





*“Our customers expect us to provide products and services that meet their exacting specifications, a responsibility we consider both a challenge and an opportunity. Quality is the basis of our existence—the foundation on which we have established our reputation for excellence. It is part of our heritage and part of our culture.”*

*Paul W. Schwegler  
Vice President, Quality and Systems Assurance  
TRW Space & Defense Sector*

*“Quality means meeting the needs of our customers, first time, every time, and on time.*

*In our global marketplace, meeting our customers’ needs is providing superior value through high-quality, technologically advanced, fairly priced products and excellent service—far above that offered by a competitor.*

*Understanding is the key to quality—understanding what our customer needs, why he or she needs it, and knowing what resources are required to meet those needs in the prescribed time.*

*Quality is creating the team environment in which everyone wins.”*

*Donald R. Beall  
Chairman of the Board and Chief Executive Officer  
Rockwell International Corporation*

*“At Hughes, we consider the quality of our products and operations to be our number one priority, and the ultimate measure of this is the degree to which our products satisfy the needs of our customers. Therefore, no operating decision will be allowed to impact negatively on the quality of our products and operations, and we will continually strive to provide the motivation for error-free performance by our employees.”*

*Donald H. White  
President and Chief Operating Officer  
Hughes Aircraft Company*









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In the early 1980s, the aerospace industry recognized that foreign competitors were aggressively pursuing targets in its arena, as they had done in many basic industries. Highly publicized "horror stories" related to the quality and reliability of defense industry products made the problem more acute. After an objective and sometimes painful self-evaluation, the members of the Aerospace Industries Association of America (AIA) are responding with firm commitments to improvements in quality and productivity.

Understanding that the pursuit of excellence through continuous quality improvement requires revolutionary cultural changes, member companies are rapidly implementing those changes through what might be called "Total Quality Management." Cultural changes do not occur overnight. They result from long-term commitments and require persistent retraining and modification of practices, covering every individual in a company—from the highest to the lowest level.

The members of AIA present this brochure to illustrate how they are successfully implementing these processes. They are addressing every phase of their business—from product conceptualization, through prototyping, testing, final design, and fabrication, to delivery and beyond. There are individual differences, depending on each company's products, size, and overall business environment. There are even differences within companies, as various divisions cope with their particular situations. In fact, each company must have the freedom and flexibility to structure a process that fits its own unique needs. There should be no constraints and no barriers.

This brochure includes entries by more than 20 members of AIA, all in different stages of implementation. Some have had programs in place for several years, some have recently started, some have already produced dramatic results, and some are seeing slower, but steady improvements. None of these programs are the result of contractual or regulatory impositions; they all are the direct result of corporate strategies designed to enhance competitive positions in the marketplace. The brochure is divided into five categories:

- **Total Quality Management**—Under this umbrella process, individual companies communicate AIA's goal of continuous quality improvement and introduce their philosophies that emphasize quality considerations in day-to-day business decisions.
- **Advanced Technologies/Techniques**—Aerospace involves some of the world's most technologically sophisticated products. The industry will have to develop even newer and more sophisticated materials and techniques to meet its needs and national defense requirements. AIA members are relentlessly pursuing, adapting, and creating advanced techniques to assure the integrity of the high-tech products being produced.
- **Statistical Process Control**—Long recognized as a powerful tool to enhance quality in high-volume production, SPC techniques are aggressively being adapted to the processes involved in manufacturing aerospace products.
- **Control of Purchased Materials**—In addition to paying attention to their own fabricated parts and assemblies, member companies are cultivating active partnerships with their suppliers, emphasizing and developing the capabilities of small and/or minority-owned businesses.
- **Motivation/Training**—Its employees are any company's most valuable resource. Well-trained, highly-motivated employees are essential in today's high-tech environment. Incentive programs and awards, as well as the possibilities of on-the-job training and courses at institutes of higher learning, are vital ingredients in "Total Quality Management."

Continuous quality improvement is a business strategy that makes companies more effective and assures that customers get the best products possible for the best price. Quality—with a capital "Q"—is regaining its rightful place at the forefront of America's aerospace manufacturing renaissance. In an industry that literally reaches for the stars, the members of AIA have renewed their dedication to making the premier aerospace products in the world. This brochure was created to demonstrate their progress.





# TOTAL QUALITY MANAGEMENT

## LTV

LTV Aircraft Products Group's TEX (Teamwork for Excellence) is a continuing, total quality-improvement process which results in better communications and more teamwork among employees, greater concern for doing the job right the first time, better supplier relations, increased productivity, and better products. TEX reaches into all work areas—management to hourly workers, white collar to factory floor.

The process includes awareness training for new-hires, problem-solving techniques, and specialized training for first-line supervisors and middle managers. An idea for improvement may result in the formation of a departmental or inter-departmental team. The TEX Idea Program offers cash and other incentives to employees whose ideas are implemented.

Examples of results of implemented TEX ideas include improved quality of aircraft skins through a new method of handling and transportation, the elimination of defects caused by chips induced by a drill cycle, and invention of a new vacuum system for removing metal chips.

## HUGHES

Hughes Aircraft Company has implemented a quality-first strategy through the company-wide adoption of a Total Quality approach. Each operating organization generates and operates a plan to achieve Total Quality Objectives. Achievement is assessed by checking progress toward measurable goals.

Under the Total Quality approach, individuals assume responsibility for their own efforts and output, and management provides systems and training so individuals can perform to their highest capability. Rather than correcting errors and defects, workers concentrate on preventing them through care in work performance, control of equipment and processes, and satisfying the needs of their customers.





Pneumo Abex

### **PneumoAbex**

Pneumo Abex Corporation's aerospace divisions have adopted total quality management programs tailored to fit their individual business needs.

The Cleveland Pneumatic Company's Total Quality Initiative includes modernization of equipment, adoption of computer technology, and development of management philosophies to encourage involvement of employees in the quality improvement process. The division works closely with suppliers to get high quality from the beginning of the manufacturing process. It hired an outside firm to conduct an audit of conformance to all contractual requirements, with emphasis on quality.

Pneumo Abex's flight control systems division, NWL Control Systems, initially focused on a program to ensure high quality conformance to contractual requirements. It has broadened the program to emphasize long-term continued improvement throughout the company. Senior management provides direction to the overall initiative through a Quality Management Council which regularly reviews the progress of a number of ongoing quality improvement processes. NWL's approach also includes company-wide training to sharpen problem-solving skills and concentrated team efforts to review and analyze improvement opportunities.

*"The rewards from producing quality are great, particularly when measured against the negative costs of 'nonquality'—costs such as scrap, rework, inspection and reinspection. These can add up very quickly if a job isn't done right the first time around. Quality not only is cost saving in the long run, but, more important, it also pleases our customers and makes our employees proud of the job they're doing."*

Norman J. Ryker  
President & Chief Executive Officer  
Pneumo Abex Corporation





TRW



The Quality Awareness and Continuous Improvement Program at the TRW Space & Defense Sector is multidisciplinary and includes operations, suppliers, designers, engineers, manufacturers, inspectors, financial controllers, and marketing and shipping specialists. The sector developed improvement initiatives throughout its operating units.

First was a corrective action process that focused on improving the quality of design. The second initiative involved improving all aspects of part acquisition, including cost, scheduling, and performance. The third concerns upgrading systems and standards through a Quality Enhancement Training Program. And the fourth focuses on developing macro and micro quality measurements that tie into the business management systems.

It is an ambitious effort, one that takes in every aspect of the business and gives employees at all levels a stake in quality improvement.

#### MARTIN MARIETTA

Quality improvement and productivity programs are a corporate priority at each of the Martin Marietta Corporation operating companies. A typical program is the Electronics and Missiles Group's performance measurement teams (PMTs), which use a structured teamwork approach to identify where quality improvements are needed, find the best solutions, and take corrective action. Organized around established work groups in manufacturing operations, PMTs

allow interaction among operators, technicians, supervisors, and support groups.

Results are measured weekly, and each team tracks its progress on wall charts in the work center. On one missile program, PMTs implemented quality improvements that increased yield by 27 percent, lowered rework costs by \$6,000 per month, reduced scrap by 60 percent, and reduced labor content by 23 percent per unit.

*"Put quality first; cost and schedule will follow."*

A. Thomas Young  
President

Martin Marietta Corporation, Electronics & Missiles Group





Allied-Signal Aerospace Company has a customized, total-organization approach to quality improvement. Employees at every level solve problems, take corrective actions, and contribute to the continuous improvement of products and services. Problem-solving begins in the initial stages of a project to ensure strict adherence to customer specifications. Management evaluations assure that efforts are carefully planned and implemented to meet company standards. Specific goals and total performance are periodically reviewed to maintain quality-conscious systems and services. Results of this approach indicate a significant increase in productivity, efficiency, and quality.

Allied-Signal recognizes that a commitment to continuous quality improvement is essential in maintaining its competitive advantage in the aerospace marketplace.



At Pratt & Whitney, the Operator Certification (OpCert) program places ownership of part quality and pride in workmanship at the manufacturing level. An operation or process being considered for OpCert application must be thoroughly evaluated to ensure all tools and gauging are adequate to perform the job.

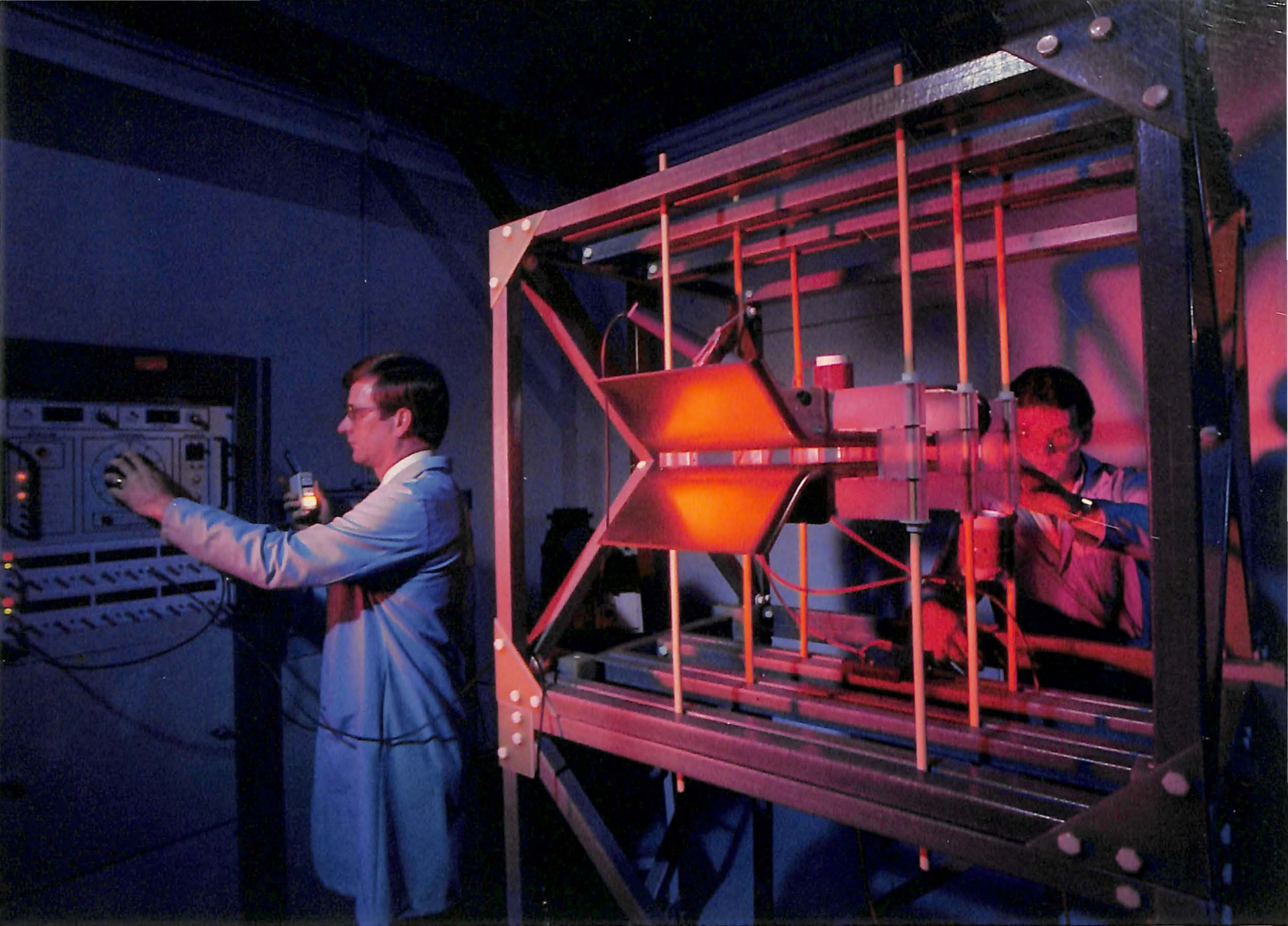
Through weekly meetings, the Product Integrity Council improves customer/supplier relationships and shows impressive results in the war on reducing nonconformances.

The Manufacturing Corrective Action Board effectively obtains corrective action with the help of teams of experts from all disciplines. The elevation of unresolved problems to a higher level of management and the method of reporting and tracking nonconformances also make the board effective.

Q Plus is a process that promotes a quality culture based on the fundamentals of conformance to requirements, prevention, doing it right the first time, measurement, customer/supplier partnerships, and continual improvement.







E-Systems

**E-SYSTEMS**

E-Systems, Inc., has initiated a corporate-wide total quality program based on prevention of discrepancies. Several elements of this initiative are in place. The Discrepancy Data System reviews and analyzes inspection reports to locate potential problems and provides a basis for subsequent preventive measures. Statistical Process Control

refines the quality program by analyzing results of the Discrepancy Data System and other data to facilitate process improvement. The efficiency of procedures and management actions is continually verified through periodic internal audits, and upper management assures that corrective actions are taken.

**Rockwell International**

Rockwell International Corporation's basic written policies require a Product Integrity Program which ensures no compromise in quality, reliability, or safety of products and services. The program emphasizes error prevention and promotes continued quality improvement. Through encouragement and support, it offers each individual an opportunity to contribute to the improvement of products, processes, and services.

Rocketdyne Division's management philosophy and practices integrate productivity improvement and quality enhancement (PIQE) into design, manufacturing, testing, and all administrative and support activities. The division strives to improve product integrity through PIQE teams and discipline in design, workmanship, and process controls. Recognizing the critical nature of its products for manned space flights, the company's commitment is to provide products that perform right the first time, every time.



Rockwell





Lockheed Corporation's quality policy is to provide customers with products and services that satisfy their quality expectations. This policy is implemented by each company and division through quality strategies tailored to customers, products/services, employees, and work environments. Basic concepts in support of the policy and strategies are employee awareness, commitment, and involvement in the quality improvement process; internal-external customer-supplier relationships; and direct supplier involvement.

All functional areas are involved in the pursuit of quality improvement, customer satisfaction, and reducing the cost of quality. The quality strategies are an integral part of the corporate and company business strategies. The corporate-wide quality improvement process is termed "Star Quality," but each company/division has its own unique process. For example, at the Lockheed Aeronautical Systems Company—Georgia Division, it is the "Total Quality Improvement Program," while at the Burbank Division, it is "Product Excellence."

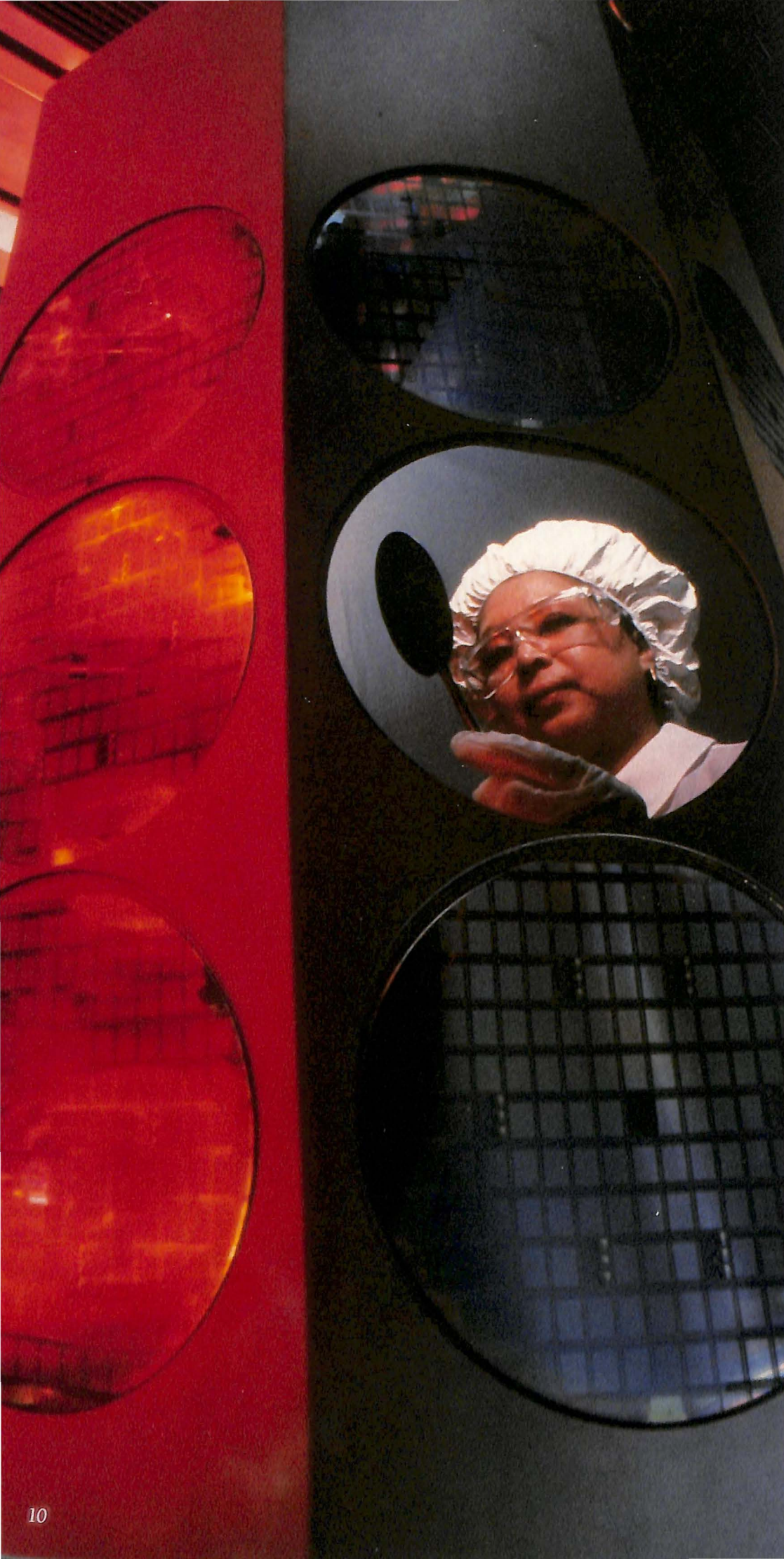


Over the years, a concern for quality at IBM Corporation has led to the Pursuit of Excellence program, consisting of a corporate vice president of quality and a quality director at each division; quality principles, including one which states that no level of defect is acceptable; Quality Councils, composed of upper-level managers; and more than 750 Quality Improvement Teams.

The present company-wide Quality Focus on Business Process (QFBP) seeks to improve the operational efficiency, effectiveness, and adaptability of IBM processes, consistent with the needs and requirements of customers. QFBP is finding ways to streamline activities, simplify procedural control, reduce bureaucracy and redundancy, and improve quality. In some areas, there has been more than a 50-percent reduction in the number of procedures. The ultimate aim of QFBP is to achieve a defect-free operation.







## Raytheon

Raytheon Company's Product Assurance Inspection Reporting System (RayPAIRS) and the Product Assurance Test System (RayPATS) are two real time, on-line monitoring systems that find problems and deviations from the norm as they occur.

Data is usually supplied to RayPAIRS within 15 minutes of inspections, giving work-center staff the ability to monitor the data throughout the day. With Corrective Action Notifications, the system shows potential problems with parts, lots, or processes; it requires responses and keeps on-line delinquency files which reinforce the need for quick corrective action. RayPAIRS provides standardized summaries, including historical data, that highlight processes and parts needing attention to quality. It also plots charts that portray the quality trend to the operators in work centers.

RayPATS is an automated test-reporting system designed similarly to RayPAIRS. A quality control oriented software system, it finds problems in electrical test areas quickly and precisely. RayPATS meets its goals through continuous analysis of test data by part number, work station, and equipment.

## GENERAL DYNAMICS

General Dynamics Corporation was one of the first defense contractors to implement a formal, structured quality improvement program in response to the government's request at the first Bottom Line Conference. This government-sponsored forum mandated top quality in the aerospace and defense industries. Due to its outstanding quality record, General Dynamic's Fort Worth Division was assigned to kick off the program in 1981. Corporate-wide application began in 1982. Program applications reduced scrap, rework, and repair (SRR) to 3.3 percent in 1984 from 7.9 percent in 1980. AIA survey data continues to show General Dynamic's SRR rates among the lowest in the aerospace industry despite ever-increasing product sophistication, complexity, and model variants. Program success is chiefly due to emphasis on measurable goals, management commitment, employee awareness, and intensive training.





Boeing

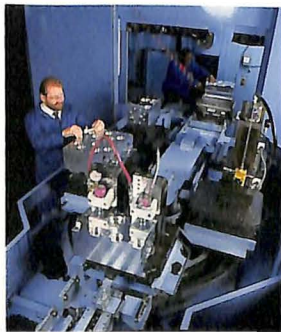
## ADVANCED TECHNOLOGIES / TECHNIQUES

*“Nothing is more important to Boeing than quality.*

*All our efforts are directed to ensuring not only the quality and integrity of our products, but to improving all our processes, from design through manufacturing, as well.*

*From top to bottom, Boeing is committed to quality improvement.”*

Frank Shrontz,  
Chairman and Chief Executive Officer,  
The Boeing Company



### **BOEING**

Boeing Aerospace scientists are using computed-tomography scanners to analyze characteristics of materials. Used by hospitals to detect tumors and other diseases, at Boeing these machines identify variances in the density of light-weight materials being produced for space use. These density variances, caused by the way the material goes together, are not predictable. Although the production process is the same, each piece needs to be analyzed. The scan shows potential flaws and the strength and heat resistance of materials.





Aerojet General

**AEROJET  
GENERAL**  
GENCORP COMPANY

Aerojet Solid Propulsion Company's unique Fourier Transform Infrared (FTIR) system uses computers to analyze the physical and chemical properties of mixed propellant. It is faster and more accurate than conventional testing, and it greatly reduces cost. The system is part of a new, continuous-mix pilot plant—the only one of its kind. It makes on-line, real-time propellant inspection possible for the first time in the industry.

Aerojet has also pioneered advanced Computed Tomography (CT) inspection. CT can locate and determine the size of many critical anomalies in solid rocket motor components. One CT system can inspect fully loaded motors like the Peacekeeper and Minuteman that are up to 100 inches in diameter and weigh 55 tons. The next generation CT-based Advanced Rocket Nozzle System is providing more reliable image analysis faster and at less cost.



Lockheed

**Lockheed**

Areas of concentration in quality technology at Lockheed Corporation include robotics/automation, computer vision, infrared inspection, CCMM/CADAM, electronics testing, non-destructive evaluation, process control, composites, and environmental stress screening.

Ultrasonic inspection is noteworthy at Lockheed's Georgia Division. Used in the production of C-130 and C-5B assemblies, the system capabilities include scan rates of 15"/second, automated setup and scan plans, and color display and plotting of inspection results. Infrared thermography enables characterization of the resin systems used to establish cure cycles, leading to control of the manufacturing process and improvement in product quality.

At the Lockheed Missiles and Space Company's Space Systems Division, the Solar Array Module Infrared Inspection System verifies on a near real-time basis the integrity of solar cells and the interconnecting circuitry weld joints and provides a printout for later evaluation. The Research and Development Division's High Energy Real Time Inspection System (HERTIS) is used commercially and by the Navy on the Trident I program. X-ray energy is converted to visible light via a Lockheed-patented conversion screen, then viewed by a high-sensitivity video camera.

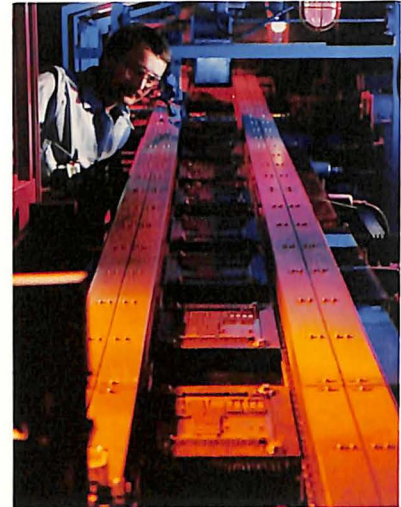


Harris

**HARRIS**

Computer-aided engineering and manufacturing tools have brought engineers into the manufacturing process at Harris Corporation. In the past, little thought was given to the "manufacturability" of the product. Now, with advanced computer hardware and software engineering tools, all of the initial product and system design work is captured and entered into the system. Engineers have access to "on-line design" and the capability of rapid visual "what if" modeling and logic simulation.

Harris believes that the combination of computer-aided tools, Just-in-Time production techniques, and people-driven quality improvements will significantly speed up the design-to-manufacture process.



Hughes

**HUGHES**

Advanced speech-recognition technology is utilized at Hughes Aircraft Company. Inspectors on the production line use a voice input system to describe problems in plain language to a personal computer. Since the inspectors keep eyes and hands on the product, it is estimated that paperwork will be reduced 80 to 90 percent and typing errors will be eliminated.

Circuit cards for the infrared-guided Maverick missile pass through a sophisticated wave solder machine at Hughes' missile manufacturing facility in Tucson, Arizona. The computer-controlled soldering equipment, part of a \$250 million modernization program, is pre-programmed to recognize each assembly and precisely adjust heat and solder levels.

Engineers at Hughes' micro-electronics facility perform final design check of the layout of a large-scale integrated circuit. It combines analog, digital, programmable memory circuits and built-in test pads. Ongoing improvements in equipment, environment, personnel training and process controls help the company meet the demands imposed by extremely high circuit densities and precise mask-making and fabrication requirements.



*“Bell Helicopter Textron is dedicated to providing products and services that satisfy the requirements and expectations of the user, both internal and external, in a timely manner and at a cost that represents excellent value. We are committed to excellence and shall strive to do our jobs right the first time.”*

L.M. Horner  
President  
Bell Helicopter Textron



General Dynamics

## GENERAL DYNAMICS

Among the advanced techniques at General Dynamics Corporation, robotics is employed at the Fort Worth Division. On F-16 assemblies, robots complete complex drilling and countersinking tasks, gauge holes for rivet grip lengths, apply sealant, install the correct-length rivets, and shave the rivet stems.

One robot, the Canopy Drill/Countersink Robot, is mobile and able to operate unattended for up to 18 hours. Working along a 50-foot track, it performs tasks that would normally require three immobile robots.

Automated inspection devices also keep pace with highly advanced manufacturing technology. Automated theodolites are used for tooling inspection and acceptance, computer-driven CATIA panels are used for surface geometry extraction, and two-dimensional non-contact measuring devices are used to inspect sheet metal.

## TEXTRON

Textron Defense Systems takes pride in its Realtime Radiographic Inspection System. It consists of a 160KV Beryllium Window X-Ray system, Lead Enclosure, and Image Amplification System, with Digital Image processing capabilities. An additional feature is a 3/4" video tape for storage of radiographic images.

The system has been approved

by the Air Force Ballistic Missile Office for production acceptance of two radiographic techniques: bond line inspection of carbon phenolic heatshields to aluminum substructures for the Peacekeeper Re-Entry Vehicle, and in-process inspection of 3D Quartz Antenna Preforms for missing elements.

Textron

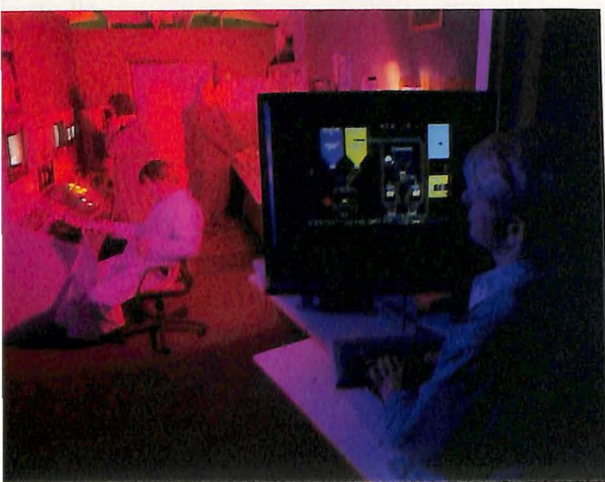




**MORTON THIOKOL, INC.**  
Aerospace Group

At Morton Thiokol's Elkton Division, small components and large rocket motors are examined in the real-time radiographic inspection facility. A Varian L-3000A Linear accelerator and Siefert 420 KVCP tube are used interchangeably with Lockheed's HERTIS (High Energy Real Time Inspection System) imaging system. An image intensifier camera assembly allows for image acquisition in the low-energy spectrum. A computer-slaved, three-axis positioner with a 20,000-pound capacity manipulates the test item.

At the Strategic Operation Division, the on-line HMX Particle Size Analyzer is a major advancement in the grinding industry and in particle size measurement. It is unique in that it allows an automated assessment of the particle size of ground HMX oxidizer, a critical component of many solid rocket propellants, while the material is being ground. It uses a probe-type sampler that transfers the material through a static-free air line to a Micron Control analyzer, which allows the operator to continuously monitor the output of the grinding operation.



Morton Thiokol



The Quality Technology Center at GE Aircraft Engines' Evendale, Ohio, facility works to meet customer needs through support of engines in the field, through development of advanced non-destructive evaluation (NDE) technologies, and through inspection automation. In devising new ways to assure higher quality engines at lower cost, the Center advances visual inspection automation, infrared technology, composite quality technology, and metallic quality technology beyond the state of the art.

Advanced technologies in NDE development include acoustic microscopy, precision robots, microfocus radiography, computerized ultrasonic testing, acoustic emission and holography, plus eddy current and laser metrology.

Visual inspection automation at the center is breaking new ground, and infrared technology is being used for in-process as well as final inspection of engine hardware.



IBM



In a program sponsored by the Department of Defense, IBM Corporation has produced the first fully tested and functional .5-micron Very High Speed Integrated Circuit (VHSIC) chips. The chips are 5.5 x 5.5 millimeters and contain 37,000 equivalent logic gates. Because of VHSIC technology, architectural design and development concepts previously thought impossible can be accomplished, resulting in improved scheduling, cost, quality, and reliability in a variety of defense systems.

IBM is building a family of .5-micron chips for defense-related applications. VHSIC technology is in use for the development of the Common Signal Processor, an all-VHSIC, Ada-programmable data and signal processor that can provide supercomputer-like performance. Additionally, IBM offers software design tools and operating systems to allow rapid prototyping and implementation of VHSIC technology into complex weapons systems.

*"Pretty good is not good enough. Must be the best, must look like the best."*

*"We need to build on our improved performance and dedicate ourselves to the concept of continuous improvement in every area of our operations."*

James R. Nelson, Manager  
Evendale Quality Operation  
GE Aircraft Engines

*"In this time of radical change, the margin for error shrinks as fast as customer expectation grows. We must not only be first in technology; we must also be first in quality."*

Gerald W. Ebker  
IBM Vice President and President,  
Systems Integration Division





Westinghouse



Westinghouse

Westinghouse Electric Corporation controls quality by imbedding computer-integrated manufacturing (CIM) and other advanced technologies into processes throughout the product cycle. Expert systems and computer simulation help prevent design flaws before prototype production. The Nonconformance Reporting System collects, analyzes, and reports product quality information at hundreds of on-line computer stations from purchased components to final system test. Machine vision systems monitor and control the quality of input materials and assembly processes. Westinghouse has developed sophisticated vision controllers for component placement robots to compensate for misaligned leads and to avoid costly rework.

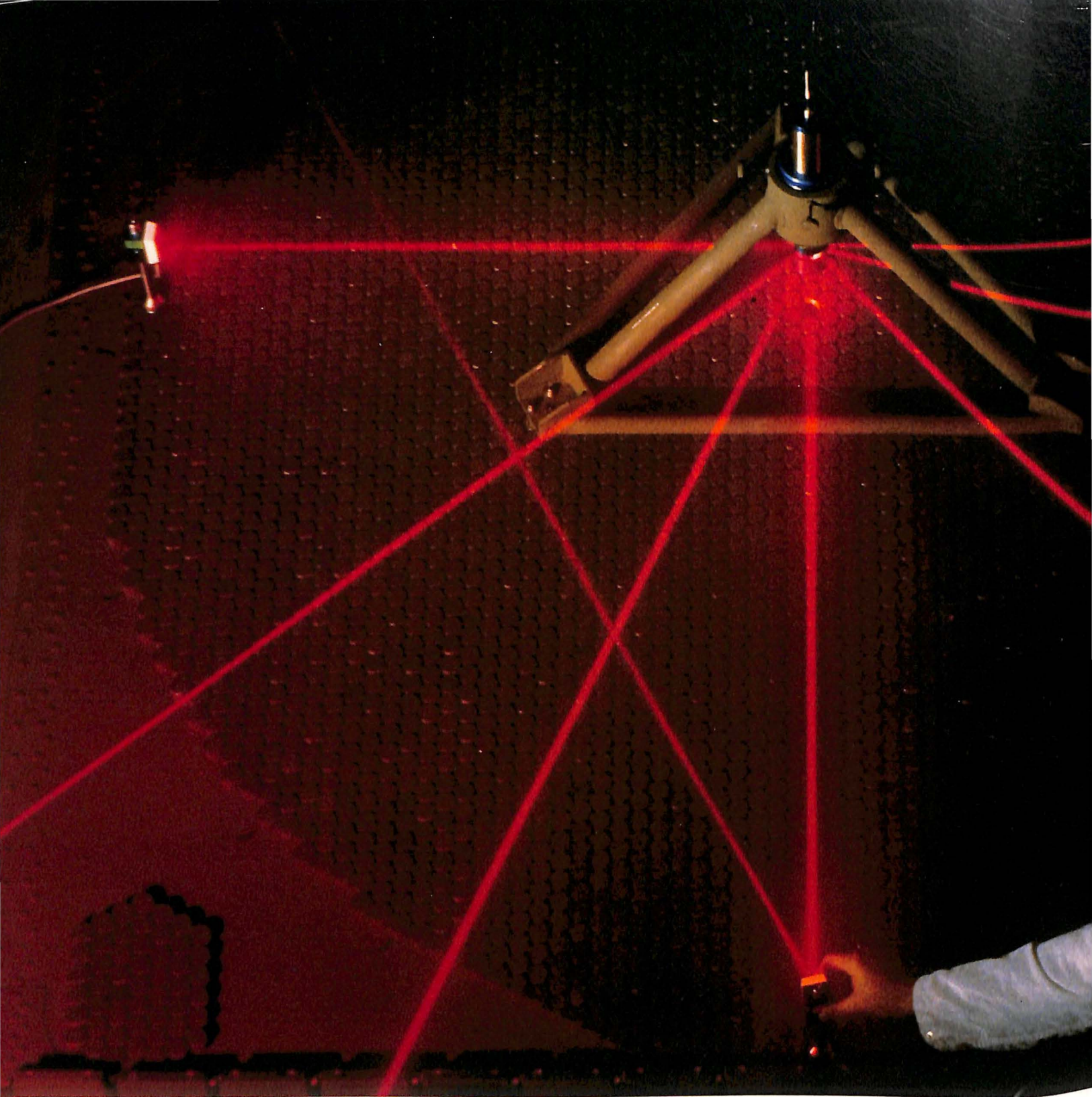


LTV



Rockwell





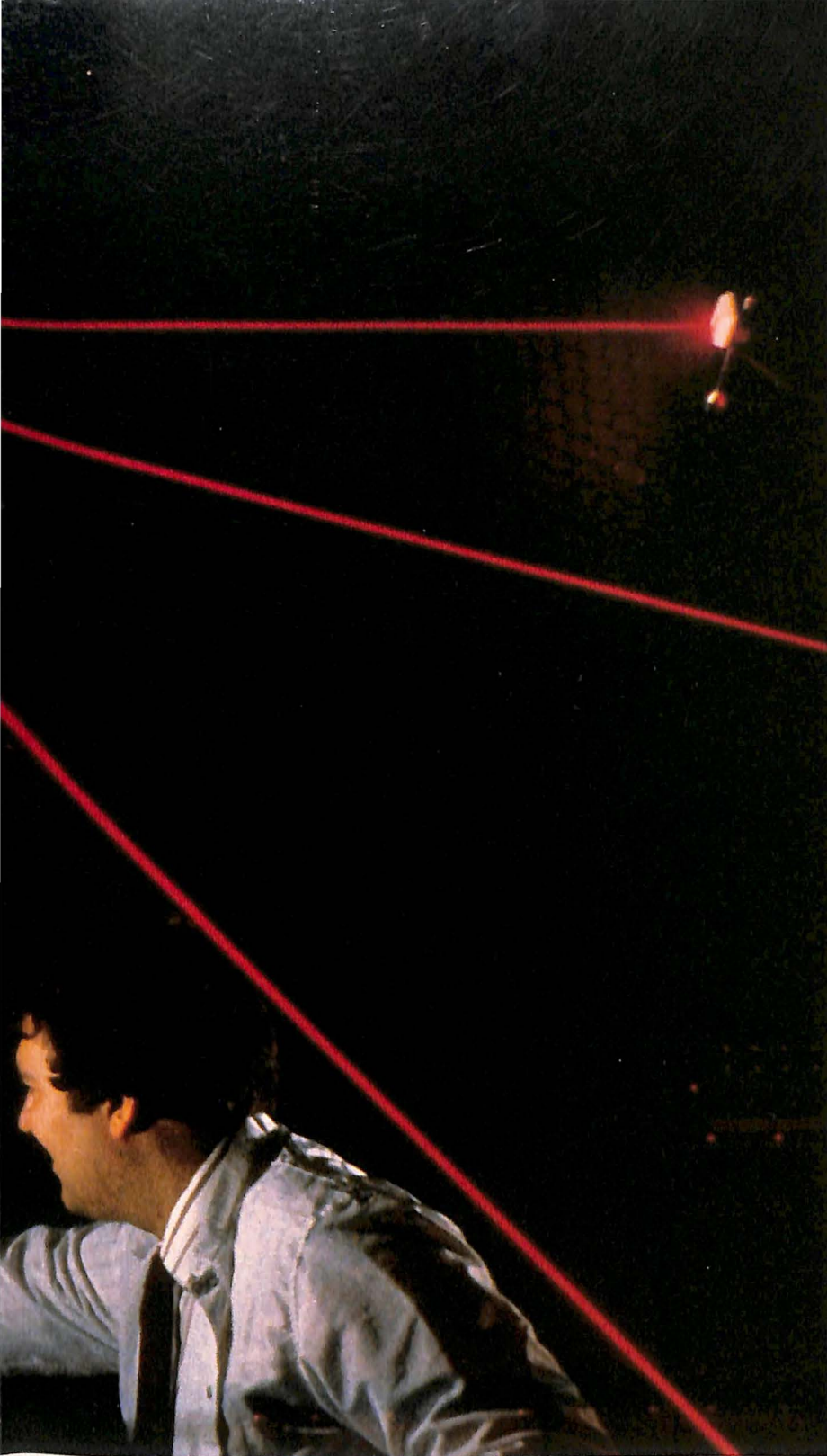
## Raytheon

Raytheon Company's Environmental Stress Screening (ESS) process is applied to all missiles and ground equipment. New equipment is temperature-cycled for 15 cycles at a 15 degrees C/min. rate of change. Then all modules are electrically tested at room temperature, and a sample is tested at high and low temperatures. Cables are temperature-cycled and tested for continuity and insulation resistance. Time-Domain Reflectometry is used for additional integrity-

testing on coaxial and twisted-pair cables. Rack assemblies receive temperature-cycling, vibration, and continuity and leakage testing.

Finally, the complete end item receives ten cycles from -43 degrees Celsius to 50 degrees Celsius at a one cycle/day rate (including four hours at the temperature extremes). The equipment is run during the heat-up and hot part of the cycles. If a fault occurs, the test is halted and the fault is fixed. The operation is continued until the cycle is fault free.





Raytheon

*"Quality depends on many things. Simple things. Fundamental things. Quality depends on the best people; the best designs; using the best materials and components; an extra measure of research, development, and testing; and attention to details. It cannot be inspected into a product or added later. Dedicated people must build it in at every step.*

*Quality has long been the driving force at Raytheon. It is our most important characteristic, and it is what unifies us as a company. To our customer, quality is simple. It is a product that works as the user expects it to when the user needs it."*

Thomas L. Phillips  
Chairman  
Raytheon Company

*"The absolute best business practice is to establish a quality culture that makes continual improvement the way to create greater value for the customer."*

Karl M. Thomas  
President-Manufacturing  
United Technologies  
Pratt & Whitney Corporation



Automation in eddy current, ultrasonic, and fluorescent penetrant inspection operations has improved reliability of aircraft engines manufactured at Pratt & Whitney. Automation of ultrasonic inspection has allowed automatic scan plans for sonic configurations, automatic analysis of the data by the computer, display of the data relative to the

finished configuration, and a means of storing the data on computer storage disks. Presently, parts are reviewed by the inspector only when the results are nonconforming.

Pratt & Whitney has implemented new technology in the area of laser holography. This technology is used to check for dis-bonds between an applied material and its base.



Pratt & Whitney



# STATISTICAL PROCESS CONTROL [SPC]



ITT Avionics

## HARRIS

At Harris Corporation, SPC meets internal requirements to assure that all end users will be satisfied. Managers and workers become mutual support teams using simple statistical methods to define problems, measure progress, and produce hard evidence of bottom-line results.

Harris participants quote the numbers with pride:

- In a semiconductor manufacturing process with a baseline of 100, output went from 80 to 177 in less than one year—a doubling of manufacturing capacity with no capital investment and no additional personnel.
- A 75-percent reduction in rework of semiconductor products was achieved over the same period.
- In Harris Government Systems Sector, SPC and problem-solving techniques such as Pareto analysis, cause and effect analysis, brainstorming, and functional analysis have contributed to savings in excess of \$20 million over the last three years through improvements in inventory, accounts payable procedures, and reports management.

## AVIONICS

At ITT Avionics, the SPC program is oriented toward the operator, who collects data to identify specific causes of process variation and establish control by eliminating the sources of variation. The operator is the key member of a process improvement team that includes engineering, quality control, and supervisory personnel.

An advanced part of the program is the use of Taguchi methods of statistical design and analysis. The methods optimize production processes and product design by minimizing sensitivity to all external noise and manufacturing variation factors.

Benefits derived from SPC range from dramatic reduction in defects, scrap, and rework to increases in efficiency, productivity, and product quality. The program facilitates communication and creates an environment of teamwork within organizations.



## Lockheed

Statistical methods are used by all Lockheed Corporation companies and divisions to varying degrees, especially in the analysis of non-conformance and quality cost data. CalComp and Sanders are using several forms of statistical control charts internally, and externally with suppliers, as an integral part of their World Class Manufacturing and Centers of Excellence programs. These tools are used by operating and management personnel in conjunction with Just-In-Time, Dock-To-Stock, Total Quality Control, and Total Preventative Maintenance programs. The results are a reduction of inventory, shortening of manufacturing span times, reduction in manufacturing and inspection costs, and an increase in product quality.

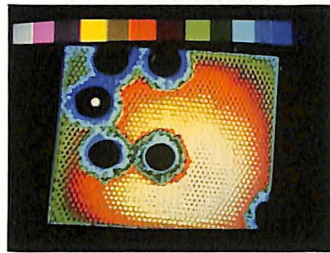
At the Lockheed Missiles and Space Company, Missile Systems Division, the use of statistical methods is extensive on the Trident II fleet ballistic missile program. The focus is on process control. The use of flow diagrams, failure modes and effects, corrective action analyses, and product-process matrices results in the identification of critical process parameters which are then subject to statistical control.



## Raytheon

SPC is receiving company-wide attention at Raytheon Company. Last year the corporate position of Director of Statistical Analysis was created to give additional thrust to Raytheon's multi-divisional SPC initiative. Corporate-wide Product Assurance Managers' Meetings have advanced the latest initiatives in SPC activity. Extensive SPC training is under way in many manufacturing activities. Several divisions have advanced programs, and, with thorough corrective action, they have been able to reduce scrap and rework as well as increase in-process yields.

Raytheon recognizes the synergism that accrues from harmonizing engineering design with manufacturing technology through the application of transition techniques. SPC is a key ingredient to ensure that manufacturing yields achieve the anticipated thresholds expected by design and manufacturing professionals during the development phase of a program. It is this close attention to good manufacturing practices and transition fundamentals that achieves desired objectives in quality and reliability.



## MORTON THIOKOL, INC.

Aerospace Group

SPC at Morton Thiokol Aerospace Group's Strategic Operations extends from the floor to engineering, and through the ranks of upper management. Measured characteristics are maintained in a data base capable of being extracted at any office or work station, in the form of a statistical control chart. Operators, engineers, and managers therefore share a common data base for identification of trends or confirmation of process stability.

When immediate visibility is required, on-line control charts are maintained for assessment and adjustment of critical processes.

The system at Strategic Operations has resulted in a substantial reduction in nonconformances. Major new programs now in development have achieved a rate of less than four-tenths of a nonconformance per year of labor.

*"Quality today means satisfying the customer's expectations in terms of performance, reliability, maintainability, delivery, and cost. Quality is the key to productivity, and results from a marriage of design and manufacture. Capital investment by Morton Thiokol in engineering, automation, and statistical process assessment is contributing to the assurance of quality in today's aerospace products."*

U.E. Garrison  
Vice President,  
Aerospace Group  
Morton Thiokol

*"Quality doesn't increase cost—it decreases it. Quality performance in any job is translated into lower costs, reduced cycle time and improved customer satisfaction."*

John T. Hartley  
Chairman,  
President & Chief Executive Officer  
Harris Corporation



Morton Thiokol





**MARTIN MARIETTA**

Using a theme of “Do it right the first time” and prevention-based instead of detection-based quality, Martin Marietta Corporation has established process controls that approach error-free performance. Processes that have been certified to produce products well within tolerance limits have reduced the need for final product inspection. Only the process control charts—demonstrating that the process was under control for the key characteristics of the product—need to be reviewed to guarantee that a proper product is being built.

Control by the worker has resulted in reduced costs because of less activity from production control, quality engineering, and the other quality control organizations.

Martin Marietta



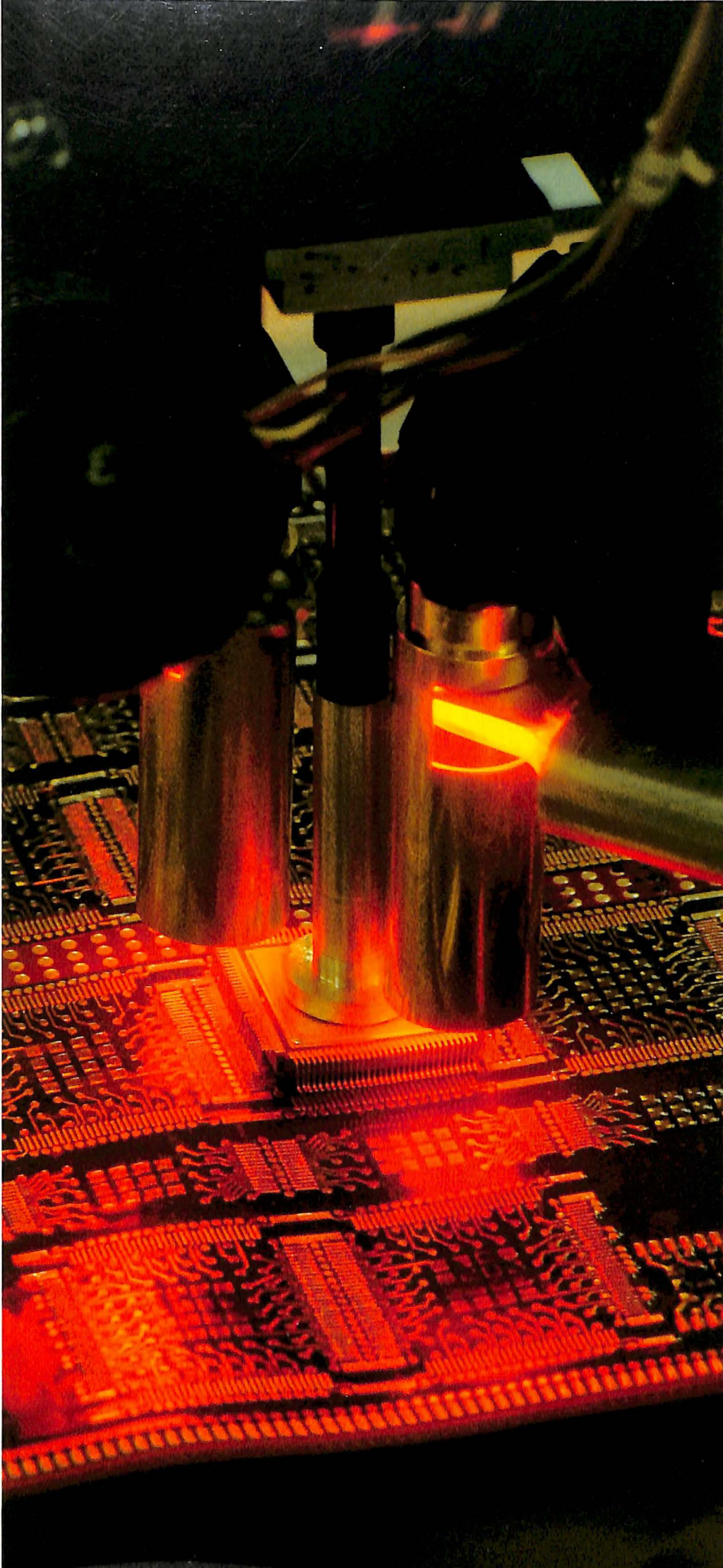
At its Hooksett, N.H., facility, GE Aircraft Engines uses SPC in the complex production of blisks, components in compressor rotors used on T700 and CT7 helicopter engines. SPC tolerancing allows realistic drawing limits to be applied when process capability is known and proven to be stable. The complexity of the process demands 540 control charts that must be generated and monitored. An on-line computer-aided statistical process control system (CASPER) was developed to perform the functions automatically. CASPER software builds a

file by work station, drawing number, characteristic, and date milled. It then calculates critical data for the process control tolerancing. If critical conditions are not met, the system warns engineers who can determine if the process is out of control and if the work station must be shut down to begin a corrective action program.

Automated SPC has reduced scrap and rework, improved quality and throughput rates, reduced dimensional variation and the number of discrepant characteristics, and saved money.







Westinghouse

At Westinghouse Electric Corporation, statistics are no-nonsense tools for a tough business environment. Widespread applications are critical to promote quality awareness, problem prevention, and process enhancement. Even before pre-production runs, the VHSIC process development team begins statistical analysis of alternative circuit designs and advanced assembly technologies to optimize producibility. For production, statistical controls have been imbedded within automated assembly equipment to achieve design tolerances beyond the limits of human capability.

#### GENERAL DYNAMICS

SPC is receiving a corporate-wide thrust at General Dynamics Corporation. The program will encompass all functions and will be operated by committees to ensure uniformity and proper documentation of resultant cost savings.

At most General Dynamics divisions, SPC is being incorporated in two phases. First, quality personnel train employees in techniques, perform initial capability studies, and determine the number and types of control charts. In the second phase, the program is turned over to the applicable line function for continuous operation.

The Fort Worth Division has assumed the leading role within the corporation for the variability reduction process (VRP), which is a cornerstone of the U.S. Air Force's reliability and maintainability 2000 Initiative. VRP integrates SPC with off-line methods such as Taguchi analysis techniques and quality function deployment to design reliable products and capable manufacturing processes that are fully responsive to customer requirements.





TRW

*“Continuous improvement is the mark of a successful company. Statistical process control and employee involvement are the keys to successful improvement efforts at E-Systems, Greenville Division.”*

B.D. Cullen  
 Vice President and General Manager  
 E-Systems, Greenville Division

## AEROJET GENERAL

A GenCorp COMPANY

Aerojet ElectroSystems Company developed a computer-assisted data acquisition and trend analysis system that provides an early alert for defect and failure trends during the manufacture of complex microcircuit components.

The computer tracks test station results, pass/fail results, failure symptoms, replaced parts, defects per unit, and performs hundreds of analytical operations—within seconds.

The result is a system that provides management with such a high degree of performance predictability that corrective action can be ordered in near real-time.



Aerojet General

## E-SYSTEMS

The basic tenets of SPC at E-Systems, Inc., are: internal and external customers have a right to expect quality products and services; each phase of a process has a customer—the next phase of the process; SPC is the primary tool used to measure and communicate the reliability of each process; and all workers and all systems should be able to perform their intended functions.

There is an evolving commitment to the philosophy of Dr. W. Edwards Deming, including his 14 Points, and immediate, positive results have been seen. SPC promotes the development of people by encouraging them to exercise their leadership and interpersonal skills as they are involved in individual and team improvement activities. Team members and leaders include production employees, engineers, and vice presidents. Numerous improvements in quality, cost, and scheduling are occurring in manufacturing areas because of SPC.





General Dynamics

## CONTROL OF PURCHASED MATERIALS

“Our Quality focus is for continuous improvement of our systems and processes for the purpose of not only meeting our customers’ specifications, but also of providing our customers with the best reliability and maintainability that we can—and doing it at the lowest cost.”

Stanley C. Pace  
Chairman and  
Chief Executive Officer  
General Dynamics Corporation

### HARRIS

Because nearly 50 percent of a system’s cost is driven by supplier performance, the internal continuous improvement policy at Harris Corporation was extended to the supplier community.

A supplier rating system, which qualifies delivery and product compliance results, was established to guide source selection. The continuous review process has resulted in a smaller but better-qualified sup-

plier base, improved communication of requirements, and improved performance feedback. It has also established the basis for long-term relationships with critical commodity suppliers. Suppliers demonstrating consistent excellence in performance will be targeted for certification. This program has already helped reduce the incoming reject rate by 50 percent.



IBM





Lockheed

## Lockheed

Lockheed Corporation suppliers are selected on the basis of performance and price, and an approved supplier must have a satisfactory quality rating. Quality surveys and audits of suppliers are performed before and after contract awards. When dictated by product complexity, Lockheed resident representatives oversee the quality systems at the supplier's facility.

The Missile Systems Division uses certified lines to control purchases. Representatives at the supplier's facility assure that conditions and manufacturing processes are uniform at critical points in the fabrication cycle. This concept, originally used in the manufacture of semiconductors, is applied to all tactical electronic devices in the Trident II program. Suppliers selected for the Dock-To-Stock program at CalComp have their products shipped directly to the production floor, without the need for receiving inspection or functional tests.

*“Whether you’re making a presentation, building a part, writing a report, or running a test, you are performing a value-added function. Improvement in the quality of your value-added task is how you can play a daily role in the Total Quality Improvement Program.”*

L. A. Wilson

*Director of Product Assurance and Safety*

*Lockheed Aeronautical Systems Company-Georgia Division*



E-Systems

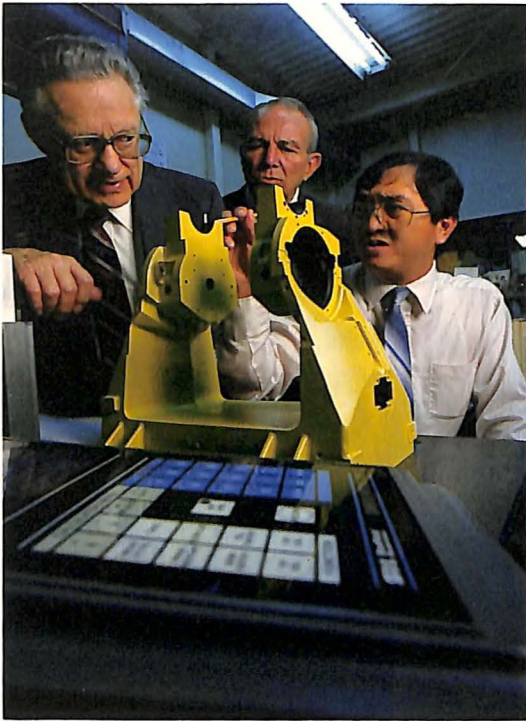
## E-SYSTEMS

Control of purchases at E-Systems, Inc., begins with a review of contract requirements and material requisitions to assure that all pertinent quality requirements are provided to suppliers. Although each division of E-Systems has its own procedures for quality assurance of purchases, a common data base of supplier performance surveys is available for use. Each division exercises its prerogative to rely on the data base or perform a separate survey for unique requirements. In addition, a vendor rating system is used to monitor performance to quality standards. Source inspection records, receiving inspection records, and manufacturing shop rejections provide data to evaluate suppliers and establish a closed-loop corrective action system.





Westinghouse



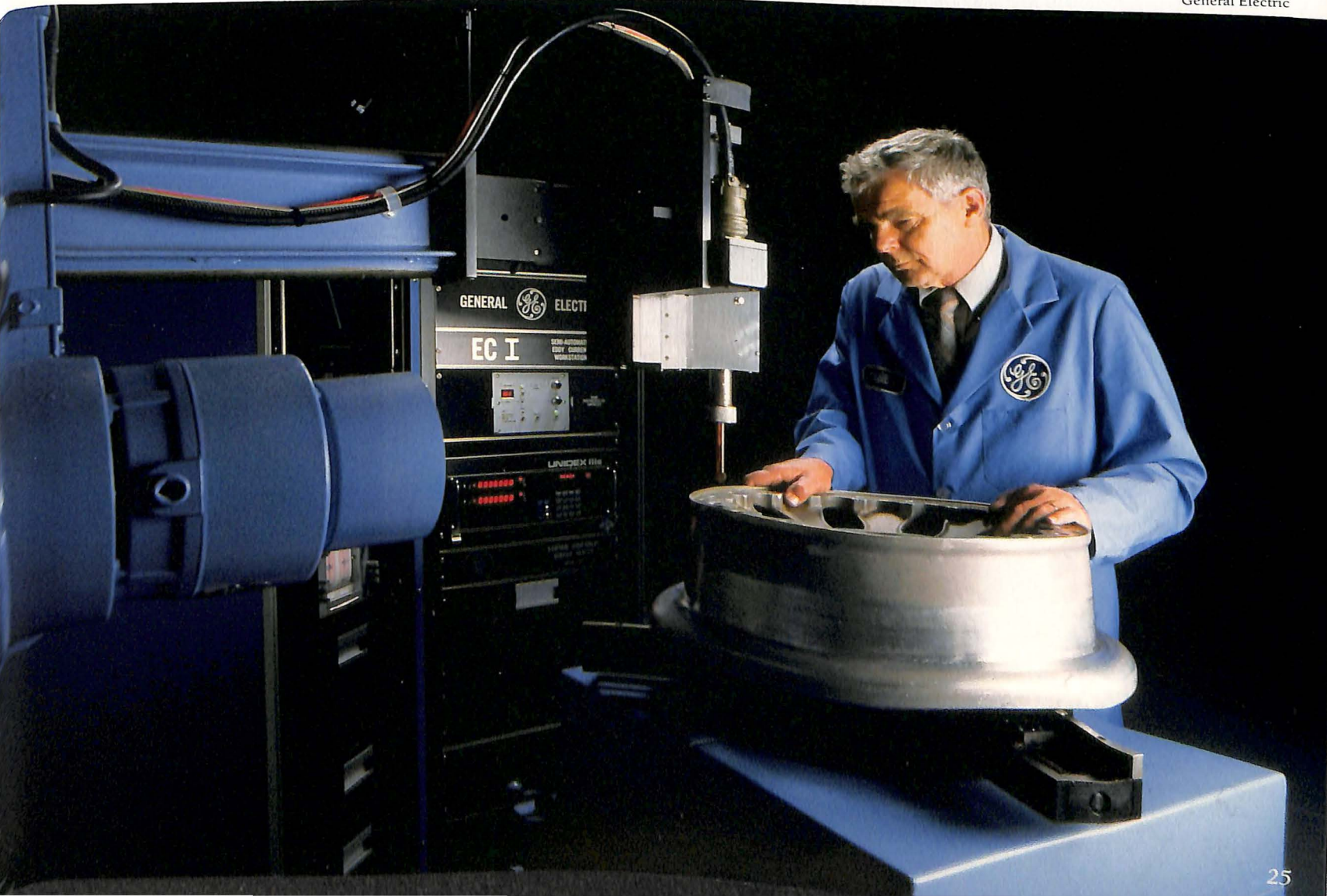
Westinghouse

A radically new concept in design for manufacturability electronically links Westinghouse Electric Corporation designers with subcontractor manufacturing equipment. Computer representatives of mating and moving parts are designed and tested in a software environment called a solid modeler. The solid modeler warns designers of potential fitting interference problems on subassemblies and finished hardware. Electronic design data from the modeler is fed directly into the subcontractor's machine tool, eliminating drafting, data input, and programming errors. The Coronet Prince Electro-optical Countermeasure System used this approach on machined parts with clearances and tolerances as small as two ten-thousandths of an inch. Every moving part operated without interference in the first assembly ever built.

*"Total quality is performance excellence in assuring customer satisfaction. . . . It is the focus of everything that we do."*

R. A. Linder  
President  
Electronic Systems Group  
Westinghouse Electric Corporation

General Electric







LTV

*"It is our policy to promote pride and excellence in each employee's performance and to deliver products and services which conform to the requirements of our customers."*

Billie M. Smith  
 President  
 LTV Aircraft Products Group



LTV Aircraft Products Group controls supplier quality with the aid of data in a real-time, computerized system. From the data, supplier-performance reports are generated as necessary, but they are evaluated at least annually and a five-year history is maintained. Reports identify open or overdue actions, repetitive problems, and corrective actions. Purchase orders, also in the computer system, will not be placed with suppliers who fail to provide appropriate corrective action.

The Supplier Performance Improvement Program is LTV's way of rating suppliers as a ratio of dollars lost (resulting from defective materials, products, or services) to dollars spent. These figures are used to adjust the supplier's quote for new orders. LTV gives certificates of achievement to suppliers with zero dollars lost. Since 1981, there has been a reduction of 56 percent in average dollars lost. Presently, 99.7 percent of suppliers' materials are acceptable.



Rockwell International Corporation has increased productivity and supplier performance by developing a method of measuring that performance and using data to motivate suppliers. At the core of its program is the use of Quality Cost Indexes that reflect the true cost (including nonproductive costs) of buying from a specific supplier.

The Rocketdyne Division motivates suppliers through conferences, workshops, teams of Rocketdyne

and vendor personnel, awards, posters, and other communicative materials. Speakers at conferences include Rockwell executives and employees, leaders of major government programs, and astronauts. Various recognition programs and awards provide performance feedback to suppliers. Documentation shows an increase in the acceptance rate of first-time deliveries in all procured hardware and services.



Rockwell





To improve its relationships with suppliers, Pratt & Whitney has a program called Supplier Teams. It involves the creation of joint councils whose members include representatives from key suppliers and P&W purchasing, engineering, and quality assurance departments. The members' collective task is to reduce supplier nonconformances.

Partners in Performance is a program to make suppliers aware of the importance of their work to the overall performance of the end product. Day-long seminars that include VIP treatment, customer pilots, quality assurance, purchasing, and supplier management impress on all supplier personnel the necessity of "Quality First."

## Raytheon

Raytheon Company purchases parts and material exclusively from qualified vendors. Before a vendor can become qualified, a pre-award survey is conducted. It ensures that a Quality Control System, commensurate with the complexity of the item to be supplied, is in place, and that the resources and experience required to produce the item are available.

To fully benefit from this source selection process, Quality Control maintains a Qualified Vendor List (QVL) which is provided to the Purchasing departments. In addition, Quality Control reviews all purchase requisitions and purchase orders to ensure compliance with the QVL.

One of the unique tools Raytheon uses is a company-wide method for conducting Vendor Quality Systems Surveys (VQSS). A corporate policy spells out an approach whereby periodic vendor surveys ensure no degradation in a supplier's performance has occurred, even though the problem might not have been identified during incoming inspection. Using a common survey form, one audit serves the requirement for all Raytheon needs. The results of the audit are centrally managed and the information is available to all Raytheon manufacturing activities.

## TEXTRON

At Textron Defense Systems, reliable suppliers are identified by vendor capability surveys. Success with printed wiring boards caused this program to be expanded to other products, resulting in improved hardware and better delivery times.

A computerized system called Dock to Stock keeps track of all incoming materials and their inspection instructions. The system allows instant access to inspection instructions by simply entering a part number.

The surveys and Dock to Stock system are integrated with vendor surveillance and line-failure and field information to form a basis for the vendor rating system and the self-release program. The self-release program minimizes inspection for qualified vendors while still assuring the quality of the product, thereby reducing costs.

Bell Aerospace Textron maintains an integrated quality data base on all purchases. It consists of an approved supplier list, supplier performance history, source acceptance data, and on-site survey results. Only suppliers with a continuously acceptable quality level of performance are selected.

## AEROJET GENERAL

Believing that quality starts with communications, Aerojet Tech-Systems Company instituted "Cross-talk" to exchange ideas and resolve glitches in procurement and incoming inspection systems. During Phase One, materiel personnel are taught the philosophy of quality, quality requirements, and the nuts and bolts of the quality system. During Phase Two, quality and materiel representatives go to suppliers to explain how Aerojet does business. With the goal of improving the quality of incoming hardware, Aerojet feels that "Cross-talk" will reduce discrepancies and costs.

Aerojet Ordnance Company's Certified Supplier Program involves an on-site survey of a potential supplier's production quality capabilities and requires an approved SPC plan. After a 100-percent quality conformance rate for a six-month period, the subcontractor can qualify as a Certified Supplier. Subsequent lots are accepted on the basis of inspection and statistical evidence that the manufacturing processes are in control. After monitoring and evaluating their performance, Aerojet formally and publicly recognizes the achievements of its suppliers.



Textron



*"We're committed to a company-wide process to improve the quality of our work across the board. We realize that yesterday's standards of quality aren't good enough today and today's won't be good enough tomorrow—and we understand Secretary Carlucci when he says, "The DOD budget leaves no room for solving problems that flow from poor quality."*

John O'Brien  
Chairman and Chief Executive Officer  
Grumman Corporation



Grumman

## GRUMMAN

Six thousand Grumman Corporation manufacturing people now participate in a program called Master Craftsmanship. They are organized into teams that compete for prizes based on their performance against monthly defect reduction goals. Additionally, teams compete for annual awards based

on a rework target derived from the previous year's performance. When a team performs at a rate better than its target, the members divide 25 percent of the savings among themselves.

In 1987, the winning team saved \$133,600 in rework, and the team members split \$33,400 after taxes.



Pratt & Whitney



## GENERAL DYNAMICS

Employee-suggested fliers, posters, brochures, and slogans are used at General Dynamics Corporation to foster quality awareness. Improved quality and productivity are promoted through employee participation in Cost Reduction Initiatives, Employee Suggestions, Good Design/Fine Workmanship Awards, Value Engineering Change Proposals, and related savings and recognition programs. At the Fort Worth Division, cost reductions saved \$138 million during the first half of 1988, and employee suggestions saved another \$7.9 million.

Intensive training, as an integral part of the Quality Improvement Program (QIP), is practiced throughout the corporation. QIP was introduced to 118 executives during a corporate-wide seminar conducted by quality mentor Dr. J. M. Juran. This same training was then repeated for top- and mid-management personnel. The training continues today through formal classroom sessions, orientation programs, film and video presentations, task team meetings, and quality awareness publications—all designed to promote a positive atmosphere for quality improvement among salaried and hourly employees.



Quality Circles that meet on company time for one hour a week have produced tangible results for six years at ITT Avionics. One group revised a record-keeping system, another changed the method for testing printed circuit boards, and another suggested revising a semi-rigid cable production method—all for a total savings of \$424,000.

Intangible results are improved morale, reduced employee turnover, enhanced organizational communications, and a work force that has increased ownership and pride in its job.

## AEROJET GENERAL

A GENCORP DIVISION

At Aerojet TechSystems Company, a creative, motivated, properly trained work force is the key to reducing product cost and improving quality. In the company's Value Management Program, employees receive value analysis training which they use to study product design, processes, and procedures. The value management technique identifies unnecessary costs and focuses on removing these costs from the product.

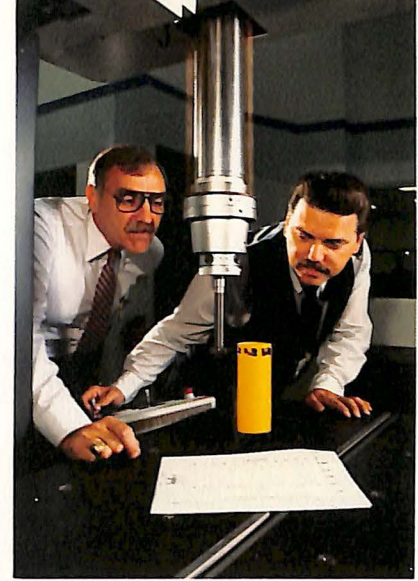
This organized approach enables employees to identify and creatively solve problems while maintaining the overall objectives of reducing cost and producing a product that retains or exceeds the level of quality specified by the customer. In the first half of 1988, Value Management ideas yielded \$5.1 million in cost reductions for the Titan IV Propulsion Program alone.

## E-SYSTEMS

In addition to excellent benefits, employees at the E-Systems Greenville Division have numerous opportunities to become true "E-Teamers."

There is an outstanding Suggestion Program. During 1987, 802 employee suggestions were submitted, resulting in \$369,000 in net savings. The company also recognizes sustained perfect attendance, and it recognizes superior performers through the "E-Teamer of the Month" and "E-Teamer of the Year" programs.

At E-Systems, a number of training courses are specifically designed to prepare employees for the work they perform. The Leadership Development Program promotes development of employees with high potential for future management roles. The Production Supervisors Course trains new supervisors in management systems and the technical aspects of their environments, and the Statistical Process Control Course allows employees to study leadership and management philosophies as well as the statistical methods for improving operations.

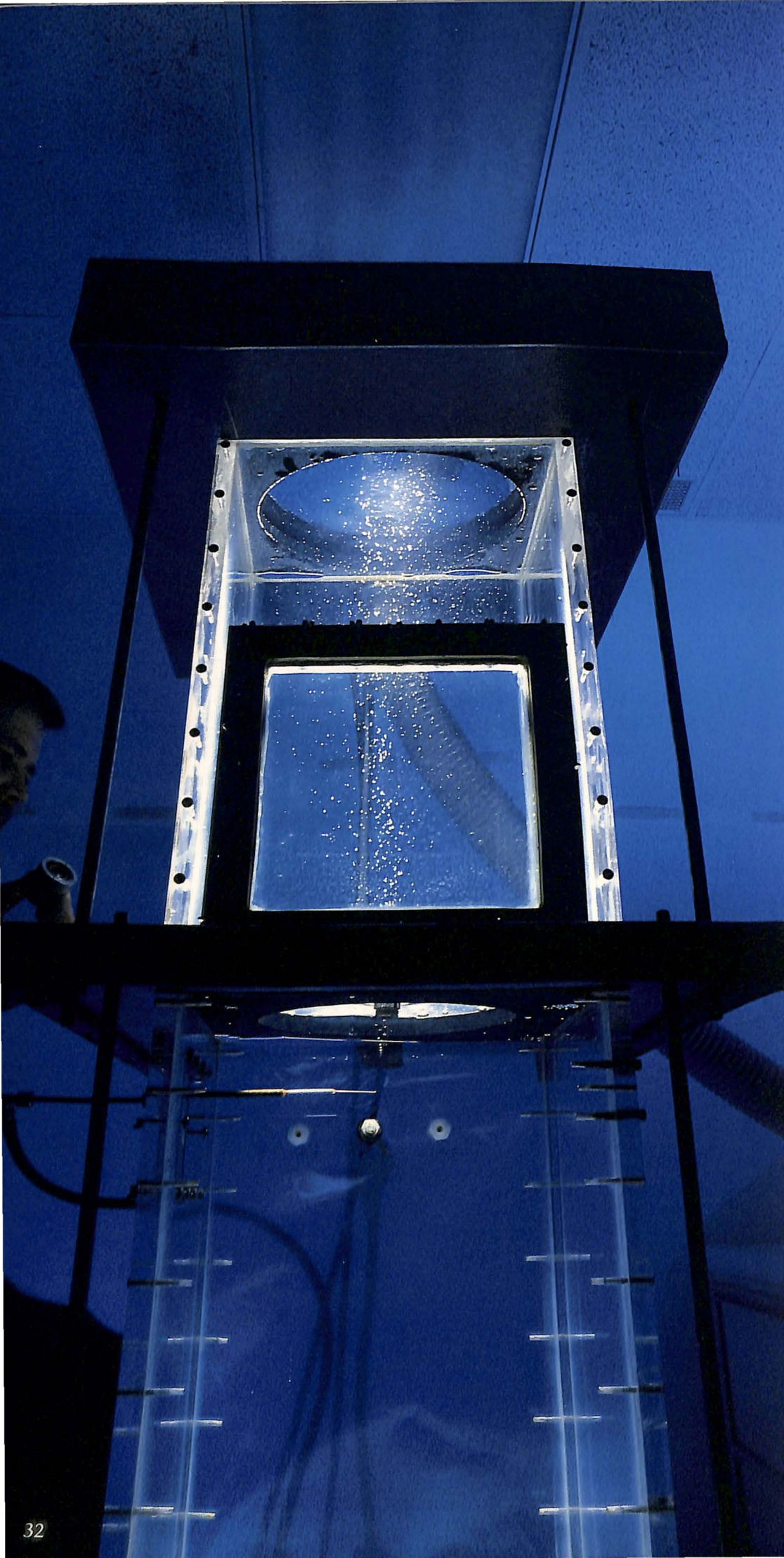


Aerojet General

*"At Aerojet, each one of our 8,000 employees is a quality inspector. Each is personally involved in constantly reviewing his or her own work as part of Aerojet's company-wide individualized program. Our commitment is to provide the highest quality in all of our business segments, and our employees are well aware of that."*

George Leisz  
President  
Aerojet General





## **TEXTRON**

Bell Helicopter's Quality Improvement Process encourages participation through awareness campaigns, suggestion programs, and cost awareness initiatives.

One of the most powerful means of improvement is Bell's use of Excellence Teams, which are based on the belief that individuals want to contribute to decisions that affect their work. Excellence Teams work to improve both administrative processes and hardware products.

Bell Aerospace Textron is fully committed to the importance of people in the quality improvement process. Employees grow in skills and knowledge through education and training. Current programs include personal computer skills, hi-reliability soldering, microcircuit workmanship, and leadership training. Cooperating with local universities and community colleges, Textron offers graduate-level engineering and specialty courses.



The Performance Management, Recognition, and Rewards process, part of Pratt & Whitney's Q Plus initiative, is a collaboration between supervisor and employee to plan, monitor, and assess the employee's performance. The process supports individual development and rewards performance.

Another program is Positive Employee Relations Leadership (PERL), designed to develop leadership and participative management. In the PERL culture, people see themselves as key to the overall success of the organization. Communication lines are open; risk-taking, candor, and teamwork are encouraged.



# AIA MEMBERS

Aerojet General

Aeronca, Inc., A Fleet Aerospace Company

Allied-Signal Aerospace Company

Aluminum Company of America

Argo-Tech Corporation

B.H. Aircraft Company, Inc.

The Boeing Company

Celion Carbon Fibers  
A Division of BASF Structural Materials, Inc.

Colt Industries Inc

Chandler Evans Inc

Menasco Inc

Delavan Corporation

Lewis Engineering

E-Systems, Inc.

Fairchild Industries/Fairchild Space Company

FMC Corporation

General Dynamics Corporation

General Electric Company

General Motors Corporation

Hughes Aircraft Company  
Allison Gas Turbine Division

The BF Goodrich Company

Grumman Corporation

Harris Corporation

Heath Tecna Aerospace Company

Hercules Incorporated

Hexcel Corporation

Honeywell Inc.

IBM Corporation  
Systems Integration Division

IC Industries  
Pneumo Abex Corporation  
Abex Aerospace Division  
Cleveland Pneumatic Company  
National Water Lift Company

The Interlake Corporation

ISC Defense & Space Group, Inc.  
ISC Marquardt  
ISC Defense Systems  
ISC Cardion Electronics  
ISC Electro-Magnetic Processes  
ISC Datacom/Microwave

ITT Defense Technology Corporation

Kaman Aerospace Corporation

Lockheed Corporation

The LTV Corporation

Lucas Western Inc.

Martin Marietta Corporation

McDonnell Douglas Corporation

Morton Thiokol, Inc.

Northrop Corporation

Parker Hannifin Corporation

Precision Castparts Corporation

Raytheon Company

Rockwell International Corporation

Rohr Industries, Inc.

Sundstrand Corporation

Teledyne CAE

Textron Inc.

TRW Inc.

United Technologies Corporation

Westinghouse Electric Corporation  
Electronic Systems Group

Wyman-Gordon Company







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