The Space Congress® Proceedings

1993 (30th) Yesterday's Vision is Tomorrow's Reality

Apr 27th, 2:00 PM - 5:00 PM

Paper Session I-B - Continuous Improvement- Transforming Yesterday's Reality into Tomorrow's Vision

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Thirtieth Space Congress
Yesterday's Vision is Tomorrow's Reality

Session:
Today's Vision

Continuous Improvement: Transforming Yesterday's Reality into Tomorrow's Vision

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Abstract:

Over the last 15 years, the Space Shuttle Program has evolved from a vision of a cost-effective, reusable space transportation system to the flagship of our manned space endeavors. In parallel, hundreds of analytical, management and administrative systems, processes, and tools were conceived, developed, and implemented to provide the required support for an evolving operational space program. Increased pressure on NASA's limited budget has demanded a reevaluation of 1) the products and services that are really required in today's environment, 2) the cost effectiveness and efficiency of these products and services, and 3) the products and services that will be required over the next 20 years of Space Shuttle operations.

This paper focuses on the experience of a unique NASA/contractor partnership in using a continuous improvement ("ci") approach to assess and change very dramatically the work performed on the Space Shuttle System Integration Contract. From the initial formation of a Cost Effectiveness Enhancement (CEE) Team at Rockwell International Space Systems Division in FY 1991, the NASA/Rockwell partnership successfully reached a 25% - 4 year cost reduction goal in only two years. Continuous improvement techniques do work! The reality of yesterday's and today's way of doing business can be transformed into a more efficient tomorrow with vision, management commitment, and empowerment.

1.0 BACKGROUND

The Space Shuttle System Integration contract was awarded to Rockwell International Space Systems Division (SSD) in July 1972 by the NASA. The System Integration contract supports major NASA centers in four states. Responsibilities include the definition of integrated vehicle flight and ground system design and mission performance requirements. Other major task areas are the definition of induced design envelopes, and the integrated vehicle certification of flight readiness for each mission.

As a result of limited resources and tight fiscal constraints over the past several years, Defense and Aerospace industries have experienced a reduction in business activity. The impact of fewer contracts being awarded has placed a greater emphasis on effectiveness and efficiency of industry contractors. The key to technological and economic survival for Aerospace companies is the transformation of existing programs, such as the Space Shuttle Program, into more cost efficient programs so as to make the savings available to other aerospace programs.

The Shuttle Program, in the latter part of 1989 and early 1990, began to reestablish an operational mode following return-to-flight. Change traffic to the program were reducing and the increased level of analytical activities for System Integration from the return-to-flight effort were no longer necessary. With the country in a recession, external criticism was directed at the NASA for the high costs associated with existing programs like the Shuttle and Space Station Freedom. It became obvious to Rockwell and the NASA that funding levels for the Shuttle program would not continue at its current level and the need to be proactive in reducing the cost of System Integration contract was necessary. Rather than waiting for top-down decreed reductions to be invoked, a self-imposed, logical and gradual reduction plan was much more desirable.

2.0 INITIAL PHASE - DEC. 1990 - DEC. 1991

An agreement was reached in December 1990 between the NASA and Rockwell program management to reduce the cost of the operations (ref. Figure 1) of the System Integration contract by 25% in four years without a loss of quality in the work performed. A portion of the savings were to be reinvested by Rockwell to implement further cost efficiencies within the Systems Integration program, while the remainder was to go back to the NASA to use as they deemed appropriate. This activity was labeled the Cost Effectiveness Enhancements (CEE) Initiative. Our NASA customer's willingness to set aside program resources to invest in recommended improvement candidates was key to enabling and sustaining the Initiative.

The initial target was a gradual 25% reduction (5% in FY91, 8% in FY92, 8% in FY93, and 4% in FY94) in operating manpower over a four-year period (Figure 1).

The CEE Initiative was a pathfinder program at Rockwell Space Systems Division (SSD). Since a program of this magnitude and scale had never before been attempted, a new and comprehensive team approach was needed.

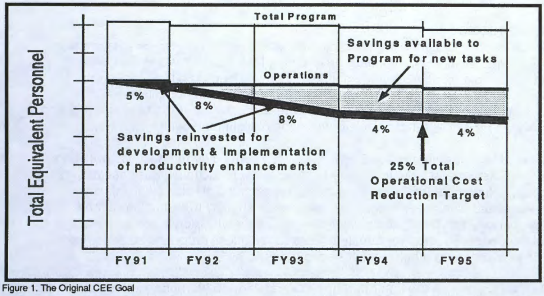

Figure 1. The Original CEE Goal

2.1 Initial Core Team Formation

Ten highly self-motivated, personnel were selected to represent key engineering functions. These individuals were known as the CEE 'core' Team. Several of these members were fully dedicated to the team and were co-located in Downey, CA. Five members represented Rockwell SSD at the off-site locations (KSC, JSC, & MSFC) and communicated with the core team in daily teleconferences. The role of the CEE Team members were to facilitate idea generation and participate in process analysis exercises and brainstorming sessions which would result in ways to reduce program cost. The core members used their individual experience, perspectives, and functional engineering backgrounds to add value and contribute to the cross-functional team.

The core team, though experts in their own respective areas, were not initially versed in "organizational improvement" theories and applications. Members used their own personal resources, outside training, and educational experiences to become exposed to as many possible theories, strategies, methodologies, and real-life case studies in various business and cultural circumstances that may be employed at Rockwell. In addition, various company resources in the form of just-in-time support and training in Total Quality Management (TQM), Continuous Process Improvement (CPI), and design to cost (DTC) were also utilized.

2.2 Initial Mode Of Operation

All Rockwell System Integration operations tasks were divided into synergistic work groups and represented as slices of an overall contract pie chart. The CEE "pie slices" were arranged by descending order of manpower budget. "Pie slices" ranged in size from 7 to 60 EP and were arranged to reflect common or related activities within a certain work process or work group. This approach also allowed the core team to perform a Pareto analysis to help identify the larger cost drivers - those task areas which could potentially provide the largest return on resources invested in the improvement process.

2.3 Initial Process Improvement/Cost Reduction Approach
The cost reduction methodology employed by the team was representative of most common continuous process improvement models we studied:

1) Organize tasks/activities of "pie slices" into major process/product
2) Select process/product to improve/reduce within each group
3) Define as-is process (customers, product requirements, process flow, etc.)
4) Analyze process (review requirements, performance, products, process interfaces, commonalties, etc.)
5) Formulate improvements/reductions (evolutionary and or revolutionary)
6) Generate improvement implementation plan and cost payback analysis
7) Obtain implementation approval if required

Several techniques for identifying cost reductions were applied within the improvement process: product elimination, requirement deletion or revision, process streamlining, automation, task consolidation, and several others. The appropriate means for achieving a given reduction was dependent upon various trade studies performed on each task. Analysis considerations included the associated product, work process difficulty, customer's present requirements, process owner's acceptance of change, level of management control, cost, and schedule. Based on these assessments, the CEE initiative followed a structured process that carried the improvement idea from conception to completion. This process, slightly modified from Dr. W. Edward Deming's Plan-Do-Study-Act (PDSA) cycle, is distinguished primarily by the four phases described below.

In Phase A, the improvement idea generation stage, the CEE core Team solicited, instigated, fostered, and championed ideas from all possible sources in the program. Formal documentation of valid cost effective enhancement ideas were presented to Rockwell and the NASA management with potential benefits, initial high level process flow diagrams of the current activities, and a detailed plan to study the improvement idea. Subsequent to management concurrence, Phase B activities were initiated.

Phase B was the coordination of activities related to the detailed investigation of the CEE idea and development of a viable improvement plan. Here a sequential flow diagram of the current process was developed by the CEE core Team and the functional stakeholders that identified all the customers and suppliers within a process. Using the Continuous Process Improvement (CPI) methodology, a survey of all associated parties yielded the definitions of requirements along with potential program risk impacts. As part of this Phase B, a cost benefit study was performed to determine estimated cost savings and payback period for implementing CEE ideas.

In Phase C, the actual implementation of the improvement tasks was performed by the respective functional groups. The CEE core Team remained an active participant in this stage, assisting the functional group by helping monitor the progress of the improvement task . The functional groups used Phase D to operate, maintain, and monitor the performance of the improved task.

The goal of this four phase approach was to complete a full cycle of the improvement process and culminate with the development of significant improvement

implementation plans. The cycle time for each improvement process iteration ranged from a few weeks to several months due to the complexity of the process, and was highlighted with an extensive status/review with the NASA customer.

Significant CEE cost improvements included:

- Streamlining and automation of the Shuttle flight software verification post-test analysis and documentation, test requirements, and Space Shuttle avionics sequencing verification processes as well as the standardization of the flight software verification checkout procedure generation process. In addition, the team led a coordinated effort involving several Rockwell and NASA entities that performed analysis and developed and implemented a plan for reducing the Software Avionics Integration Lab (SAIL) flight cycle test case requirements by approximately 20%. Overall the team produced a 40% cost reduction in SAIL related processes in a 2 year period.

- In various sub-teams, members of several engineering disciplines (Ascent Performance; Guidance, Navigation & Control; Structures; Propulsion; and Aerosciences) cohesively analyzed existing Flight Margins Assessment (FMA) tasks, processes and products and developed cost (manpower, schedule, computing time) and quality improvement options. The result was a 60% reduction in tasks by implementing methods for enveloping and automating several critical pre-flight launch assessments, eliminating non-value added analyses and products and improved cross-department data transfers.

3.0 EXPANDED RESTRUCTURING OF THE CEE INITIATIVE DEC 91 - SEPT 92

In FY92, several factors redirected the CEE effort. The co-location of core members facilitated the planning and development of improvement work, but the core members became alienated and began to be perceived as "outsiders" to their "home" departments - the same departments that were to implement the improvements. The breakdown in the partnership between the core team members and the departments diminished the progress and hindered the spread of CEE Initiative to other task areas using this approach.

At the onset, the core team approach proved effective in capturing the "low hanging fruit" for specific activities such as SAIL and Flight Margin Assessment. However, to develop further improvements for other areas of System Integration contract, the core members needed a broader range of support from the process owners. To layout an integrated plan, a strategy meeting was held in January, 1992 to develop an expanded approach to implement cost reductions for the System Integration Program. Approximately 60 program, project, and functional managers were brought together using a team workshop approach for the purpose of finding a solution.

3.1 Restructured CEE Team Approach

Based on the recommendations from the strategy meeting, a new organizational structure for the CEE Initiative was created (see Figure 2):

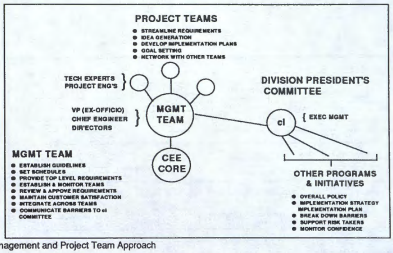

Figure 2 CEE Management and Project Team Approach

First, a CEE Management Team was established to elevate the priority of the CEE Initiative and to create and maintain a sense of urgency with management involvement. The team consisted of high level management members whose primary role was to provide a top-down guidance for reducing costs and improving quality. This was accomplished through setting goals and schedules, establishing teams and team guidelines, monitoring Project Team progress, reviewing and approving team recommendations, and communicating information across project teams. The CEE Management Team also provided an important communication channel to the SSD President's Steering Committee to help remove division level barriers.

Second, 20 Project Teams, ranging in size from five to 12 members, were established around a regrouping of all System integration tasks. This membership consisted of the project office and department functional managers, the stakeholders of the product and/or process, and the NASA customers when at all possible. The primary role of each Project Team was to identify and assess task requirements and develop specific cost and quality improvement plans. The CEE Team core members roles were redefined to effect improvements through a facilitation role and dissemination of information between teams. The stakeholders - those most capable of understanding, defining, recommending, and instituting improvements to their own process, were encouraged to do so.

3.2 Project Team Activity

The Project Team activity flow (Figure 3) was provided to each team as a template that could be adapted to meet the needs of the individual teams. The purpose of this knowledge capture of existing detailed process flows and work definitions standardized approach was to document the input/output detailed definition to adequately analyze improvement possibilities. Also by using a normalized improvement process, management was able to consistently evaluate Project Team progress and have a uniform set of recommendations based on the cost/benefit study. The Project Team process resulted in each team becoming intimately aware of customer needs, process

characteristics, upstream and downstream interfaces, product cost, and opportunities for improvement.

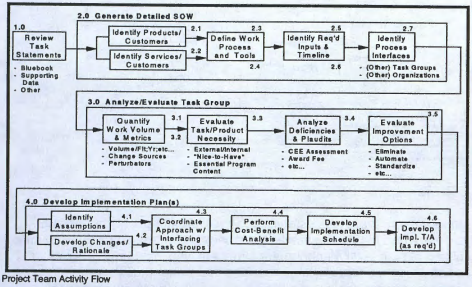

Figure 3 Project Team Activity Flow

4.0 FY 92/93 CEE ACCOMPLISHMENTS

As a fallout of the heightened cost awareness and a better understanding of tasks, products, and processes, many tasks were reduced in manpower through task content negotiations between the customer and Rockwell management eliminated non-essential program content. Many of the Project Team recommendations were small, incremental improvements that were not directly visible in the final product delivery to the customer. These "invisible" improvements provide returns by increasing capability, improving response time, and enhancing other value-added service characteristics. In addition, other less tangible, but valuable, accomplishments were also achieved:

- Captured detailed definition of work processes.
- Enhanced individual understanding of customer and supplier roles.
- Increased management involvement in continuous improvement.
- Enhanced cost and quality awareness.
- Increased focus on customer requirements.
- Improved communication channels within RI-SSD.

The CEE Initiative exceeded the original 4-year goal of a 25% cost reduction on the System Integration contract in less than two years. As a result of these significant accomplishments, the CEE Team was awarded the first annual Rockwell Corporate Chairman's Award for FY92. This award recognizes the most outstanding continuous improvement team and their efforts from the Space Systems Division.

4.1 Lessons Learned

Though the CEE Initiative was successful, it did not come easily or without some setbacks and restarts. The chance to observe and experience the working dynamics within an established system and to gain an insight into team/organizational psychological behavior during this cost reduction and process improvement exercise was invaluable. Following is a summary of knowledge gained from these experiences:

1) Team membership lessons learned

- Team members forced to participate do not make value added contributors.
- Members must overlook personal biases and their own special interest for the good of the team.
- Team members should be stakeholders committed to the improvement activity.
- Involve the customer as a team member for identification of problems and solutions
- A small dedicated and trained core team was invaluable in facilitating the "ci" Initiative.

2) Team process issues

- Involve all stakeholders in the team decision process.
- Externalize team goals with written mission statement.
- A structured approach and process was successful in keeping the activities focused on end objective.
- Care should be taken to assure that cost reduction does not degrade process/product quality.
- "ci" should be part of ones baseline task. "ci" should have proper resource planning and time allocation.
- All team members must accept ownership of the task. Responsibility should be taken in developing the team's goal and understand their own role within the team.
- Over time, different approaches may be tried in an effort to adapt to changing environmental conditions

3) Organizational support of CEE Team

- Top management support was necessary to establish priorities.
- Top management should demonstrate their support by continuous involvement in the team process.
- Public acknowledgment and award recognition to participants should be emphasized and used as a strong motivating force.
- An initiative should be flexible and allow for change and refocus.

4) Results

- Performance measures can be developed for engineering processes.
- A survey with demographics is an excellent means for obtaining open and honest feedback to determine how teams are performing and what changes can be done to improve the team's effectiveness in the future.
- Cost reductions are achievable on a mature program.
- The best time to implement process improvement/cost reduction initiatives is when the company is on an up-swing in the business cycle, not as a reactionary means during a down-turn.

5.0 TRANSITION FROM CEE TO "ci"

For FY93 the CEE Team has accepted the challenge of facilitating a transition from the formal CEE Initiative with prime focus on cost effectiveness to a self-sustaining continuous improvement environment focused on providing value to the internal Rockwell and external NASA customers. Value to the customer is the optimum balance between quality assurance, cost effectiveness, and schedule efficiency. Our goal is not just to meet our customer's expectations, but to exceed them.

The CEE core Team will continue as a catalyst to help stimulate, train, and support the functional department and project improvement teams continuing assessment of their processes and products. A key task is the development of a "ci knowledge tool box" of successful techniques, templates, models, metrics, and presentations. Other FY93 tasks range from a knowledge capture pilot program of senior engineers' mental checklists for analyzing and assessing changes to sponsorship of a lunch time "ci" speaker series.

6.0 TRANSFORMING YESTERDAY'S REALITY INTO TOMORROW'S VISION

"We should all be concerned about the future because we will have to spend the rest of our lives there."

C.F. Kettering

The CEE Initiative has provided opportunities to make a difference in the way Rockwell and the NASA work -- to update the methods and processes of a large, complex, entrenched organization. This initiative proved that a bold customer/contractor vision of the future backed by a proactive management approach and resource commitment can set the course for change. Training on continuous improvement philosophy, approaches, and techniques is a key element to help ensure maximum results from improvement teams. Empowerment of the "stakeholders", who own the processes and products, seems to unlock a myriad of ideas and suggestions that were just waiting for implementation. The unique partnership and success that Rockwell and NASA shared with the CEE initiative proved that continuous improvement techniques really do work! If the reality of yesterday's and today's way of doing business do not match the vision of what tomorrow should be, accept the challenge to change it.

It is time for the American Aerospace Industry to once again lead the world in new and profitable technologies. Past successes guarantee nothing in the future. We need only to look at our cousins in the Automotive Industry to see how redefining organizations, improving internal processes, and giving the customer what they want can help reinvigorate a whole industry. We must look at ourselves without fear and change the way we do business. The future success of this industry hinges upon the ability to adopt new, more efficient and effective work processes NOW before it is too late.