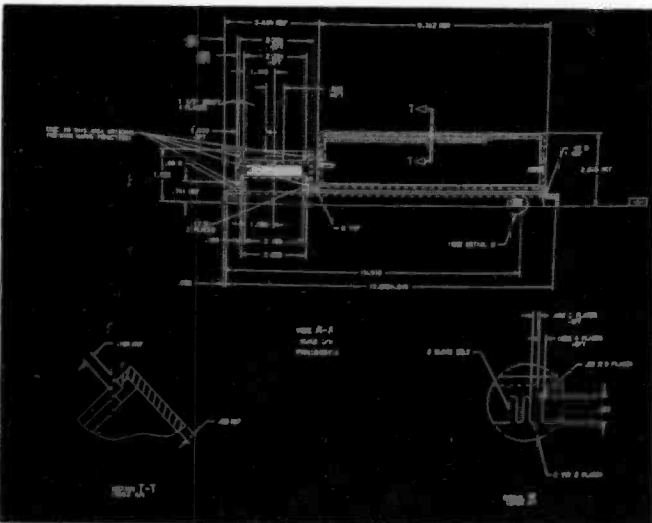
The other area of engineering concern in mechanical design is that of structural integrity. At CISD we have ANSYS (a widely used finite element and model solver) input capability from any of the designs created on the CAD workstation. In an interactive session, an engineer can create a mesh model from existing geometry using a wide variety of ANSYS-supported elements (2-node beams, 4-node plates, 8-node isoparametric solids, etc.). By working in the environment of the Series 7000 software, the engineer has a greater number of graphics tools at his disposal and doesn't need to learn



(a)



(b)



(c)

**Fig. 2.** Detailed design progression: (a) shows the designer's layout (note the utility of color part definition); (b) shows a part "cut" from the layout; and (c) shows a page of the fully dimensioned product drawing.

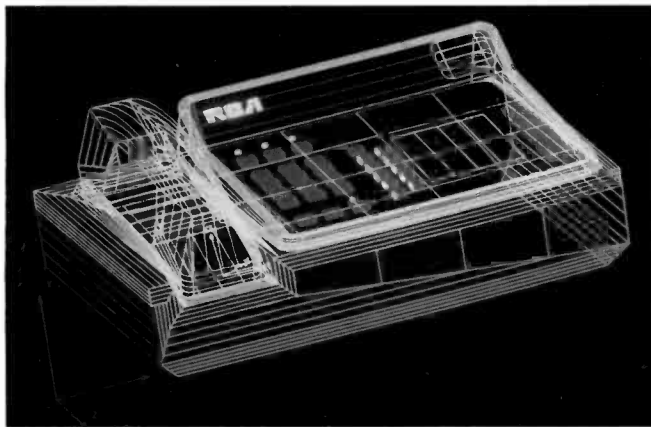
electronic components increases approximately exponentially as a function of increasing temperature. The designer of an electronics assembly is typically faced with the problem of maintaining a semiconductor junction temperature below  $125^{\circ}\text{C}$ . In fiber optics applications, light emitting diodes should not exceed  $64^{\circ}\text{C}$  for proper operation. Hence, the need for CAD for thermal modeling and analysis becomes apparent.

Many computer programs such as NASA's SINDA (Systems Improved Numerical Differencing Analyzer)<sup>3</sup> and industry codes such as MOTH (Moorestown Flow and Thermal Analyzer)<sup>4</sup> are presently available for general-purpose heat transfer analysis. Although these programs are fast and accurate, they do require extensive thermal modeling and very carefully prepared data input files for the effective use of the respective computer codes. The RADC *Thermal Guide for Reliability Engineers*<sup>5</sup> estimates that a heat transfer specialist with at least five years of experience would need one week to perform one 20-node model of a printed board, and two weeks for a 70-node model, using a general-purpose heat transfer program.

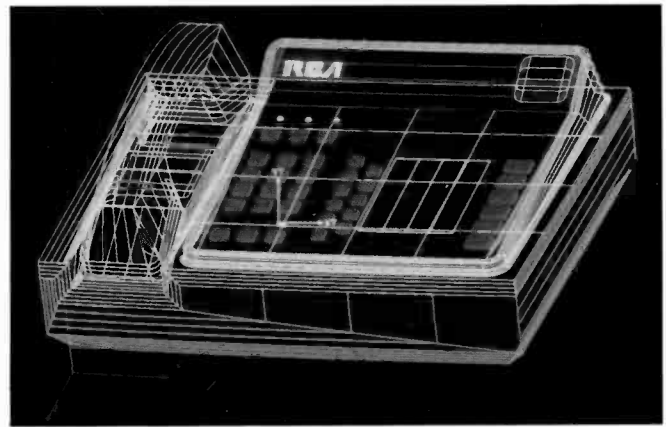
CISD has developed GCSMOTHA, a FORTRAN program with a user-friendly, menu-driven front end, which has a 3-D graphics modeling capability for a complex electronics package thermal analysis. The Auto-Trol mechanical design CAD system, on which GCSMOTHA is currently operating, first discretizes the physical model using the Series 7000 Finite-Element Modeler (FEM). It then performs the necessary data extraction by utilizing Auto-Trol's Applications Interface (AI) fortran programs for generating user-friendly menus and command instructions. Data input is fast and reliable, and is done by responding to screen prompts and by interrogating the FEM-constructed thermal mode. The input data file is automatically created by the CISD-developed AI programs for running GCSMOTHA in the operating system. Both transient and steady-state heat transfer solutions are used for temperature predictions. GCSMOTHA uses the lumped-parameter explicit finite-difference network solution in MOTH for thermal predictions. In addition, GCSMOTHA dynamically couples MOTH to CHTC (convective heat transfer),<sup>6</sup> a CISD FORTRAN program for performing convective heat transfer calculations; PROPTY, a CISD FORTRAN program that is a resident library of 12 common fluid coolant properties; MATPROP, a resident library of materials properties; VIEW, a resident library of radiation view factors; and applications interface (AI) FORTRAN programs for creating user-friendly, menu-driven data entry and thermal model network data extraction.

GCSMOTHA features include:

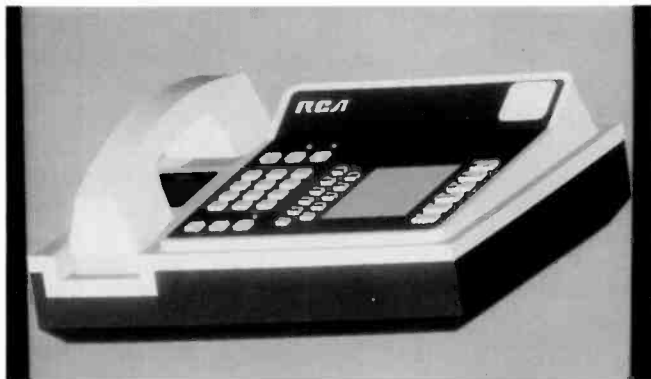
1. 3-D thermal modeling using the Auto-trol Finite-Element Modeler for creating nodes (temperatures) and elements (thermal resistors);
2. Transient thermal analysis using MOTH's explicit finite difference equation algorithm;
3. Multiple grids (or meshes), currently up to 25;
4. Linear conduction coupling between adjacent grids;
5. Special thermal resistors accounting for contact resistance, perpendicular conduction (in depth), and non-



(a)



(b)



(c)



(d)

**Fig. 1.** An example of conceptual model evolution: (a) represents a wireframe outline of the design; (b) shows

surfaces defined for shading; and (c) and (d) show different views of the shaped solid.

pulled from the layout. Here again, the detailer has a head start in preparing a fully dimensioned drawing.

It is in this detailing phase that many tailored time-saving applications programs can be developed. The tedious, repetitious tasks such as dimensioning, adding fabrication, material and finish notes, generating schedules and formatting a drawing can be automated. This automation not only saves time in the design process, but allows the designer to concentrate his effort on fit and functionality problems. This results in a more productive, challenging work atmosphere.

For example, we have developed a drawing note and material note program that has frequently-used embedded notes. If a designer wishes to choose a material, he can "page" through a list of standard materials by their commercial designations, make a selection, and the proper Federal Specification for the material will be placed on the drawing. This ensures that the manufacturing community will receive drawings that call out a standard set of materials across diverse programs (a purchasing advantage), and that typographical and numerical transposition errors will be virtually eliminated. Applying this philosophy to numerous in-house program tools has benefited our design process.

Another area where these savings have been demonstrated is in parts list documentation. At CISD we employ a CRP (Configuration Records Processing) system that is an accumulated parts list database on an IBM mainframe. This system allows users to sort, by a variety of methods, the parts and documents that make-up any particular program. The standard method of input to such a system is to manually

generate a parts list, and then have keypunch personnel prepare the information with the proper database coding. This is a rigorous, redundant process prone to error. We have developed an applications program that allows our designers to enter their parts list information into a text file while they are working on their drawing. With this file on the system, it is possible to convert it to a form that is compatible with our parts list system on the IBM and transfer it directly to that system. This represents increased efficiency in the flow of information.

### Engineering analysis

Concurrent with the design of hardware, engineers are concerned about the structural integrity and the thermal impact of their designs. Again, with the hardware in a 3-D database, engineers can spend their time performing analyses of parts and systems of parts rather than entering the geometry. The CAD software that we use has a finite-element mesh generation module. With this capability, an engineer can quickly and easily prepare a finite-element model of the existing design and pass this model into one of the finite-difference or finite-element solution programs.

### Thermal analysis—GCSMOTHA

One of the most frequent causes of electronic component failures in complex electronics equipment is heat.<sup>1</sup> An examination of MIL-HDBK-217<sup>2</sup> indicates that the failure rate for

# Comprehensive application of a CAD/CAM system to mechanical design

*RCA integrates CAD/CAM into all phases of the mechanical design process.*

The benefits of CAD/CAM in the mechanical design process can best be seen when the system is tailored to the design flow process in a particular industry. At RCA's Communication and Information Systems Division an abundance of programs are developmental, short production, or large-scale systems-integration projects requiring design of a wide variety of hardware. Whereas many industries look at CAD/CAM as an efficiency tool in the design of a family of high-volume production products, at CISD we are attempting to automate the process flow of mechanical design to minimize duplicated efforts, improve overall productivity, and reduce development schedules.

This comprehensive approach includes:

- Preliminary marketing modeling using surface-shaded wire frames
- Design layout of a product assembly from the preliminary design
- Structural and thermal analysis when deemed necessary on this design
- Production drawings of parts "cut" from the layout

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**Abstract:** *At RCA's Communication and Information Systems Division, a CAD/CAM system is being integrated into many phases of the mechanical design process. Starting with conceptual design, the 3-D database created can be used to start design layouts, generate detail drawings, perform engineering analysis, pass parts list information to a centralized database, and generate machining, fabrication, and assembly information for manufacturing. This is made possible by tailoring a versatile graphics software package (Auto-trol Technology's Series 7000) to meet the particular needs of the communications industry. The benefits of this approach are twofold: much redundancy of effort is eliminated, and better communications are established between various design disciplines.*

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- Parts lists transferred to a centralized database
- Machining, fabrication, and assembly data
- Libraries of repetitive or evolving hardware for use in future designs.

This requires the use of a functionally versatile 3-D graphics package (Auto-trol Technology's Series 7000), and the development of custom software tailored to the design flow.

## Conceptual design

The first step in mechanical product design is to consider the design parameters as determined from a specification of performance and to generate a conceptual design. This design is generally the joint effort of engineers and marketing people who must communicate to the customer the proposed aesthetics of the product in addition to its functionality. This process can be quite evolutionary and often many design concepts are generated. In a non-CAD environment the rate at which alternative concepts can be generated is dependent on the rate at which artists and designers can manually produce sketches.

Figure 1 shows a case where 3-D modeling can be employed to develop a geometric model and easily show different views and color combinations of the proposed product. This allows the proposal team to visualize alternatives and make decisions on form and aesthetics prior to model making.

## Hardware design

Once the appropriate model has been chosen and it is time to start the actual design, the engineer or designer already has a configuration with which to work. The detailed design has a "head-start." The design layout may now progress with the designer working in a 3-D frame of reference to best see the relationship and fit of the assembled parts. Figure 2 shows one such layout that was generated from a conceptual sketch. This shows the ease with which individual part details may be

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**Fred Voto** is a Senior Administrator in ASD's Operations Control Department, where he is responsible for cost control and cost proposal preparation. He received a BS degree in Finance from Boston College, and an MBA from the Boston College School of Management. Since joining RCA in 1975, Mr. Voto has pioneered the use of interactive computers for cost estimating, using Data General and VAX Basic. Over the next couple of years, Mr. Voto used Data General's C-350 to eliminate keypunched cards for DEPICT applications by writing various data entry screens and programs in Cobol to create electronic card images. He has also initiated other business applications in Supercomp-Twenty and DATATRIEVE. In his current assignment in supporting the Avionics group, Fred is using the Macintosh PC for a variety of cost reporting and cost analysis applications.

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**Morton D. Stern** joined RCA Automated Systems Division in 1966. As Manager, Program Control and Pricing, Mr. Stern is responsible for the management of two departments at ASD: Program Administration and Control, and Cost Analysis and Pricing. He was a charter member of the Committee that developed the Program Manager's Guide. He received his BS degree in Engineering Management from Norwich University in 1961, and did his MBA studies at the University of Rochester. After college, he was on active duty with the U.S. Army Signal Corps Procurement Agency, where he was a Project Manager. He spent several years with General Dynamics/Electronics Division as Business Supervisor for the F-111 ATE program, and was a Senior Value Engineer for Bell Aerosystems prior to joining RCA. Mr. Stern has been an active instructor in the RCA After Hours Training Program, and was a member of the Evening Division Faculty at Northeastern University for several years.

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with an impressive and meaningful demonstration.

### Preparing illustrations with the PC

A further PC application is in engineering design. The design process involves the creation of many technical illustrations that may be changed several times as the design evolves.

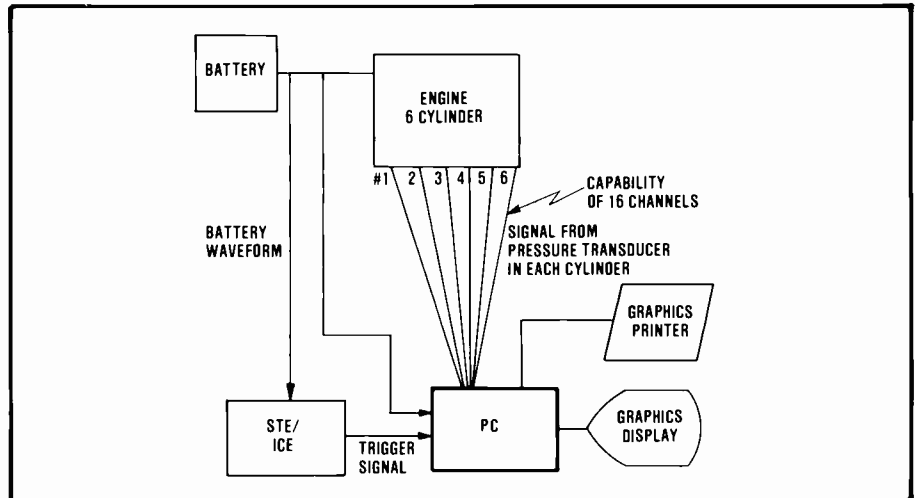
In the past, all illustrations were produced by the Technical Publications Department. The results often exceeded the level of quality required for internal engineering use, and the normal processing time required to produce these illustrations tended to slow down the iterative design process. Now, engineers have begun using an Apple Macintosh PC 512 for their design tasks. Analysis of results showed that by using the Macintosh in engineering, the cost per illustration was considerably reduced. From March through September 1985, Vehicle Electronic Systems Engineering produced 1600 engineering drawings on the Macintosh, resulting in a well-illustrated system. By facilitating the iterative design process, a higher quality design has been possible.

### Program administration and control

The Apple Macintosh has helped ASD standardize scheduling in all of its Program Management Offices (PMOs). This has improved the quality of output and reduced the cost of monthly schedule updates. Figure 5 is a typical example of a production schedule developed on a Macintosh by the Avionics Planning Group.

In the past, schedules were hand-generated in draft. Once agreed upon, the schedules were manually converted to master vellum, a labor-intensive process that involved hand taping letters, symbols and bars. This was followed by a quality check prior to reproduction and distribution.

Today, standard templates and symbology are stored in the Macintosh's memory. A project planner can now create the schedule by moving a mouse, using either *MacDraw* and/or *MacProject* software. Additional savings occur during the program evolution since all changes can be entered directly onto the screen. The Macintosh system allows for rapid resequencing and redrawing, thus eliminating the tedious and time-



**Fig. 4.** Personal computers are appropriate as portable, low-cost field data acquisition systems. In this system, all components were purchased commercially, including the data acquisition software. This significantly reduced costs for the STE-ICE Data Collection System.

consuming manual schedule updates. In addition to reducing overall labor, this technique has also lowered the cost of updates by over one third. Another big plus has been the exceptional quality of output. With a standard printer, schedules are suitable for viewgraphs; with a laser printer, schedules are nearly book quality.

Other business applications using the PC are increasing daily. The Cost Analysis and Pricing Group uses IBM PCs to rapidly update cost proposals. By using electronic spreadsheets that facilitate revisions and updates for such common things as rate changes, this group has been able to handle an increase in workload of forty percent with essentially the same resources.

The administrative community relies heavily upon the need to produce accurate, constantly revised and updated spreadsheets for internal and customer consumption. Because of the dynamic nature of these spreadsheets, their utility is greatly enhanced in a PC environment. Frequent and rapid spreadsheet modification can be accomplished with extreme ease using the Macintosh system and its mouse and pull-down menu features. Final output can be rapidly produced on hard copy, using either the ImageWriter or LaserWriter printer, depending upon output quality requirements.

The Macintosh has become a true business machine at ASD. With over 500 pieces of retail software, eight major hard disk systems, telecommunications, high quality printing, half a

megabyte of standard memory, and the support of respected names in the software and peripheral industry, the Macintosh has grown into a system that offers untold dividends in even its simplest configuration.

### Office automation with PCs

The evolution of office automation has stemmed largely from the desire to become less dependent on the mainframe while still having it available for data access. The minicomputer was thought to be a good solution to this problem, and quickly became a way of life here at Automated Systems Division. However, new problems soon emerged in using this equipment. Minicomputers became overloaded with users and various business software applications suffered from poor response times. This pointed clearly to the need for smaller, self-contained units. Personal computers became a very attractive option for this particular application.

For most of our day-to-day business applications, PCs provide virtually the same results as software loaded on a mini or mainframe for a lot less power and far fewer dollars. The PC can access a distant mainframe via modem, access and download the required source data, and reconfigure the data as desired without fear of destroying it.

Over the past few years, office automation has accelerated, with users exchanging ideas, resources and, most especially, learning skills. Technology



## The personal side of the PC

1985 was a banner year for the acquisition and use of PCs in Engineering at ASD. The currently most popular PC choice of ASD engineers is the Apple Macintosh (Mac). Engineers prefer the Mac over its closest competitor, the IBM PC, by a ratio greater than 2:1. Our most numerous PC in Engineering is still the DECmate, which is used for word processing by most of the secretaries.

It is not difficult to understand why engineers prefer the Mac. It is easy to learn to use in a short time due to such features as icons, pull down menus, and the mouse. Thus, an engineer who has no prior experience on the Mac can become productive in a matter of hours—not days, weeks, or months. No training is necessary on the Mac; just turn it on and start getting familiar with the interaction of the mouse and the user. Before long, the user has the hang of using the mouse and clicking on the menu bar and the fun of using the Mac begins. To some, this may appear to be a contradiction—implying that work can be fun—but this is the feedback from Mac users.

PCs are used to create PERT

diagrams for schedule visibility and critical path; high-quality presentation material (in a short amount of time); technical illustrations (use of the Mac was found to be about four times less expensive than previous manual means); specifications, test plans, and status reports (using *MacWrite*); viewgraphs, block diagrams, and work breakdown structures (*MacDraw*); free-form graphics (*MacPaint*); and project and budget planning (using *MacProject*, *Jazz* and Microsoft's *Excel*).

PCs are used in both a stand-alone mode and interfaced to our Ethernet/DECnet system in order to communicate with our installed base of engineering VAX systems. We have used both terminal emulators (such as *MacTerminal*) and the communications feature of Lotus *Jazz* to transfer files from the Macs to our VAXs and vice versa.

Engineers I have talked to are excited about the Mac's capabilities, so much so that demand for Macs far exceeds current supply. Engineering managers report that Macs already acquired are receiving heavy use. They facilitate the creative process such that an engineer can quickly see and improve

upon the results of his or her own thinking. This fast responsiveness is an important reason why the Mac is fun to use and a morale booster among engineers.

The bottom line for engineering managers is a good one—quality improvements, cost savings, and cost avoidance as a result of using the Macs. I've been told by several managers that on a recent proposal effort, the Mac in combination with a LaserWriter printer was indispensable; without it, timely response to the customer would have been impossible.

At ASD, a number of engineers have bought Macs (mostly the "Fat Mac" with 512K of memory) for home use. With a Mac of one's own, there is a tendency to take more work home than would otherwise be the case.

Based upon our experience with PCs so far—quality improvements, and hours and dollars saved/avoided—I would have to say that the PC is turning out to be a good investment for ASD.

—Dr. Vaughn Grace

filtering routines. The command processor/expert system is written in Pascal, which includes the detection algorithms. Basic expert system technology is used to determine the rules for fault detection.

### Field data collection with the PC

In a unique engineering application, an IBM PC is used in conjunction with an internal combustion engine test set (STE-ICE) for field data collection and development. The PC collects dynamic cylinder pressure data and electrical waveforms from an operating internal combustion engine. The cylinder pressure is collected from each cylinder in

the engine simultaneously in real time and stored on disk, along with the battery cranking waveform and several parameters from the STE/ICE. The data is then analyzed to determine the compression balance of the engine and to calculate several internal constants to be placed in STE/ICE memory. The system implementation is shown in Fig. 4.

### PCs and Vetronics testing

Another application of the IBM PC in engineering addressed a crucial component of the Vetronics crew station. Vetronics involves heavy automation of complex military vehicles using a broadband bus for interstation audio/video

and high-speed data communication. One of the many tasks of the Vetronics crew station core processor is to control this communication, allowing a crew member to select from the various channels.

During the initial bus testing and integration, in preparation for the preliminary design review, not enough core processor boards existed to support the broadband bus demonstration. In the interest of time, IBM PCs were used to simulate the Vetronics Computer Resources Subsystem. The I/O and graphic capabilities of the IBM PC hardware and software allowed for an easy implementation of a high-quality simulation and provided our customers

bearing that has a small spall on one of its races, as shown in Fig. 1. During the early stages of failure, the spall is small and will not immediately jeopardize the bearing's functionality. If undetected, the spall will grow in size until the bearing fails completely, possibly endangering the operation of the entire machine. Even during the very early stages of failure, the bearing assembly will emit bursts of energy at a repetition rate equal to that at which the balls encounter the small spall. These bursts of energy cause the machine elements to vibrate at specific frequencies and, if isolated from the other concurrent machine vibrations, the failing bearing can be detected and identified at a very early stage.

The vibration signal levels associated with the failing bearing at this early stage of failure are, however, typically 30 to 50 dB below the background machine vibration levels. Until recently, this has prevented the early detection of most minor bearing faults. However, the advent of small, powerful computers such as the IBM PC AT and the commercial availability of signal processing software have greatly simplified the implementation of complex vibrational analysis techniques.

Many of the processing techniques used in detecting bearing faults are also common to modern spread-spectrum radar signal processing. As in radar processing, the fault signature is masked in noise from various sources including clutter and synchronous and asynchronous noise from mechanical sources. Unfortunately, unlike radar signal processing, no transmitted reference signal is available. Many classical digital signal processing techniques similar to frequency filtering, pulse width identification, demodulation, and time-to-frequency domain transformation are used.

All of these special signal processing techniques require considerable sophisticated computational capabilities which, until recently, were not available in portable equipment.

### Fault detection using the PC

Engineers at ASD have found the PC to be a helpful tool for fault detection in truck transmission and transfer assemblies. In this system, a laser velocimeter is used to detect vibration signals with-

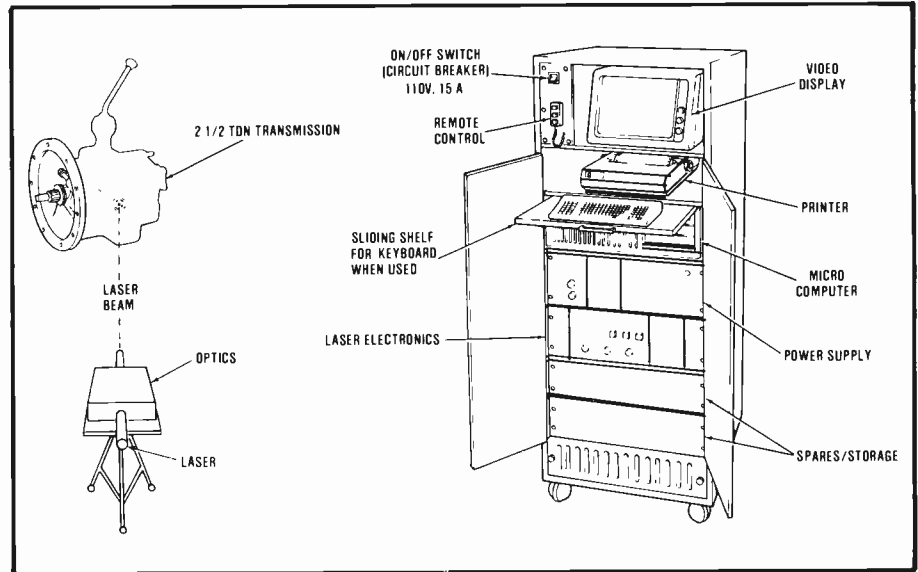


Fig. 2. A laser velocimeter works with a PC to detect transmission vibration signals. The PC provides a user-friendly interface to the test system while handling system control, data acquisition, and display functions.

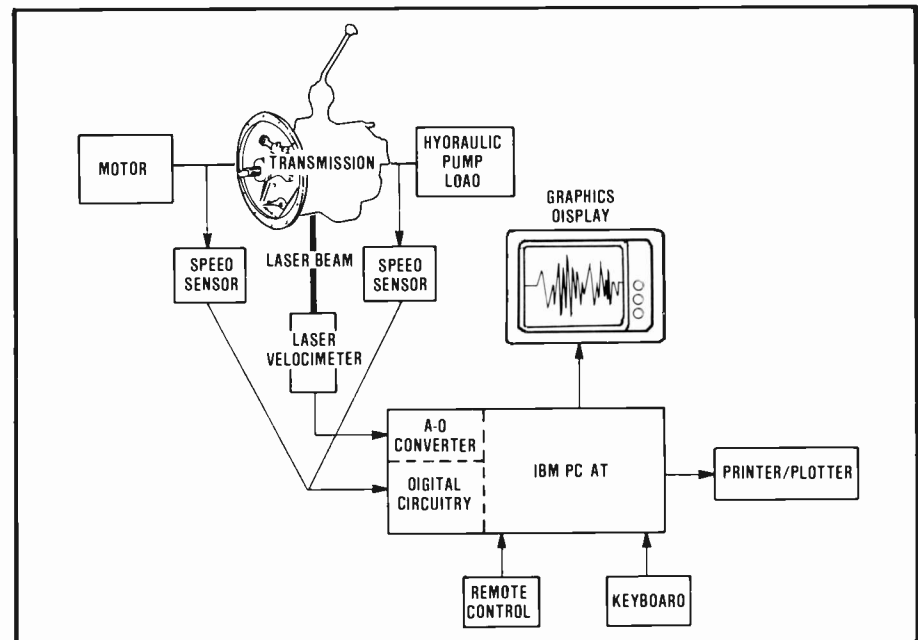


Fig. 3. Fault detection hardware includes an IBM PC AT. The PC's architecture allows easy integration of custom peripherals, a powerful microcomputer and a large existing software base.

out physically contacting the transmission (see Fig. 2).

The vibration signal, along with input and output shaft rotational position information from the transmission, is sent to the PC. Functionally the hardware consists of an IBM PC AT with graphics display, printer/plotter, and analog to digital (A/D) converter and sensors, as shown in the block diagram in Fig. 3. System capabilities make full use of the PC's features including dis-

play, storage, and hardcopy output of signals, variables, and test parameters. The fault detection software is run as commands under the standard disk operating system. The signal processing core programs are purchased from an outside vendor and modified for the specific application, thus allowing a significantly reduced programming task. Processing features that require optimized coding are written in Macro Assembler, which includes A/D and

# Personal computers in the engineering workplace

## The innovator amongst us

*At Automated Systems Division, nobody questions the "why" of PCs—they want to know when they will have more.*

As the PC becomes more and more of an "external brain," a subtle change is beginning to emerge, with greater emphasis being placed on quality. We can now differentiate between what we have to learn and what we simply want to access. As the pocket calculator replaced the slide rule, the PC is changing how we perform engineering and run the office.

RCA Automated Systems Division (ASD) has, over the past few years, been a part of this evolutionary process in the areas of office automation and engineering. This transformation has been enhanced through the accumulation of 21 VAX computers, ranging in size from the MicroVAX I to the VAX 11/780. These are supplemented by over 300 ter-

minals, 10 IBM PCs, and 28 Apple Macintosh PCs.

We are all familiar with the burgeoning use of digital logic and circuitry in implementing algorithms in operational equipment. Special signal processing techniques are incorporated into reliable compact hardware through VLSI designs. These designs are the end result of extensive engineering using small, powerful computers like the IBM PC AT.

### PCs and vibration analysis

An example of engineering design using PCs is the effort in vibration analysis.

The PC has been used to help develop a technique for non-intrusively assessing the condition of rotating machinery components through vibrational energy signal processing. This technique is not dependent upon trending analysis, and can be implemented in inexpensive portable multipurpose test equipment using personal computers. The introduction of commercially available digital signal processing software for an IBM PC has made these advancements economically feasible.

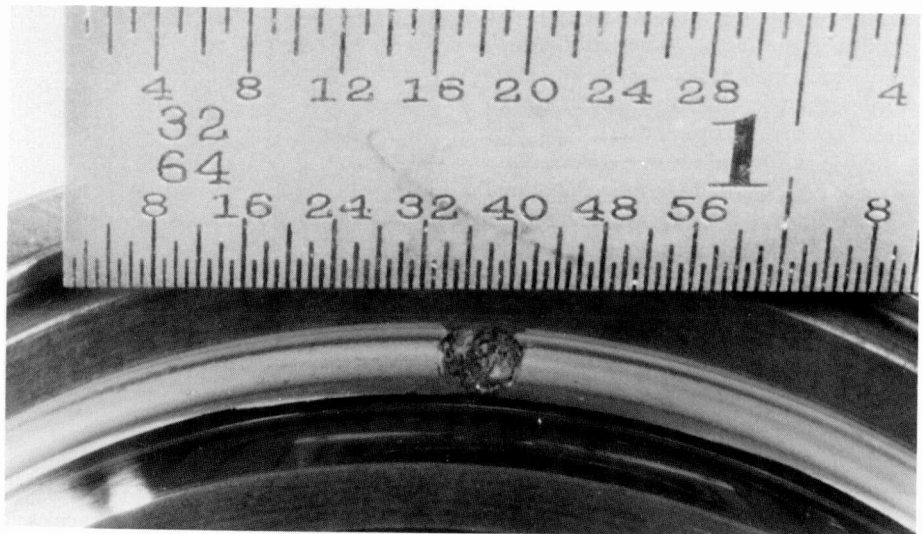
To illustrate the difficulty of detecting faults through vibration analysis, consider a machine incorporating among its many components a rolling element

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**Abstract:** *Automated Systems Division has found innovative applications for PCs in engineering, business and management. In engineering, PCs are useful for vibration analysis, fault detection, field data collection, and Vetronics testing. Business applications of the PC include program schedules and proposal updates. In management, PCs are used for producing engineering data in graphic format for management reviews. In the future, the PC will serve as a laboratory aid, and will play an integral role in automatic test equipment and test architectures.*

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**Fig. 1.** This magnified photograph shows a bearing outer race that contains a Class C fault as graded by the Army. This class of fault does not immediately impair the bearing's functionality, but warrants replacement. With PCs and signal processing software, minor bearing faults such as this one can now be detected earlier.

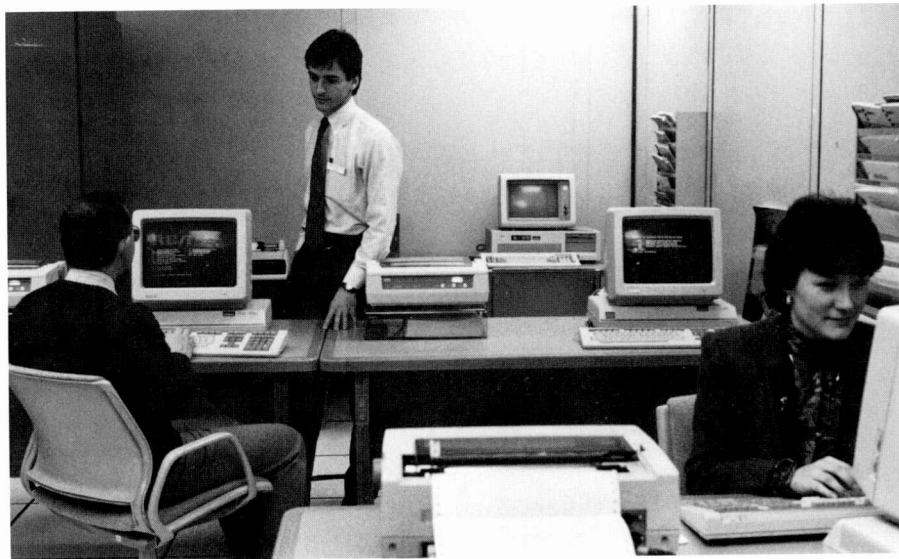
Wang PC or DECmate word processors. The DECmates and Wangs can access VAX as terminals or transfer text files, eliminating the most notorious form of pseudo office automation—managers typing memos into a terminal, printing it and handing it to their secretaries for retyping. We are also employing IBM personal computers for spreadsheet-intensive applications and to access specialized PC applications software. All IBM PCs are connected to the VAXcluster and can double as terminals. We have recently installed DEC's All-In-One package, which replaces DECmail, as well as adding an applications integration environment and some enhanced features, such as calendar management. The migration of users to All-In-One will be a continuing process over the next year.

### User support

No investment in computer facilities makes sense unless people know how to use them. We have made substantial efforts to provide supporting services to our user community. A weekly schedule of classes provides instruction in DECmail, DECalc, and DECgraph. Special classes can be arranged for busy managers. Computer-based instruction covering office automation, VAX/VMS and touch typing can be accessed at any time at any terminal. We have established an information center adjacent to our office area that includes top-of-the-line DEC VT241 terminals and IBM PC ATs. It is used for training classes as well as individual use and evaluation. We publish a bimonthly newsletter, *Mailbox*, which includes hardware and software news, user tips, and system schedules. To insure the integrity of our systems, we maintain a rigorous data backup policy, offsite data storage, and we have installed sophisticated security systems to protect our facilities. Most important of all, we provide a telephone help line—**Tacnet: 325-7273**—which is the central point for reporting system and performance problems, as well as asking for help or advice on any of our products and services.

### Future

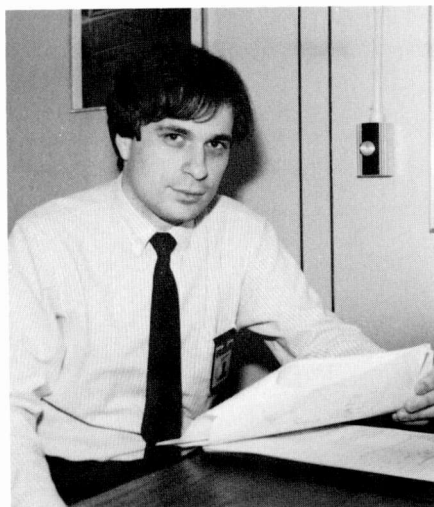
If current trends continue, we expect to see an expansion of the overall user



*The MEC Information Center is equipped with DEC VT241 graphics terminals and IBM PC AT PCs. In addition to serving as a site for classroom and individual instruction, the information center can be used by employees who do not otherwise have access to PCs.*

base, as well as increasing emphasis on engineering workstations and personal computers. To meet these needs, ECS will be providing supporting services on new engineering workstations in 1986, as well as expanding its support of personal computers. We expect a major shift of manufacturing processing to VAX systems in the next few years as obsolete versions of IBM software are phased out and the HP-3000 systems are

retired. Probably the most important trend will be towards computer-integrated manufacturing (CIM), wherein all design, administration, and manufacturing is completely integrated through common databases and communication links. We will be working with Somerville's CAD, CAM, and MIS organizations over the next few years to bring the CIM evolution to Somerville.



**Louis Judice** joined the RCA Solid State Technology Center (now the Microelectronics Center) in 1978 after receiving the BE degree in Electrical Engineering from Manhattan College

in New York City. As a Member of the Technical Staff in the Design Automation department he worked on computer-aided design software development, including automatic VLSI routing algorithms and the porting of the production ART system to superminicomputers. In 1983 he became Project Leader of CAD Technical Support and was responsible for expanding Somerville's engineering computer capabilities and commercial software support. Between 1983 and 1985, VAX-based computing capacity was increased seven fold, as the subscriber base swelled from 20 to over 400, and overall usage increased 1600 percent. In late 1985 he was appointed Manager of Engineering Computer Services, and in that capacity he is now responsible for the Engineering Computer Center and VLSI Design Center, as well as office automation systems for the Microelectronics Center and Solid State Engineering. Contact him at:

**Microelectronics Center  
Somerville, N.J.  
Tacnet: 325-6425  
DECmail: JUDICE @SMDCDM/SMDC::LJJ**

## Electronic mail links most RCA engineers . . . Why aren't you using it?

One of the least known benefits of tying together most of RCA's VAX and IBM computers is the ability of virtually any user to exchange electronic messages with another. One stumbling block is the existence of several electronic mail programs and some slightly obscure rules for addressing mail to remote sites. The current status of networked electronic mail systems is as follows:

Somerville (Solid State Division, Microelectronics Center)—DECmail, VMSmail, HPmail, ISMEF

Princeton (RCA Laboratories)—DECmail, VMSmail, ISMEF

Cherry Hill (Corporate Information Systems and Services)—PROFS, ISMEF

Moorestown (Advanced Technology Labs)—VMSmail

Cherry Hill (A&D Staff)—VMSmail

East Windsor (Astro-Electronics)—VMSmail

Essentially, all systems with DECmail can talk to other systems with DECmail, and all systems with VMSmail can talk to other systems with VMSmail. ISMEF is a special communications system developed by Information Systems Planning in Princeton Labs. It translates one mail protocol to another mail protocol, thus allowing a PROFS user at 30 Rockefeller Plaza to send mail to a DECmail user in Somerville.

Almost anyone in the above sites with access to VAX or CMS can send mail to almost anyone else in the same or another site. Of course, you should contact your local VAX systems administrator or MIS department for additional information on using the systems at your site.

Here's an example of an electronic message that starts in Somerville, and will be read by Wilson in Somerville, Roosevelt in Princeton, Cleveland in New York, and Churchill in Brussels:

**Command** > CREATE (This is the DECmail command to "create" a memo)

**To:** WILSON (Wilson is in Somerville)

**To:**

**Cc:** ROOSEVELT @COPSDM (Roosevelt is in Princeton,

and @COPSDM is the address of the DECmail VAX in Princeton)

**Cc:** MAILMAN (MAILMAN is the local mailbox for the ISMEF message switch)

**Cc:** CHURCHILL @MRGATE@RCABRU (Churchill is on VMSmail, which requires routing through the VAX's Message Gateway)

**Cc:**

**Topic:** SOS Device Characteristics Proposal

**Enter Message Text**

@PROFSCH:GCLEVELAND (This is the PROFS address that ISMEF will use to route from DEC to IBM)

Type in your message text . . .

**Command** > SEND

This may look very complex. How on earth does one remember so many names and addresses? Well, Engineering Computer Services in Somerville has published an Electronic Mail Directory, with assistance from Corporate Information Systems and Services and Princeton Information Systems. Although we print the directory, we can also provide a VAX/VMS command procedure that searches through the directory online. VAX groups interested in contributing to the directory should contact me at Tacnet: 325-6425 for further information, or better yet, send me mail at SMDC::LJJ on VMSmail, JUDICE @SMDCDM on DECmail, or @SMDC:JUDICE through ISMEF.

Of course, another excellent use of electronic messaging is transmitting your *RCA Engineer* manuscript to your Editorial Representative or to the *RCA Engineer* staff in Princeton. For example, this article was mailed electronically to:

Somerville: Sue Suchy (SUCHY @SMDCDM or SMDC::SPS)

and

*RCA Engineer* Staff: Tom King (COPS::TEK)

A final note: my electronic mail address is shown after my biography at the end of this article. It is typeset in the form that we are suggesting that people at Somerville use on business cards, in articles, on memos, etc.

the process of acquiring a 36-inch color Versatec plotter.

### Office automation

In 1984, our organization was given the responsibility of developing a comprehensive office automation system for the Microelectronics Center and Solid State Engineering. The philosophy of our approach to office automation is to make maximum use of the synergy that will exist between engineering, manufacturing, management, and administration using one computing environment. Therefore, we chose to center our

office systems around the VAXcluster, choosing specialized workstations for users with very specialized needs. To integrate communications we installed DECmail, a comprehensive electronic mail and filing system. We wrote a frontend menu system, called Integrated Office Services, to allow novice and casual users to log in and select from DECmail, DECalc spreadsheets, DECgraph graphics, bulletin boards, corporate mail directories, and other functions. During the past six months, we have solidified our system by installing links to Princeton's ISMEF electronic mail exchange and direct DECnet

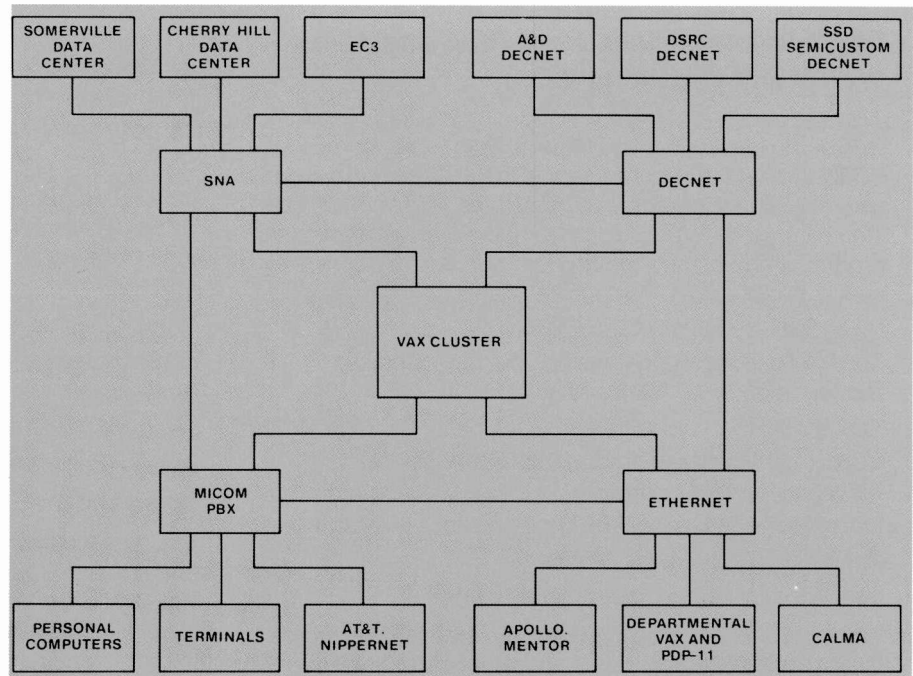
links to the Princeton "LINX" DECmail system. These allow users in Somerville to communicate with users of Princeton DECmail, as well as users of the corporate PROFS office automation package on IBM. We are working with Princeton and Somerville MIS to extend the network to include the SSD HP-3000-based manufacturing systems.

In terms of workstation choices, we have taken a very conservative approach. For most users, inexpensive DEC VT220-type terminals provide adequate access to text and data processing applications. Text-intensive users, such as secretaries, are served with either

modems on the Micom to allow users to access our systems from home terminals or personal computers.

A major design goal of our terminal network was to let any user access any computer resource in Somerville from *one* desktop workstation. Amazingly, until the introduction of the Micom, there were offices that contained two or more terminals for accessing different services. Though VAX and HP computers were easily supported on the Micom, special-purpose emulators were required for IBM access. We employ a Local Data Datalynx 3274 protocol emulator, which allows DEC terminals to enter the RCA SNA network and access Somerville and Cherry Hill IBM computers as if they were IBM 3278 terminals. We have also provided autodial modems on the Micom to allow a user at his or her office terminal to easily connect to outside databases such as Dow Jones News Retrieval or the Source. The Micom also supports a network of about 20 local printers, including laser printers and letter-quality impact printers, which are scattered throughout the Somerville facility.

Though the Micom provides an excellent medium for terminal communications, we support many other local- and wide-area networks. Engineering Computer Services is a part of the Aerospace and Defense DECnet network, linking VAX systems in Moorestown, Burlington, Camden, Cherry Hill, East Windsor, and Somerville to each other, and to the CISS Engineering Computer Facility (EC<sup>3</sup>). Somerville and RCA Laboratories established DECnet communications in late 1985 to support electronic mail file transfer and remote terminal access. We are also networked to the SSD Semicustom DECnet, which links Somerville to the Brussels and Santa Clara design centers. Closer to home, DECnet, over Ethernet, connects the Engineering Computer Center to departmental VAX and PDP-11 computers within the Somerville Plant. All groups with DEC hardware are being encouraged to join the network to take advantage of the VAXcluster's immensely greater computing and storage capabilities, and to help integrate various types of design, test, and manufacturing databases. The same Ethernet that allows DEC computers to talk to each other also allows DEC and Mentor engineering workstations to communicate, allowing remote terminal emula-



At the center of the ECS network is the VAXcluster. The Micom, DECnet, Ethernet and SNA each play a role in the overall communications architecture.

tion and file transfer. This has been accomplished by providing special UNIX-to-VAX/VMS communications emulation software on the VAX and Apollo systems.

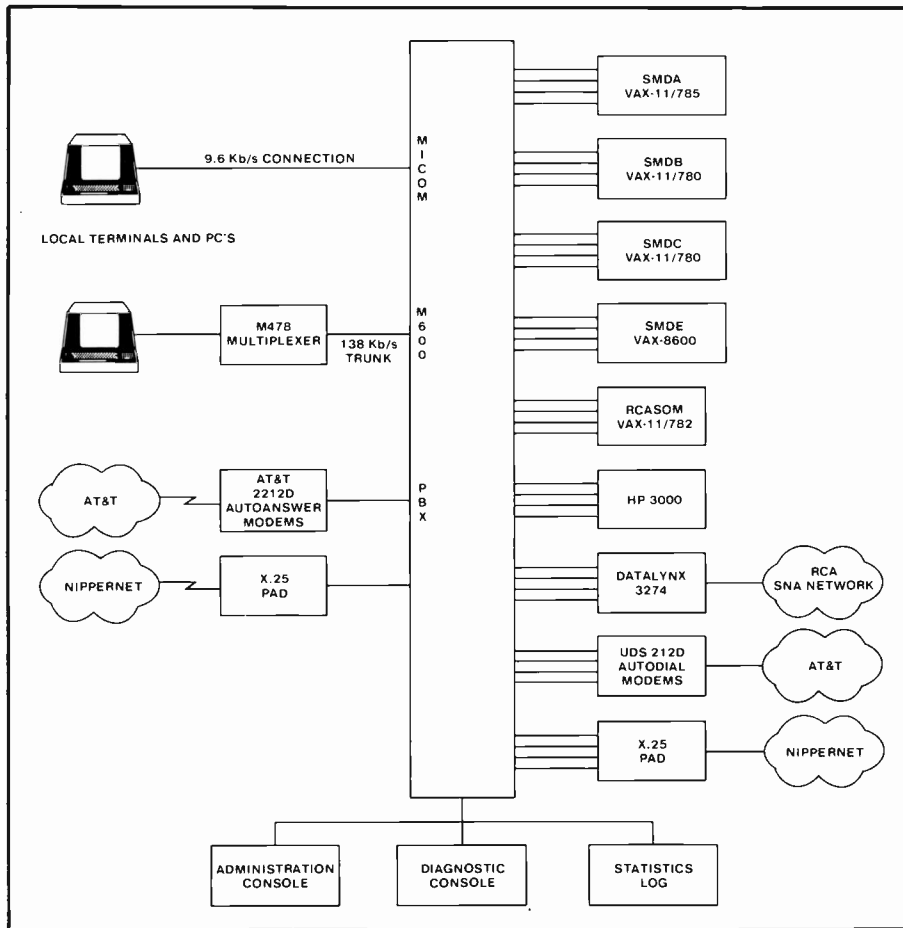
Although the majority of engineering computation is VAX-based, it is important to maintain tight communications with the Corporate mainframe computers in Somerville and Cherry Hill, since there are certain classes of problems that lend themselves well to solution on IBM mainframe hardware. We are implementing a DEC SNA gateway on the Somerville Ethernet to link our systems to IBM. This network will replace an aging and unreliable remote job entry (RJE) system based upon outdated 3780 protocols. The SNA gateway will also allow new functionality, including the ability to route IBM printouts to the VAX lineprinters, maintain multiple VAX-IBM connections, and permit more flexible file transfers. The SNA gateway will operate at 56 kbps, as opposed to 9.6 kbps for the existing RJE link.

### VLSI Design Center

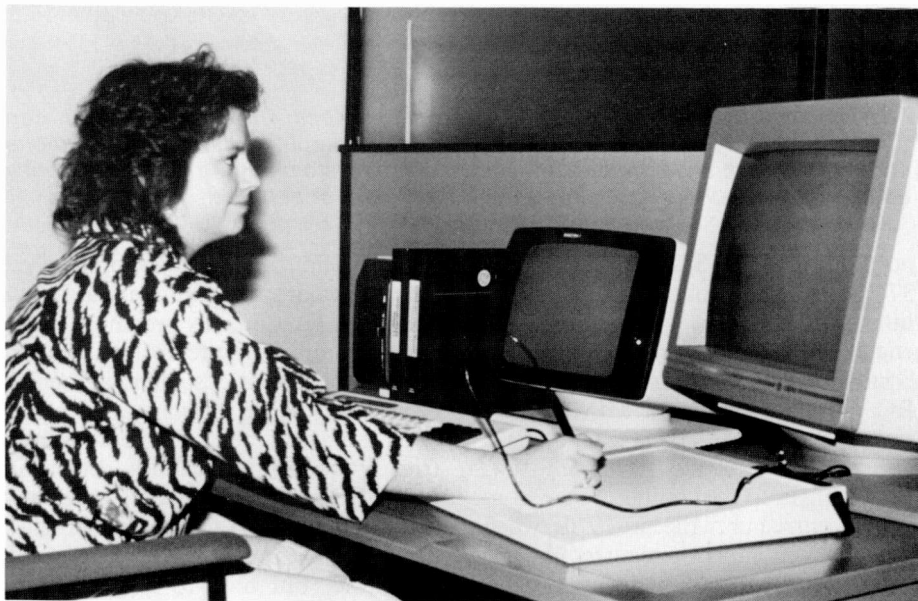
Of principle importance to the Somerville community is access to sophisticated computer graphics systems that allow custom integrated circuits to be laid out and edited in the quickest and most productive manner possible. The

VLSI Design Center, located in the Microelectronics Center, has been fulfilling this function for four years. Originally formed from the merger of SSD and MEC design centers, the facility today consists of both workstation and shared-logic graphics systems. Five Calma GDS-II/32 and two Mentor Graphics workstations are employed, along with three Calma shared-logic systems and one Applicon shared-logic system. In addition, a Calma S/280 minicomputer provides background processing capabilities for the Calma workstations. Over the next two years we expect to replace the remaining shared-logic terminals with either Calma or Mentor workstations. An interesting benefit of our new workstation equipment is the ability to network into the VAXcluster. Both Calma and Mentor users can now transfer files to and from the VAX systems, thus eliminating the tedious and very error-prone task of writing and reading magnetic tapes.

The VLSI Design Center also supports several specialized pieces of equipment. The Calma Fast Mask Engine is a dedicated CPU that is optimized to execute design-rule verification algorithms. It is networked to the Calma workstations to allow high-speed local verification of circuit designs. Three black-and-white Versatec plotters, including two 72-inch units, provide high-resolution plots of circuit designs. We are also in



The Micom M600/2 Data PBX is the central switching system for terminals in the ECS communications network. Over 300 terminals are connected to the Micom—every office cubicle in some 90 percent of our service area is provided with at least one terminal.



Calma GDS-II/32 VLSI design workstations provide a significant improvement in layout designer productivity since they are based around dedicated 32-bit supermicrocomputer technology. Each station is connected to Ethernet, allowing design files to be transferred to the VAXcluster.

neering Computer Services was formed to manage what had grown to become a four-node VAXcluster consisting of two VAX-11/780s, one VAX-11/785 and one VAX-8600. These four systems share a pool of 52 megabytes of main memory and over eight billion bytes of disk storage. An important feature of VAXcluster is the ability of each processing node to share disks, common batch queues, and print spools. This lets users view the cluster as one giant computer complex. Since each machine operates in an independent (but cooperative) manner, there is built-in redundancy. In nearly two years of VAXcluster operation, we have experienced complete clusterwide failures only a handful of times. Our overall uptime consistently averages over 99 percent month after month. The VAXcluster supports over 500 subscribers—mostly based in Somerville, though many Princeton, Moorestown, and Mountaintop users also access our systems. Somerville's VAXcluster is the largest such installation in RCA, and supports one of the largest user communities of any divisional computer center in the corporation.

### Networking

To support this user population, a Micom M600 Data PBX is used to switch some 350 terminals and telephone lines between the VAXs, as well as to provide access to Somerville's HP and IBM computers. We selected the Micom approach to terminal access over other approaches, such as Ethernet, due to its very low cost per connection, open architecture, and maintainability. In some two years of service, our Micom switch has displayed 100-percent reliability, an impressive statistic. Most office areas are connected to the Micom switch by time-division multiplexed trunk lines operating at 138 kbps over twisted-pair cabling. The vast majority of our terminal population consists of DEC VT220, VT240, and VT102 video display terminals. A growing population of IBM personal computers, including XT and AT models, are supported as VT100 look-alikes. A number of Wang and HP personal computers, as well as DECmate II and III word processors, are also connected to our terminal network. We have provided a large number of the latest AT&T 2212D autoanswer

## Engineering Computer Services keeps Somerville online

*Integration is the key to building an information system that serves engineering, manufacturing, and administrative users.*

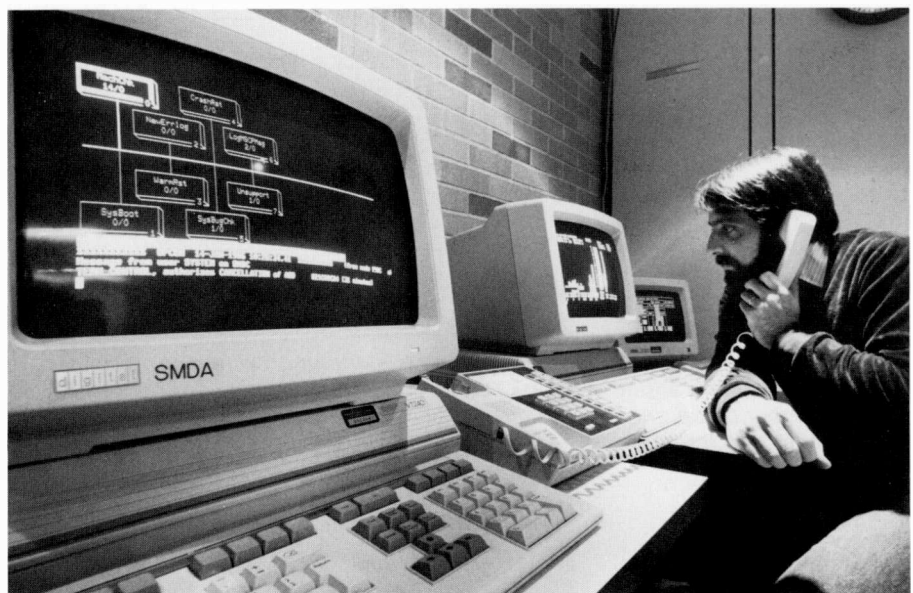
Somerville's Engineering Computer Center has its roots in a 1972 Digital Equipment Corporation (DEC) PDP-11/20 minicomputer. Purchased by the Design Automation department, the PDP-11 was a great step forward from the PDP-8 computers then in use. The system was used for the initial development of the ART program, the production software system still used to convert mask artwork into numerical control tapes for optical and electron-beam pattern generation equipment. ART grew and grew, and was eventually trans-

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**Abstract:** *RCA's Somerville plant is the home of the Solid State Division and the Aerospace and Defense Group's Microelectronics Center. Somerville is the focal point of RCA's LSI technology and integrated circuit product development. Providing information services to this diverse community is the responsibility of the Engineering Computer Services (ECS) organization. ECS is a part of the Computer and Design Services function of the RCA Microelectronics Center. Its responsibilities include the operation of Somerville's Engineering Computer Center, the VLSI Design Center and office automation systems for the Microelectronics Center and SSD Engineering. This article is a brief look at Engineering Computer Services and the ways we serve our user community.*

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*Technicians in the Engineering Computer Services Operations Center can pinpoint and correct problems anywhere in the computer and communications complex. A sophisticated telephone and paging system can be used to instantly contact other staff members anywhere in the plant or at home.*

ported to the Solid State Division's IBM 370/168 mainframe. Many other internally developed computer-aided engineering tools were developed in Somerville over the years, including the RCAP circuit simulator, MIMIC logic simulator, and the AUTOROM ROM pattern generator, just to name a few. Few changes to the computing environment occurred until the late 1970s, when a new phenomenon occurred in the computing industry—the super mini-computer—epitomized by machines such as the DEC VAX-11/780 and the Prime 750. The Design Automation department purchased a VAX-11/780 in

1981 to help speed the development of new automated layout software systems. The VAX quickly became the preferred computer system for software developers, layout designers, and engineers, due to wide software availability, good response time, and numerous user friendly tools and utilities. Most of RCA's IBM-based CAD tools were converted to run on VAX in the early 1980s. Concurrently, the phase-out of several venerable, but hard-to-support programs such as CRITIC and SMART occurred during this period.

By 1985, the majority of engineering computation was VAX-based. Engi-



ties installed. The actual programs reside on the network system volumes and look for this "key diskette" in drive "A" when loaded. Other packages, like *WordPerfect*, are available with network licenses and no awkward copy-protection schemes.

The standard issue of software includes *WordPerfect* (wordprocessor), *Lotus 1-2-3* (integrated spreadsheet), and *PC-VT*. Additional software packages being used are *Harvard Total Project Manager* and *Timeline* (project management), *dBase III* (relational database), and *Dr. Halo II* (high resolution graphics). At this time, pointing devices such as a mouse, light pen, or graphics tablet that might further enhance the PC graphics capability are being evaluated.

All PC users have received formal training via three separate courses: Introduction to PC-DOS and the ATL/LAN; *Lotus 1-2-3*; and *WordPerfect*.

### Plans for the future

A new version of the PC-DOS mail software that will allow the interchange of mail messages between VAX/VMS and PC-DOS is expected to be released in 1986 from Syntax Systems. This capability will allow us to further integrate the two environments and offload additional VAX processing to the PCs. Additional mechanisms to integrate the VAX/PC installations will be investigated.

The new version (2.0) of *Lotus 1-2-3* will be installed as soon as it arrives. Some of the new features are file level password protection, linear regression analysis, an increased size of 8192 rows by 256 columns, 8087 math co-processor support, and improved memory management.

The latest release of *WordPerfect* (4.1) will also be installed on the network. A few of its new features are a built-in thesaurus, split-screen editing of multiple files, newspaper (snaking) columns side by side on the screen, memory caching, and cutting and pasting of rectangular blocks of text.



Authors, left to right: Rosenthal, Peters, and Abrams.

**Gary Abrams** has been a computer systems analyst at ATL since March 1985. His first achievement was the creation of ATL's comprehensive PC network. Currently, he is responsible for all phases of the operation and enhancement of this network. His other efforts involve ATL's VAXs and parallel Ethernets.

Before coming to ATL, Mr. Abrams was in charge of all PC hardware and software support at MicroAge. During this time, he became certified to service and support innumerable kinds of PCs: IBM, ATT, Compaq, and Altos, for example. Earlier, at UNIVAC, he was responsible for the repair of minicomputer systems. Contact him at:

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Moorestown, N.J.  
Tacnet: 253-6676**

**Jack Peters** is Manager of Computer Operations and Administration in ATL's Software Engineering Laboratory. The computer center he manages contains a cluster of VAX computers. This center services over 300 user accounts. Currently, he is in charge of a system of networks connecting all nonsecure computers in ATL. This networking extends, also, to other divisions of Aerospace and Defense and an IBM 3083 mainframe. His

experience includes systems and software programming, operations research, and numerical control programming. Mr. Peters studied Computer Science at Carnegie-Mellon University.

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### **Xerox disk server**

A Xerox disk server was also considered. In addition to a disk server, an interface board (with software) was needed for each PC. The server would provide moderate performance via Ethernet connection, scheduled backup, some file security, and limited shared resources. Among the disadvantages were high initial and incremental costs. Additionally, non-IBM personal computers would not be supported, the disk server required operator attention, and very little commercial software was supported.

### **Corvus Omninet**

Corvus Omninet was another candidate. A stand-alone disk server, interface board (with software) for each PC, and twisted-pair cabling was required. This network supported both IBM and DEC PCs, had moderate initial and incremental costs, and an electronic mail utility was available. However, at 1 Mbs the transfer rate was relatively slow, the total distance of the network was only 1000 feet, and no scheduled backup was available. Furthermore, no bridge or gateway to the VAXcluster via Ethernet was available.

### **3Com 3Server**

The 3Com stand-alone 3Server was evaluated. When used with the 3Com Etherlink board and software, it provided each PC with a virtual hard disk. The Etherlink board supported direct Ethernet connection via a DEC DELNI or transceiver, or through PC-to-PC chaining with Thin Ethernet cable. Either way, the transfer rate of 10 Mbs provided high throughput. A streaming-tape backup unit, permitting scheduled backups, was available. 3Com's 3Server provided good file security, required little end-user retraining, and posed few software compatibility issues. However, the cost/Mbyte was comparatively high, and no bridge or gateway to the VAXcluster was available. Maintenance and lack of failover protection (explained below) also caused a concern. The server, along with operating software, only supported 60 users; after that, another server would have to be added. Only IBM PCs and compatibles were supported by the Etherlink product, and an additional

board had to be installed in the 3Server to provide a bridge to the AppleTalk Network.

### **Syntax VAX Interface Manager (VIM)**

The last alternative, VAX Interface Manager (*VIM*) from Syntax Systems, used in conjunction with the 3Com products, was the design of choice. *VIM* was found to be a software product that runs as four detached processes under VAX/VMS. To a PC connected to the network using 3Com's Etherlink product, the VAXcluster emulates a large 3Server. The initial cost is low, and up to 200 users can be supported. Virtual disk capability is provided, as well as shared access to two printer queues. A mail utility is included, although the IBM PC-DOS mail software from 3Com is needed to use it. A number of utilities to facilitate file transfers between VMS and DOS are included, but require VMS privileges to use. If the VAX that the software is running on goes down, the software can be started on another VAX in the cluster, thus providing failover protection. Backup is provided through normally scheduled VAX/VMS backups. An extra software package, called Remote File Manager, allows file transfers between DOS and VAX/VMS to be initiated from the PC. To connect the Apple Macintosh computers to the rest of the network, a 3Server, with an AppleTalk interface board in it, is used as a bridge between the *VIM* software on the VAX and AppleTalk.

### **Current network**

The current PC network allows PC users to share VAX disk and printer resources. System volumes containing various utilities and application programs can be linked to by any user on the network. Each non-secretarial PC has its own local dot-matrix printer and a link to a letter-quality printer through the network. A small laser printer is included as part of the standard PC secretarial system. Acting as local print servers in addition to being workstations, these systems allow localization of high-quality printing resources for each laboratory.

Each PC has two connections—one network connection and one asynchronous serial line for terminal emulation to the VAXcluster. All Ethernet connections are made through standard trans-

ceiver cables from either DELNIs or transceivers. No Thin Ethernet cable is used because it greatly limits the overall distance of the network and requires the use of repeaters.

Each user has a five- or ten-megabyte data volume on the VAXcluster server, depending on needs. This volume is the user's own private area, and cannot be accessed by another user unless the owner allows it. There are two system volumes that support PC-DOS 3.1 for the IBMs, and MS-DOS 2.11 for the DEC Rainbows. Other than having different versions of DOS utilities on them, these system volumes contain basically the same application programs wherever possible. The system volumes are read-only so users cannot alter the installation parameters of the individual packages once they have been established.

The 3Com 3Server not only bridges the gap between the Apple Macintoshes and the rest of the network, it provides secure storage for a management database. Although *VIM* stores the DOS files in a translated manner (from a VMS standpoint), additional security was desired. Users who need an extra layer of security for their data store it on the 3Server, which is kept inside a limited-access computer center. At the end of each day the 3Server is backed up and powered down, making the data stored on it inaccessible.

The mail utility allows users to send messages as well as binary files. When a user receives a message with an attached binary file, both can be stored for later use with another application. This feature is especially useful for spreadsheet files that must be updated periodically by various people, or for the production of large documents by combining a number of smaller documents that have been mailed from different sources.

A site license was obtained for a DEC VT100 emulation package (PCVT). It allows the IBM and compatible PCs to communicate with the VAXcluster through an asynchronous serial connection. Some software, such as 1-2-3 from Lotus Development Corporation, is not available with a network license, but employs a copy-protection scheme that requires a "key diskette" to run. This difficulty has been overcome without violating the license agreement by erasing (not formatting) the files on the diskette and making it a DOS system diskette with network drivers and utili-

## Expansion of the RCA Engineering Network by means of PCs

*ATL's personal computer local area network is designed to take maximum advantage of, integrate with, and build upon the existing ATL VAXcluster and RCA Engineering Network.*

Enhancement of the data handling and processing capabilities for personnel in the Advanced Technology Laboratories (ATL) required the addition of computer processing power for management, support and technical engineering use. Additional power was obtained via establishment of a personal computer (PC) local area network (LAN).

The resultant implementation allows PCs to network directly and to integrate with the ATL local VAXcluster, comprised of a combination of VAX 8600/780/750 equipment running VAX/VMS. In addition, a variety of other computers are connected to the VAXcluster. As the hub of the RCA Engineering Network, the VAXcluster interfaces with over 40 VAXs and the ATL-resident IBM 3083-J of the Engineering Corporate Computer Center.

The ATL network of IBM, Macintosh, and Rainbow PCs provides both shared hardware and software

resources. System-wide backup is easily provided. The PC network performs high-speed (10 Mbs) data transfers via extensions to an existing ATL Ethernet. In addition, a separate management database is provided by an independent server whose files cannot be accessed by unauthorized users.

The system will be discussed from the standpoint of design requirements, alternatives investigated, and utility.

### Requirements

The goal was to take maximum advantage of, integrate with, and build upon the existing ATL VAXcluster and RCA Engineering Network. Asynchronous transmission of ASCII and binary files was one requirement—others included support of IBM, Apple Macintosh, and DEC PCs; ease of use; high speed/performance; scheduled backup; transparent operation; reliability; versatility; data security; expandability; minimal incremental costs of adding users and increasing disk storage; PC-to-PC direct transmission and electronic mail; shared resources such as high-quality printers and large-capacity disk drives; the ability to move applications from the VAXcluster to the PCs in order to free VAX resources for large jobs; and easy maintenance. Additionally, management wanted to avoid completely rewiring the building since two Ethernet coaxial cables were already in place.

A formal study was done to determine the level of functionality that the

general ATL userbase expected from a PC. After the results were tallied, standard PC configurations were defined. The base system consisted of a dual-drive IBM-PC XT with a 12-inch (diagonal) amber display, a 3Com Etherlink board, a Tseng Laboratories multifunction graphics board providing 720×348-pixel resolution, a real-time clock with battery backup, RAM expansion up to 640 kbytes, a parallel printer port, and an asynchronous serial port. Okidata Microline 193 printers were chosen for local non-secretarial output. Their characteristics include a draft-mode print speed of 160 characters per second and compatibility with standard IBM PC graphics. The selected DEC Rainbows have 256 kbytes of RAM, an amber display, and a DEC LA100 printer. The Apple Macintoshes have 512 kbytes of RAM, an external disk drive, and a numeric keypad.

### Alternatives investigated

#### "Walk-LAN"

The first design alternative investigated was "Walk-LAN" (i.e., non-networked PCs). Although this would be very flexible in terms of relocation of equipment and low initial cost, it provided no shared resources, scheduled backups, VAXcluster integration, or PC-to-PC mail utility. In addition, having to "walk" floppies throughout ATL was considered too time consuming and, therefore, not very cost-effective or efficient.

---

**Abstract:** *Enhancement of the data handling and processing capabilities for management, support, and engineering personnel at the Advanced Technology Laboratories (ATL) required the addition of specialized computer processing power. This was achieved through the establishment of a personal computer network integrated with the ATL VAXcluster.*

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**in this issue . . .**

**PCs & engineering workstations**

■ **Abrams/Peters/Rosenthal:** "The ATL network of IBM, Macintosh, and Rainbow personal computers provides both shared hardware and software resources."

■ **Judice:** "Somerville's VAXcluster is the largest such installation in RCA, and supports one of the largest user communities of any divisional computer center in the corporation."

■ **Stern/Voto:** "In a unique engineering application, an IBM PC is used in conjunction with an internal combustion engine test set (STE-ICE) for field data collection and development."

■ **Butt/Miller/Hoke/Piazza:** "We have developed an applications program that allows our designers to enter their parts list information into a text file while they are working on their drawing."

■ **Marett:** "Most of the commands of PERSONAL870 are the same as those used by the Applicon software."

■ **Solomon:** "Our experience has shown that reliability predictions can be done using Monte Carlo simulations instead of analytical solutions."

■ **Kunz/Miller/Renfro:** "This integrated approach allowed us to build a system that is reliable, has fast response times, supports a large number of users, and is easily taught to new users."

■ **Law/Bernard:** "Note that once an actual feature algorithm has been identified, without the functional simulation capability, the building of these features on breadboards would have been required."

■ **Lazarus/Kelley:** "Repeated attempts to stretch PC-based systems to plan multiple large projects were only partially successful."

■ **Kjellquist:** "With a superbly engineered man-machine interface and a singular focus on a weighted-criteria analysis, Lightyear is a unique engineering tool."

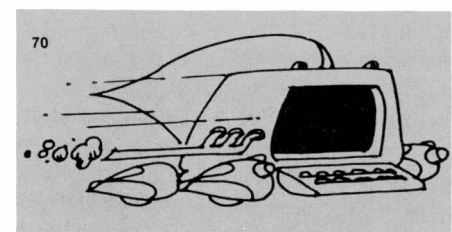
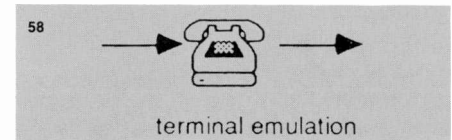
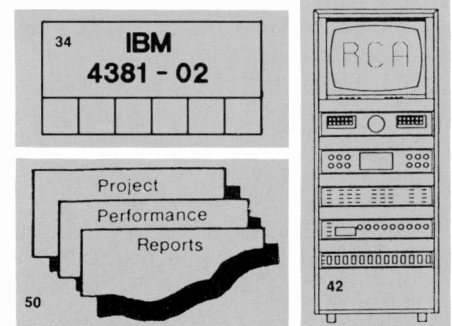
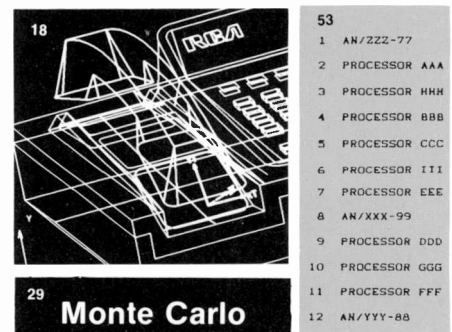
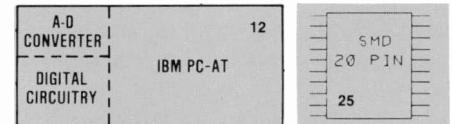
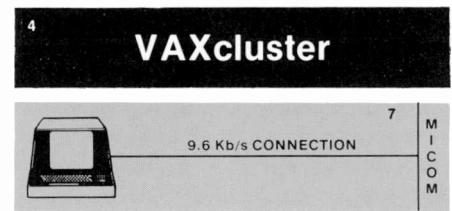
■ **Barton:** "For some time we have been recommending the Macintosh as a low-end graphics terminal."

■ **Zarodnansky:** "... just because there are some fancier machines around doesn't mean that you should relegate your PC to the scrap heap yet."

■ **Stranix:** "Software . . . is an intellectual property that has value beyond its direct utility to RCA."

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## Personal computing workstations in engineering

Lower cost and increased functionality have made PCs and Workstations (PCWs) the ubiquitous sliderule of the decade. PCWs have greatly changed the engineering environment. A continuum of computing power is now available—from PCWs through micro and minicomputers to mainframes and supercomputers. The distinctions among computing machines are becoming increasingly blurred.

What are the opportunities and problems arising from this technical cornucopia? First, it is clear that significant administrative and technical tasks will be done on PCWs. Strong productivity gains are already documented. The market is brimming with useful tools aimed at the engineer/manager, and these will increase in power. Second, as change accelerates, the need to integrate the work product of individuals with the broader purpose of organizational groups will place a high premium on sharing and cooperation. More engineers will work across multiple computer systems to solve their technical and administrative problems. Better tools merely let us solve bigger problems.

Many business units have invested in PCWs, but mostly on an *ad hoc* basis with limited access. Too often, progress is driven by departmental technical activists without senior management involvement. Several Divisions have already achieved significant results from the coordinated use of PCWs on a near-saturation basis and are at the beginning stages of broader system integration.

What do we need? Helter-skelter individualism must yield to shared approaches that are driven from large, sophisticated computer systems, strong in integration and communications, and from a variety

of PCWs and stand-alone, dedicated machines. Unfortunately, today's technology cannot combine all approaches into a seamless whole; the crunch comes at the interfaces between dissimilar systems.

The technical community requires a communal vision or purpose: an evolving "single technical computing system"—not one vendor or one way, but rather an overall view of how best to assemble and mesh smaller discrete systems into a larger, cooperative whole. This is a bold step, truly beyond a comprehensive solution today, but a requirement for our future business.

There are several principles that can be followed incrementally: a guiding architectural view, integrated telecommunications, gentle but firm system standards, a cautious narrowing of the vendor base, and use of common systems for common tasks. The benefits of following these principles are enormous, but we must use care to do it right the first time. Tip-toeing into shared computing on a massive basis is like staging a ballet in a mine field.

Looking forward to our new relationship with General Electric Company, we can anticipate even more support for this vital area.



*James C. Miller*  
Director, Engineering Computing  
Corporate Information Systems and Services

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Color is often used in computer graphics to enhance the display of selected information, especially when the data set is complex or busy. These three examples are from the Kunz/Miller/Renfro article on page 34.

At the left is a 3-D wireframe model of a 26V COTY picture tube. At the bottom left is a complex CADAM isometric. At the bottom right is a false-color plot of a picture tube mask-frame assembly. The colors in this last photo represent z-axis displacements of the assembly resulting from a given thermal distribution.

