GEORGE M. LOW TROPHY
NASA'S QUALITY AND EXCELLENCE AWARD

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1990 RECIPIENTS

Large Business Category
ROCKWELL INTERNATIONAL CORPORATION
SPACE SYSTEMS DIVISION

Small Business Category
MAROTTA SCIENTIFIC CONTROLS, INC.

Sponsored by the
National Aeronautics and Space Administration
Office of Safety and Mission Quality
NASA Quality and Productivity
Improvement Programs Division

with the assistance of the
American Society for Quality Control

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Contents

INTRODUCTION

George A. Rodney
Associate Administrator,
NASA Office of Safety and Mission Quality

NASA's major goal is the preservation of America's position as a leader in the aerospace industry. To maintain that status, it is crucial that the products and services we depend upon from NASA contractors, subcontractors, and suppliers meet the highest quality standards to ensure the space program's success.

The George M. Low Trophy: NASA's Quality and Excellence Award is the result of NASA's desire to encourage continuous improvement and Total Quality Management (TQM) in the aerospace industry and is awarded to members of NASA's contractor community that have demonstrated sustained excellence, customer orientation, and outstanding achievements in a Total Quality Management (TQM) environment. The purpose in presenting this award is to:

- increase public awareness of the importance of quality and productivity to the nation's aerospace industry and the nation's leadership position overall;
- encourage domestic business to continuously pursue efforts that enhance quality and increase productivity which will strengthen the nation's competitiveness in the international arena;
- provide a forum for sharing the successful techniques and strategies used by applicants with other American organizations.

The benefits the applicants derive from participation in the award program are shared by an even broader business community. This award provides a unique learning environment for all organizations that seek to improve their products and services. Notably, benefits are reaped from the learning experience of applicants that assess themselves against the criteria, develop strategies to improve, and then willingly share not only the successful strategies, but also the lessons learned from approaches that failed. The insight provided from both perspectives has been invaluable to quality improvement.

This publication of "Highlights" is another indication of NASA's commitment to the continuous improvement process. It is designed to transfer the successful strategies that were used by Rockwell Space Systems Division and Marotta Scientific Controls, Inc., in their pursuit of quality performance at all levels in each company's organization. Both companies have provided a road map for others to follow.

We encourage other organizations to use the ideas, tools, and strategies provided in this publication to further America's quest for excellence.

F O R E W O R D

Admiral Richard H. Truly
NASA Administrator

NASA's commitment to quality is based on our conviction that continuous quality and performance improvement, both in products and in services, is the only mechanism or strategic device that will help America maintain its leadership position in the aerospace industry, the domestic marketplace, and the international arena. NASA is not alone in this commitment to excellence. The ranks of organizations that share the same belief have increased immeasurably as companies have embraced the Total Quality Management (TQM) philosophy and employed quality and productivity improvement strategies that provide substantial benefits. To promote excellence in the aerospace industry, NASA annually presents the George M. Low Trophy: NASA's Quality and Excellence Award to those aerospace companies—both large and small—whose products and services exemplify the highest standards in American business.

I want to thank all the contractors that participated in the 1990 award process. More than just applicants, these organizations belong to a growing corps of businesses that strive for continuous improvement in every endeavor. I extend my special congratulations to Rockwell Space Systems Division and Marotta Scientific Controls, Inc., the award recipients of the 1990 George M. Low Trophy. Both organizations have demonstrated that quality, safety, and reliability built into products and services provide the key to mission success for NASA, for the space program, and for America.

NASA congratulates these two organizations and encourages the entire NASA/contractor team to commit to the standards of excellence demonstrated by these award winners.

Total Performance Improvement at Rockwell's Space Systems Division

The Apollo command and service modules that first took men to the moon . . . the experimental X-15 plane . . . the reusable space shuttle orbiters. Rockwell International's Space Systems Division (SSD) has been privileged to work with NASA on some of America's most important space programs. This rich legacy of manned space-flight programs is the foundation for SSD's spirit of commitment and teamwork.

SSD is involved in several NASA enterprises. However, the space shuttle program in particular reflects many of the division's roles and capabilities:

- Designing, building, and testing the fleet of shuttle orbiters.
- Helping NASA integrate shuttle system elements.
- Maintaining the technical integrity and configuration of the operational orbiters.
- Providing other shuttle services like cargo integration, logistics support, launch operations support, mission planning, crew training, and ongoing engineering support.
- Investigating space products and services associated with shuttle missions.

The range of these past and present programs is a hallmark of the Space Systems Division. Not only does SSD design, produce, and operate unique and complex spacecraft, it also coordinates vast, multi-disciplinary efforts.

After three decades of participation in NASA's manned space projects, it's easy for SSD employees to care about the products they design and build. Of all American products, the shuttle might have the highest recognition quotient, both nationally and internationally. SSD employees identify strongly and proudly with such a product, and they understand the need for uncompromising commitment to quality.

FIGURE 1

ROCKWELL CREDO

We believe maximizing the satisfaction of our customers is our most important concern as a means of warranting their continued loyalty.

We believe in providing superior value to customers through high-quality, technologically advanced, fairly priced products and customer service, designed to meet customer needs better than all alternatives.

We believe Rockwell people are our most important assets, making the critical difference in how well Rockwell performs; and, through their work and effort, separating Rockwell from all competitors.

We believe we have an obligation for the well-being of the communities in which we live and work.

We believe excellence is the standard for all we do, achieved by encouraging and nourishing:

- Respect for the individual
- Honest, open communication
- Individual development and satisfaction
- A sense of ownership and responsibility for Rockwell's success
- Participation, cooperation, and teamwork
- Creativity, innovation, and initiative
- Prudent risk-taking
- Recognition and rewards for achievement

We believe success is realized by:

- Achieving leadership in the markets we serve
- Focusing our resources and energy on global markets where our technology, knowledge, capabilities, and understanding of customer needs combine to provide the opportunity for leadership
- Maintaining the highest standards of ethics and integrity in every action we take, in everything we do

We believe the ultimate measure of our success is the ability to provide a superior value to our shareholders by balancing near-term and long-term objectives to achieve both a competitive return on investment and a consistent increase in market value.

Our challenges have more to do with coordinating continuous total performance improvement. That's quite a challenge, considering the range of SSD's activities and the size of its work force. From 1987 through 1989 alone, SSD had 28 NASA contracts representing extremely varied efforts, mainly focused on shuttle-related support. Six different NASA centers in six different states sponsored the contracts. About 12,000 SSD employees in five different states—along with hundreds of subcontractors scattered across the nation—did the work that earned the 1990 George M. Low Trophy: NASA's Quality and Excellence Award.

SSD's productivity and product quality improvement activities were formalized in 1982. The road from there to 1990 was one of incremental improvement, learning, and growth—along with occasional bumps and potholes. We began self-appraisal of our productivity and product quality improvement (P&PQI) processes and achievements in late 1984.

Before receiving the George M. Low Trophy in 1990, SSD had entered the award competition in 1985, 1988, and 1989, finishing as a finalist each year. Each time, we paid

The Endeavour crew module support team in Downey, California, poses for a group photograph just prior to shipment of the component to Palmdale for final assembly.

close attention to the comments of NASA/ASQC evaluators and re-evaluated and adjusted SSD's processes. Each year the competition got tougher, which made the success of 1990 even more rewarding.

Participating in this rigorous award process has helped SSD significantly improve its competitive posture. This report highlights the achievements that NASA considers outstanding and the processes that led to them.

Customers aren't just pleased—they're delighted

Any business must strive to keep its customers satisfied. For SSD, that's the top priority—number one in our corporate credo (Figure 1). We believe that to inspire customer loyalty, we must strive for maximum customer satisfaction. That requires the best possible products and services at the best possible price (offering better value than anyone else). SSD strives to achieve that by performing beyond the requirements of its contracts. The work force has enthusiastically met the challenge of making each new orbiter surpass its predecessors, both in product quality and in the efficiency of the processes. So in August 1987, when SSD was awarded the contract to build Endeavour, the new replacement orbiter, a battle cry went up throughout the division: "Let's make this the best orbiter yet—the highest in quality, the lowest in cost." And it has become so: Endeavour is truly the new quality leader of the orbiter fleet.

The customer has been more than satisfied with Endeavour. We measure that satisfaction by NASA's award-fee ratings, which indicated outstanding performance and constant improvement over the past three years. SSD also received three Team Excellence Awards from two NASA centers in the same period. In its overall appraisal of SSD's performance, NASA cited management leadership and effective teamwork as our primary strengths. Following are some specific elements that pleased the customer.

Delivering quality products on time and within budget is basic to good performance; delivering early and under budget is evidence of excellence. How does SSD respond quickly to its customers' changing needs? The division controls master program schedules and detailed lower-level schedules with a change authorization system. The system incorporates NASA's latest direction and shows progress and forecasts. SSD's key tool is the Artemis automated scheduling system. It processes, stores, and graphically depicts schedule data at both SSD and NASA for quick-response schedule support. A computerized system monitors and measures cost and schedule performance. NASA praised the integrated cost and schedule report that this system produces, as well as SSD's ability to track and communicate schedule information.

These scheduling tools are used in response to customer requests. SSD prides itself on its ability to make customers' priorities its own priorities, and to change its plans and schedules without jeopardizing important program milestones. For example, we were able to schedule priority production of shuttle modifications and improvements after the loss of the Challenger. To support

Space Systems Division partnership with NASA is widely diverse, including the test operations center at the Johnson Space Center, Houston, Texas.

NASA's urgent need for a safe return to flight, we delivered 376 mod kits and associated hardware between 1987 and 1989.

Along with numerous return-to-flight activities, SSD began work on Endeavour at the same time. That program met a scheduled April 1991 delivery date, despite the incorporation of many improvements and modifications.

In the area of cost, NASA commended SSD for:

- keeping its contracts, on the whole, at or under cost targets.
- supplying detailed, accurate, and timely cost analyses and reports that facilitate decision making.
- achieving significant savings through Team Excellence processes.

NASA evaluations over the three-year period indicate that cost problems are rare and solutions are prompt.

This success begins with accurate cost forecasts. SSD's cost performance overall was within 0.8% of NASA's annual funding targets. Next is timely communication through scheduled, formal reviews and meetings, as well as informal interaction. Thus, all members of the team—NASA, SSD, and suppliers—are kept aware of current performance, potential problems, and ideas for handling cost changes and concerns.

Cost savings are gratifying to both SSD and to the customer. Even though Endeavour contains more improvements and modified systems than any orbiter, the program has saved NASA $40 million. That's in spite of scheduling difficulties like re-establishing SSD's supplier base and training new staff in the skills lost through attrition. In addition, Team Excellence plans are submitted by employees at all levels. These ideas helped improve technology, streamline work processes, and heighten performance, resulting in cost savings of over $20 million. And our employee suggestion program yielded ideas that resulted in nearly $3 million in savings over the past three years.

Quality improvements: communication, problem solving, and product assurance

SSD's quality and productivity improvements reflect an understanding of what the customer wants and greater efficiency in delivering it. It would seem to come down to a now-familiar word: responsiveness. But that word must be qualified by adjectives like efficient and effective. Like the waiter who constantly interrupts your dinner and conversation to ask if everything is all right, simple willingness to respond can miss the mark. It must be directed by a thoughtful, accurate definition of the customer's desires and effective, efficient processes to fulfill them.

SSD supplies NASA with products and services that range from sheet metal bending to sophisticated avionics software and multifaceted mission support. Our challenge is to create improvement processes that pervade these diverse activities, in every organization and at every level. NASA considers several of SSD's quality and productivity accomplishments noteworthy.

One is SSD's communication and reporting methods. NASA cited the short, responsive lines both within SSD and with the agency's centers, and SSD's continual updating of communication systems. This communication—meetings and presentations, documents, and informal one-on-one conversations—is driven by a sense of teamwork. SSD is open and honest, responds quickly and thoroughly to NASA's requests for information, and works together with NASA to overcome obstacles.

To increase responsiveness, we shortened lines of communication and increased the number of SSD employees at NASA centers. One example of the spirit of teamwork is the daily phone conference to discuss orbiter processing agendas. SSD staffers and NASA staffers work together to support changing shuttle launch schedules.

Responsiveness was critical, for example, when NASA notified us that fasteners from an outside supplier might be substandard. We searched our receiving records to identify the fasteners in question and isolated certain lots for further testing. SSD gave NASA data on all possible places in the orbiter where the fasteners could be used, as well as the criticality of each. This timely information was valuable to NASA's decision-making process during the impending shuttle flight readiness review.

SSD has improved the communication network linking SSD, NASA centers, and suppliers. These upgrades (which NASA called "exceptional") include Databeam, video conferencing, and electronic mail systems. Now, for example, the product assurance department issues a weekly highlights communique through electronic mail. This raises awareness, both within SSD and at NASA, of problem-solving activities, quality and productivity initiatives, and metrics of performance improvement.

Good communication is essential for effective problem prevention and solving. NASA commended SSD's information flow for reaching those in need, our excellent system of controls, and our ability to learn from the past and avoid future errors. Error prevention is SSD's main focus. A readiness to do work without errors encourages employees to promptly identify and correct problems. And that is done

through total team involvement—managers, workers, and customers.

This policy and the division's control/prevention systems are demonstrated by an incident at the Palmdale, CA, site. A machine operator doing routine density verification of the reusable shuttle surface insulation tiles thought that some of the units were misidentified. Aware of the significance of insufficiently dense tiles, he immediately notified his manager, who notified SSD executive management. They in turn notified appropriate functions by electronic mail.

Within 24 hours, an interdisciplinary team, headed by SSD's Problem Action Center, had been established. SSD's field quality representative was contacted to inform the supplier of the questionable materials. NASA representatives were alerted through SSD's Quality Assurance Corrective Action Notice. Thus, the total team was involved, and the corrective action plan prepared, within 48 hours.

After the suspect tiles were inspected and re-identified, a complete tile inventory was conducted. The receiving inspection instructions were revised and flyers were posted to alert the work force. The incident was discussed in workmanship meetings to prevent any recurrence of the problem. Finally, the problem and the corrective actions were documented so that all interested parties could learn from the experience.

One of SSD's major error prevention processes is cross-functional improvement. Representatives from various groups, e.g., engineering, manufacturing, material, and suppliers, meet early in the design stage. They make sure that products will meet requirements and can be delivered within cost and schedule constraints.

There's also a Design for Competitiveness process involving engineering, manufacturing, and QA personnel. Using team techniques and software, they speed up the assessment of alternative designs and costs as they analyze concepts and identify potential difficulties.

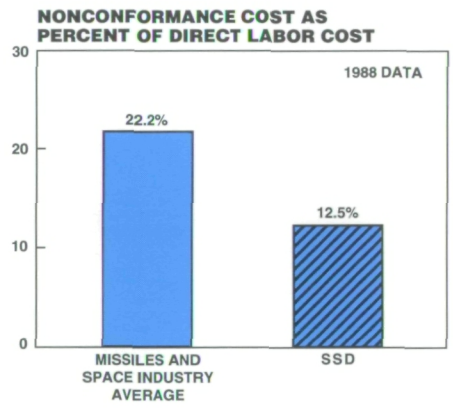
This philosophy of planning for efficient design benefits both existing products and new ones. For instance, the decision was made to protect the orbiter chin panel (an area between the nose and landing gear door) with reinforced carbon-carbon instead of tiles. The tiles had been repeatedly damaged during ascent and atmospheric re-entry. During the redesign process, we took the initiative of using existing test articles to conduct fit and function tests of the new components. Thus, engineers could make unforeseen modifications before production began. This expedited the fabrication and installation of the new chin panels on the first orbiters.

Another planning initiative that NASA commended involved an early fit check of the orbiter crew module and forward reaction control system with the forward fuselage. This was done at the Downey site to prevent a repeat of the problems that had occurred when elements were mated for the first time at the Palmdale site.

NASA also praised SSD's use of SPC to prevent hardware errors. In recent years, we have worked to control production processes and understand our capabilities. The goal is to learn to trust the processes and reduce the need for inspection.

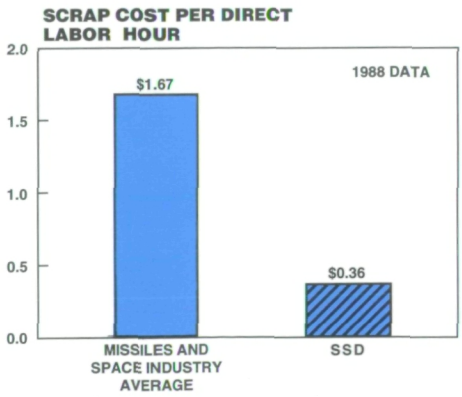
To assess its control over critical variables, SSD has developed checklists that identify key processes for many manufacturing areas. For appropriate production units, both variables and attribute forms of statistical analysis are used to develop variability reduction programs and control charts. These are compared with engineering requirements by manufacturing and QA person-

FIGURE 2



Our performance compares favorably with industry average

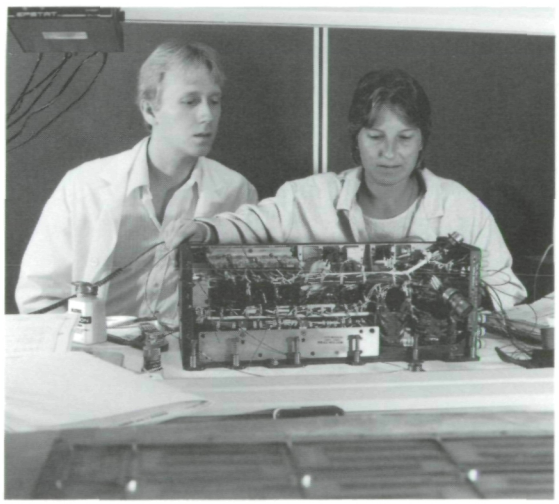
FIGURE 3



SSD scrap rates are among industry's lowest

nel. Certain critical spacecraft parts are placed on a special list for high-level attention and subjected to even more rigorous process controls, tests, and inspection.

To give feedback to the work force, monthly indicator charts are posted on each department's commitment boards. These charts plot the percentage of error-free hardware produced. Discrepancy reports are discussed with the operators. Product quality improvement logs are kept on the manufacturing floor to help operators identify possible obstacles to getting things right the first time. Engineers monitor the logs daily and discuss ideas with the operators. This process reinforces the importance of the operators' contributions to the process. Floor-level personnel also have the authority to stop production if they think something is wrong.



Repair and testing of shuttle electrical components and avionics equipment are conducted by Rockwell technicians at NASA's shuttle logistics depot, Cape Canaveral, Florida.

Managers and machine operators review product quality performance data each day to monitor the effectiveness of process controls. The same information is also used by cross-functional product quality improvement councils in each department to assess problem prevention and corrective actions. Automated procedural, process, and product quality audits are used to assure management that the process is working and requirements are being met.

The results of these QA methods can be measured in numbers that NASA evaluators found very impressive:

- Decreasing nonconformance rates (twice as good as the industry average)—100% conformance on Endeavour's lower forward hard mate; 83% increase in successful tile bond verification (Figure 2).
- Scrap rates four times better than the industry average and among the best in the industry (Figure 3).
- Material review rates cut in half over the three-year period.
- 98.5% first-time-through, error-free sheet metal runs because of automated CAD/CAM.

Improving support and services

Process and quality improvements for non-hardware products like services and mission support focus on a set of rigorous plans and procedures. These are based on a clear understanding of customer and multiple-contractor requirements. That understanding depends, again, on effective communication. To enhance service and communication at Kennedy Space Center, SSD shifted its repair function from the Rockwell Services Center to NASA's Shuttle Logistics Depot (NSLD).

Like the hardware quality improvement efforts, controls over services are based on a series of actions meant to minimize variability (certification data base, calibration data base, automated scheduling, laboratory testing, etc.). Error prevention systems provide quick, accurate information about the status of processes: discrepancy tracking and reporting, auditing, corrective action review, open-item status, program requirements review, review item discrepancy data base, and quality flashes.

NASA particularly liked the flash report system that we use to alert functional managers that errors have escaped to the field. It expedites corrective action by all functions and helps prevent recurrences. There has been an average of only 30 flashes per year for several hundred thousand product deliveries. SSD's outstanding performance at the NSLD (in 1989) is demonstrated by its delivery of more than 30,500 items in support of mission processing—99.98% of which were acceptable (only five flashes).

Since roughly 50% of the work at SSD is subcontracted, suppliers are our partners in excellence. The same Team Excellence initiatives and performance measurement methods used at SSD are also carried to the suppliers. The goals are the same—100% product conformance through process control and reduced dependence on inspection. To that end, SSD and its suppliers use several techniques:

- Continual performance monitoring
- Improved communication and feedback
- Cross-functional product quality improvement councils
- Supplier training programs
- Error prevention/correction initiatives

SSD visits many of its major suppliers to present a continuing series of commitment-to-excellence videos (called "Our Commitment") and motivational briefings. We hand out materials, conduct manufacturing and test readiness reviews, help develop and implement quality and productivity improvement programs, conduct special skills

training programs, and share information to prevent errors. As team members, suppliers are eligible for many of the recognition awards available to SSD employees. We also recognize exceptional performance in the diverse supplier base with seven separate categories of Supplier of the Year awards.

This proactive participation with suppliers has paid off. The FAX FIX program, for example, corrects documentation errors found during receiving inspection within 48 hours via FAX. The program saved SSD over $25,000 in its first year.

More important, our suppliers' cost of quality has steadily declined over the past three years. We know that figure because of our supplier performance rating process, which NASA called "excellent" and "well managed." Because SSD procures such a wide variety and quantity of products, it uses two rating systems. One is for suppliers of high-volume, competitive product types. These products are rated for cost of use (i.e., hardware quality, on-time delivery, and price reported by the quality and material functions). The other rating system is for suppliers of low-volume, high-complexity products. These are rated according to quality, cost, schedule, and technical, management, and data criteria.

Both rating systems establish a supplier cost-effectiveness rating called the quality cost index. This helps SSD (and our customers) during source selection to create the best possible supplier base.

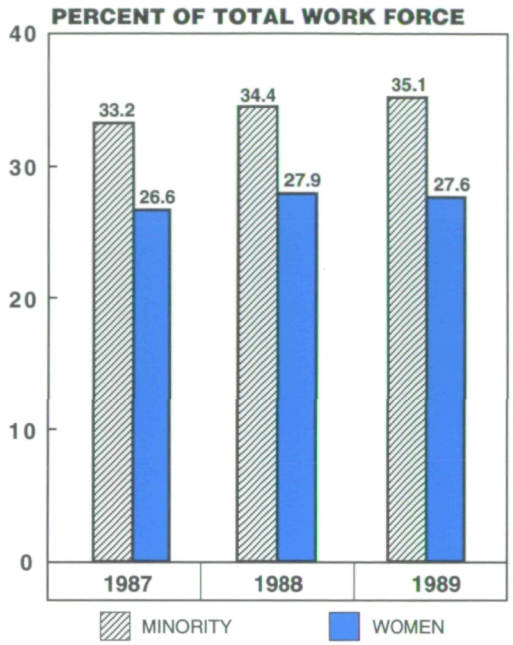
Productivity improvements: software, new equipment, energy, and the work force

In the area of productivity improvement, NASA evaluators were most impressed with SSD's process improvements in business systems and its trend toward using software to do so. This area was identified as a concern in a previous NASA review. In recent years, SSD has made major investments to modernize, streamline, and automate its business and technical systems. We determine which areas will be automated and modernized through a comprehensive, long-range plan based largely on the potential enhanced value to customers.

One investment that NASA praised highly is the Aerospace Integrated Management System. When fully implemented, it will replace 14 stand-alone business systems and save tens of millions of dollars. SSD is also working on a computer-integrated manufacturing project to modernize, streamline, and automate technical processes from preliminary design through manufacturing. The following areas of investment have improved the quality of products and services, made processes more efficient, and, in some cases, enabled us to develop new technology beyond the state of the art:

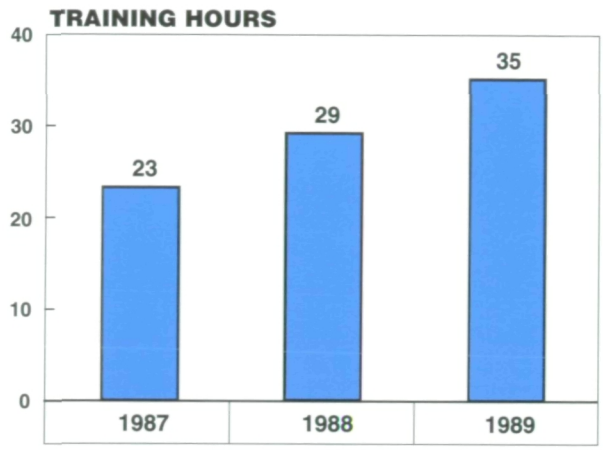
- Aerospace Simulation and Systems Test Center—the latest hardware and SSD-developed software, including a robotics lab, to evaluate space vehicles and systems.
- Rockwell Operational Software Engineering System—advanced programming, including Ada and artificial intelligence, to enhance software engineering projects (NASA commented, "You are working on future uses of technology yet to be developed . . . and providing special training not commercially available.").
- Computational Fluid Dynamics Lab: state-of-the-art tools for advanced analysis.
- Automated order release system—computer-generated manufacturing orders, by schedule, for repeated production requirements.
- Bar-coded tool crib inventory.
- Distributed numerical control system—PC-based network linking programmers, machine shop supervisors, tool room, and machining centers. This system tracks the movement of work-piece lots, cutting tools,

FIGURE 4



Women and minorities are well represented in SSD's work force

FIGURE 5



Average training hours per employee continue to increase

and numerical control programs through each operation processing station.

- Drawing/document imaging system—access to engineering drawings and specifications by internal and off-site personnel.
- Tile information processing system—information on progress of thermal protection system installation.
- Numerical control verification—simulation of metal removal prior to cutting (savings of $450,000 per year).

In addition to making work processes more efficient, some of SSD's equipment investments were aimed at conserving energy. New energy-efficient lighting and heating units, a central computerized control system, and other improvements were combined with a program to increase employee awareness. The result was an annual savings of $1.7 million over the last three years.

Deploying the work force productively is a bit more complicated. The production of Endeavour at the lowest cost, however, attests to SSD's efficient use of the work force. The process begins with a detailed hiring plan designed to phase in appropriate workers when the contract segments require them. The hiring plan also accounts for balanced representation (commended by NASA) of minorities, women, and handicapped employees. This balance is aided by SSD's work in the local community. By notifying nearby schools of the skills in demand at SSD and holding on-site classes for high school students, we can hire qualified employees, some of whom are already known to be good workers (Figure 4).

The entire division was streamlined to ensure maximum efficiency. Levels of management in many functions were eliminated. Staffs and resources of duplicate operations from various sites were consolidated in a central location. Succession planning is a major area of emphasis, with the goal being to staff at least 90% of all management positions from within the company.

Of course, the most efficient employees are those who are well trained. The policy of training and certifying employees in multiple skills (favorably noted by NASA) gives management greater flexibility in assigning tasks. It also ultimately reduces the number of people required and, therefore, the cost of doing business. SSD ensures that the proper skills are assigned to each job through the material process procedure, which lists the training/certification required for all tasks (Figure 5).

SSD's commitment to training is demonstrated by a $600,000 capital investment for a new state-of-the-art training facility. Here, 150 courses are presented in a variety of disciplines. Almost

New facilities enhance effectiveness of training

FIGURE 6

ORIGINAL PAGE
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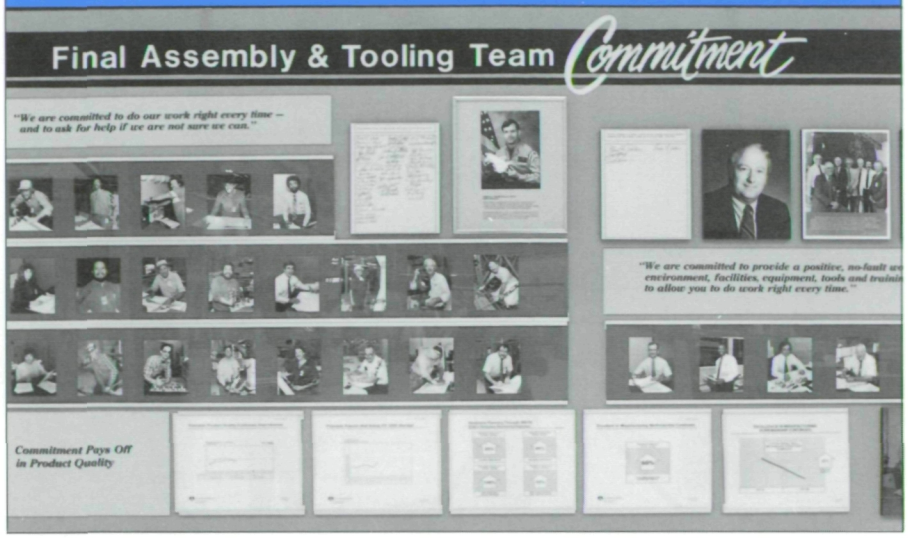
all technical training requires retraining annually or biannually. In addition, retraining is available continually to technicians so they can stay up-to-date with the latest technology. As an indicator of employees' commitment to training, more than 92% of the professional training was conducted after hours (Figure 6).

Managers are trained in various skills and in the Team Excellence processes. All new managers must complete a nine-module curriculum. This promotes consistency of purpose and philosophy throughout the division. Leaders and members of improvement teams also receive training to enhance their efforts. Selected employees from production operations and product assurance functions are trained in applied SPC. New employees receive a six-month orientation program and a handbook to gain an immediate focus on SSD's improvement goals and expectations. Educational reimbursement and career counseling are also offered to encourage employee development.

Total performance improvement processes

Infusing all SSD sites and thousands of employees with the Team Excellence goals, objectives, and improvement processes has required strong, long-term management commitment. This is a characteristic lauded by NASA evaluators. When this formal process began in 1982, it was a management-initiated effort focused mainly on production activities. Since then, the Team Excellence movement has become a management-led process in which everyone participates. It has grown beyond the production area and steadily improved through the difficult period following the Challenger tragedy. Those three years also saw major restructuring of the division and its leadership.

FIGURE 7



Examples of employee commitment to excellence are prominent in every shop

SSD's corporate credo, established in 1987, stresses top management's commitment to continuous improvement. NASA was pleased with the employees' understanding of the credo and its emphasis on customer satisfaction.

Management's commitment to continuous improvement is reflected in many ways. One of the most obvious ways is how SSD spends its money. Capital expenditures for centers of excellence, new equipment, automation, and a better work environment doubled in the past three years. SSD also increased investments by 145% in the work force, travel, awards, and recognition and commitment displays to strengthen the Team Excellence processes (Figure 7).

The increased investment in the work force, to a large extent, was for human resources to improve the Team Excellence efforts. These activities are spearheaded by SSD's Management Council and led by the division president. They include cross-functional improvement teams (and even cross-contractor teams at NASA centers) at all levels of the organization. They are coordinated by the division vice president of product assurance. These key people make sure that TQM principles and tools are incorporated in the Team Excellence plan. The most dramatic result of their widespread influence is the emergence of Endeavour as the new quality fleet leader.

Thanks to a top-down/bottom-up process, Team Excellence initiatives pervade the division. Goals are established at the Rockwell corporate level and become specific management and functional performance standards. For example, manufacturing goals, posted in appropriate departments, are tracked and reported monthly; they branch out to top-level goals reported to the corporate office.

Our Team Excellence initiatives seek to improve quality, reduce cycle time, and lower customer life cycle costs by enhancing all aspects of processes. For instance, in 1989 manufacturing management set a goal to lower the overall nonconformance rate per 1,000 direct labor hours by 20% from the 1988 rate. The actual result was a 30% improvement. Similar efforts throughout the division, again, account for the triumph of Endeavour.

After corporate goals are set, the division prepares a five-year strategic business plan and an annual operating plan. These are

reviewed and approved by corporate management. The plans contain specific goals and inputs from each function. They forecast specific resource needs for employee skills, new technology tools, and improvements in the work environment.

Finally, all salaried employees are asked once a year to meet with their supervisors and develop individual job objectives that tie in to the department's annual objectives. This policy was begun in 1988. It gives the employees a clear idea of what is expected of them, what the department is trying to achieve, and how their work contributes to the overall success of the company. Employees know that they will be appraised according to those objectives at the end of the year. This kind of goal-setting promotes teamwork by ensuring that all levels of the work force are participating and coordinated in the effort to reach division and corporate goals.

A structured approach disseminates goals, plans, and progress

Getting these messages out to the whole SSD population is no simple task. NASA applauded our dissemination process, calling it effective in reaching employees, "especially those who can make a program difference," and called the messages "strong" and "clear."

It begins with the division president's annual all-supervision meeting, which outlines business pursuits and improvement goals. Either specific functional groups or cross-functional teams take up the challenge by developing programs and plans. These strategies are implemented through such vehicles as training and concurrent engineering activities, SPC, all-employee meetings, staff meetings, customer reporting, videotapes, electronic and traditional bulletin boards, departmental commitment boards, posters, newsletters, and training manuals.

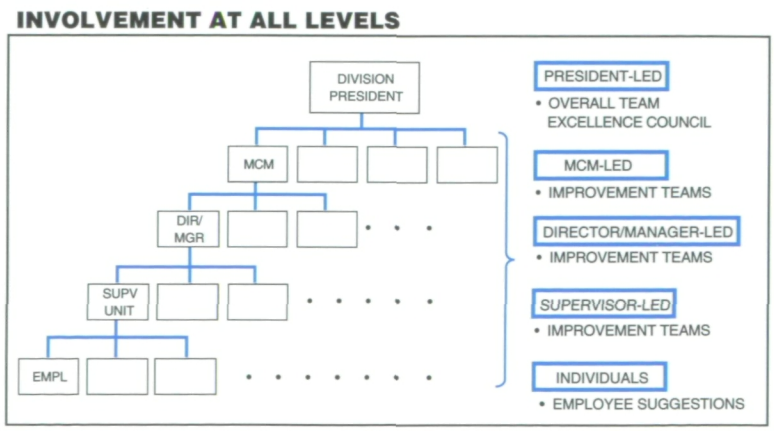
Just as important as communicating goals is keeping employees informed of progress toward meeting them. Feedback takes a variety of forms. Of course, the yearly individual performance appraisals let all employees know how they are doing with respect to the goals they set with their supervisors. On a larger scale, monthly measurements of progress in specific areas (e.g., production) are displayed on wall charts and published for customer review. Statistical process data for more than 70 manufacturing activities are accumulated and displayed weekly. In the case of a high-profile product like Endeavour, performance measurement charts for major tasks are posted to let employees know if, overall, they are surpassing the standard of excellence for the previous orbiter (Atlantis).

Another important avenue of employee feedback is the awards and recognition program. It is based on SSD's commitment to achieving its goals and on the application of the Rockwell credo precepts. (As mentioned earlier, this program includes recognizing excellence in subcontractors.) All employees receive a brochure explaining the awards that are available to them. Recognition for outstanding performance not only provides feedback, but also increases motivation. Categories for awards and recognition correspond to the diverse work trends and motivational needs of the work force. The award categories include:

- innovative engineering or technology developments.
- contributions to safety in manned space flight.
- excellence in management.
- outstanding job performance.
- good citizenship.
- quality and productivity achievements like improvement team initiatives.
- Team Excellence accomplishments.
- Technology Utilization submittals.
- employee suggestions.

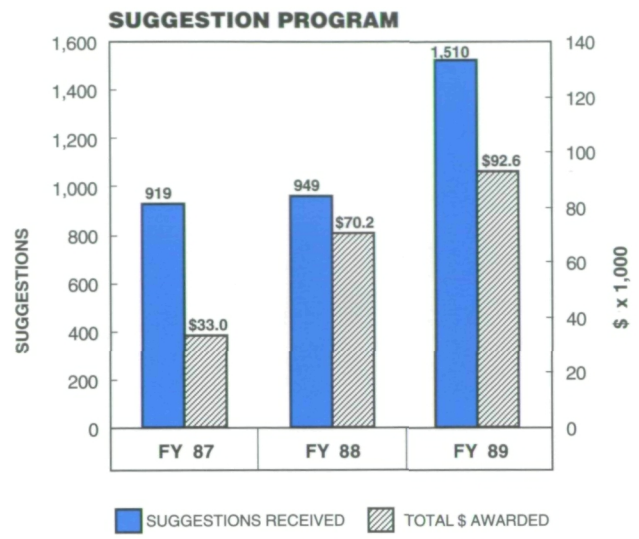
The awards themselves vary as much as the categories: presentations by the division president, instant cash, trips, plaques and certificates, letters, tickets to local entertainment events, luncheons and photographs with executives, pictures, pins, coffee mugs, etc. In addition, photos of honored individuals and teams are displayed in recognition centers in each function. Each function also has its own proce-

FIGURE 8



Continuous improvement vehicles are integral to the organization structure

FIGURE 9



Employees participate vigorously in suggestion program

dures for recognizing an employee of the month.

It is also important for executives and managers to receive feedback from various perspectives so that they can identify opportunities for improvement. To generate input on how SSD is doing as a division, various self-appraisal exercises are used. For the past three years, SSD has also used criteria and lessons learned from the award competition to evaluate and strengthen its improvement processes. In addition, the feedback from NASA/ASQC evaluators is used by top managers to target further improvement. A special internal survey has provided a baseline for improving on the Deming 14 Points. And a benchmarking effort was begun recently to see how we rate against the very best in the world. In 1988 and 1990, division-wide surveys were conducted to find out what the employees feel are SSD's strengths and weaknesses. The results of these surveys were published and disseminated to all employees. The division also established ongoing communication in the company newspaper to let employees know that their recommendations are being acted upon.

The results have provided insight into the effectiveness of the improvement efforts and have helped pinpoint areas that need more emphasis. In general, employees consider SSD a good place to work and do not seek work elsewhere, as evidenced by the low turnover rate.

Daily involvement in continuous improvement

NASA liked SSD's "strong top-down approach" to involving the work force in Team Excellence processes. Through the Team Excellence plan and top-level management involvement, an organized system of management reviews, performance appraisal goal setting, employee communication and recognition, and training has developed a work force committed to continuous improvement. Challenging employees to find better ways instills pride in improvement and a sense of ownership of their work processes. They have responded enthusiastically and creatively.

At the core of the process structure are the Team Excellence councils. They develop, study, review, and implement improvement plans at every level of the organization. These are management-led groups comprising select individuals from various functions. A Team Excellence council can be either a permanent body that meets regularly to seek improvements in production and work processes or an ad hoc team tackling a specific issue. The highest-level group, the President's Team Excellence Council, does the strategic planning and supplies the top-down leadership for analyzing strengths and weaknesses and setting goals (Figure 8).

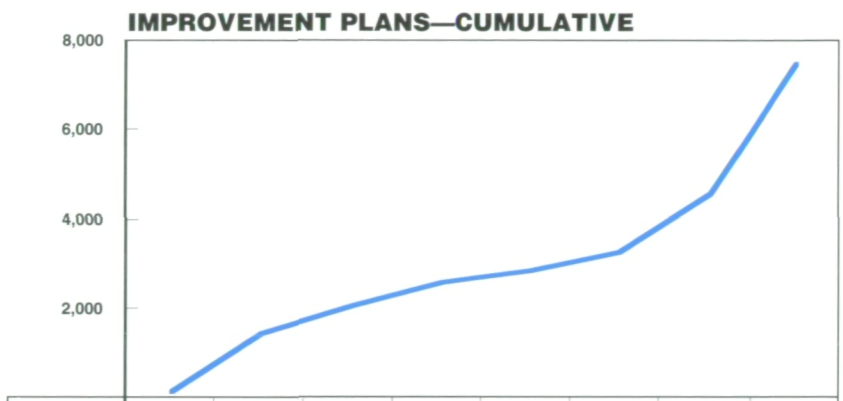
In addition to the Team Excellence councils, product quality improvement councils operate throughout SSD. These multilevel, cross-functional teams consist of members from concerned functions. They perform preventive or corrective actions for products that have a history of trouble.

The final element of the structure is the employee improvement teams, which are an active and integral part of the work force. The number of teams and the total employee participation have grown steadily since we began tracking their activity nearly a decade ago. However, this is a targeted opportunity for improvement, and we are striving to expand involvement in the 1990s.

A vigorous suggestion program—culminating in an annual Suggest-a-thon—has gained momentum in recent years. In 1989, employees from all sectors of the work force (management, salaried, and bargaining unit) submitted 1,510 suggestions that saved SSD $1,560,000. Two hundred and seventy-four employees were awarded $92,600 for their suggestions (Figure 9).

The Team Excellence data base tracks the cumulative growth and trends in quality and productivity improvement activities. These activities have increased dramatical-

FIGURE 10



YEAR	1983	1984	1985	1986	1987	1988	1989	1990
PLANS	173	1,454	2,112	2,603	2,879	3,268	4,582	7,483

Meaningful growth in Team Excellence participation signals process strength

ly in the past three years. Fewer than 300 plans saved the division $3 million in 1987, while nearly 1,500 plans in 1989 saved us $20 million (Figure 10). Team Excellence processes are so ingrained in the work structure that employee involvement is nearly 100%. Almost every employee participates in a formal review, submits a suggestion, or works on a structured team project each year.

This continuous pursuit of improvement—the habit of always questioning processes and systems to enhance efficiency and quality—shows that employees are SSD's most important asset. They're second only to customer satisfaction in the top credo priorities. While the awards and recognition program lets employees know they are appreciated beyond rhetoric or a pat on the back, health and safety programs demonstrate that the employees' well-being is important to the company. And well it should be: a healthy employee is the most motivated, productive, and competitive.

SSD promotes good health, safety awareness, and mishap prevention in many ways, such as:

- regular and continuous surveillance of the work environment.
- incorporating safety requirements in all tasks.
- motivational and training programs.
- a no-smoking policy.
- industrial safety and hygiene programs.
- emergency preparedness efforts.
- a health services and recreational facility.

These operations are administered by a team of qualified professionals. They have resulted in an accident/incident rate that has remained 72% lower than the industry average for three consecutive years.

The new decade brings new challenges

NASA's award initiative has helped us assess and focus our improvement process each time we enter the competition. The business has benefited from this experience in many ways, some of which are intangible and hard to quantify. Perhaps the most important lesson SSD has learned is the value of a vigorous continuous improvement process and the heightened awareness that it brings. The success of the process directly correlates to improved business posture.

As all successful companies know, there is no respite from continuous productivity and product quality improvement. We have worked hard to enhance our processes each year—to strengthen areas targeted by both NASA/ASQC and our own leadership—and to make each new shuttle orbiter better than the last. But the process never ends, even after such an honor as the NASA Award. Having reached this point merely suggests a new baseline for improvement.

Now, it only makes sense to aim higher. For example, the new benchmarking effort. Rather than compare the whole division with another company, we will focus first on a few of our functions that offer the greatest potential to enhance competitive posture. Next, the leading companies in each area will be identified, their performance for those functions measured, and their methods determined. Then we will compare our performance with theirs, design programs and actions to meet and surpass that performance, implement the plan, and monitor the results.

These assessments, and SSD's plans to extend them to all phases of its business, might seem quite ambitious in the context of today's changing environment. The maxim to accept and master change is more challenging today than ever. The nation (and the world) faces major economic, political, ecological, and philosophical changes—changes that directly affect business at SSD.

Our strategy is to broaden, strengthen, and accelerate total performance improvement. We believe that this pursuit will realize the full potential of our employees and maintain SSD's competitive advantage in a challenging market as the future of space business unfurls.

Marotta Scientific Controls, Inc.: A Rich Legacy of Quality and Performance

The quality culture at Marotta Scientific Controls, Inc. is the legacy of the combined efforts of many people for close to 50 years. However, we attribute much to the ideas, ideals, and persistence of Patrick T. Marotta, who implemented and imposed his drive for perfection throughout the daily work life and on the products we produce. That heritage is permanently ingrained in the minds and hearts of every employee from the oldest to the newest. It is transmitted throughout the generations of managers and employees. This legacy is rooted in what are called 'The Policies,' which were first stated in 1950:

1. To operate this organization to the best and equal interests of the owners, the customers, the employees, the community, and the country as a whole.
2. To engineer, design, develop, manufacture, and sell products, including all types of aircraft component parts and specialized mechanical and electrical units. Also, the manufacture to specified designs and orders of such products.
3. To maintain the highest standard of quality in all operations.
4. To have the right people in the right jobs at all times.
5. To maintain and base all bids and contracts on the fairest rate of exchange that can be determined, and to divide all income of operations accordingly among the factors of production.
6. To strive in every way to make proud all associated with Marotta Engineering Company.

These six common-sense policy statements were written over 40 years ago, and Pat Marotta's commitment to management and demanding ideals has been passed on to all who have followed. The corporate environment insists on the highest-quality performance from each of us. This has been and will surely continue to be the way of life at Marotta. Our daily efforts and the products we produce are the legacy, the living trust, that is passed on from generation to generation.

NASA Administrator Richard Truly presents Thomas Marotta with the George M. Low Trophy: NASA's Quality and Excellence Award.

During the early 1940s, Marotta's facilities were devoted to the production of items for the U.S. war effort, mainly in the aircraft industry. Many of the company's first products were made to either government or customer drawings and specifications. In those years, Marotta was a creative job shop. Shortly after the end of World War II, the corporation established a long-range corporate strategy in which all commercial efforts were abandoned. All design, development, and manufacturing efforts were directed to the high standards of performance found in the high-technology, post-war industries or the U.S. government's procurements. Marotta chose to satisfy the need for high-reliability fluid handling products rather than risk sacrificing its quality standards to compete with lower-cost commercial products.

In 1944 Marotta supplied its first rocket engine propellant control valves to Reaction Motors, one of the early developers of rocket engines. Thanks to the success of those early development efforts, our company's components were soon being used in the control of corrosive, toxic, and sometimes unstable fuels and oxidizers for rocket engines and other difficult liquid or gas process controls.

The first repetitive production products were delivered in 1951. They were designed, developed, and manufactured by Marotta with no outside funding. These specialized valves were incorporated into the Bendix in-flight jet engine starter system. The applications included both high-pressure air and fuel controls. Over 10,000 starters incorporating Marotta products were produced and were standard equipment for the F84 and F86H intercepter aircraft. In 1952 Marotta filed the first of over 200 patent applications.

Also during those early years, the company worked closely with the predecessors of NASA and

the companies that supported the early missile and rocket development efforts: the National Advisory Committee of Aeronautics (NACA), Vanguard Division of the Naval Research Laboratory, the Jet Propulsion Laboratory, the Development Operations Division of the Army Ballistics Missile Agency, and the Missile Firing Laboratory. Marotta Scientific Controls, Inc. has participated in every manned and unmanned NASA program.

We have been privileged to share with NASA not only a vast number of space-related achievements, but many other achievements in programs related to energy, solar, wind, nuclear, fossil fuel, and advanced aircraft development programs. We attribute the success of our products to the high standards of performance maintained by our employees. It is their desire to constantly improve and maintain these standards, guided by an attentive, involved leadership.

On February 13, 1991, all Marotta employees accepted with justifiable pride the George M. Low Trophy: NASA's Quality and Excellence Award. Receiving the award was especially satisfying for Marotta and its subcontractors. This is the first time this honor has been awarded to a small business. The following paragraphs discuss Marotta's ability to concentrate on customers' needs, our support services, the organization, various improvement methods we use, and our continuing efforts to improve and perform as a world-class manufacturer.

Marotta Scientific Controls, Inc. continues to be a leader in the design, development, and manufacture of aerospace liquid and gas control systems or components. The corporate environment promotes and sustains a focus on quality. Today's performance standards are vastly different from those that existed when the company produced its first product. Today's business environment measures performance on an international basis. In order to remain competitive today and tomorrow, an alert and innovative approach to meeting or exceeding customer requirements is necessary. Marotta has always believed that its performance, reliability, quality, and productivity are the result of a creative, and sometimes unique, problem-solving approach in design and manufacture. And over the years we have been honored by numerous awards from U.S. and foreign government agencies, prime contractors, and subcontractors.

The Customers' Needs Are Important

We believe customer satisfaction results from our ability to listen to our customers' needs and to then apply our experience, knowledge, and scientific disciplines to meeting the customers' specialized product requirements on schedule. Our customer satisfaction efforts include a manufacturing resource planning system (MRP II), a shop floor data collection system, computer-aided design, and computer-integrated manufacturing systems and equipment.

Implementing these systems required the development of work process flow programs that satisfy customer requirements. For example, our order processing system was custom designed to accommodate the unique characteristics and requirements of the government's procurement system. The challenges of Marotta's customers and markets are many, particularly since we provide fluid control products and services for specialty applications. Products are rarely purchased in single-order quantities. The norm is short-run production that averages between 10 and 25 units. Our organizational structure, mode of operation, and human resources allow us to produce both unique and special customer requirements from the quote stage through the delivery and follow-up service.

A pre-proposal review between the sales and engineering departments is used to help document the initial customer order. This review ensures that the customer's requirements are clearly understood. After the sales department reviews the order to ensure that the customer's requirements are within our technical expertise, engineering evaluates the specific technical requirements.

Depending on the complexity of the customer's requirements, a special requirement quotation sheet is prepared. This three-page document, coupled with any supplementary information, ensures that all requirements are communicated. This includes things like government source inspection, certifications, special cleaning, special packaging, test requirements, age control, failure analysis, contamination protection, reliability data, documentation, progress reports, special instructions, etc.

Finally, the input from each department goes to the master scheduler. The final result is a commitment to the customer that performance, delivery, and price requirements will be satisfied. After these evaluations are complete, Marotta begins preparing the formal quote.

Structure for Performance

The organizational structure for disseminating customer requirements at the quote stage and for executing the customer sales order is clearly defined. The contracts administrator, the project engineer, and the master scheduler play key roles: ensuring that technical requirements, the planned program schedule, and the target costs are met. Post-delivery reviews determine whether improvements are required in our organizational

structure, mode of operation, or human resources for future contracts.

The contracts department reviews orders received to verify that the customer's order agrees with the original quotation. If the contracts department finds differences between the two documents, it obtains resolution with the appropriate departments and with the customer. A sales order is issued to all involved departments, specifying the customer requirements and referencing all applicable customer documents. The quality assurance department reviews selected sales orders to ensure that quality issues are consistent between the sales order and the customer order. Each department (engineering, manufacturing, and quality assurance) develops written work instructions or procedures based on the specifics of the sales order.

A Creative Approach to Using Computers

Marotta uses a sophisticated computerized management resource planning system (MRP II) that integrates all facets of the manufacturing environment. Engineering, manufacturing, production control, material requirements planning, inventory management, purchasing, and cost accounting are totally interfaced through the MRP II system. Master schedule requirements are entered into the system via the material requirements data. This automatically develops information for set-backs and lead times for the master schedule plan. Weekly production and master scheduling meetings are held to highlight and alleviate problems before they occur. Corrective or alternative actions are taken to ensure that schedules are met.

We have been very successful with our computerized information/data handling systems. We implemented a nationally recognized Class 'A' MRP II computer system, deemed necessary because of the unique requirements of highly engineered products in the make-to-order Department of Defense environment. We aligned the requirements of the system with corporate strategic plans and then molded a standard MRP II system to fit an 'actual driven' business environment. By creating and integrating a system that controls actual customer purchase order requirements, actual people time, actual costs, actual status of schedules, and impact of plans, we ensured that the MRP II system satisfies both our business requirements and our customers' demands.

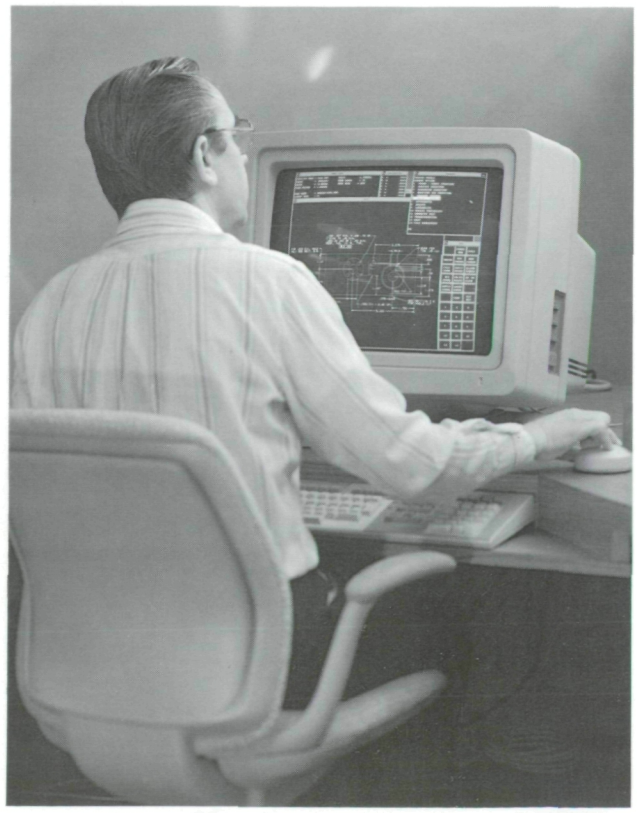
We integrated a data collection bar coding/security system with the MRP II system, as well as a 'design-to-produce' distributive CAD/CAM network. Through management's total commitment to integrated automation, Marotta is at the leading edge of computer integrated manufacturing (CIM). IBM chose Marotta as one of three customers to represent the advances in CIM in today's American manufacturing industry.

Engineering and manufacturing are totally networked through a sophisticated CIM system. The core of this system is a Digital Equipment Corporation Virtual Memory Extended Configuration Five Computer (DEC MICRO VAX II Q5). All information is correlated through a number of systems and applications, joining word processing, graphics, and interactive business systems processing through a one-station approach.

With the MRP II system, bar code inventory control is not required. A one-transition complete pick is the only transaction necessary. Marotta uses bar coding for labor and time utilization reporting systems, providing total accuracy for these cost accounts. They provide rapid, automated information feedback to lead operators and managers for continuous improvement in operating efficiency.

The software programs we use include Unigraphics II, developed by McDonnell Douglas Corporation Information Systems. The capabilities available at our engineering and manufacturing facility include:

- Basic design/ drafting



CAD/CAE (Computer Aided Design/Computer Aided Engineering) permits solid modeling, Finite Element Analysis to be conducted on a design. This effort is integrated with the manufacturing requirements to assure that a product is designed to manufacture.

- Unigraphics access
- Graphic Finite Element Module (GFEM)
- Finite Element Analysis (FEA)—Magnetic, Structural, and Thermal
- Graphic Mill Module (GMM)
- Surfaces
- Graphic Multi-Axis Machining (GMAS)
- Basic machining
- Graphic Sequential Surface Machining (GSSM)
- Graphics Lathe Module (GLM)
- Plot queues

We've directed similar planning efforts to our costing systems. We can continuously plot actual costs against estimated or planned costs. This capability begins with a sophisticated business control system that has been continually enhanced over the last eight years—IBM MAPICS II (Manufacturing, Accounting, Production, Inventory Control System). MAPICS II can accumulate and segregate costs by work breakdown structure (WBS) from time of contract to point of shipment.

We've enhanced our MAPICS II system so that it tracks time, materials, and other costs at all levels, rolling up both estimated and actual costs from the lowest level of the structure to the line item of the contract. Material costs, subcontract costs, manufacturing and assembly, and test actual time are captured through a manufacturing order that is updated continuously (instantaneously) by means of on-line input. Direct labor is captured through a data collection system that uses bar coding and wanding to record the time spent on each operation. A job in process can be viewed at any time, with the most current cost figures shown by each level of operation undertaken. After each operation is completed, estimates are checked against actual results. For example, the manager of manufacturing compares the actual machining time to the target machining times for operations completed the previous day. The process is improved through this type of review and analysis.

Management Information Systems has the key responsibility of overseeing the flow of electronically stored information throughout the company.

Indirect labor that can be charged to a contract is controlled through an internally developed system known as time utilization. Time charges captured through time utilization notations are recorded daily through the use of the time card. These are summarized weekly, retained in the data base, and reviewed by department managers.

Visibility and Control

Through the use of MAPICS II, as supplemented by the data collection and time utilization programs, labor, material, subcontract, and other costs are continually visible and controllable at all levels of the contract. Thus, it is easy to compare actual costs against planned costs.

Product costs are reviewed and analyzed weekly by the Gross Margin Team. Most of our products are sold on a fixed-price basis. Thus, analyzing the gross margins achieved each week and the reasons for any deviation ensures prompt manufacturing cost analysis and appropriate corrective action.

The basis of our estimating (forecasting) system is an internally developed software program known as Estimated Cost Development Tool (ECDT). ECDT is somewhat unique in that it takes the historic data contained in the MAPICS II business control system (e.g., actual cost to manufacture in the past) and allows the input of known factors that could affect the historic data (e.g., modifications, changes, passage of time). Through an interactive process of combining old

and new information, ECDT helps us forecast costs and develop prices. As a contract progresses, ECDT is used for changes, modifications, or other items for which cost effects must be forecasted.

Supplier Development Key

Suppliers are a key element of Marotta's manufacturing capabilities. Suppliers that are cultivated over many years provide either an extension of our capacity, or provide a unique service that is not economical for Marotta to perform. Vendor activities are the responsibility of the manufacturing, purchasing, and quality assurance departments. Manufacturing ensures that the vendors have the appropriate skills. Purchasing uses a competitive bidding process with quotes being received from more than one vendor. Manufacturing also validates the vendors' quotes against manufacturing estimates.

A New Approach to Customer Service

In our business, close relationships with each customer are necessary to ensure that each customer request is understood. Marotta helps design the performance options, recommending and evaluating alternative designs, concepts, and the associated risks. We offer a unique method of responding to customer service requirements for repairs, training, and overhauls.

Customer service is one part of the responsibilities of marketing and sales. This reporting line of authority ensures that these elements of our customers' needs are fulfilled without diverting normal production needs and demands. Our approach to this element of customer service offers our customers immediate attention to scheduling of either routine production, repair, and overhaul, or emergency service.

Customer service is a total corporate obligation. It requires everyone's involvement and participation. The main ingredient of customer service is person-to-person contact. Recognizing this fact, Marotta has focused on its most important asset: its people. Investments in educating, training, motivating, and challenging our people precedes everything else. Marotta fosters individual and team innovation and creativity. The teams usually include one representative each from the marketing, engineering, manufacturing, and test areas.

Growth Through Training and Reward

Over the years, Marotta has made a significant effort to give its employees opportunities to enhance their growth and self-esteem through award and training programs.

Employees can attend both in-house and off-site educational programs such as college/advanced-degree programs and courses in soldering, packaging, CAD/CAM, MAPICS, performance appraisal techniques, statistical process control, and process improvement.

Through the years, Marotta has recognized or recommended its employees for customer recognition for excellence or quality performance. This has been done through programs such as AWARE, Zero-Defects/AWARE, Error Cause Removal, and the SPC Awards Program. Marotta encourages both job-related and after-hours events. The company sponsors team sports (bowling, golf, baseball, tennis), a summer picnic, and a holiday dinner dance. The Marotta Employees Association (MEA) receives contributions from each employee on a voluntary basis. The purpose of the MEA is to promote camaraderie among employees by doing things like sending flowers for family events, etc. Marotta supports an employee-managed Federal Credit Union. Other programs include:

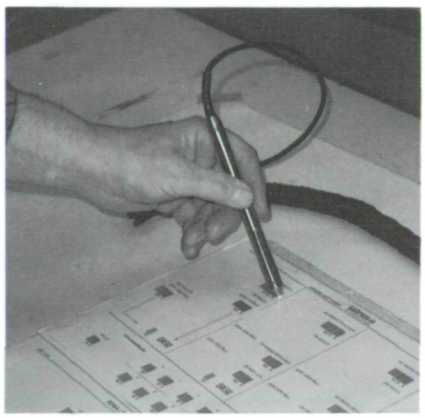
- a regular quarterly profit sharing plan.
- a deferred profit sharing plan.
- a 401K employee retirement plan.
- a paid education policy.
- service awards.
- process improvement contests.
- customer awards.
- a bimonthly newsletter.

These programs are offered as opportunities for improvement, work satisfaction, enhanced communications, and understanding among employees. They also provide insight into each of our responsibilities and challenges. Additionally, all company officers frequently meet with employees in their work areas to discuss problems and potential improvements.

Individual and Team Efforts

To maximize individual and team efforts in creative innovation and productivity, we work in small teams on most company projects. These teams are empowered by management to apply their innovative and creative

Hourly workers utilize bar codes for up-to-the-minute time reporting on all job functions.



talents to each project. It is their responsibility to ensure that the development of the product remains on schedule, meets customer requirements, and is competitive.

In general, team efforts have helped improve communication, understanding, and teamwork among disciplines and departments. Cross-functional specialist teams are used in many areas. Two examples are the CIM (computer-integrated manufacturing) Team and the Manufacturing/Engineering Design-to-Produce Teams.

More Than One Approach or Responsibility

Quality circles and productivity teams throughout the company work on various improvement efforts. These groups are generally called improvement teams. Consistent with our goals of continuous improvement, teams are formed to address particular issues. After a team analyzes the situation, it recommends or implements corrective action. The team is disbanded after the problem is determined to be under control or resolved.

Participants often work on more than one team. The teams are multi-leveled, and about 80% are cross-functional, including production workers, department supervisors, managers, and officers of the company. Most teams are cross-functional because few issues are totally contained within one group. Even if the problem is within one department, involving personnel from other departments encourages communication, teamwork, and an appreciation of the challenges faced by other departments. Open discussion by people from all levels is strongly encouraged.

When the groups are in the brainstorming mode—analyzing and developing corrective actions—they usually meet weekly; a few groups meet monthly. At any one time, about 50 employees, or 20%, are active in various improvement groups during the year. It is estimated that about 50% of these employees are salaried exempt, 15% are salaried non-exempt, and 35% are hourly.

Attention to people's needs is required before management can expect employees to give their best. We continuously exchange ideas to maintain an entrepreneurial problem-solving environment. The ability to solve or develop solutions to the technical and business challenges of the future is our heritage and remains our continuing goal.

Teams meet in the company cafeteria on a scheduled program.

Marotta's facilities and people ensure that each customer will encounter a unique and vital organization that will become an active member of the team or project. Our heritage enables us to direct our resources to problems and deliver innovative products cost effectively (Figure 1).

On-Site Testing: A Unique Asset

Marotta's testing capability consists of uniquely trained and experienced staff and specialized testing facilities. Employees have the necessary technical expertise, motivation, and analytical methods to conduct component system development and testing that are both innovative and creative. All of our efforts are aimed at advancing basic and applied technologies for aerospace, military, and critical/severe industrial requirements.

In our facilities, we can simulate the extreme requirements or rigors of tomorrow's environments. These capa-

FIGURE 1

A HERITAGE OF TECHNOLOGICAL ACHIEVEMENTS
(Only major developments listed)

1944 - 1945
Marotta develops technology to permit balanced pressure concepts to be applied to solenoid, regulating, and relief valve designs.

1945 - 1955
Marotta develops and patents:
- First 3000 psig balanced pressure solenoid valve for production
- High-pressure seat design
- R & D Contract and develops in-flight refueling coupling

1955 - 1960
Marotta develops and patents:
- Quarter-turn pressure regulator for production/test facilities
- Spacecraft/environment, lightweight, energy-efficient latching valve
- High-temperature (1200°F) solenoid valve

1960 - 1965
Marotta develops and patents:
- Cold gas attitude control regulators and valves
- Control valve to eliminate explosions (compression/dieseling) in high-pressure air systems
- Pressure regulator incorporating full flow relief capabilities

1965 - 1970
Marotta develops and patents:
- Pressure regulator and noise filter
- Misalignment coupling/fitting for high-pressure systems
- Electro-mechanical sensor responsive to reciprocating part
- Electronically controlled pressure/flow regulating system and/or valves
- Electromagnetic actuator for reduced power in space environment
- Excess flow safety device for liquid or gases
- Manifold valve systems incorporating mechanical or remote electrical control

1970 - 1975
Marotta develops and patents:
- Systems for accurate control of rolling mill coolant
- On-line high-pressure/high-flow pressure control
- Contamination-resistant, straight-through flow control valve
- Contamination-resistant excess flow check valve
- System for controlling rolling mill force
- Proportional flow control
- Compact actuator requiring low-level force
- Automatic pressure control system

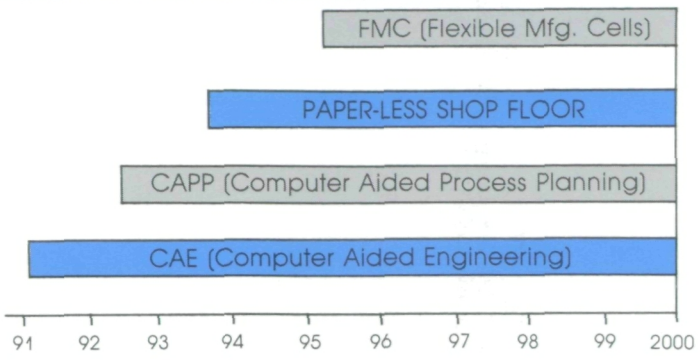
1975 - 1980
Marotta develops and patents:
- Sensor to accurately measure small movements or gaps

1980 - 1985
Marotta develops and patents:
- Self-contained, closed-loop electronically operated valve (Smart Valve), flow control system, wide rangeability

1985 - 1990
Marotta develops and patents:
- Fast-acting explosion suppression device/system
- Structure-borne noise-quieting element

(Note: Over 200 U.S. and world patents issued within the years listed)

FIGURE 2



Marotta looks to the tools of the future

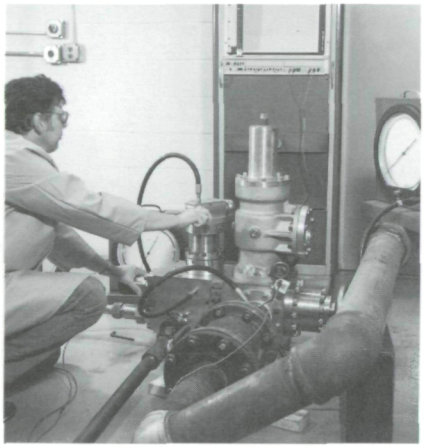
bilities include testing products by simulating underwater conditions or detecting vibration or structure-borne noise in a product or system in service. We can test both liquids and gases at high pressure and flow. This testing can be done while exposing the system or component to severe environments.

Marotta's high-pressure/flow capability can be quickly set up to perform either experimental, unique production, or quality verification tests. In one quick response to a customer's request, we duplicated a shipboard system and tested the system and its components within one week of receiving the products to be tested. The government and the prime contractor advised us that it would have taken them months to accomplish the same task.

Marotta is investing now in platform technologies required for the products and systems of tomorrow. Future products will require lower power consumption, miniaturization, special materials, material compatibility, and extreme operational temperature capabilities. Some of these development programs are nearer term; others look much further ahead, past the year 2000 (Figure 2).

Today, as in the past, we invest in talented people, high-quality test equipment, and new manufacturing technologies and equipment. Marotta is positioned to act today for tomorrow's challenges. That's our commitment to our customers.

Shipboard piping system duplicated in flow test area to respond to customer's needs.



Thomas A. Marotta, president, on the heritage of quality

Being named a finalist for, and then receiving, the George M. Low Trophy: NASA's Quality and Excellence Award, has made this year especially exciting and rewarding for everyone at Marotta. Receiving this award confirms that we are achieving our goals. We continue to strive for superior quality and the highest standards of performance in everything we do.

During the early 1940s, the formative years at Marotta, my father wrote the following statement concerning his ideals:

"Two factors can assure the continued success of our company:

"1. The production of good quality products;

"2. The delivery of these products on schedule.

"Evolution in the aircraft industry is constantly on the march. Our policy is to keep abreast of changes and new developments so that we can assure ourselves of continued success with these new developments and products that we are now making and will make in the future."

Thomas S. Marotta, chairman and president

Today Marotta has an almost 50-year heritage of striving for excellence that includes:

- committed, involved, and effective management.
- teamwork by all employees.
- professionalism and quality in all disciplines.
- initiative and a desire to respond to the technical challenges in the design, development, and manufacture of liquid or gas systems and components that offer the highest levels of quality, reliability, and performance.

We believe that the results of all these efforts can be clearly seen in every product we produce.

A unique aspect of the Second NASA Symposium on Quality and Productivity held in Washington, DC, in December 1986, was that attending organizations were invited to send teams of high-level executives as well as individuals. An outcome of this symposium was the development of seven strategies to guide and focus quality development efforts in succeeding years.

STRATEGY 1

Leadership Must Commit to Revitalization

Rockwell International has long recognized the need for responsible, visible top management commitment to quality and productivity efforts. Rockwell's CEO established quality and productivity policies in the mid-1970s. This was the foundation for a revitalized commitment to strong, viable upper management involvement in improvement activities. The Rockwell corporate offices solidified and restated their commitment by issuing a corporate credo in 1987. Customer satisfaction is the basis of this credo.

Rockwell's Space Systems Division (SSD) used that credo to strengthen and refocus its division quality improvement objectives and goals, which were first formalized in the early 1980s. This dimension of top-management support helped strengthen the existing grassroots efforts in quality improvement and product quality excellence. We formalized these objectives and goals in 1988-89, tied them to our strategic business plan, and ensured that all employees were involved in realizing these objectives. Central to our recent successes were fostering and encouraging teamwork at all levels, shifting emphasis from management support to management leadership in the improvement process, and regularly communicating progress and achievements to all levels of the work force.

ROCKWELL

Marotta Scientific Controls, Inc. provides the strong leadership that is required in developing and marketing leading-edge technologies. The management team provides continuous leadership through motivation, training, and other efforts that ensure continuous improvements in quality and productivity.

This top-level commitment has been apparent since our formative years. More recently, under the guidance and direction of the president, Tom Marotta, we have revitalized and strengthened our reputation as leaders in new technology, quality, productivity, and cost-effective performance. Our performance standards are recognized and understood by everyone on the Marotta team: the board of directors, executive management, middle management, and shop floor supervisors. Most important, these principles are a way of life at the grassroots level.

Marotta's leadership continually supports the implementation of new technologies, equipment, processes, and investments in our most valuable asset, our people. The quality culture nurtures creativity and ingenuity, and rewards persistence and the determination to do each job right the first time.

MAROTTA

STRATEGY 2

Make Quality Integral to the Organization's Culture

Commitment to excellence in everything we do is a mainstay in our strategy for integrating quality and productivity enhancements. We have used innovative methods of expanding work force involvement and fostering employee teamwork, such as the 'commitment boards' in the manufacturing areas of our facility.

Space Systems Division has a proven, maturing dedication to customer satisfaction—which we believe is necessary to realize a robust quality culture. Systematically analyzing our work processes allows us to cultivate the improvement ethic at all levels of the organization. From Team Excellence councils at the top level of the organization, to management-led product quality improvement councils, to individual employee suggestions—SSD is determined to provide excellent products and services.

Cultural change does not happen overnight. Our approach has been to improve those processes systematically and incrementally when it makes business sense. If we do things right the first time, our product performance will be outstanding. This, along with judicious use of lessons learned, will help us make continuous improvement an integral part of the way we do business.

ROCKWELL

Each product is only a reflection of the quality found throughout each function and job within our organization. Quality begins with the attitude and desire to satisfy our customer. The receptionist, security staff, maintenance workers, and all support services contribute to our quality culture.

Quality becomes a part of every customer contact even before we receive an order. Through the years, we have modified our systems to better suit our customers' needs and to help ourselves meet these needs more efficiently. We constantly monitor new techniques and systematically evaluate and measure our work processes and equipment.

We actively seek improvement suggestions and ideas from the entire work force. Improvements in our team efforts ultimately increase customer satisfaction in our products, performance, reliability, cost effectiveness, and delivery.

MAROTTA

STRATEGY 3

Focus on the Customer

Communication is the key to understanding unique customer needs, expectations, and concerns. At SSD, we strive to maintain open, frequent customer communications with daily, weekly, and monthly interfaces. Because our business of providing man-rated space vehicles demands a thorough understanding of what our customers want and need, we work closely with them through all phases of designing, developing, and delivering products.

Beyond timely and effective communications is our commitment to respond quickly and aggressively to customer concerns. Our problem identification and resolution processes focus on prompt involvement of the entire team. When errors do occur, we use corrective action measures that preclude recurrence—a practice that has often drawn praise from our NASA customers.

ROCKWELL

Marotta Scientific Controls, Inc. has, and will continue to have, a close and direct line of communication with each of its customers. We invite direct contact by our customers with whatever department or person can best address the customer's need. The sales and marketing department is staffed by technically qualified, experienced, and knowledgeable people familiar with the unique specifications, requirements, and concerns of specific markets.

Our engineering staff is similarly structured to respond to the numerous markets we serve. Our customers have come to rely upon the technical support, experience, and ideas offered through our constant contact. The specialized nature of our products requires that we communicate freely with almost every department within each customer's organization.

Our customer service department is separated from traditional reporting lines and the dependency upon production for customer needs. This allows the department to provide emergency field or factory assistance unencumbered by routine scheduling demands.

MAROTTA

STRATEGY 4

Accept and Manage Change

Space Systems Division highly values innovation and technology advancements and is dedicated to improving the way we do business. For example, our five-year strategic business and annual operating plans integrate the latest inputs for employee skills improvement, acquisition of new technology, and capital expenditures. We understand the elements needed for managing our growth and enhancing our technological capability.

Technology and innovation are critical to our business, as the following examples illustrate.

1. In 1990, SSD launched a three-year plan to make major automation improvements in procurement and production management.
2. SSD-developed hardware and software are used to simulate and test aerospace vehicles and ground systems in our Aerospace Simulation and Systems Test Center.
3. The Rockwell Operational Software Engineering System uses advanced programming and artificial intelligence to improve software engineering systems.

ROCKWELL

Marotta has a 50-year history of creativity and innovation. As a small business, it is vital that we adapt quickly to the external environment. To do so we must anticipate our customers' future needs and quickly adapt to the sociological needs of our community and the laws and regulations that guide our business. Because technology, creativity, and innovation are requisites of our business, our tactical and strategic planning includes development efforts in platform technologies. These platform technologies will form the basis of our future business and product directions.

To support our long-range efforts, we have developed hardware and software that will advance our design and manufacturing capabilities. Similarly, we are updating software directly related to monitoring and performing our daily work tasks. Marotta's future products will be ready to meet our customers' growing needs.

MAROTTA

STRATEGY 5

Establish a Process to Involve and Recognize Employees

Rockwell SSD is constantly working to improve its systems and processes. We recognize that involving employees in the improvement process is critical to success. We have learned from experience over the past decade that our employees are the heart of the improvement process. As significant improvements were made by employee teams, they were given high-visibility recognition by top management from both SSD and the customer. This further stimulated team participation throughout SSD.

Our performance review process requires every salaried employee to develop individual goals and objectives each year. Employees realize that their success in achieving these objectives, which are related directly to their jobs and discussed openly with their supervisors, will be the basis for possible rewards at the end of the year. Involving employees in goal setting and change mechanisms gives them a sense of ownership in their work processes.

SSD has highly structured appreciation, reward, and suggestion systems. These programs help motivate the work force to participate actively in improvement initiatives. A new reward, a form of gain sharing, gives instant compensation in the form of a check to outstanding contributors. Management realizes the importance of encouraging employees to participate in a journey that is never-ending—the continuous improvement of all of our work processes. The award/reward systems stress the importance of both team and individual contributions. They are keyed to enhancing the employees' awareness of continuous improvement.

ROCKWELL

Marotta uses many methods of recognizing and involving its employees. In a company of our size and structure, one of the best methods is daily recognition with a 'thank you.' The specialty nature of our business constantly demands individual attention, whether it's a complex contract, a product testing program, or an emergency customer need. Complimentary letters from customers are published in the company newspaper and are also placed in employees' corporate records.

Marotta formally rewards individuals or teams financially for high achievement: patents, improvements, or enhancements in productivity, quality, or cost. We strive to eliminate obstacles to creativity or imagination. We encourage the attitude that there is always a better way to do things—and 'Let's do it now!' Indirectly, part of our individual and corporate recognition is found in our corporate profit-sharing policies. These policies were implemented in the company's early years.

MAROTTA

STRATEGY 6

Measure Activities to Evaluate Success

A mature system of recording and communicating measures allows SSD to continuously evaluate and improve its performance. We are working hard to define and develop more comprehensive measures to cover all aspects of our business. The following examples illustrate some of these methods.

1. Each month we distribute a Product Quality Report, which contains over 100 charts, graphs, and measures of scrap, rework, nonconformance, and material review activity. Departmental and program charts display the current month's performance with indicators of the previous year's performance and progress toward new annual goals set by the manufacturing departments. This information is distributed to both customers and hands-on manufacturing employees.
2. Many types of measures have helped us focus on improvement objectives. Perhaps one of the most meaningful is the feedback we received each time we competed for the NASA Excellence Award. It let us use the unique insight of an outside assessment to judge our improvement performance and progress, and to target new opportunities for improvement.
3. Our thermal protection system (TPS) manufacturing and installation departments use various process control measures to evaluate and control their processes. TPS file coating application operators get instant, visible feedback on their performance to minimize deviation in coating weight. Variability charts plot average deviation of TPS tile dimensions to maximize yields.

ROCKWELL

Marotta continually monitors and evaluates the production and performance results of its products against project goals. As a small company, we measure performance targets at weekly meetings. The weekly master scheduling meeting is attended by representatives from almost every department. This meeting addresses schedules, 'chokepoints,' 'work around plans,' work loads, etc., to ensure a smooth manufacturing process.

To monitor long-range plans, the president and the board of directors established a long-range planning committee, finance committee, marketing committee, and an operations and engineering committee.

Members of these committees include officers of the corporation, the CEO, COO, and the board of directors. The long-range planning committee has developed an in-depth plan for the 1990s. The mission statement and corporate goals have been developed and approved. The operations and engineering committee has used these goals to provide lower-level objectives.

Marotta has set specific goals for providing quality products on time. The on-time delivery goals were established and implemented in June 1988. Statistical process control (SPC) was used to create plans for achieving delivery goals and to outline methods for measuring progress. Departments responsible for Quality/Personnel Indoctrination (Q/PI) goals also developed their own programs using SPC.

MAROTTA

STRATEGY 7

Emphasize Education as a Key to the Future

Because we believe that people are our most important asset, we encourage professional and personal growth with various educational and training opportunities. A continuous learning process demands the educational means to keep the work force well trained and motivated. Our employees are enthusiastic about learning; in 1989, more than 90% of our professional training was conducted after work hours.

Space Systems Division's commitment to educational and career excellence is indicated by the following examples of recent initiatives and achievements.

1. In 1990 we built a 20,000-square-foot training facility to expand our capabilities and enhance professional development.
2. During the past four years we have focused a significant effort on improving the management skills of our people. Special emphasis has been given to team building, human performance management, and interpersonal skills.
3. Our educational reimbursement program provides opportunities to pursue certificate and degree programs, and educational career counseling is offered through our Professional Development Office.
4. We continue to be progressive with state ETP training for advanced disciplines like artificial intelligence and Ada programming.

ROCKWELL

Marotta recognizes the importance of education and training as a requisite to being a world-class supplier. During the first week of employment, all new employees receive indoctrination and training through the Quality/Personnel Indoctrination (Q/PI) program. During the last three years we have invested an average of $166,000 per year in indoctrination programs.

Marotta supports many educational and training opportunities, including undergraduate or graduate degree, special credit and non-credit job-related courses, training in job skills, computer operation, program training in management, etc.

Statistical process control is an important course in teaching employees improvement techniques. Marotta has trained 168 of its 250 employees in SPC techniques.

All employees are encouraged to further their technical competence and skills. Marotta compensates employees who take courses that enhance their ability to grow and assume increased responsibilities. Employees are also given special consideration and encouragement for training and learning experiences that benefit the corporation's long-range plans.

MAROTTA

Award Finalists' Recognition

NASA would like to congratulate the following companies for achieving the status of Award Finalist for the 1991 George M. Low Trophy. For more information on these companies, contact the representatives below.

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