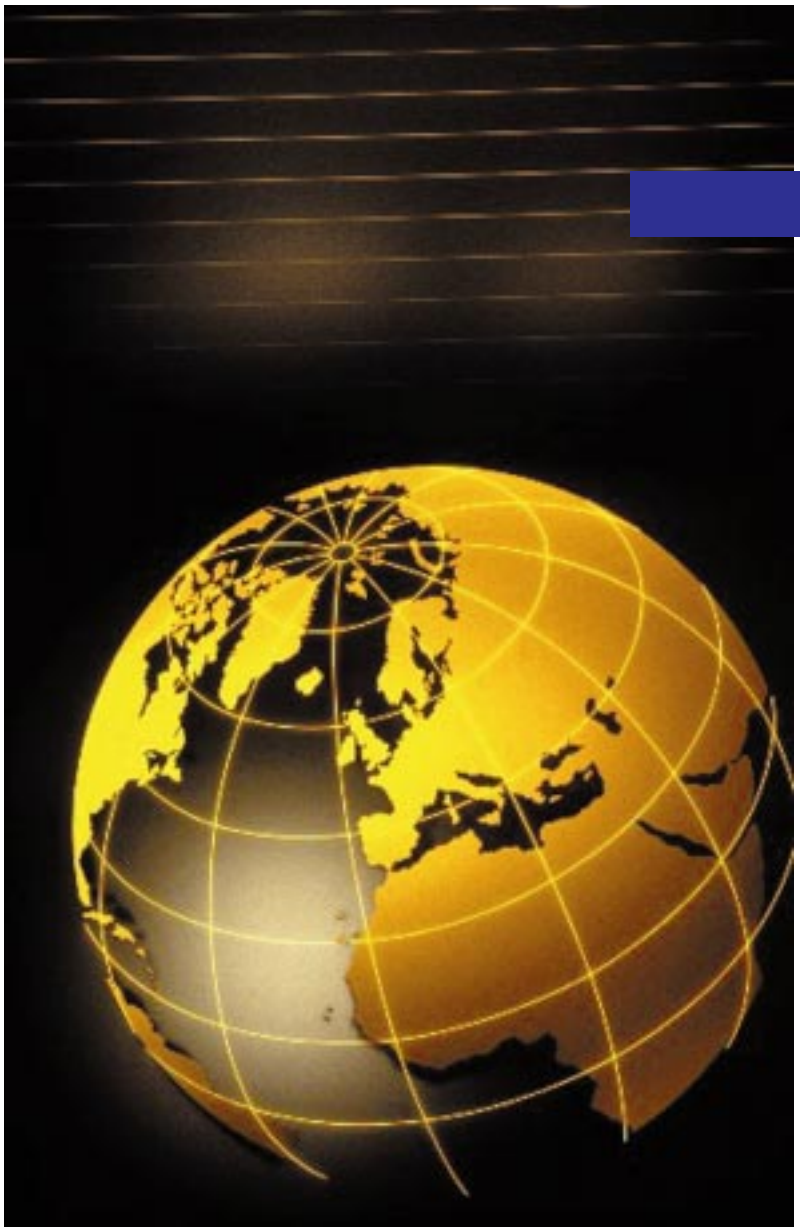


Content

DVR Consulting

Reengineering ... Reinventing ... Re structuring ... As we near the 21st Century, the driving force in today's volatile business climate is change. Information processing systems are the key to managing this change, and you need the right partner to help.

Founded in 1985, DVR has earned widespread recognition for our ability to integrate the most advanced object-oriented tools, knowledge navigation techniques and databases to provide our customers with client/server applications that are expanding the envelope of technology.

For more than a decade, we have been a leading provider of information management systems to clients nationwide. Through the strategic application of flexible, adaptable solutions, we've made quantum improvements in the way organizations do business. We're widely respected for our ability to manage large, complex projects that integrate advanced technologies with a broad spectrum of hardware, vendors and other resources.

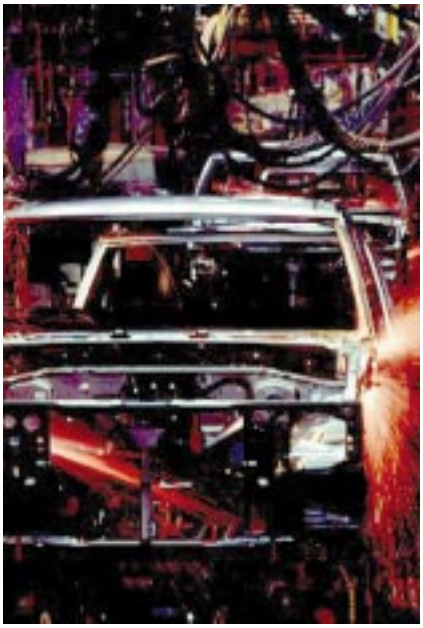
Over the years, our clients have found that while we can provide the expertise and resources of a large consulting firm, our emphasis is on responding to the special needs of each client. This client focus has made us keenly aware of the importance of developing partnerships with our clients. And it's why we make an up-front investment in getting to know your organization. We actively listen as you discuss your goals, expectations and priorities. Then, with a clear understanding of your current and future needs, we can help you develop successful data management solutions that are cost-effective, versatile and powerful.

At DVR, we are proud of our reputation for responsiveness, innovation and resourcefulness. Our clients have learned that when we make a commitment we keep it. And when we say we will find a solution, we do it.

We Solve Problems – Not Create New Ones

Time. In today's fiercely competitive business environment, project timeframes are being steadily compressed – a challenge we view as an opportunity to excel.

To produce a customized data management application in short period of time requires can-do attitude, rigorous attention to detail and the successful integration of cutting edge technologies. The purchase request system DVR developed for NASA Ames Research Center is an example of our ability to rapidly deliver real-world solutions. Before beginning the development process, we thoroughly studied the current system and actively listened as Ames staff members outlined their requirements and priorities. Then we developed a new customer client/server purchase request system that included sophisticated electronic editing, routing and tracking capabilities. Intensive user involvement during the development process allowed us to create a system which implemented smoothly and dramatically shortened the time it took get a purchase request though NASA's approval structure.



DVR

DVR: Continued

People working together more productively and more creatively ... that's the powerful advantage of building partnerships and the key to achieving superior quality.

Our Success Has Been Built On Out-Of-The-Box Thinking

At DVR, we believe that the true measure of any company can be found in the people who represent it. That's why we select our team members with great care. Then we provide them with the resources, training and guidance they need to meet our exacting quality standards. This means that at every phase of the systems development process, your project is in the hands highly motivated, creative problem-solvers.

Forecaster, a custom software application written by DVR links together LSI Logic's nationwide sales force. Running on Powerbook 170s, the software program collects realtime data from each sales person, sends it to the company's IBM IMS mainframe. The continually updated database is the basis for timely, accurate sales forcasts.

From the very beginning, our firm's emphasis has been on creating an organization that encourages innovative and personal initiative. Such an environment is an important reason why, in an industry where high employee turnover is the norm, we have been able to recruit and retain exceptionally skilled specialists.

Over the years, we have found that the smallest glitches – if not caught quickly – can cause problems that are expensive and time-consuming to fix. During the development process, our team members experienced and broad-based technical knowledge assures successful results of your project by "red-flagging" potential problems and helping you make informed decisions.

However, no matter how carefully you prepare, however, unforeseen problems can arise. At DVR, we believe that an inherent part of providing excellent service is the ability to successfully handle the unexpected. When areas of concern are detected, our development team has the experience necessary to respond with timely solutions to keep on schedule.

Experience ... Customer focus ... Advanced Technology

Our expertise with a broad spectrum of client/server tools and relational database products allow us to design and develop applications that can be quickly learned and easily used by employees with varying levels of computer proficiency

A case in point is the state-of-the-art quality control data collection system DVR recently developed for New United Motor Manufacturing, Inc. (NUMMI). This system was implemented using client/server technology with custom-written external procedures for special graphics handling and interfacing with a DEC VAX 750. Extensive use of graphical input methods using touch screens was designed into the system for ease of use by production line personnel.


MacWEEK

Performa, IIvx, IIvi to redefine Mac line

Developers head Apple's OCE call, give users a peek

Dockable Duo ready to join notebook cast

"What we can do with one screen on a Mac, you couldn't do with 15 3270s," said Don Von Rotz, president of DVR Consulting Inc. of Pleasanton, Calif.

"You're able to bring someone's client application up into the 1990s, but still that old 1970s and 1980s mainframe stuff remains intact – you don't impact the back end at all," Von Rotz said.

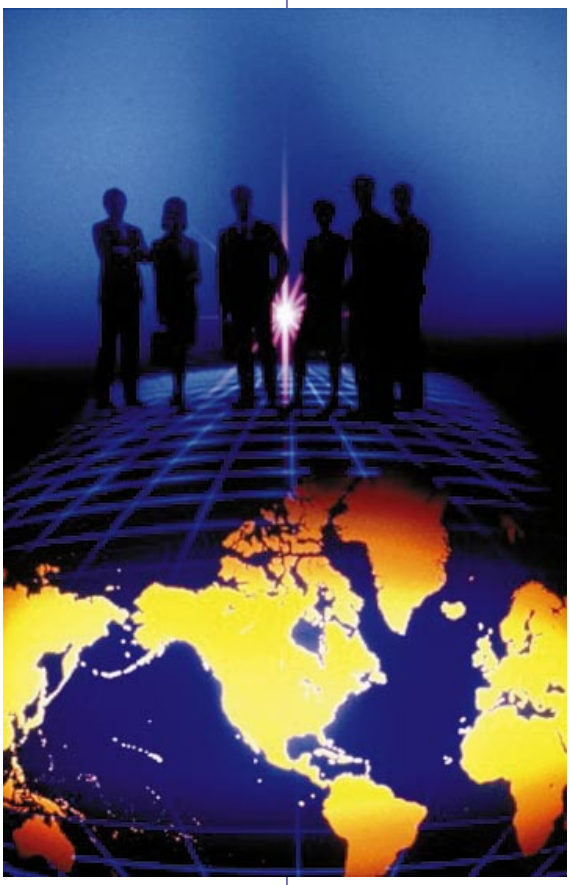
DVR

DVR: Continued

The system, which has proven to be highly reliable, runs in a high-transaction, multi-user environment which currently supports NUMMI's production line.

As one of the leading MIS solution providers, DVR staff members are frequently asked to demonstrate, at national and international conferences, how we solved data management problems for companies like Apple, LSI Logic, Bank of America, NUMMI and NASA.

Experience ... Customer focus ... Advanced technology. Together they serve as a solid foundation for an exciting new era of growth for DVR. We are committed to broadening our service spectrum so that we can offer the cutting edge solutions successful companies need to become more productive and more competitive. And we have gathered the people, the technology and the systems necessary to meet that commitment.



DVR: Continued

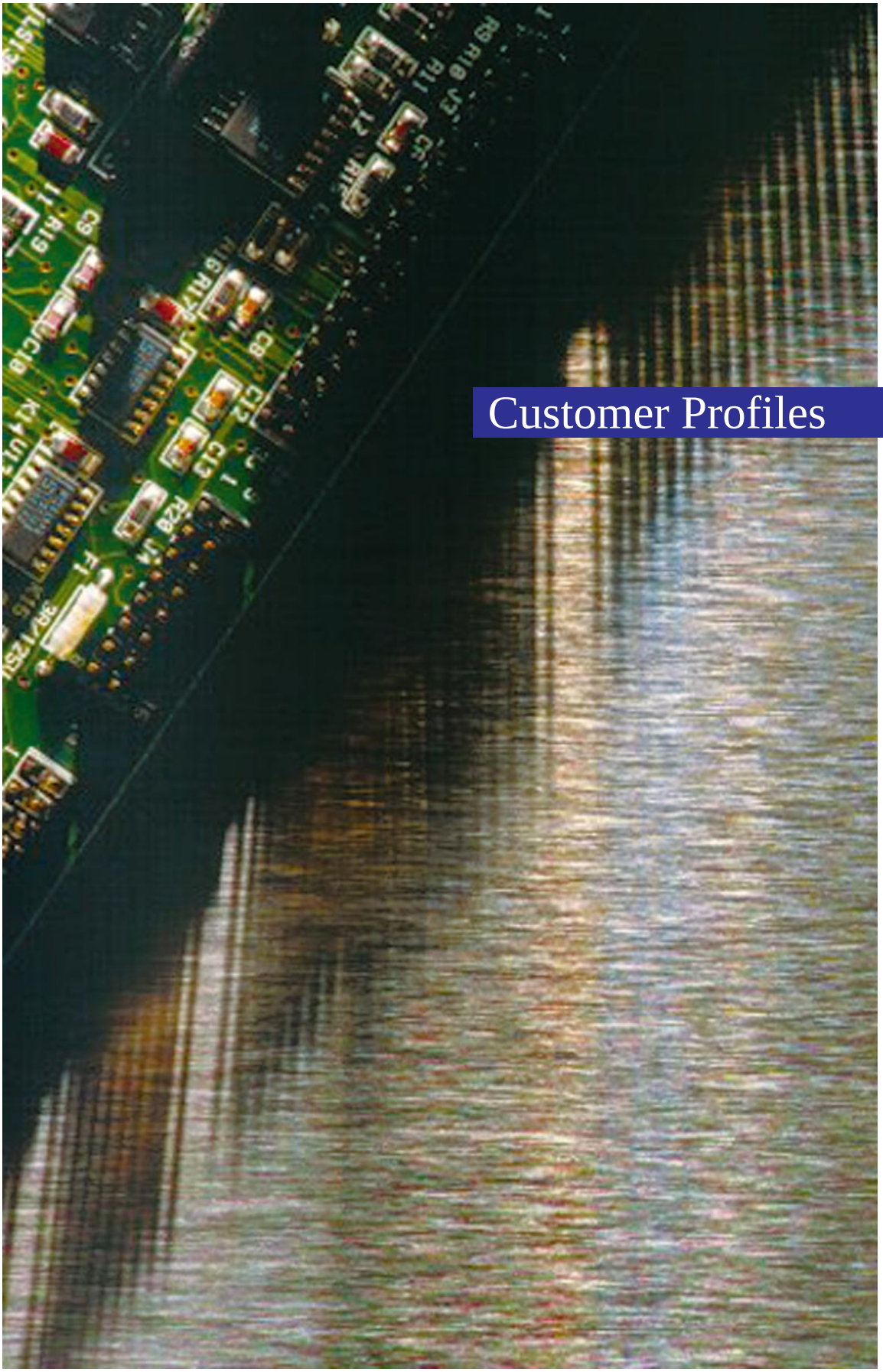
In addition to developing highly speciaized database management systems, DVR Consulting recently introduced Badger, a proprietary software product. This revolutionary new photo I.D. system is designed specifically for Macintosh and power Macintosh computers.

Badger is in every way superior to its competitors, offering customers:

- High quality images
- Lower cost
- Minimal training
- Ease of use
- Relational database support
- Integrated scanner support for signatures

Initial consumer testing of Badger has been extremely favorable. With interest in high-quality, easy to use photo I.D. system at an all time high, Badger appears to be the right product at the right time.

Nationwide marketing rollout of Badger, targeting companies with over 250 employees or members, educational institutions and government agencies, is scheduled for the second quarter of 1996.



Customer Profiles

Ames Research Center

The Ames Research Center, at Moffett Field, California, specializes in research geared toward creating new knowledge and new technology. Major activities occur across the spectrum of NASA interests. In information systems technologies research is performed in supercomputing, networking, numerical computing software, artificial intelligence, and human factors to enable bold advances in aeronautics and space.

In aeronautics, Ames is the NASA Center of Excellence in airspace operations systems, including air traffic control and human factors, and the lead center for rotorcraft technology. Ames also has major responsibilities in the creation of design and development process tools and in wind tunnel testing.

In space activities, Ames is the lead center for understanding the effects of gravity on living things, and plays a major role in understanding the origin, evolution and distribution of stars, planets and life in the universe. Mission to Planet Earth is supported by Ames' research in atmospheric and ecosystems science. Finally, Ames is the lead center in provid the thermal protectic systems that are criti for future access to space and planetary atmospheric entry vehicles.

Ames is home to more than ten major wind tunnels, including the world's largest; several advanced flight simulators; a variety of supercomputers, including some of the world's fastest; and several unique aircraft — both fixed-wing and rotorcraft — used for aeronautical flight research and as flying scientific laboratories. Ames also has a variety of facilities for life science and advanced life support research.

Ames was founded December 20, 1939 as an aircraft research laboratory by the National Advisory Committee on Aeronautics. In 1958, Ames became part of NASA along with other NACA installations and Department of Defense facilities. The facility is located in Northern California, in the heart of "Silicon Valley" at the southern end of San Francisco Bay. Ames occupies about 430 acres of land, and serves as host to a number of other federal, civilian, and military resident agencies on an adjoining 1,500-acre former naval air station.

About 1,600 civil servants and over 2,000 contractor personnel are employed at Ames. In addition, approximately 500 graduate students, cooperative education students, post-doctoral fellows, and university faculty members work at the Center.

Adecco SA

Founded in 1957, Swiss-based AdeccoSA is one of the world's largest suppliers of temporary and full-time personnel. Adecco's 1100 offices in 31 countries generated revenues of over CHF 2.8 billion in the nine months ending September 30, 1995. Additionally, Adia has 5100 full-time employees and employs nearly 700,000 temporaries yearly worldwide.

Services

Adecco is an international personnel service corporation, providing business solutions for companies at the local, regional, and global levels. Across cultures, time zones, and languages, Adecco delivers one consistent, reliable product - people. Wherever the need for quality services in temporary help, permanent placement, consulting, auditing, and outplacement, Adecco supplies the best employees available, selected and trained by local branch office managers who really understand their customers' needs.

To be a full-service human resources supplier, Adecco has invested in hardware and software automation that helps customers increase their productivity and keep track of staffing needs. In addition to offering the latest technology, Adecco also generates valuable management information, providing customized reports and analysis that assure quality results.

Adecco's approach now works for hundreds of companies in all business categories around the world. The difference is knowing how to manage thousands of employees with a global perspective, without losing an individual approach. From local businesses to multinationals, Adia has the people and means to meet changing human resource needs, while providing more control, better information, and higher performance.

Mainstream, Adecco's Global Network, provides staffing services to business, including placement of temporary and permanent employees in 30 countries worldwide.

Specialty Specialized services are offered under separate brand names to better serve clients, to recruit professional personnel within each category, and to maximize market penetration.

Accountants on Call (AOC), specializes in temporary and full-time placement of clerical accounting assistants and has 70 branches in the United States, Canada, the United Kingdom, and Australia.

Lee Hecht Harrison is an outplacement and career management firm firm with over 20 years of experience supporting organizations and employees through transitions. The firm has 51 branches in the United States, the United Kingdom, and continental Europe.

Ajilon (formerly Adecco Information Technologies) offers consultants in systems planning, enterprise and process modeling, testing and installation, operations configuration support, software and system maintenance for numerous industries. Ajilon has 28 branches in the United States.

Management

Klaus J. Jacobs, Chairman, Adecco S.A

John P. Bowmer, Chief Executive Officer, Adecco SA International

Peter Pfister, Chief Financial Officer, Adecco SA International Manfred Atzert, President, European Operations

George J. Gremse, President, Adecco Personnel Services

Jon Heaney, Zone Manager, Asia-Pacific

Headquarters Adecco SA Place Chauderon 4 CH-1003 Lausanne Switzerland

Bank of America

BankAmerica Corporation and its consolidated subsidiaries provide diverse financial products and services to individuals, businesses, government agencies, and financial institutions throughout the world. BankAmerica Corporation is the second-largest bank holding company in the United States.

BankAmerica's principal banking subsidiaries operate full-service branches in California, Washington, Texas, Arizona, Oregon, Nevada, New Mexico, Hawaii, Idaho and Alaska, as well as corporate banking and business credit offices in major U.S. cities, and branches, corporate offices, and representative offices in 36 countries.

Bank of America Illinois, created as a result of BankAmerica's 1994 acquisition of Continental Bank Corporation, provides a full range of financial services to business and private banking clients in the Midwest. large corporate clients are served through Bank of America's U.S. Corporate Group, which, since the acquisition of Continental, has been headquartered in Chicago.

Bank of America

Backed by $232.3 billion in total assets and 6,400 employees, Bank of America provides diverse financial products and services to individuals, businesses, government agencies, and other financial institutions throughout the world.

The $20 billion that Bank of America traders move on average daily is more than that traded per day on either the New York or Tokyo stock exchanges.

Bank of America processes 20 million checks in a typical day — more than any other single processor in the U.S. and exceeded only by the entire Federal Reserve System.

Bank of America's network of more than 5,500 ATMs is the largest proprietary ATM network in the U.S. Of those, 3,400 are in California. The bank handles more than 1.4 million transactions each day; 1 million in California. Through shared ATM networks, VERSATELLER cardholders can access local currency at more than 167,000 ATMs in 71 countries.

LSI Logic Corporation

It Takes Two To Make One Of A Kind

LSI Logic Corporation, The System on a Chip Company, is a world leader in the design, production and sale of advanced custom semiconductors.

The company reported 1994 revenues of $902 million ($101 million in net income) and revenues of $918 million ($166 million in net income) for the first three quarters of 1995.

LSI Logic, headquartered in Milpitas, California, has approximately 3,700 employees worldwide. The company operates manufacturing facilities in California and Japan, with a future complex under construction in Oregon.

Founded in 1981, LSI Logic helped create the application-specific integrated circuit (ASIC) business. For more than a decade, LSI Logic has been the world leader in ASICs, customized chips that are tailored to the specific application requirements of customers.

LSI Logic's traditional strengths have been:

- ASIC design methodology for Right-First-Time™ products;
- Libraries of preconstructed building blocks to expedite ASIC design;
- Leading-edge process technology and manufacturing facilities.

The tight coupling of software design tools and libraries with LSI Logic's manufacturing process enables it to offer high-performance chips and a rapid transition from design to volume production of custom ICs for makers of electronic systems from workstations to video cameras.

For more than five years, LSI Logic has been moving the custom microchip business to a new plane through the development of its CoreWare® design program. High-level, industry-standard building blocks that were previously independent chips, such as microprocessors, networking controllers or video compression engines, are used as "cores" that are connected together to form a whole system on a single chip.

The ability to quickly combine multiple cores and to simulate and validate the operation of a system on a chip, all in a matter of a few months, is what distinguishes LSI Logic from other semiconductor companies. No other competitor has as comprehensive a library of cores, such a rapid and reliable methodology for connecting them, and such a long, successful track record of system-on-a-chip products as LSI Logic.

Market Strategy

- Enable trendsetting customers to quickly secure leadership positions by working closely with them to develop system-on-a-chip products in record time.
- Focus on key markets, such as advanced digital consumer electronics, telecommunications and high-performance computing, that are rapidly changing, high-growth areas and in which LSI Logic can uniquely add value.
- Develop engineering expertise and IC building-blocks, or cores, appropriate for those markets.
- Utilize only those cores and technology in a system on a chip that are precisely tailored to the needs of a particular type of system or application — an approach that LSI Logic terms "application-optimized engineering".
- Increase system reliability and performance and decrease system costs by rapidly advancing process technology and integrating increasingly complex systems on a chip.
- Facilitate customer use of design tools of choice through alliances with third-party design tool vendors in which their best tools are tightly linked with LSI Logic's tools and manufacturing processes.
- Assist customers in maintaining leadership positions as markets evolve by providing cost-effective technologies, reusable cores (for quick transitions to new generations of products) and custom solutions (for differentiation).

Primary Capabilities

CoreWare® Design Program:LSI Logic's program for creating custom systems on a chip in record time by offering:

- The industry's most comprehensive collection of cores, or industry-standard instruction sets,

protocols or algorithms (e.g., MIPS microprocessors, Ethernet controllers, high-speed interconnect standards, MPEG decompression algorithms, and much more).

- The industry's most fully developed methodology for quickly connecting cores and verifying their performance together.
- Engineers skilled in system-on-a-chip design for particular markets.

ASIC Design Approach: a strategy that has produced an industry-leading 14,000 successful designs that includes:

- Precise design rules closely linked with efficient production facilities (fabs) to ensure fast turnaround of prototype parts that work the first time.
- The ability to couple third-party design tools with LSI Logic's tools and manufacturing processes to give customers the broadest selection of tools in the industry.
- Approximately 50 design centers and sales offices worldwide in which customers are supported by local LSI Logic engineers.

Leading-Edge Process Technology: a commitment to rapidly develop process technology to stay at the leading edge in the ASIC business (e.g., LSI Logic's industry-leading 0.25-micron G10™ technology that offers up to five million usable gates [49 million transistors] on a single IC), which makes systems on a chip a reality and enables customers to achieve the highest performance, greatest integration and lowest cost.

Volume Manufacturing Capabilities: sufficient state-of-the-art manufacturing capacity to meet customers' needs at LSI Logic's fabs in Tsukuba, Japan; Milpitas and Santa Clara, California; and Gresham, Oregon (starting in the first quarter of 1997).

Charting A New Course

The 1990s are unfolding as the decade of system-on-a-chip integration. Few companies have the expertise or the resources to rapidly create and produce custom systems on a chip. LSI Logic is uniquely positioned to play a leading role in this new area.

LSI Logic draws on its rich ASIC heritage to customize and differentiate customers' products. The company has the high-level blocks needed for systems on a chip as well as the methodology to rapidly design and produce such products. It maintains the engineering expertise for the markets in which it participates. It offers applications support in numerous design centers around the world. It offers leading-edge process technology and volume manufacturing facilities to make system-level designs a reality and get them into volume production quickly. It has a proven track record no other company can match.

Finally, LSI Logic has developed strong relationships with trendsetting customers to make the CoreWare design program work. A system on a chip requires a great deal of trust. The customer relies on LSI Logic for the heart of the system and the capacity to meet volume demand. LSI Logic relies on the customer to place and maintain volume demand. It takes two to establish a leadership position in markets with solutions never previously thought possible and to maintain that leadership position over time. Ittakes two to make one of a kind.

Executive Biographies

Wilfred J. Corrigan, Chairman of the Board and Chief Executive Officer: Mr. Corrigan is the principal founder of the company and has served as Chairman and CEO since its organization in January 1981. Prior to founding LSI Logic, he was Chairman of Fairchild Camera and Instrument Corporation (Mountain View, California). He joined Fairchild as a group director in August 1968, and held a variety of management positions before becoming chairman in May 1977. Mr. Corrigan was born in Liverpool, England, and is now a U.S. citizen.

Brian L. Halla, Executive Vice President, LSI Logic Products Group: Mr. Halla is responsible for the development of all of LSI Logic's product lines. He joined LSI Logic in 1988 to head up the newly formed microprocessor group, and was promoted to his current position in 1992. Prior to joining LSI Logic, Mr. Halla was with Intel Corporation (Santa Clara, California) for fourteen years, most recently as director of marketing for the Microcomputer Group.

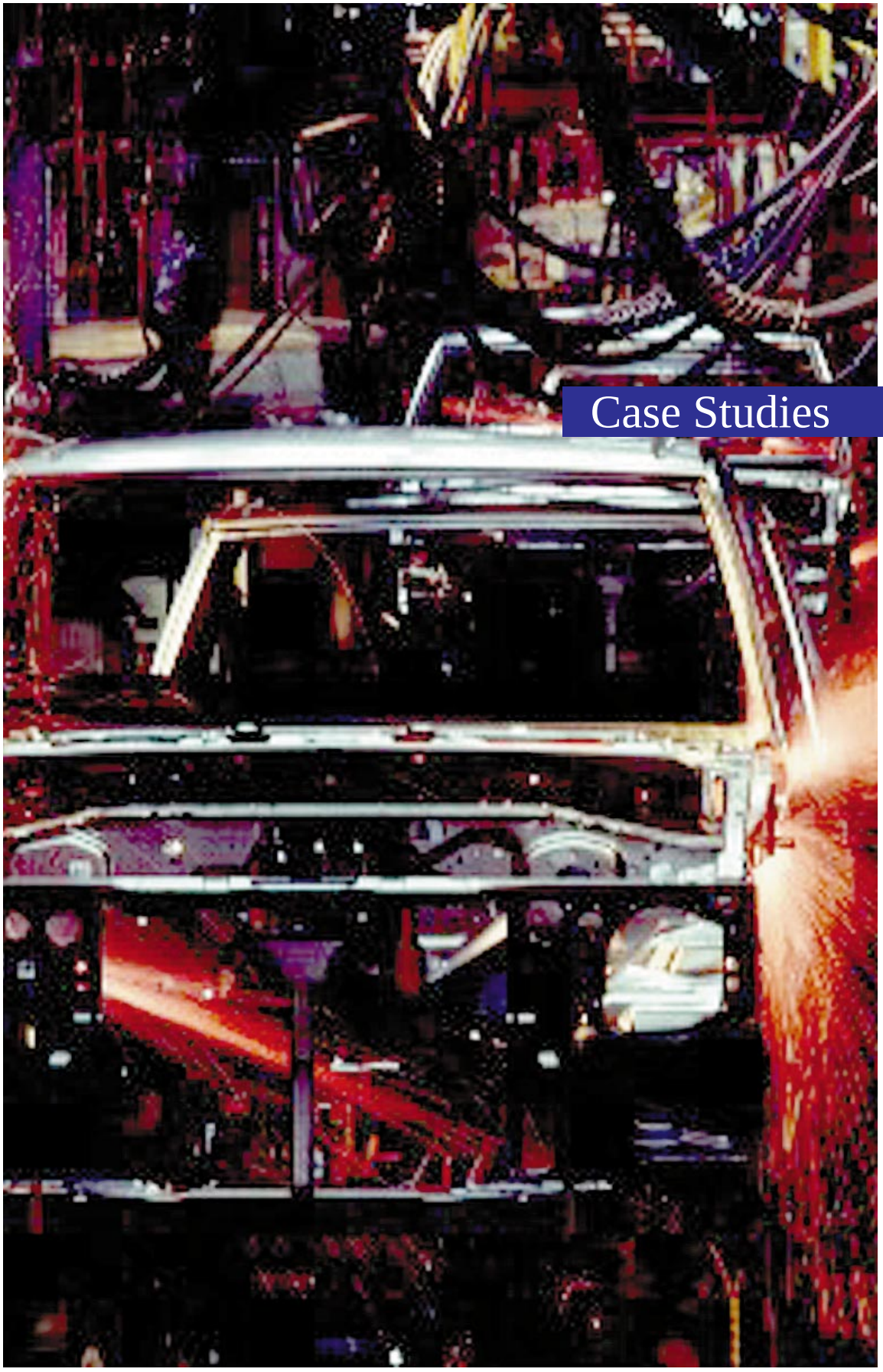
Cyril F. Hannon, Executive Vice President, Worldwide Operations: Mr. Hannon is responsible for the

LSI: Continued

development of the company's worldwide manufacturing capabilities, package development and engineering, purchasing, and customer order management. Mr. Hannon joined LSI Logic in 1984 as vice president of Advanced Products and Technology. Prior to LSI Logic, Mr. Hannon was president of Optimetrix, Inc., a subsidiary of Eaton Corporation, specializing in reduction steppers.

Albert A. "Rocky" Pimentel, Vice President and Chief Financial Officer: Mr. Pimentel is responsible for the overall management and direction of the company's worldwide finance, tax, treasury and legal functions. Prior to joining LSI Logic in July 1992, he was Vice President of Finance for Momenta Corporation (Mountain View, California), and earlier was a founder of Conner Peripherals, Inc. (San Jose, California).

Bruce L. Entin, Vice President, Investor Relations, Corporate Communications and International Marketing & Engineering Support: Mr. Entin is responsible for investor relations, corporate communications and international marketing & engineering support. He joined LSI Logic in 1984 and was named a vice president in 1986. Prior to joining LSI Logic, Mr. Entin was Vice President of Corporate Communications at Atari, Inc. (Sunnyvale, California).



Case Studies

NUMMI: The International Joint Venture

General Motors constructed their Fremont, CA plant in 1962 when competition from foreign imports was almost nonexistent. At the time, the United States automobile industry dominated the world market and the GM factory prospered under such conditions, employing over 6,500 employees who produced an average of 300,000 automobiles per year. In 1978, however, GM's decline at the factory began when company sales decreased as foreign imports gained a greater share of the U.S. market.

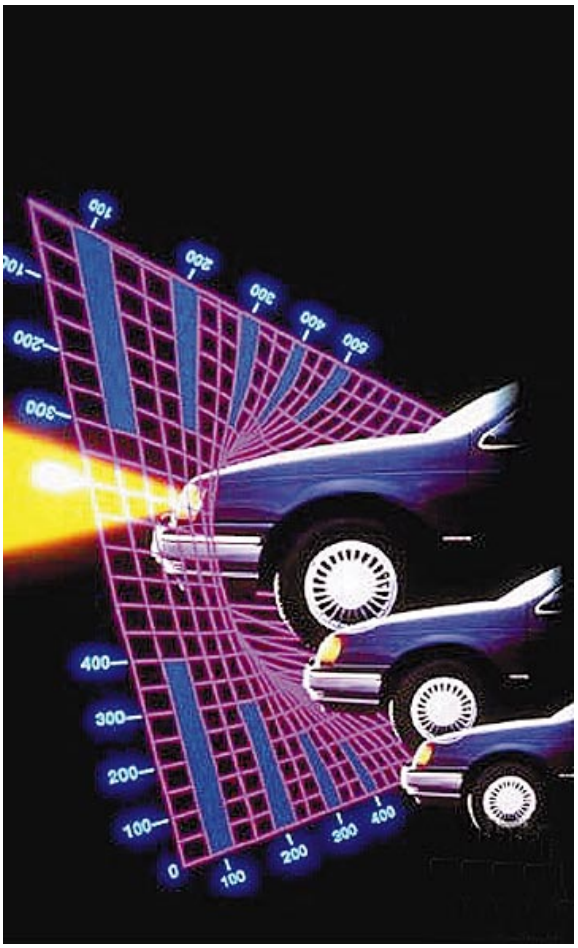
Simultaneously, the plant was plagued by union-management strife and a profusion of disciplinary infractions which resulted, at an extremely high cost in labor time, in the production of inferior quality automobiles. Ultimately, economic pressures forced GM to close the operation in 1982.

In 1984, GM was able to reopen the factory with Toyota as a new partner, creating a revolution in cooperative automobile manufacturing. The joint venture was named New United Motors Manufacturing (NUMMI). Toyota's goals in the venture were to gain an understanding of American unionized labor that would be beneficial to future business dealings with the United States and to alleviate trade tensions between the two countries. While learning the American manufacturing system and employing American laborers, Toyota consequently saved money on export tariffs.

GM's goal in the partnership was to learn successful Japanese management and production techniques. The American company also benefitted from the enterprise by acquiring a first-rate automobile similar in style to the high-quality and popular Japanese products.

The three types of automobiles manufactured at the plant are the Geo Prizm, the Toyota Corolla and the Toyota truck. By the end of this year, 320,000 vehicles will be made at NUMMI.

In 1984, 80 percent of the employees hired to work for NUMMI were the same workers who had been laid off in the 1982 GM plant closure. Under improved management practices, disciplinary problems have been dramatically reduced and the automobile-per-worker production ratio has risen considerably; this being accomplished with virtually the same work force that burdened GM's previous system. The differences are direct results of innovative new management policies that now characterize the company.



Toyota provided personnel to fill the two top positions at NUMMI. Although strain originally occurred because of diverse decision making approaches and planning procedures—Toyota managers typically plan for long-term results while GM managers had planned for short-term solutions—the two dissimilar companies now work together in a precedent setting venture. The joint enterprise is so successful

As seen on Computer Chronicals TV program.

NUMMI: Continued

that it has been made a prototype of labor-management collaboration by the International Labor Organization.

This honor is partially due to kaizen, one of the company's guiding principles. A Japanese term, the word means the search for continued progress and perpetual improvement through a consensus-based decision making process. This concept allows the employees themselves to participate in the arbitration of new procedures.

Another important contributor to the efficiency at NUMMI is the assembly line computer system applied in 1989 to solve the encumbering tally sheet method used earlier. The tally sheets were legal sized papers listing principle automobile items to be checked and containing a grid on which inspectors marked each defect. Each paper traveled with its corresponding vehicle to the next area where repair personnel reviewed the defect tally marks and performed necessary repairs.

The confirmation group then verified whether the defects had been properly fixed. This process used daily tally sheets to report the number of defects found on general areas of the automobiles for a particular day. Weekly sheets were employed by team leaders to tabulate the total week's defects. Tally sheets were such an obstacle to competent and rapid production of automobiles that leaders at NUMMI urgently needed a powerful and reliable solution.

Challenge On The Assembly Line

Each inspector at NUMMI examines 470 vehicles per shift. The inspector has 60 seconds in which to check over 100 items on every car. The tally sheet process was slow and inefficient as pages were often misplaced or damaged. At the end of the month, the papers were stapled together and filed in a box to be stored in another section of the building. To track a defect, an engineer had to go to the storage area, find the particular box and search through the papers to obtain pertinent figures. Any reports or graphs necessary had to be produced manually.

Team leaders, who were paid overtime, counted the tally marks to create a report that was eventually available after the shift had ended. This represented a significant amount of money spent on overtime hours. "It used to take us hours," says Frank Maldonado, the NUMMI LAN administrator and ex-team leader. The team leader had to go to each station on the assembly line (which is 1.3 miles long) and, for an hour or more, copy the tally marks, add them up, find the top three defective items, and create a daily report of the results. This caused, says Group Leader Hal Campbell, "a tremendous amount of homework time" for the workers who tabulated the reports.

Although defective cars were repaired, this system lacked the capacity for prompt and specialized information processing. For example, hundreds of vehicles could be impaired by one repetitive flaw before management discovered the widespread problem and remedied the situation. "What these guys are looking for is very specific," says developer Don Von Rotz, "it's not like 'is a door missing?'" An individualized computer application was necessary that would not only show in minute detail each item on the vehicle, but could also work quickly enough to maintain the vital assembly line pace.

Besides consuming time, the tabulation process provided no way of tracking defects. Cathy Kirstein, an inspector on the new truck assembly line, reports that the tally system "didn't give you the right defect. It would just say 'part missing,' but it didn't say what part was missing." Detecting the source of the defect is important to prevent future flaws from occurring. With the tally system, work was slower and more frustrating for the inspector who continually reported and repaired the same recurrent defect without being able to pinpoint the source of the problem.

Choosing The Consultant

Upon the reopening of the plant, NUMMI managers decided to eliminate the tally sheets and introduce computers to the assembly line. Their goal was to save time and money and to manipulate statistics in a manner which would ultimately improve automobile quality. Many companies vied for the NUMMI contract to solve the inefficiency problems existing at the automobile manufacturer. However, the systems suggested by all but one of the competing firms were not only extremely intricate and difficult to use, but their software was viewed as unable to fulfill NUMMI's needs. DVR Consulting, a firm specializing in designing innovative client/server applications, presented a solution that was readily seen to be

NUMMI: Continued

quicker, easier to use, and offer more flexibility and reliability. As a result, NUMMI decision-makers decided that DVR Consulting was the right firm to head up the project.

DVR President Don Von Rotz and his team, which included Fred Radley and Bill Hawes, built a prototype exemplifying workstations that could be installed on the assembly line. His platform choice was that of the Apple Macintosh.

"Usually I try to exceed expectations and I can do that with the Mac. It's great because with the Mac, you can come in with a presentation that's better than anyone else's." With his Macintosh and 4th DIMENSION, Von Rotz created a winning combination of versatility and power.

DVR Consulting, explains Von Rotz, was chosen since it "was the only one who was able to show them what they wanted and we did all this in 4th DIMENSION." The interface and relational capabilities of 4th DIMENSION enabled Von Rotz to enhance his data management system. Those capabilities, combined with 4th DIMENSION's ability to store graphics within the database and create custom applications, convinced Von Rotz that ACI, ACIUS, Inc. was essential to his solution.

Frank Maldonado immediately recognized the indispensable qualities of 4th DIMENSION. The other software programs he was shown were not able to provide his group with the graphics and speed required on the assembly line. He decided to implement Von Rotz' suggestion after seeing 4th DIMENSION's picture fields and scripting capabilities since they were as unique as what he had envisioned for his solution.

One of Maldonado's specifications for the new application was that a person without computer knowledge could learn it quickly and understand it well enough to use it effectively. He believes that DVR's choice of 4th DIMENSION fulfills this prerequisite well. "I love 4D because it's easy to use," he says. "It's logical; it makes sense to me." Von Rotz maintains Maldonado's support of 4th DIMENSION. "With 4D," he says, "a relatively non-technical person can use the data that's in the database and make it work for them."

Steering Through The Options

NUMMI's initial plan had been to emulate the Fujitsu computer application utilized in the Japanese Toyota plant. However, that system, which featured a touch-board with a changeable overlay similar to a McDonalds cash register, was extremely slow. This, among other obstacles, made importing the computer application to the United States prohibitive. Consequently, NUMMI managers opted for an original application.

The subsequent solutions demonstrated before NUMMI used everything from bar code readers to complete MIS systems to touch screens. Maldonado was disappointed with them. "The other companies were having trouble with graphics," he says. Their pictures weren't clear, an aspect of vital importance when an inspector must refer to the screen to verify the exact appearance or position of an automobile part.

Another major problem with the various systems was that the screens typically redrew too slowly. According to Maldonado, every second to the inspector "is an eternity." When the equipment cannot keep pace with the workers, productivity suffers.

Although Von Rotz originally wanted to use a Hypercard-like interface, he recognized the necessity of having a database. Being familiar with 4th DIMENSION, Von Rotz admired its adaptable and graphic qualities. In addition, he perceived the value of 4th DIMENSION's Quick Report editor which builds immediate columnar reports with user-specified data. His choice of 4th DIMENSION would permit rapid, quality information management as well as allow for potential expansion and individualization of the system.

The Assembly Line System

"It works," says Von Rotz of the assembly inspection computer system, or AICS as it is called by NUMMI employees. "It doesn't create a new problem, it solves problems." AICS accommodates Von Rotz' preference for the Apple Macintosh and 4th DIMENSION. At the center of the application is a DEC VAX 11/750 mainframe connected to the master console via DEC PathWorks file sharing software. The VAX sends automobile information such as sequence number,

NUMMI: Continued

model, interior and exterior color, and options to the master console which consists of an Apple Macintosh IIci.

Every thirty minutes, the VAX sends a new file to the master console. The file is automatically imported in background with 4th DIMENSION to the server which is an Apple Macintosh II*f*x using AppleShare and a Hammer 300 megabyte drive. These elements are connected by the Ethernet network.

To print, a FastPath gateway is used in conjunction with a QMS 820 laser printer and an Apple ImageWriter. Predesigned Quick Reports made in 4th DIMENSION are printed at this station to immediately inform the repair department of detected flaws. Each inspector's defect entries are automatically inputted into the database and team leaders periodically create Quick Reports using that data. Since these defect ratio reports are available at any time, repairs can be made before cars even leave the assembly line.

Each of the 23 workstations (6 on the passenger line and 17 on the truck line) consists of a Macintosh IIci with five megabytes of RAM and a 40 hard disk. The monitors are Apple 13" color fitted with touch screens from Troll. Since time restraints on the assembly line are such a significant concern, Von Rotz decided to forgo a keyboard in favor of such a touch screen. His primary condition for the screen, since most react only to porous surfaces, was its compatibility with a gloved user. The Troll was one of the few suitable solutions for the gloved NUMMI inspectors. Each screen uses 256 colors except at the confirmation center where, because photographs are displayed on screen, the monitors are accelerated by RasterOps 24-bit color cards.

In both the passenger and truck lines, the automobiles are examined by the inspectors, fixed by the repair persons, and verified by the confirmation group. An off-line confirmation center for severely defective vehicles exists for the truck line as well. Here, the screen contains scanned pictures of the repair person responsible for fixing a defect in order to link responsibility to a specific individual. In this area, the confirmation group can actually specify the reason for a defect.

Similar upgrade refinements are being added to the passenger line this year.

4th Dimension At The Wheel

Last year's AICS system contained records for 300,000 vehicles—a number expected to increase this year. This data utilized approximately 235 megabytes. These records were entered by users on 23 computers. Since the system is multi-user, certain precautions were taken in order to maintain database speed. Optimizations include storing data locally for each workstation and referencing the file server only if absolutely necessary. Numerous arrays created at launch time are essential to the design. The arrays are kept in memory to increase operation speed. Buttons on the data entry screen are grouped into five external areas instead of being controlled individually.

Although operating on generic code, each station features a unique layout. The System Control File screen lists all the characteristics possible for the various workstations. Instead of creating new layouts for each screen, DVR Consulting has designed a single versatile layout on the Station Set Up screen which contains all the screen possibilities to be utilized in any combination. This option enables the designers to change anything at a workstation without entering the design mode and re-compiling the application. Depending on the needs of a particular area, sets of data entry buttons controlled by the same code can be mixed and matched to create new screens.

To log on to the system, the user must select the appropriate identification number listed on the screen and then enter his/her personal password. A security file in the database structure identifies each user, validates authorized access and tracks the time and date of activity. Each user is permitted three attempts to log on correctly and periodic reports are printed which detail the number of failed attempts at system entry. Besides preventing unauthorized access to the system, password control is important in tracing personal responsibility for each inspected and repaired automobile.

After logging on, the inspector reaches the data entry screen. The NUMMI defect reporting process is basically a "next record," "previous record" system that allows the user to switch between records at will. Each record represents one vehicle. The graphic automobile identification system colors the car logo to match the interior and exterior colors of the car. Vehicles are further identified by their sequence numbers which appear both on the cars themselves and

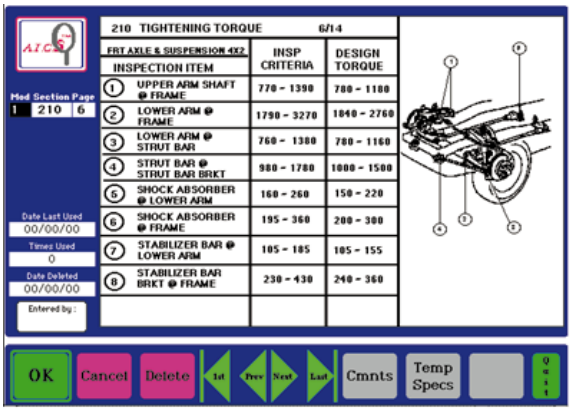
on the touchscreens. The sequence number of the following automobile to be examined also appears on the screen. These numbers are read into the database from the VAX and change automatically when the inspector pushes the Vehicle Logo button to progress to the next record.

Major Item icons change the graphic within the center, or Portion area, of the screen. The Portion area features detailed pictures of the particular automobile segment being inspected at that position. Layered buttons, related files in the database structure, further display secondary and tertiary part elements of the major automobile component. These minor elements allow highly specific defects to be reported.

The bottom section of the screen contains Phenomena buttons which specify the type of defect found. Such problems as “Missing,” “Disconnected,” and “Damaged” can be reported through these buttons. To avoid mistakes, certain phenomena are applicable only to certain vehicle parts.

To report a defect, the inspector presses three buttons: the Major Item to display the main vehicle component, the Portion to specify a particular part, and the Phenomena to classify the type of defect. To accelerate this reporting process, five Memory buttons are available to record specific defects and report those exact flaws when pressed again. Easily changeable, the Memory buttons can be reset by pressing a “C/E” button and entering information for the new problem. A defect confirmation scroll box lists all the flaws entered by the inspector to be reviewed later by the repair and confirmation groups.

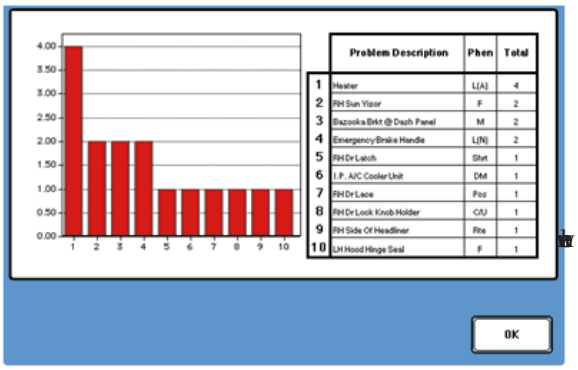
Special buttons on each screen can be utilized for a variety of reasons. A Message button is provided to permit inspectors to send and receive electronic messages throughout the system. Pre-written messages such as “Shortages on this Vehicle” or “Hold for Engineering” can be attached to an automobile record. Additionally, messages to an individual station or a group of stations can be sent using this option.



A Delete Entry button is useful to modify an incorrect entry and a Previous Car button allows the user to recall a vehicle record for any necessary alterations. To view a graphic description of an automobile part, a Specification button exists for immediate, manual-free reference. The Help button gives information about various screen functions. The last of the Special buttons, the Station Activity Chart button, instantly displays a color coded graph of defects for an individual vehicle, a brand of vehicle, or even a certain colored vehicle. This option is simple to use—the inspector presses the screen only once—and it produces detailed graphic reports on the assembly line.

Two other data entry screen buttons are the Break and Log Off. The Break button displays a screen saver

NUMMI: Continued



pressed and, if the user logs on again, returns the data entry screen. The Log Off button chronicles employee working hours, exact vehicles checked during the shift, number of defects entered and amount of times the Help screen was requested.

A Skip button allows specific vehicle records to be placed aside in the case of a serious defect. To access these records, the Sequence button can be pressed to display a pop-up menu containing the sequence numbers of the skipped vehicles. Since this particular sequence number is the only non-repeatable number for each vehicle, this is the field by which records are sorted.

The NUMMI system has been installed for over six years and has been completely dependable. "It's an unusual application and it's not like an office setup. I mean, you're down for five minutes and five cars go by," says Von Rotz of the system's critical demand for reliability.

The Result: High Quality Automobiles

Says Maldonado, "We've achieved our goal which was to eliminate overtime, to generate accurate information, to provide real time data when needed and, using all of these, to save car quality." Both efficiency and productivity have been improved by DVR's application. Most importantly, however, is that the quality of the American-produced NUMMI automobiles has increased significantly.

Since reports can now be created at will, it is easy to publicize repetitive defects at an early stage. Consequently, necessary repairs and production modifications can be performed before additional flawed automobiles are manufactured. The newly implemented communication network between the master console and the workstations decreases the amount of future problems. According to Von Rotz, the system works because, "you're able to go through and detect defects much earlier because of the database and the ability to get information at will. So basically, you're able to cut back on the amount of defects because you have a way of tracking the quality."

Now that the system is computerized and is able to trace flaws at an early stage, the average defect to car ratio has improved 150 percent. After the first six months of installation, Maldonado ran a computerized summary that listed defects per vehicle per month and the graph showed a significant—almost 45 degree—decrease of flaws. NUMMI managers are pleased by results such as these which demonstrate a marked improvement of defect control and vehicle quality.

The system encourages standardized work by monitoring each inspector, thus ensuring that he or she is checking the correct car at the correct time. Standardization was implemented at the plant by the Toyota managers to guarantee that, no matter who is on the job, it is accomplished in the most efficient manner possible.

This increased efficiency has resulted in financial benefits for the company. The money saved by eliminating overtime is substantial. What used to take two people over one hour each to accomplish now takes one team leader less than 15 minutes. Time that was once spent adding figures is now spent tracing defects, an improvement that, according to Maldonado, helps avoid automobile recalls.

Now that the inspectors use the computers, they agree that the system works well for them. Says team leader W.C. Lee, "I think the computer system's great because it makes our job a lot easier." Lee maintains that the system was easy to learn, especially since NUMMI management consulted frequently with the inspectors and team leaders in creating an application that was completely personalized to the workers' needs. The training classes for new assembly line employees are two hours long. Hal Campbell, a group leader, reinforces Lee's opinion, "anyone who works with the system likes it."

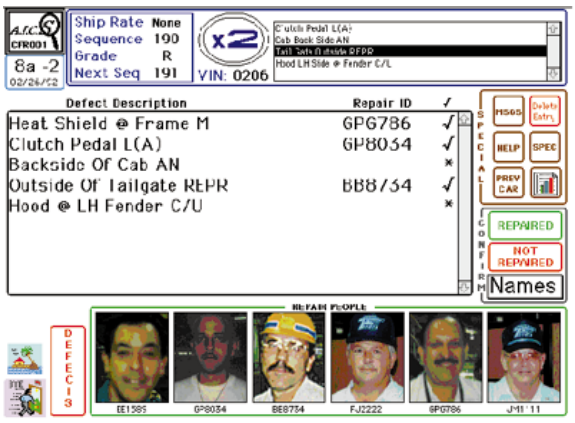
Since the technology was unfamiliar, the management at NUMMI originally doubted the feasibility of

the project. Now, however, they are pleased by the decrease in defects. Von Rotz qualifies the system's success in terms of his customer's satisfaction. "I think this thing has totally exceeded all of their expectations" he says. Initially, his group installed six workstations at NUMMI. Today, the total has reached 50, a number that will increase later this year. NUMMI is so pleased with the results that it has retained DVR Consulting's services to develop further uses of the system. "The initial thing was just a pilot and they were so thrilled with the way this thing was working that we just kept going," says Von Rotz.

Future Application Upgrades

Besides the upgrades on the passenger line, new enhancements of the system are being planned at NUMMI.

A new division to be added to the passenger line is vehicle performance. This innovation tracks if, at any time or place, the automobile has a performance problem. The 4th DIMENSION application for this sector will be more individualized for particular problems. Whereas the Phenomena buttons on the assembly line screens report problems such as "missing," "damaged," or "cracked," similar buttons in the vehicle performance screen will specify if a tire, for example, is "flat," "low on air," or "not whitewall."



In all the areas, new confirmation screens will be added to the application. The confirmation group will have the ability to read the inputted defects on the computer screen and check them off once the repair group has succeeded in fixing the defect. This addition will completely computerize the assembly line, an improvement which will further promote efficiency.

Expansion of the system might also include the installation of Quick Time, Apple's new media technology package, to include video training clips if the user has a question about standardized work procedures.

Speed is so vital to this multi-user application that Maldonado plans to add the 4D SERVER to his system. The 4D SERVER is the client-server technology from ACI, ACIUS, Inc. that accelerates multi-user data manipulation by actually performing calculations, thus decreasing the number of network passes to two. Additionally, the server possesses a multi-user design mode which permits multi-user development.

These upgrades further exemplify the principle of kaizen. The original computer system was installed on behalf of NUMMI employees and was created under the guidance of their suggestions. Ongoing improvements are continuously being added at the request of the assembly line workers to further increase their efficiency. Through such ideas as these, NUMMI has succeeded in building a productive assembly line which runs at maximum efficiency and manufactures high quality automobiles. Through the computer application, Von Rotz has contributed to this accomplishment and is proud of NUMMI's system. For according to Von Rotz, "if you don't make somebody's life easier, then you haven't done your job."

NASA Ames Research

NASA Ames Research center was confined with an outdated manual paper-based Purchase Request system which processed in excess of 15,000 PR's annually. The average PR took up to 15 days to flow through the system due to the internal mail routing which was necessary for the required management approvals. This session will chronicle the steps which were taken to Initiate, Plan, Budget, Develop and Implement a new custom client/server Purchase Request system resulting in dramatically improved efficiency due, in part, to electronic editing, routing and tracking capabilities.

NASA Ames Research Center, has successfully implemented an Electronic Purchase Request(E-PR) System. The system was the creative efforts of a team of Users, Information Technologists including contractors and Management.

The circumstances that led the initiation of an Electronic Purchase Request system were recognized by the years of symptomatic scenarios of researchers and engineers spending their time hand carrying purchase requests through a chain of approvals and processing organizations. If they mailed the purchase request the average turnaround time from initiation to order was 20-30 days. Because the process was completely manual and dependent on the internal mail service there was zero visibility into where the purchase request was in the system at any given time.This process was complex, confusing and unmanageable. The purchase requester was ultimately responsible and had no means of tracking where the PR was unless he of she walked it through by hand carrying their PR. This situation reached unacceptable levels and resulted in counterproductive heated debates and finger pointing when deadlines were missed. It was time to take action.

An enterprise-wide, Information Systems Planning(ISP) activity comprised of a User Group, a Management Steering Committee and Information systems teams was formed. This activity brought together the key elements needed to support a Centerwide development such as the Electronic PR. The User Group was empowered with the responsibility for requirements, prioritization and resource allocation recommendations to the Steering Committee. The User Group unanimously established the Electronic Purchase Request System as their number one priority.

In the budget reduction climate of the 90's, the ISP User committee was immediately challenged with finding investment resources for this project. However, with the help of the IS organization, they prepared and presented a business case to senior management that detailed the problem, the recommended E-PR system and how this project would produce savings.

NASA Ames: Continued

The savings were described as Direct Savings, Indirect Savings and included Metrics. Direct Savings were described as money back in management's pocket, e.g. reduction of a full time contractor position, savings on paper supplies and postage. Indirect Savings were described as Productivity gains, e.g. Buyers reduced turnaround time, time savings of elimination of expediters in walking through PR's, time saved in rejected PR processing, time savings in tracking status of PR's. Metrics included ease of use, accomplishing the savings projected and cost and schedule. The advocacy was presented to management by the User Committee Chairperson with support from the IS organization.The proposal was accepted and a prototype was funded (out of a contingency budget reserve). If the prototype was successful then the funds for the implementation would be considered via a similar process. The User Committee were to be the sponsors and reviewers of the project's process.

The User Committee and Center Management established a quality improvement, Process Action Team (PAT) consisting of process owners and the Information Systems technologists. The team mapped the current process and re-engineered for the Electronic PR process. This was a significant step in the process that enabled the success of the development team.

In a parallel effort the IS organization began the process for selecting the application tool. The IS organization fell into a common dilemma. They had split opinions that were strongly argued for 2 different approaches. One approach was a client/server database application the other a forms based application with database linking. They each had strong features and were competing for the first client/ server opportunity within Ames. This debate actually eroded a good deal of the schedule and the IS organization could not get a decision either way from management. It was finally resolved by the User Committee Chairperson's recommendation after hearing presentation's on both approaches. After considering the facts and comparing the capabilities of both approaches to the requirements, and consulting with other IS organizations at another NASA Center. The decision was to employ a database application.

Although the technical issue was resolved in perhaps a peculiar manner, because of rapid-prototype capabilities it would have been evident quickly had we embarked on the wrong path without too much risk to the project. For others who may face this dilemma, because management is unavailable to make a decision, or may not be ready to make a decision because they need more data, or whatever. It may be wise to gently urge them to consider that timing is everything and there comes a time, when a decision, as opposed to no decision, makes a difference between doing something and doing nothing. There is always risk. Finding the person in the process who can influence management to make a decision and accept the calculated risk, was a successful tactic. As it turned out, the need for the database to meet requirements was proven a good decision.

After the initial contract was awarded to DVR Consulting Inc., we realized that we would quickly have to assess the many factors which could impact the project and then create a workable project plan. The initial mission was to prototype an automated Purchase Request Process system within the Ames Research

NASA Ames: Continued

environment and to deliver it within a 2 month period of time. Many factors and constraints had to be quickly analyzed to determine how they would impact the development process.

Factors such as:

a. Project Expectations & History

b. Project Scope

c. AMES environment

d. AMES dedicated project Resources

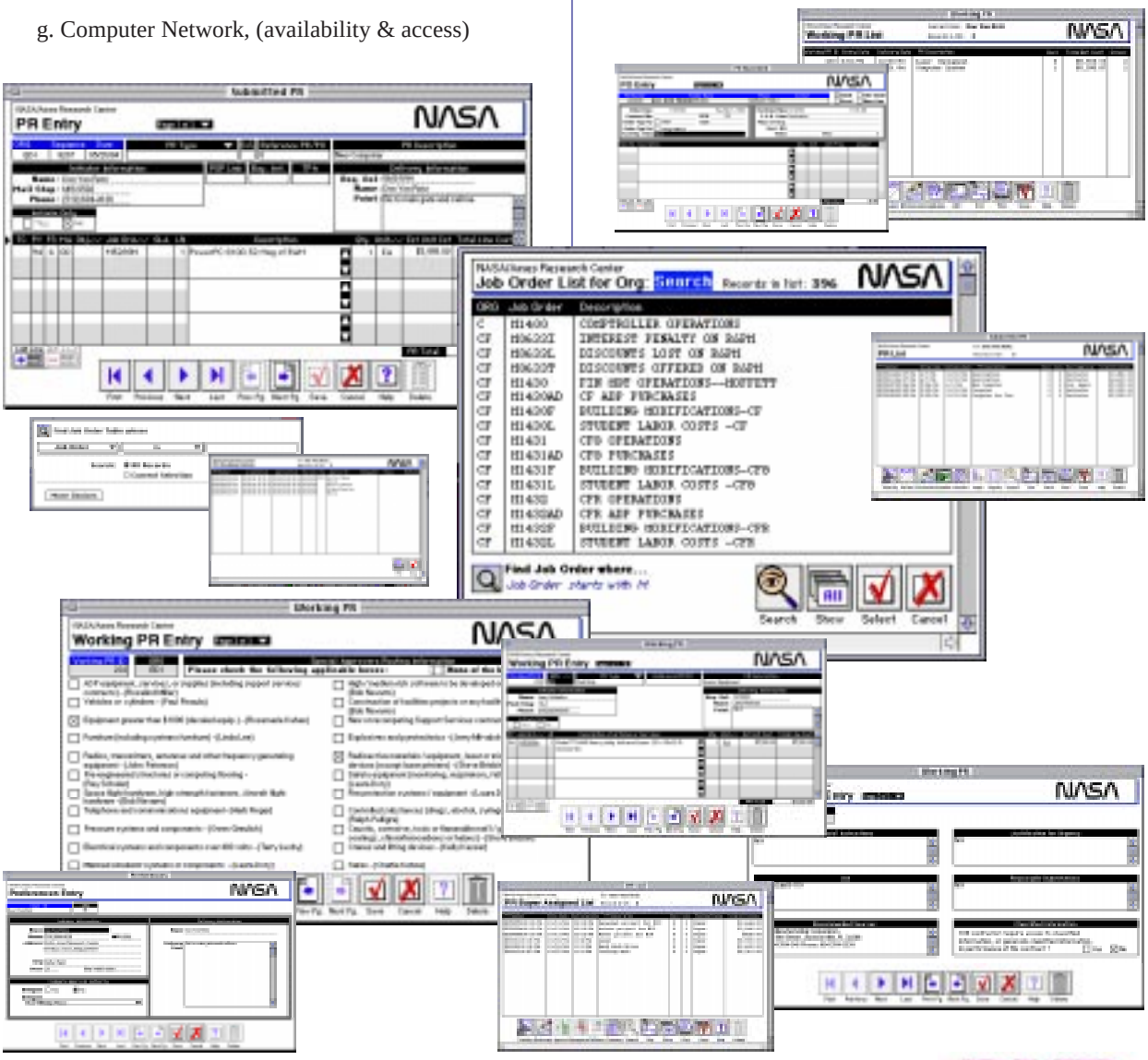
e. Existing IS methodologies & standards

f. Hardware / Software Tool Standards

g. Computer Network, (availability & access)

Each factor was analyzed and evaluated as the project plan was prepared. Several factors were leveraged to there fullest extent and utilized in the development process.

After the site assessment was completed, work began quickly on a project plan. Since the prototype deliverable date had been predetermined, we proceeded to work back from that date with the development tasks that we knew (at the time) were required to develop a prototypical PR client/server product. Since we were able to bypass the in-house “Standard” methodology, we could create a development plan that would work in a limited time-frame.



NASA Ames: Continued

Although a rough requirements list did exist it for the PR Prototype, the current PR process needed to be documented and more fully understood so that a complete requirements list defining the project scope could be created. A data flow model was created which documented the existing PR process, helped redefine the scope of the project and aided in finalizing the initial set of requirements. The data flow and associated procedure flow was documented by interviewing key players in the process, perusing existing forms, and by reading procedure documentation which included instructional memos. The existing Process Action Team (PAT) (made up of key NASA/ Ames employees and select contractors) was used extensively to review the data flow model and to help develop the requirements. The requirements were then re-reviewed by the developer and when necessary either de-scoped or scaled back due to time frame constraints.

After the requirements were reasonably clear, development started on the prototype. Screens were developed by functional processes which were detailed in the data flow and were reviewed by the PAT each week for their approval. The software was modeled after the existing processes, but consideration was also given to process re-engineering where relevant. The prototype was built using "Interactive Iterative Design Methodology" where key users review the software as it is being created and have an open dialog with the software engineer as each iteration of the system is delivered. Each new iteration would be reviewed by holding live demonstrations weekly (sometimes daily) to PAT group members and selected power users of the existing NASA/AMES PR paper system. Suggestions would be collected and sometimes additional requirements would be generated which would be included within the next iterative cycle. This process allowed us to create a system which we knew would work because of the high degree of user involvement during the development phase.

Implementation and system rollout of the "electronic PR" (E-PR) Prototype software was the responsibility of the existing IS group, which was under the direction of RECOM Technologies. A select group of approximately 45 users were seeded with the software and participated in the E-PR evaluation, which was conducted over a period of months. Meetings continued with the PAT each week for the purpose of evaluating and documenting the E-PR prototype software.

After successfully piloting the E-PR Prototype for months, funding was procured to enhance the system with many additional requirements. New requirements which had been documented by the PAT, were as a result of user input from the prototype phase.

DVR consulting was awarded the follow-on contract of 1184 hours, which were used to make the system more robust, handle more users, and include additional features. Since we had already been successful in our previous development effort, we decided to use that plan as a model for our new development.

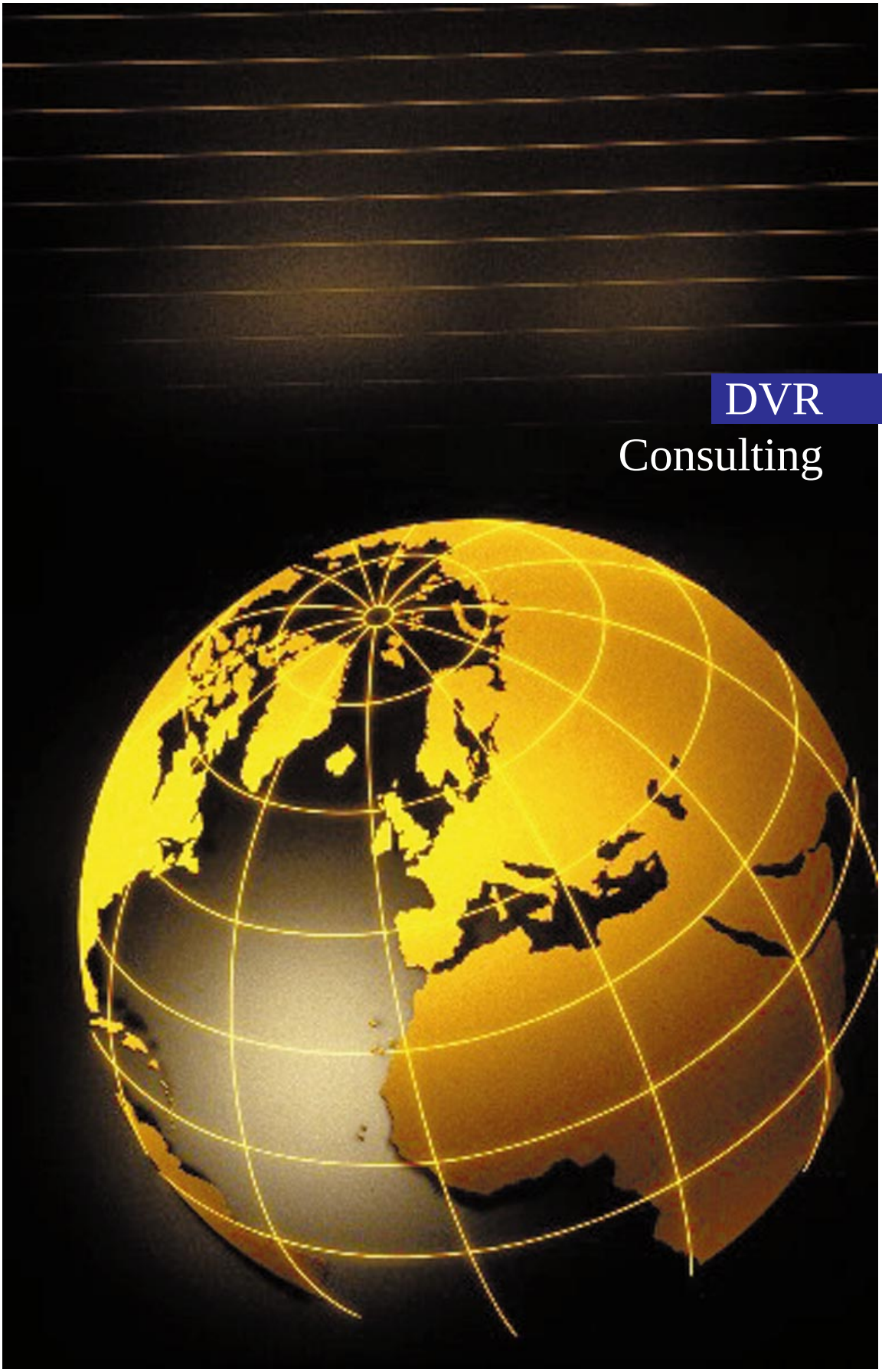
The completed E-PR system was delivered in October of 1994. It now serves approximately 500 users of the NASA / AMES Research community.

Conclusions

3 elements which led to the success of this project were,1. Management Supported, high level of user involvement, 2. a good business case and 3. good technical design.

E-PR System Features include:

- PR Entry screens for Entry of PR built in a Client/Server Relational Database environment.
- PR Editing including referential editing with tables supplied from the mainframe accounting system.
- Process specific screens for accounting and purchasing.
- Flexible Dynamic Routing
- PR Organizational Routing tables supporting dollar limits and organizational hierarchies for both Serial and Parallel approval structures.
- PR Special Approval Routing tables supporting both Serial and Parallel approval structures.
- Instant access of routing for PR tracking, showing Date/ Time of last approver.
- Disapproval Routing
- Multiple enclosures for a PR
- Seamless integration with the eMail system to provide management notification of PR's awaiting their approval.
- Delegation of approval authority to authorized approvers.
- Full printing of government form (8) pages when desired.
- Automated P/R number assignment for each organization.
- AD-Hoc reporting and graphing
- Security


DVR
Consulting