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**IMPLEMENTATION OF QUALITY IMPROVEMENT TECHNIQUES FOR
MANAGEMENT & TECHNICAL PROCESSES IN THE ACRV PROJECT**

**Final Report
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ABSTRACT

Total Quality Management (TQM) is a cooperative form of doing business that relies on the talents of everyone in an organization to continually improve quality and productivity, using teams and an assortment of statistical and measurement tools. The objective of the activities described in this paper was to implement effective improvement tools and techniques in order to build work processes which support good management and technical decisions and actions which are crucial to the success of the ACRV project. The objectives were met by applications in both the technical and management areas. The management applications involved initiating focused continuous improvement projects with widespread team membership. The technical applications involved applying proven statistical tools and techniques to the technical issues associated with the ACRV Project.

Specific activities related to the objective included working with a support contractor team to improve support processes, examining processes involved in international activities, a series of tutorials presented to the New Initiatives Office and support contractors, a briefing to NIO managers, and work with the NIO Q+ Team. On the technical side, work included analyzing data from the large-scale W.A.T.E.R. test, landing mode trade analyses, and targeting probability calculations. The results of these efforts will help to develop a disciplined, ongoing process for producing fundamental decisions and actions that shape and guide the ACRV organization.

INTRODUCTION

Total Quality Management (TQM) is a cooperative form of doing business that relies on the talents of everyone in an organization to continually improve quality and productivity, using teams and an assortment of statistical and measurement tools. JSC management has made a commitment to understanding TQM techniques, and to implementation within JSC organizations. The Assured Crew Return Vehicle (ACRV) Project Office began to investigate and utilize the applications and benefits of continuous quality improvement techniques during the late spring and summer of 1991. As the ACRV project continues to move through its various stages of development, it remains vital that effectiveness and efficiency be maintained in order to provide the Space Station Freedom (SSF) crew an affordable, on-time assured return to Earth. The challenge is magnified by an increasing pressure to adhere, if not reduce, schedules and cost while meeting strict technical objectives. The introduction of ESA and NPO Energia into the picture has created a whole new set of issues and processes that need to be addressed. An additional factor for the success of the ACRV is attaining the maximum benefit from the resources applied to the project.

This paper documents the work performed over a 10 week period which involved examining, measuring and assessing processes being utilized by the ACRV Project teams. A major portion of this work involved determining specifically where certain statistical tools would be appropriate, and demonstrating their application. Major areas of interest included ACRV testing techniques, probability of mission success (POMS), and support contractor processes. The results from this work are aiding the ACRV office in implementing a disciplined, ongoing process for producing fundamental decisions and actions that shape and guide the organization. The resulting activities of the ACRV Project teams will serve as models for other organizations which are attempting to use TQM effectively to anticipate and respond to changing environments.

METHODS IMPLEMENTED FOR IMPROVEMENT ACTIVITIES

The activities conducted over the summer were supported by a series of four tutorials presented by the Summer Faculty Fellow (SFF) to the New Initiatives Office (NIO) and associated support contractors, a briefing to NIO management, and interaction with the NIO Q+ Team, and the ACRV and NIO manager. Direct application of numerous quality improvement techniques was accomplished in conjunction with the administrative support contractor personnel in the ACRV office. The SSF also encouraged and supported direct use of concepts and tools presented in the tutorials. Throughout the tutorials, participants were asked to brainstorm and discuss related topics, particularly with regard to implications and applications within their own organizations. All tutorials were videotaped, and copies of the tapes and the viewgraphs used may be obtained through the NIO Library in the NOVA building. The four tutorials presented are described below.

1. Implementing A Total Quality System: Process Improvement and The Role of Deming's Points

This tutorial presented the basic concepts included in a total quality system, and discussed the elements needed for implementing a quality improvement system. Topics included leadership involvement, team structure, team facilitation, quality training, and quality planning. The first 7 of Deming's 14 points were presented, including discussions relating the implications of the points to the attendees' organizations. In the Deming context, a model of quality was presented as it relates to a business strategy. Time was also spent discussing a methodology for process improvement, and how to make implementation of the various steps happen.

2. The Implications of Variation on Continuous Improvement and Deming Points 8-14

It is vital that all team members understand some of the basic statistical concepts needed to interpret variation. This tutorial presented an overview of the impact of variation, how it can be measured, and how it can be monitored for valuable results. Deming's Red Bead experiment was performed, and the results were

analyzed through the use of control charts and discussion. The necessity to make a distinction between patterns of variation was stressed in order to minimize the losses resulting from the misinterpretation of the patterns. These losses can be minimized by understanding that variation can be caused by either common or special causes, by knowing how to determine whether a system is stable or not, and by basing action on this analysis. Some methods for creating control charts were presented, with significant time spent on discussing the interpretation of control charts.

3. A Toolbox for Quality Improvement

This tutorial began with a re-introduction to the role of problem solving, and a strategy for process improvement. The roles and responsibilities of team members was presented and discussed. The remainder of the tutorial presented a wide range of tools which may be used by teams in continuous improvement efforts. Effective use of brainstorming and its relations to team activities was presented. The various tools presented included:

Seven Old Tools: flowcharts, cause and effect diagrams, pareto diagrams, checksheets, histograms, scatter diagrams, and control charts.

Seven New Tools: Affinity Diagrams, Interrelationship Diagrams, Tree Diagrams, Matrix Diagrams, Matrix Analysis, PDPC, and Arrow Diagrams.

Quality Function Deployment

Brainstorming

4. "ReInventing Government"

This tutorial presented a discussion of the recently published book of the same title. Discussions included a relation of Deming's 14 points in light of relationships to government organizations. Significant time was spent discussing examples of successful applications of continuous improvement efforts in a widespread assortment of governmental organizations.

IMPLEMENTATION OF QUALITY IMPROVEMENT TECHNIQUES

One highly focused team improvement activity was accomplished over the 10 week period. This involved the work being done by the ACRV support contractor - Eagle Engineering. An office of three people performs all of the administrative support for the ACRV project office. These activities include typing letters, typing presentations, copying, preparing viewgraphs, sending and receiving faxes, scheduling telecons, keeping files and retrieving documents, maintaining an office calendar, and numerous other activities. In preparation for an expansion of the activities of the project office, this team wanted to understand and improve their processes before the introduction of international activities completely confounded the support activities.

Throughout the summer, data was collected by tracking many of the activities performed in the support office. A log was kept of copying performed, copier breakdowns, and fax breakdowns. An "Administrative Support WORK REQUEST" form was also developed and tracked throughout the entire 10 week period. This form helped keep track of how long it took jobs to go through the office, who was requesting work, what type of work was being requested, and barriers that were encountered along the way. Two surveys were also given to customers during two weeks of Configuration Review meetings that were supported by this same team. Towards the end of the tracking period, all results were collected and analyzed. Through the use of control charts, bar charts, pareto diagrams, and flowcharts, the support personnel were able to understand the current state of their processes, and determine methods for improvement.

The results of these activities helped the support contractor team to improve the processes that they dealt with daily in supporting the work of the project office. The results of this activity also helped other project office personnel understand the significant amount of activity necessary in project support, and how their help was needed to maintain effective support on the part of the contractor. This eliminated some of the barriers between management and personnel, and between the contractor and the project office personnel.

ENGINEERING ANALYSIS ISSUES

Three major activities took place in the area of statistical analysis. These included the analysis of W.A.T.E.R. test results, aiding the Landing Mode Decision Team in decision analysis, and further calculation of targeting probabilities.

W.A.T.E.R. Test Results

This activity involved analyzing results from a test which the SFF helped design during the previous summer. The Wave Analysis & Test of Extraction Requirements (WATER) Test was a large-scale testing effort which focused on the post-landing phase of the ACRV mission, specifically a water-landing vehicle. The development of a full scale, generic ACRV mockup was the centerpiece of the crew egress evaluation. A mockup to simulate the water dynamics of both the Apollo and a NASA study vehicle concept, SCRAM. An entire week of unmanned testing took place in May, prior to the SFF's arrival. The SFF was then able to attend a portion of the manned testing which occurred throughout the first week in June.

All of the results of these testing efforts had to be analyzed using experimental design analysis techniques. This included synthesizing numerical, quantitative, results with verbal, qualitative input offered by the Search and Rescue (SAR) personnel. Response variables such as flotation attitude, pitch amplitude, yaw rate, and wave run-up had to be analyzed relative to input variables such as vehicle configuration, wave state, hatch location and crew composition.

Landing Mode Decision Team

This effort involved the use of a tool called the Analytic Hierarchy Process (AHP) to help the team come to a recommendation regarding the required capability of an ACRV to land on land or water. The team had already gone through a process of defining criteria/objectives to make the decision, definitions of these criteria, and measures of effectiveness for each criteria. Throughout the summer, for each measure of effectiveness, a score was determined for one of five landing modes: land only, water only,

land and water, land primary with water back-up, and water primary with land back-up. The SFF then helped the team in the use of AHP to rank by importance the measures of effectiveness, rank by importance the mandatory and highly desirable criteria, and then to combine all of these rankings together into a final recommendation. The results of this work will help provide the direction for future development efforts of the ACRV.

Targeting Probabilities

This effort involved calculating targeting probabilities for landing the ACRV on land sites throughout the world, and the related probability of mission success. Initial engineering studies were performed to estimate the targeting accuracy to a landing point of a range of ACRV configurations due to navigation, entry guidance, and parachute drift dispersions. Information was used to generate a two-dimensional probability distribution which characterized the probability of landing over a given region. Using information obtained on obstacle coverage at two specified landing sites, a probability distribution for the obstacles was also generated. When these two probability footprints were combined, the results provide the capability of estimating the probability of the ACRV hitting an obstacle upon landing. This measure is one of a number of criteria that play into the overall probability of mission success. This also will play a role in determining the landing mode decision described previously.

JSC CENTER ACTIVITIES

Along with the activities described above, throughout the summer the SFF also spent some time working with groups outside of the ACRV Project Office. These activities included meeting with the JSC TQM Steering Committee, presenting a TQM tutorial to the Budgeting office, and talking to the Manager of Training and Development regarding center-wide training in quality improvement methods and tools. All of these activities grew out of the initial work and tutorials provided to the ACRV project team and NIO personnel, and will help support the Center's efforts in implementing and sustaining continuous improvement.

CONCLUSIONS

During the course of the summer's activities, numerous people in NIO and the ACRV project office have gained a better understanding of TQM - not just as a philosophy, but also as knowledge of the tools available to support the philosophy. This has resulted in more people thinking about how to use the available tools, and possible applications in the work and process of NIO activities. Members of the ACRV office, and NIO, expressed a strong interest in finding more applications, and continuing the quality improvement activities so that knowledge of the tools is not lost. For the administrative support team, significant improvements have been made in the processes evaluated by the team.

More people are now looking at how to implement TQM in their own organizations and processes. Contractor attendance was very high at all of the tutorials, and they gave valuable input. The involvement of all of these organizations improves internal customer/supplier relationships, helps provide some focus on internal processes as well as external, and provides many additional people with direct experience working with TQM tools, and operating under the corresponding philosophy. All of these people will have to be supported by their management in carrying out these activities as they move into future activities.

Improving product and/or service quality is achieved through improvements in the processes that produce the product or service. Every activity and every job is part of a process - and can be improved. Improvement comes through people and learning. A strategy for process improvement used by teams helps provide a roadmap for further improvement. The roadmap includes the development of team members who possess the ability to determine a common objective, define the relevant process, define the current knowledge, and build on that knowledge to make a change in the process using the improvement cycle. If the enthusiasm, and team activities, initiated in the projects described in this paper are used as a roadmap into the future, the ACRV office and other organizations within NIO can realize significant improvements in processes, and can leave a well-defined trail for others to follow along the road of continuous improvement.

