CRAIG W. McHENRY, RICHARD C. BROCATO, and WILLIAM T. PULLIN

THE QUALITY TEAMS PROGRAM

As technology advances and designers, technicians, and craftsmen are given new tools to work with, new tools must also be implemented for effective organizational communication, for the solution of work-related problems, and for the maintenance of quality standards. Guided by the belief that people are an organization's most important asset, a Quality Teams Program has been implemented that combines teamwork (the dynamics of participative small groups) and structured problem-solving techniques to focus efforts on work-related improvement goals. The problem-solving process of the Quality Teams Program, some of its successes thus far, and the program's direction for the future are described.

INTRODUCTION

A commitment has been made to revitalize the essential facilities and laboratories that support APL's engineering and fabrication programs. There are many facets to and reasons for this commitment, but without a doubt it reflects the Laboratory's long-standing support of hardware programs that deal with conceptual and prototype scientific and engineering developments. As pointed out in Potocki's overview article, the many successes achieved in past hardware endeavors can be attributed to the high-quality work of skilled engineers, technicians, craftsmen, and designers who are the major resource of the Engineering and Fabrication Branch.

This combination of skilled, seasoned personnel and rapidly changing technologies for performing engineering and fabrication tasks has resulted in an environment fertile for a participative, team-oriented approach to problem solving and to quality control issues. The effectiveness of new technology is directly related to its proper use. Quality, as defined and perceived by the customer, while related to technology, is most influenced by the people doing the work. Therefore, effective communication, both horizontally and vertically within the organization, produces a significant impact on quality; it also enhances direct problem solving by people performing engineering and fabrication tasks where those problems and their resolutions affect quality the most.

The Quality Teams Program uses a "quality circle" or creative problem-solving process. Implementation of the program has significantly improved communication within the Engineering and Fabrication Branch, resulting in the completion of several major problem-solving projects and thereby achieving real improvement in overall Branch operations. This article describes the Quality Teams problem-solving process, some of the successes achieved thus far, and the future of the program as currently perceived.

THE QUALITY TEAMS PROCESS

The Quality Teams creative problem-solving process effectively combines the dynamics of participative small groups with the skills and training and a structured problem-solving discipline of team members and management to accomplish work on issues important to the organization. Management and staff are thus tied more closely by defined, accepted, and congruent goals and interests. Teams systematically follow a problem-solving sequence that focuses the team on work-related improvement goals. The process emphasizes the belief that quality, productivity, and effective communication should be built into the system of design and fabrication on a continuous basis and that people are the most important asset of the organization and the most effective means of assuring that these goals are met. The creative problem-solving process associated with effective team operation is shown in Fig. 1.

Shown in Fig. 1 are three major stages of the process with 12 sequential steps. Although the prescribed structured process is the same for each team, empirical evidence shows that each team, like each individual, is different. Differences include size (number of team members), degree of intimacy (how well the members know one another), backgrounds of the members (technical experience), history and length of time the team has been operating, types of assignments or goals the team has to carry out, type of leadership, length of time the team will be in existence, and turnover or changes in membership. These differences add to, rather than subtract from, the powerful synergistic effect the team members' individual skills generate when they meet and apply the creative problem-solving process.

Experience to date has shown that the structured process can lead to more meaningful improvement goals and more effective problem solving. Yet the structured process still allows for a diversity of approaches. One team, for example, could decide to study the job at hand, measure the outcomes of job activities, identify problems and goals, create a plan of action to solve the problems or reach the goals, and implement a solution after management approval. Another team may recognize a faulty condition under the members' direct control, make an immediate decision on the best way to eliminate or improve the condition, and simply implement the solution.

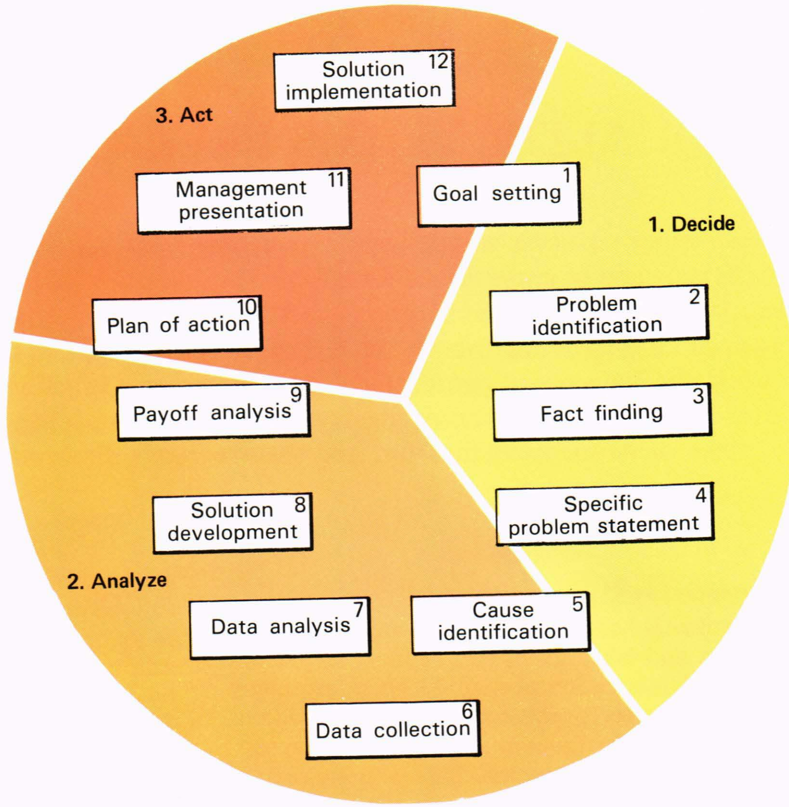

Figure 1—The creative problem-solving process.

The latter method is called a "quick fix," and many times in the process of working on a stated goal or problem the team will uncover opportunities to perform quick fixes in its work area.[1]

QUALITY TEAM PROGRESS

The creative problem-solving process as presented here with its structured sequential steps facilitates the team's formulation of initial and subsequent improvement goals and problem-solving efforts. It is the method currently followed by the teams. Application of the three major stages and 12 sequential steps by the currently active Quality Teams has produced several significant successes in problem solving. The successes include voluntary participation in this program involving approximately 60 people; completion of a structured training curriculum in problem-solving techniques by most team members, team leaders, and supervisors; 16 quick fixes that resulted in immediate improvements; five major projects; four management presentations; and two completed projects, including purchase requisitions and letters of justification that provided detailed specifications for the equipment to be acquired.

By working with their supervisors and using the structured approach to problem solving, four teams received management approval to implement their proposed solutions. Two of the teams not only proposed the solutions but provided implementation plans with the complete documentation required to carry out the improvement. The machine shop team first established its goal to reduce the number of machined parts requiring rework or resulting in scrap. The team then brainstormed problems that prevented it from achieving its goal. By using a consensus-building technique, the team members selected as a problem area the digital measuring system used to position the workpiece relative to the machine tool. They used material inspection logs to collect data on machine usage relative to the type of digital system and on whether the finished piece passed inspection.

As a next step, the team decided to set up a preventive maintenance program for the digital measuring and positioning equipment. By identifying which machines still produced out-of-tolerance work, the team isolated the problem to two manufacturers' systems and then focused its efforts in that area. After brainstorming alternative solutions and evaluating the cost and time to implement those solutions, the team documented its findings and recommended to management that the unreliable systems be replaced. The replacement equipment was also specified. The thoroughness of the justification package prepared by the members of the machine shop team helped to produce immediate management support at all levels. Figure 2 shows an experimental machinist using a machine tool that has been fitted with one of the new digital positioning systems.

A team from the electronic component assembly shop chose lighting deficiencies as its project. The project included ambient lighting in the shop, workbench lighting, and microscope task lighting. Ambient lighting measurements were taken and a bar graph of the data was produced. The data were compared both to the Mil Spec requirement of 100 footcandles at the workpiece and to requirements at other electronic assembly facilities (Wes-

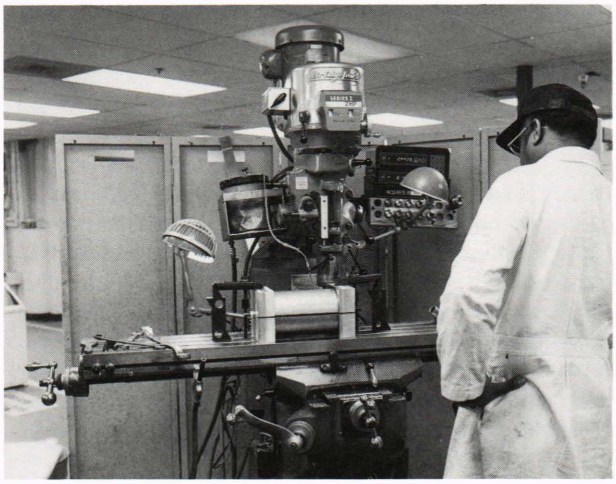

Figure 2—An APL machinist using a machine tool with a new digital readout.

Figure 3—An APL technician with a new microscope and fiber-optic task lighting.

tinghouse and General Electric). Although a significant deficiency was shown, the team only recommended a simple cleaning of fixtures and replacement of dead tubes because of plans to relocate the electronic fabrication shops to new facilities.

Continuing with its project, the team then concentrated on improving task lighting. Workbench-mounted floodlights and desklamps with high-wattage bulbs produced heat and cluttered the workbenches with bulky items and numerous cords that hindered work. Insufficient light and magnification still hampered the soldering of microscopic wires. The team brainstormed solutions and developed detailed specifications for microscopes with a wider field of view, sharper image, and greater magnification. Also included was compact fiber-optic task lighting for heatless illumination without obstructing the work area. The team's recommendations were approved and supported by management and have been implemented. Figure 3 shows an engineering technician using a new microscope with a fiber-optic light ring. Of particular note is that the team members demonstrated a high degree of responsibility and concern in selecting their recommended solutions by factoring in overall cost and space considerations as affected by the near-term relocation plans.

FUTURE PLANS

Continued successes in the Quality Teams Program, such as those described above, indicate that improvement is an ongoing, never-ending process, a process that requires the support of specific mechanisms. The fact that the Quality Teams Program has been successful does not mean that new significance has been ascribed to quality, that there was a lack of quality before the program, or that specific recent quality problems generated a sudden emphasis. As technology advances and designers, technicians, and craftsmen are given new tools to work with (e.g., computer-aided design and engineering workstations and computer-assisted mechanical- and electronic-fabrication equipment), so, too, must new tools be implemented for effective organizational communication, for the solution of work-related problems, and for the maintenance of quality standards. The Quality Teams Program, using proven methodologies of quality control circles, is one new mechanism that has been effective in achieving these results.

Continued support of the Quality Teams Program provides an opportunity to investigate how the science of quality relates to the unique needs of APL's engineering and fabrication projects. An important requirement for effective problem solving using quality-control circle methods is the communication of clear, measurable goals from management to the Quality Teams. As quoted in a recent paper at the meeting of the International Association of Quality Circles, Chesapeake Chapter, Lord Kelvin once said:

> When you can measure what you
> are speaking about,
> And express it in numbers,
> You know something about it;
>
> And when you cannot measure it,
> when you cannot express it in numbers,
> Your knowledge is of a meager
> and unsatisfactory kind;
>
> It may be the beginning of knowledge,
> but you have scarcely in your
> thoughts advanced to the stage
> of science.[2]

Quantitative measurements are the foundation of science and engineering, including the science of quality control. Similarly, a quantitative definition of what quality means within the framework of APL's requirements is needed to communicate quality-related goals effectively. A frequently stated opinion of some fabrication personnel is, "To us, quality means building it perfect every time." Although an admirable goal, the ability to achieve this goal requires a quantified definition of "perfect." Similarly, a requirement stated in terms such as, "Quality means that it works," is, in Lord Kelvin's words, "knowledge of a meager and unsatisfactory kind."

One example of the "language of quality" is shown in Fig. 4,[3] which relates various costs of quality that directly affect the cost of fabricated hardware. The

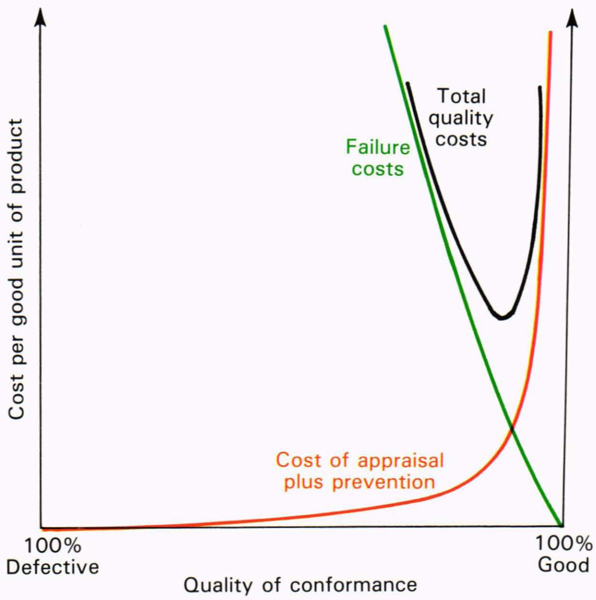

Figure 4—Generic model for optimum quality costs.

curves are generic in order to demonstrate concepts by which communication in regard to quality can be achieved. Shown are the cost of knowing about and preventing problems (cost of appraisal plus prevention) and the cost of repairing failures (failure costs), both as a function of how good the product is (quality of conformance). The sum of the two curves is the total quality cost curve. The curves as drawn show that optimum quality (lowest total quality cost) is less than perfection. They also show that small resources applied to appraisal and prevention will always result in high failure (or repair) costs when highly reliable hardware is required. Translating these concepts quantitatively into APL's requirements will assist in communicating quality specifications to those involved in engineering and fabrication projects. The Quality Teams Program cannot provide the definition of overall quality requirements; it must come from program and Laboratory management. However, the Quality Teams Program can assist in applying guidelines and in providing data to help formulate quality requirements.

In conclusion, the objective of improved quality through better communication, by more effective use of tools and equipment, and by creative problem solving through employee involvement has been achieved with the Quality Teams Program. Direct employee involvement has also helped to guide the rapidly changing technological environment resulting from commitments to revitalize essential facilities. These tangible results have been complemented with other, less tangible ones. For example, an increase in employees' sense of responsibility for the quality and cost of their work has been perceived. Many have seized the opportunity to learn and develop personal skills through the program and work enthusiastically with management to make changes. Finally, the program has helped to establish the larger context of communicating overall quality requirements so that future hardware projects at APL will be as successful as those of the past.

REFERENCES

[1] R. C. Brocato, "Quality Circles: Participative Small-Group Problem-Solving," presented at The Johns Hopkins University School of Continuing Studies (1984).

[2] J. R. Coleman, "Are We Communicating," presented at Meeting of the International Association of Quality Circles, Chesapeake Chapter (Feb 1986).

[3] J. M. Juran and F. M. Gryna, Jr., *Quality Planning and Analysis*, 2nd ed., McGraw-Hill Book Company, New York, p. 27 (1980).

ACKNOWLEDGMENTS—This article has resulted from the contributions of a large number of enthusiastic, highly capable, dedicated people who have all helped to make the Quality Teams Program a success. The authors would specifically like to thank the other members of the Quality Teams Program Steering Committee: Cliff Bennett, John Coleman, Marty Malarkey, Gary Starstrom, Howard Taylor, and Lew Wears for their active support. In addition, the authors would like to thank David Saunders of ARBOR, Inc., who has contributed valuable experience, training, and guidance in the planning and implementation of the program.

THE AUTHORS

CRAIG W. McHENRY (center) was born in Muskegon, Mich., and received his M.S. degree in mechanical engineering from the University of Michigan in 1976. He is a Ph.D. candidate in mechanical engineering at Rensselaer Polytechnic Institute. During 1976-83, he worked at General Electric in Schenectady as a project engineer in the development of liquid metal collectors for large power generators and of superconducting power-generation technology. Related to that work, he developed advanced computer-aided design and engineering systems. Since coming to APL in 1983, Mr. McHenry has helped lead the effort for upgrading APL's essential central facilities and has developed and applied basic operations management techniques in the area of hardware design and fabrication. He is group supervisor of the Engineering Information Group in the Engineering and Fabrication Branch. He is a member of the Society of Manufacturing Engineers and is co-chairman of the Technical Services Department's Quality Teams Steering Committee.

RICHARD C. BROCATO (right) was born in Baltimore and received his M.S. in applied behavioral science in 1985 from The Johns

Hopkins University. Since joining APL 17 years ago, his experience has been primarily in the design, implementation, and evaluation of technical management systems. Currently, he is manager for personnel, training, and development in the Engineering and Fabrication Branch of the Technical Services Department and program coordinator for the Department's Quality Teams Program. Mr. Brocato is an Advisory Committee member for electronics/computer service technology at Catonsville Community College and for electronics technology at Howard Community College. He is a member of the International Association of Quality Circles and the American Society for Quality Control.

WILLIAM W. PULLIN, Jr. (left), born in Baltimore, is fiscal manager of APL's Technical Services Department and chairman of the Department's Quality Teams Steering Committee. He received both the B.E.S. in electrical engineering (1968) and the M.S.E.E. (1971) at The Johns Hopkins University. After joining APL in 1968, he became a specialist in computer systems engineering and configuration management, and, as financial manager of APL's McClure Computing Center, he developed and implemented business operating plans and cost-recovery budgeting strategies.

Mr. Pullin is responsible for the development and direction of fiscal management for the Technical Services Department, including budgeting, finance, and subcontracting, with emphasis on cost factors, fiscal control, and chargeback mechanisms. He has been an instructor in The Johns Hopkins University Master's Program in computer science and is president of the APL Professional Chapter of The Johns Hopkins University Alumni Association.