This management technique led to a steady increase in competence and attitude of hardware maintenance people, with a steady decrease in costs

Building a Hardware Maintenance Team

Computer system hardware maintenance has always been a problem and a headache for management. In most instances, the problem is aggravated by high costs, contractor dependence and unreliability of work produced. Some of the basic problems are:

1. Low commitment of the assigned technicians.
2. Hazy job objectives.
3. No performance standards.
4. No measurement of effectiveness.

An evaluation of the maintenance effort at the Naval Electronics Laboratory Center in San Diego, Calif., revealed that the highly contractor-dependent operation was not only doing a poor job, but was causing many other problems. There was no control over personnel selection or performance. Cross-training was not possible. Rival contractors resorted to buck passing, frequently causing scheduling delays and other operational problems.

Low commitment to the task is a traditional problem in a system maintenance area for the following reasons:

1. The work is generally considered to be uninspiring.
2. There is little challenge or incentive to do a good job.
3. No advancement potential.
4. Inadequate reward system.
5. Results seldom identified with an individual.
6. Technicians are given "second-class-citizen" status in the technological community.

Hazy objectives, inadequate performance and measurement standards and a lack of supervision by the installation managers headed the problem list as a set of items generating a generally apathetic work group.

Our first step in attempting to solve these problems was to prepare a specific function statement so that all members of the staff and the contractors would clearly understand our objectives.

1. To establish and perform preventive maintenance programs for computer systems.
2. To identify and resolve computer system malfunctions.
3. To test and evaluate computer system equipment.
4. To establish and control adequate spares inventories.
5. To establish performance requiements (for people).
6. To implement training programs necessary to maintain technical competence.
7. To maintain competent hardware

TASK	TITLE	% OF TIME
1.	Preventive maintenance	25
2.	Emergency maintenance	10
3.	Training	25
4.	Administrative (sick leave, holidays, meetings, etc.)	15
5.	Planned Work (leverage)	25
	Total	100%

Fig. 1. Maintenance technician job analysis

EQUIPMENT	LEVEL OF DIFFICULTY INDEX
CP-642A	1.0 (Standard)
CP-1230	1.3
CP-1218	.8
CP-1240 MTU-2	.9
CP-1232 I/O	.3
CP-642B	1.2

Fig. 2. Performance measuring system

JOB CLASSIFICATION SCALE	UNITS PER DAY	DESCRIPTION
GS-7	3.0	Training at 50%
GS-9	4.0	Must include cpu
GS-11	5.0	Must have system assignment
GS-12	5.0	Acts as Group Leader (Planned Work)

Fig. 3. Personnel performance requirements

oriented software capability.

After obtaining management approval of the objectives, we first directed our attention to the contractor dependency problem in an ineffective effort that consisted of two approaches: (1) convert contractor personnel to Civil Service positions and (2) purchase training courses from contractors for Civil Service employees.

The contract personnel that we managed to convert stayed only for a short time and usually went back to private industry with a 20% pay increase. The contractors who taught the extremely expensive courses made lucrative job offers to our brighter students and failed to teach much of anything to the less qualified students. In essence, our proselyting did not work and we paid them for proselyting our people.

An entirely new approach was needed and we focused on the root of the real problem, which was the overall lack of commitment of maintenance personnel.

Six specific actions were taken:

Skill, level of difficulty and task classification was accomplished. Drawing from work standardization defined and used by such institutions as Corn Products Co. and International Nickel Co., the tasks were analyzed and levels of difficulty and required skills were established. A major premise is that for every X units of physical work performed in troubleshooting, design or problem solution tasks there are Y units which are allotted for gathering of pertinent facts, problem analysis and theoretical review. The amount of Y units allotted relates to the level of difficulty of the task. This general definition is of no benefit for the calculation of a single task, but if standards are carefully prepared, they become accurate when predicting man-months or man-years of labor required provided "experienced judgment" is used in the selection of the level of difficulty classification.

Planned Work was the base used to achieve the first objective. Planned Work consists of:

1. Initiation and development of new systems test programs to expedite fault definition.

2. Feasibility studies of modifications of existing equipment to enhance

	CP-642B	1240 MT	RD-281	1232 I/O	1469	CS-1	individual scope
Tom	4	1	2	3	2	1	13
Dick	3	2	4	2	0	1	12
Harry	0	3	2	1	2	4	12
Pete	2	3	0	3	2	0	10
group strength	9	9	8	9	6	6	

4=expert/instructor 2=know basic system
3=expert 1=trainee 0=no ability

Fig. 4. Visibility chart

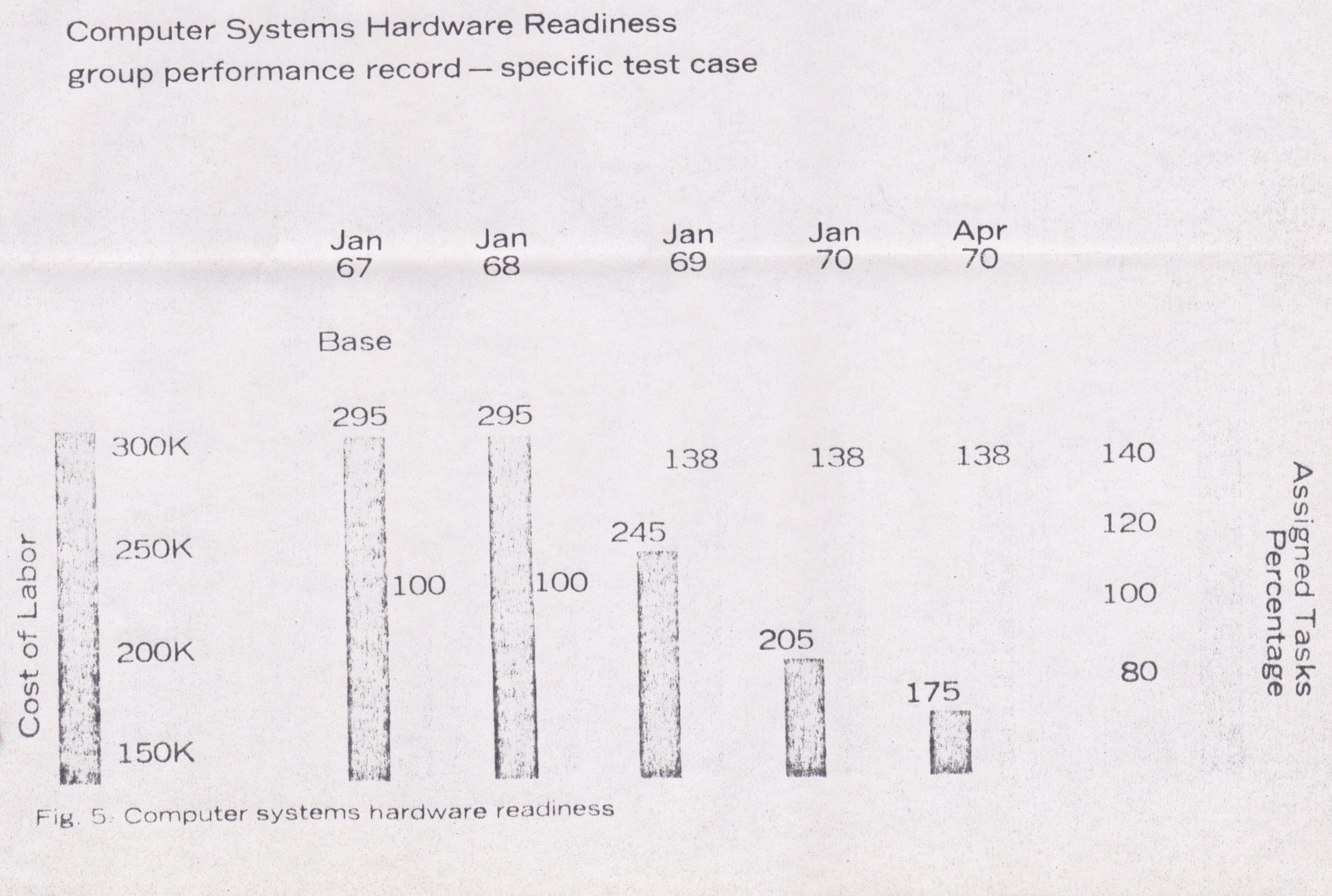

Fig. 5. Computer systems hardware readiness

performance or utilization beyond original design.

3. Systems configuration planning and execution maximizing utilization with minimum degradation of reliability.

The purpose of Planned Work is to gain leverage to minimize future preventive and emergency maintenance by closing the feedback loop between problems encountered and planning phases.

The job analysis established a general workload pictured in Fig. 1, with an average of 25% of each technician's time spent in Planned Work.

A performance measurement system was established. A system of estimating the relative complexity of maintaining each unit of a computer system was determined by an area-wide survey which listed all equipment maintained and posed this question: If Unit A is assigned a complexity level of 1, what would be the complexity level of all other units?

Consulting people with current technical expertise such as design engineers, field engineers, experienced data systems technicians and Civil Service employees resulted in data which was used to establish a Level of Difficulty Index. In combination with task classification date, "units/day" was established. Fig. 2 shows the units established for a group of Univac militarized computers and peripheral equipment.

Basic personnel performance measurement requirements were specified. Performance requirements were established in the same manner as described above for equipment, with the additional factor of job classification pay scale included in the calculation.

Fig. 3 specifies the personnel performance requirements in units-per-day increments.

A mandatory training program was effected. Each person was encouraged to sign up for available training in areas related to his weaknesses. Lists of courses were made available and all costs were absorbed by the organization. Skilled training advisors were made available to furnish advice and assistance.

Mandatory career and professional development were encouraged to the fullest extent possible within the framework of workload requirements and goals. At the lower pay levels, training and cross-training was an absolute requirement.

The system responsibility concept was established. This concept requires that one man be fully responsible at the lowest level possible for the operational state of an entire system. The person selected for system responsibility is either the most qualified person or one who needs system responsibility for advancement. System responsibility, then, is a personnel development tool.

All other members of the organization support the assigned system responsibility. The use of the system responsibility approach eliminates potential gaps in coverage of problems and disallows buck passing. It helps establish an atmosphere where group relationship and authority/responsibility shifts can be dynamic, shifting from the structure-oriented formal organization to the problem-focused systems responsibility assignment.

This technique aids in solving the problem of how the boss or a senior specialist can assist or support a junior technician in a palatable relationship. In essence, the administrative authority remains constant in the traditional organizational structure, while working authority shifts from man to man depending on the task at hand. This allows each systems specialist to freely and openly request support from his peers and his boss and rely on their response consistent with conditions at the time.

A group interaction "visibility" model was devised and put into effect. The basic intent of this model is to maintain open, candid group communications and to obtain maximum individual commitment to a goal set by the group. The group keeps a large

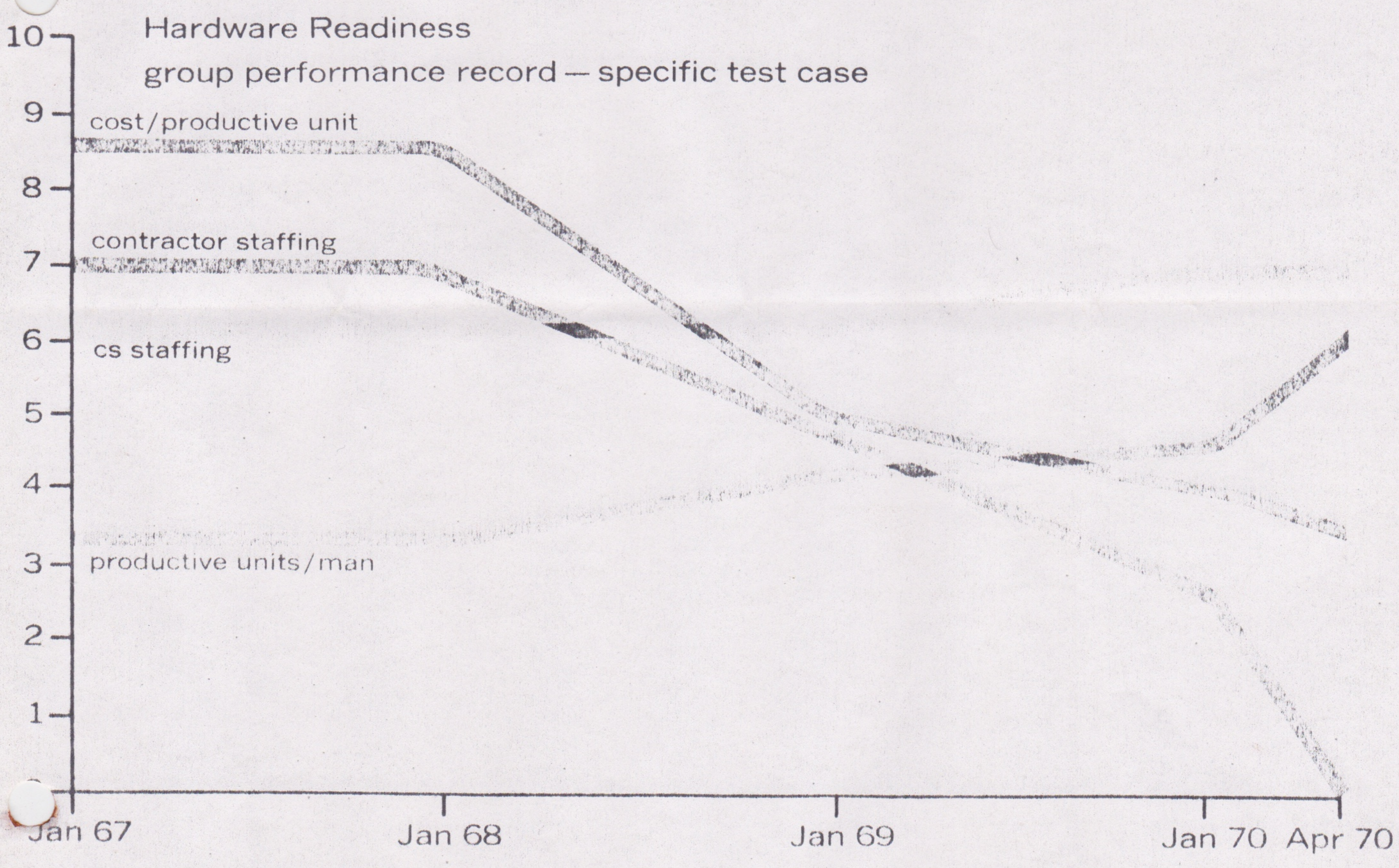

Fig. 6. Hardware readiness

chart with each man's name on the side and 32 different types of systems subtasks across the top. Each man rates his capabilities on each of the subtasks according to the following numerical scale:

1 Capable of running diagnostics and test routines.

2 Capable of locating and repairing minor problems.

3 Fully qualified in the definition and solution of equipment problems.

4 Excels in locating and repairing problems, can teach and give on-the-job training.

Fig. 4 shows a sample Visibility Chart. Because it is public, is filled out by each individual and is changed at will, it tends to be quite accurate.

At a glance, it shows the strength of the group on any particular piece of equipment and it automatically shows the scope of knowledge of each individual in the group.

When such a chart is first established, it causes a certain amount of trauma, but the advantages soon outweigh any feelings of inadequacy on the part of an individual.

Results

The results of these innovations can be expressed in a single phrase—costs came down and reliability went up. A specific test case was developed which is depicted in Figs. 5 and 6.

In order to present the results of the Hardware Systems Readiness Program, a series of comparisons was made on a like family of equipment involved in several different NELC projects. Fig. 5 shows the gross measurement of labor cost versus level of work. January, 1967, was selected as a base for the comparison since it coincided with the first action steps in our improvement program. The equipment and tasks assigned as of January, 1967, were accepted as 100% of our workload. By January, 1968, one year later, there had been no measurable change in either the workload assigned or the cost of the labor force on assignment. However, during that year it was apparent that general ability, attitude, and technical competence of the group was increasing. During the second year, the results became more measurable. By January, 1969, we had received a 38% increase in workload assignments yet cut costs from $295,000 to $245,000. By the end of the third year, the costs had been reduced another $40,000 to $205,000. Three months' experience in 1970 indicated a forecasted ability to further reduce the fourth year costs to $175,000.

Fig. 6, based on the same data, shows the relative changes in cost per productive unit and productive units per man. Over the three-year period, the productive units of work per man increased from [illegible] to [illegible]. The cost per unit reduced comparatively although some additional cost leverage was evidenced by the replacement of contractors by lower cost personnel.

The final result of the total effort was an excellent, closely knit team with a high degree of efficiency, capability and team spirit.

Some of the specific accomplishments resulting from these innovations, as fallout to the main effort, were:

1. Increased cost effectiveness by a factor of 2.5 in a three-year period.

2. Designed and installed several general purpose diagnostic software packages.

3. Initiated and implemented numerous design modifications to existing equipment.

4. Established in-house training capability.

The most significant result of this total effort is the fact that so-called uninspiring tasks can become dynamic and uninspired employees can become highly committed and motivated. □