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IMPLEMENTING CONTINUOUS QUALITY IMPROVEMENT (CQI) IN A LARGE ENGINEERING ORGANIZATION

Robert H. Hammer—Director of Engineering
David W. Harris—Chief Engineer, CQI
Boeing Commercial Airplane Group
Renton Division
Renton, Washington, USA

Abstract

This paper reviews the implementation of Continuous Quality Improvement (CQI) in a large engineering organization. CQI processes strive to eliminate errors, promote technical excellence, and provide customer satisfaction. Toward those goals, a process called "Plan, Do, Check, Act," (PDCA) has been adopted that is complementary to this technically-oriented environment. Working together, management and nonmanagement are incorporating this action plan into their daily work routines. Employees also receive training that concentrates on the application of problem-solving "tools" to reinforce quality improvement methodology. In addition, tools called Process Error Prevention (PEP) and Design Success Measurement System (DSMS) have been adopted throughout engineering, using data from our products to identify problems with the related processes. Continuous monitoring through periodic progress reviews and data analysis ensures standardization and sustaining of quality improvement goals and objectives. A summarized examination of this CQI philosophy as well as its implementation and monitoring is discussed.

Introduction

In the past decade, it has become increasingly evident that customers worldwide are concentrating their spending on products and services that are produced in a total quality system. No longer are customers loyal to domestic products and services that cannot or will not meet their demanding requirements and standards. Customer-induced global competition will not diminish, and only those companies willing to embrace a total quality business strategy, such as CQI, will survive in this competitive environment.

The drafting of a total quality strategy for any business must encompass all organizations and personnel, particularly those in management. Before Boeing Commercial Airplane Group, Renton Engineering, subscribed to the practice of Continuous Quality Improvement, our traditional ideas focused on improvements made during the manufacturing phase. Solutions to problems uncovered during assembly were thought to be the responsibility of production personnel to solve. We have since accepted our share of the responsibility for many of the problems encountered by our manufacturing counterparts, recognizing that these problems are directly related to the quality of our engineering. We now realize that in order to build quality into a product, every phase from development to design, through production and service, must focus on the needs and desires of the customer. Engineering is learning that providing a first-class product cannot be accomplished through second-class engineering.

As the engineering organization for Boeing Commercial Airplane Group, Renton Division, we are committed to achieving technical excellence in the design and definition of our airplanes. We define technical excellence into three areas: (1) use of the latest and most appropriate technology; (2) technology that is fit for use (it must work as intended); and (3) release of error-free and producible product definition. Satisfying or exceeding our internal and external customer requirements is the underlying priority for our quality improvement endeavors.

Appropriate Technology

The application of the most appropriate technology is not always easy to distinguish since technology is continuously changing. Because our orientation is technical, engineering must keep current on the latest developments for enhancing our performance and products. As an example, the old mechanical calculators delivered the correct answers and were manufactured according to very high quality standards, yet mechanical calculator technology became obsolete virtually overnight when innovative, simple-to-operate, less costly electronic calculator technology was introduced by companies that had not been in the calculator business. The Swiss mechanical clockwork watch was similarly outdated with the introduction of quartz watch technology. The older windup watches became antiquated because the newer quartz coil technology offered consumers better accuracy at lower product cost. Global marketing of quartz technology, primarily by Japanese companies, sent shock waves through the Swiss economy, which had traditionally been renown for their watchmaking skills. For a company to prosper, it must be willing to recognize the need to change products, processes, and technology to support future market innovations. Engineering must constantly be aware of new technology and conduct benchmarking to ensure products are the best in their class.

Fit-for-Use Technology

The use of the latest technology does not necessarily equate to the making of a quality product, especially when the technology is not validated under applicable circumstances. An example of technology that was not fit for use was the infamous Tacoma Narrows suspension bridge in the state of Washington, later nicknamed "Galloping Gertie." The bridge was a technological marvel when built in the 1930s, designed and erected using the most up-to-date engineering advancements. Yet it collapsed in a steady, 15-knot wind (figure 1). The bridge design and test analysis had not considered the effects of a steady, long-duration wind. It is imperative that any new technical advancement be thoroughly tested and continually validated for fitness of use.

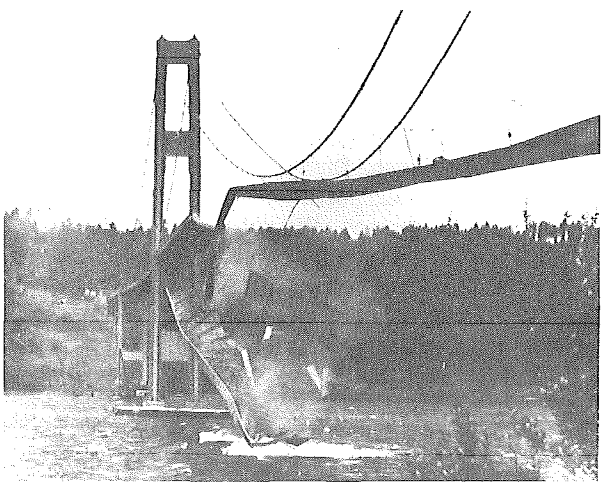


Figure 1. Tacoma Narrows Bridge, or "Galloping Gertie."

Release of Error-Free and Producible Product Definition

Engineering must relentlessly strive to release error-free product definition in order to satisfy our customers with affordable quality products. Today in many traditional companies, there seems to be a standard of a 30% engineering error rate in work completed (i.e., almost one-third of all engineering products, memos, drawings, specifications, etc. require subsequent change). If we are to offer our customers superior products that cost less, we must eliminate the practice of releasing error-prone engineering data. Figure 2 is an example of a part that is obviously impossible to produce, but many parts defined by engineering drawings are equally impossible to produce.

In many cases we have designed our systems to accommodate error correction. In fact, many employees see error correction as a large part of their normal work assignment. Today's methods for reducing engineering errors generally focus on end-item inspections. That is, we have "checkers" who check the compliance of completed drawings just prior to their release to manufacturing. In the future we must have reliable engineering design processes and reliable methods that will preclude the need for downstream inspections. One

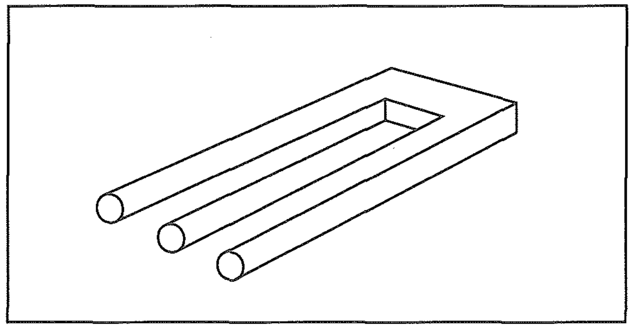


Figure 2. Example of Erroneous Drawing.

key in meeting this goal is the "empowerment" given to employees. We give complete responsibility for the development of a quality product to our employees. They are authorized to make decisions regarding needed changes for the achievement of quality in their products and services.

We also place great importance on the issues of housekeeping and safety in the workplace as a means to achieve technical excellence. It would be difficult to perceive ourselves as a quality organization if we operate in an unkempt, cluttered, and unsafe environment. It is vital that we mold an image for ourselves that portrays a clean, conscientious, healthy, and dynamic department.

This paper primarily concentrates on the implementation of CQI processes that help eliminate engineering errors as a means to consummate technical excellence and customer satisfaction. The following is presented with the Plan, Do, Check, Act (PDCA) methodology used as our formula to evolve total quality implementation. This methodology, also known as the Deming Wheel or Shewhart Cycle, is conducive for implementation in any large organization which has the desire to improve.

Figure 3 depicts the four primary segments of the Plan, Do, Check, Act cycle, and the activities used for achieving continuous improvement.

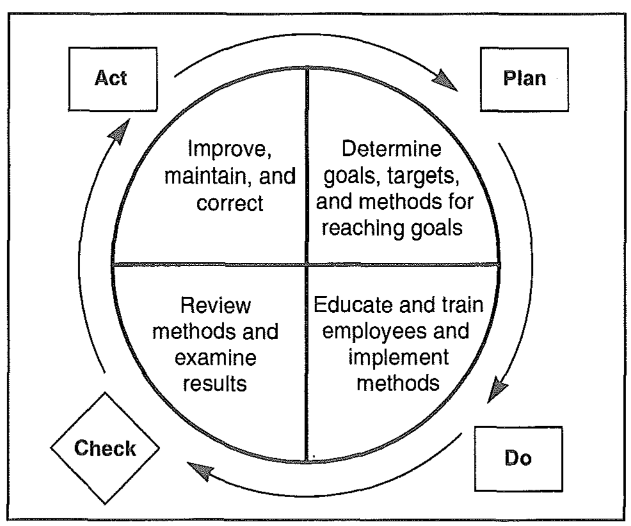
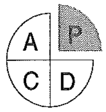


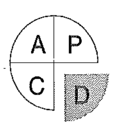
Figure 3. The Plan-Do-Check-Act Cycle.



Plan

Attainment of our goal to provide our external customers and internal downstream customers with error-free and producible product definition necessitates the use of a well-defined, structured plan capable of changing existing processes to embrace continuous quality improvement. This plan must be detailed enough to include such items as what changes are required, when data are needed as well as to determine if the data are available, what will be done with the data and which manager is responsible for each detail item. The difficulty of implementing this plan into the large, technical population in our engineering department cannot be underestimated. As Boeing observed during participation in recent studies of Japanese world-class companies, the specialized, technical setting is not without quality improvement implementation challenges, even in a country that has been implementing total quality for nearly 40 years. While the application of Continuous Quality Improvement principles may not be directly applicable to innovation, these principles are directly applicable to the many other functions and processes that take a great deal of an engineer's time. The elimination of non-value activities along with standardization will provide more time for engineers to be innovative in their designs.

More importantly, before a Continuous Quality Improvement plan can be implemented into a large organization, there is an overriding requirement for total commitment and ownership of the plan by management. Management owns the processes. As such, it is management's responsibility to lead the quality movement by defining the company's mission and objectives and leading the detailed implementation plan. Most importantly, these leaders must remain active and loyal to their commitments through actions and not just in words. All organizational continuous quality activities must be in alignment to support the company's mission and objectives.



Do

In support of the overall Boeing Commercial Airplane Group Company Business Plan, Renton Division has established a number of key objectives. Renton Engineering has established a detailed plan that includes objectives, tactics, and specific measures that directly relate to and support each of the division objectives. To ensure adherence to this quality planning, chief engineers have accepted ownership of specific objectives and measures. Each level of management is required to develop plans to achieve the goals and to accept accountability for specific activities that support tier-down goals and objectives. This tier-down effect establishes a framework that results in a common and focused vision throughout the engineering department. It is our resolve that all engineering personnel will develop plans outlining CQI implementation at their respective working level, thus consummating a focused alliance throughout the engineering ranks for achievement of technical excellence.

Throughout the deployment process, it is important that communication travel up and down, as well as across the various levels of the framework. Management may select the quality goals, but it is the worker level of the framework that recognizes the tasks and methods to improve that will support accomplishment of the goals. At this worker level, a detailed list of resources needed to execute quality tasks is established and submitted to management, along with suggestions for removing obstacles which might hinder scheduled improvements. The ensuing communications between nonmanagement and management can best be portrayed by envisioning a ball as it is passed back and forth between the tiers of the framework. This "catchball" deployment process ensures that management does not mandate quality implementation to the working tier, but rather seeks their input and support (figure 4). The "catchball" philosophy accommodates agreement and buy-in by all parties involved, thus establishing a viable means of open communication, from which goals and their implementation costs are weighed according to their value.

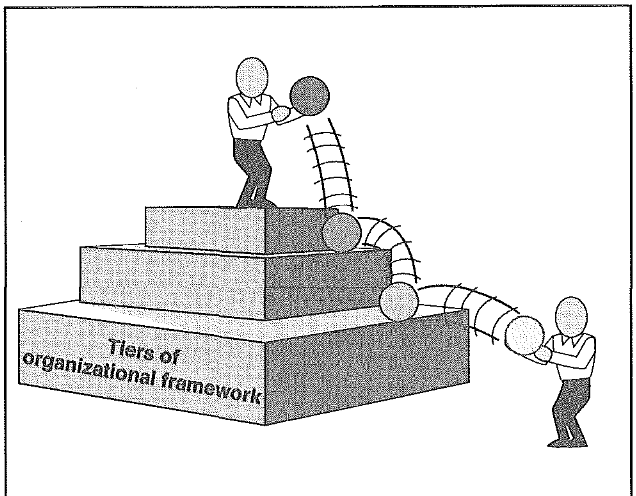


Figure 4. "Catchball" Philosophy.

In our department, deployment of current-year engineering objectives and targets with plans begins with an all-managers meeting which convenes in January of each year. A mid-year meeting is held to relate progress and to incorporate any mid-course corrections deemed necessary to maintain our schedule for CQI implementation. The mid-year session also is the beginning of the catchball process for the next year's plan.

Leading the quality movement in engineering, along with the director, are chief engineers who realize the significance of their involvement in and commitment to a CQI system. In weekly council and strategy sessions, these chief engineers discuss incremental implementation strategies, making modifications, recommendations, and policies as required to ensure continued progress is made. This council has responsibility for personnel empowerment, defining processes and owners, training of personnel, recognition of significant efforts, establishing error detection and prevention methods, and implementing metrics to measure progress. It is fair to say that reaching consensus within council regarding quality improvement activities is no simple task, and many hours of debate are required.

At this point, we will examine more closely what our Quality Council has implemented to date with respect to establishing error detection and prevention methods through the use of training, communication, personnel empowerment, and employee recognition.

Training

By training, all of our employees gain the background, knowledge and practical experience to utilize nine basic tools of quality improvement. These tools are shown in figure 5.

To understand and apply the tools, education is required and, in our case, accomplished through a planned and structured core training curriculum. This curriculum consists of formalized training courses as well as videos and books focusing on the concepts, applicability, and benefits of quality improvement. Characteristic of our

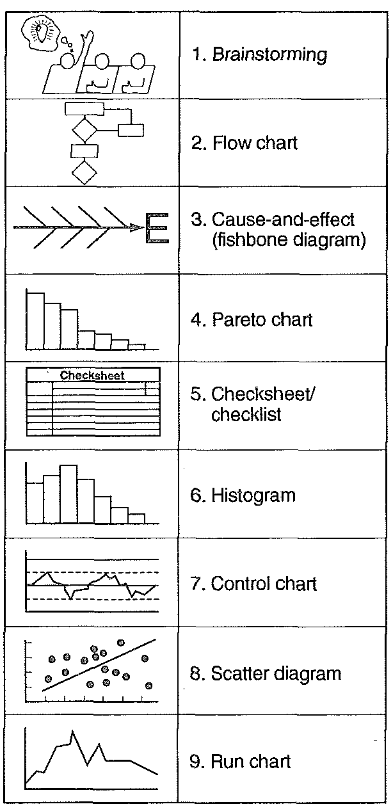


Figure 5. Problem-Solving Tools of Quality Improvement.

educational program is team-building training (both team member and team leader), as well as the use and application of statistical methods. In addition, we employ cross-functional rotation of engineers and managers as a means of training employees to become versatile in and acquainted with many aspects of designing aircraft. This rotational training generally lasts for six months, giving individuals an opportunity to absorb the numerous and distinct facets specific to other disciplines.

Less formal education on quality improvement is also accessible to engineering employees. A library-like Quality Improvement Resource Center is available to personnel where extensive information regarding quality improvement methodology, tools, implementation strategies, and principles can be loaned out for study. Books on the philosophies and implementation strategies of the quality management styles adopted as our foundation for improvement are distributed as required reading for all managers. This required reading ensures that all engineering management are familiar with a common set of quality principles.

Instruction in the tools and methods of quality improvement and offering employees the means for obtaining information on this topic are insufficient in themselves to make the changes needed to survive in today's global market. Any education not followed with experience can quickly be forgotten or later inadequately used. Engineering is concentrating on ensuring that employees promptly put their improvement knowledge into practice through timely participation in quality-committed activities.

A continuous quality improvement telephone service center with an employee "hotline" has been established by engineering. Manned by trained personnel, this service provides employees instant information on a wide spectrum of quality improvement topics from answering general concerns to specific information on how to formulate a quality team, or referrals of experts in specific quality tools or topics. This service accommodates immediate need-to-know response and eliminates the delay or losing of such communications in traditional channels.

Empowering

As a means of empowering our employees, we have successively implemented an entirely voluntary teaming concept designed to identify quality improvement opportunities at the worker level. Deployed at this level, teams establish their own goals and objectives that concentrate on improvements within their working environment, while maintaining a direct relationship to the division's objectives and the achievement of technical excellence.

The engineering voluntary team program at Boeing Commercial Airplane Group, Renton Division, was launched in late 1990 with a total of 41 teams participating. Since its inception, the program has grown to a total of 86 teams encompassing nearly 2,000 nonmanagement employees, responsible for identifying and taking personal ownership of over 700 goals for improvement, all without management intervention. In addition to the 86 committed teams currently participating in the program, numerous calls are taken weekly from individuals expressing an interest in forming a voluntary team. This activity has far exceeded our expectations in the benefits achieved through a team approach to implementing quality.

Believing that some competition is good for the mind and spirit, a team achievement/progress methodology has been established in a nonthreatening, peer-controlled environment. For the purpose of evaluating achievement, a degree of difficulty or a weighting factor is assigned to each goal by the team members. A nonmanagement peer steering committee is in place to guarantee impartiality, a level of consistency, and that identified goals and their respective weightings are compatible with engineering and division objectives.

1992 TEAM RECOGNITION PROGRAM GOALS TALLY SHEET

Team: Liason Drafting　　Date: 2/7/92
Team leader: Del Platter
Focal point: Wenarto Candra

Period	1st	2nd	Year	
Points	5484 pts	5358 pts	10,842	TOTAL POINTS FOR THIS YEAR
% Average	100%	99%	99.5%	AVERAGE % FOR THIS YEAR
# of goals	7	7		

Goals	Weight	1st period %	1st period Pts	2nd period %	2nd period Pts
Reduce APL errors by 5%	7	100%	700 pts	100%	700 pts
Process 95% of R/Ts within 3 days in drafting group	9	100%	900 pts	98%	882 pts
Process 95% of ELRs on time	9	98%	884 pts	100%	900 pts
Maintain overtime at less than 5%	7	100%	700 pts	100%	700 pts
Obtain 100% attendance in on-hour training	6	100%	600 pts		
Reduce resubmittals from change board from 5% to 3%	9	100%	900 pts		
Obtain and maintain 97% on time ESWR	8	100%	800 pts	100%	800 pts
Maintain 100% attendance in on-hour training	6			100%	600 pts
Maintain less than 3% resubmittals from change board	8			97%	776 pts
Increase ELRs worked in LIASON to 85%	9				
Work maximum of 1% overtime	6				

Figure 6. Sample of Team Goal Sheet.

Biannually, teams submit their scores to the peer committee for review. Figure 6 shows a typical team goal sheet. Those who achieve significant progress are honored with their guest at private receptions, hosted by senior management. However, all participants in the program receive some special form of recognition. This program's emphatic acknowledgment of accomplishments ensures ongoing selection, actuation, and achievement of quality improvement tasks. Empowering our workforce to establish their own goals and to judge their progress and achievements has been paramount to the success of this program. It is interesting to note that many of the voluntary teams have established goals relating to process improvement as a means to achieve error reduction.

Recognition

Other means used to cultivate an active, quality-conscious employee include special recognition as a way for commending quality work. The Peer-to-Peer Program gives workers the opportunity to recognize co-workers who exemplify a quality-committed attitude, both in function and service toward others. Like the Voluntary Team Program, this program is governed by a peer committee that validates nominations submitted for recognition.

Each chief engineer has been allocated funding for the sole purpose of applauding distinguished achievements made by an individual or team within their organization. With established budgets and numerous recognition programs to choose from, chief engineers have been able to tailor their recognition presentation to a more personal level. Award presentations range from onsite cafeteria luncheons and delivery of pizzas to the workplace, to special-interest gift items, cash, gift certificates, and certificates for outstanding performance. Engineering is proud of the achievements our employees are making, and our immediate acknowledgment of their accomplishments lets them know we appreciate their commitment to quality.

Error Prevention

In our efforts to establish error-detection methods, engineering has implemented a nine-step tool that we call Process Error Prevention (PEP). See Figure 7 for a graphic representation of the nine-step process. This structured tool for identifying errors in written/drawn products has been introduced into our technical engineering setting, and is becoming institutionalized through management's commitment to every engineering organization. PEP methodology is being deployed through a standardized approach, using peer focals as local teachers and trained moderators.

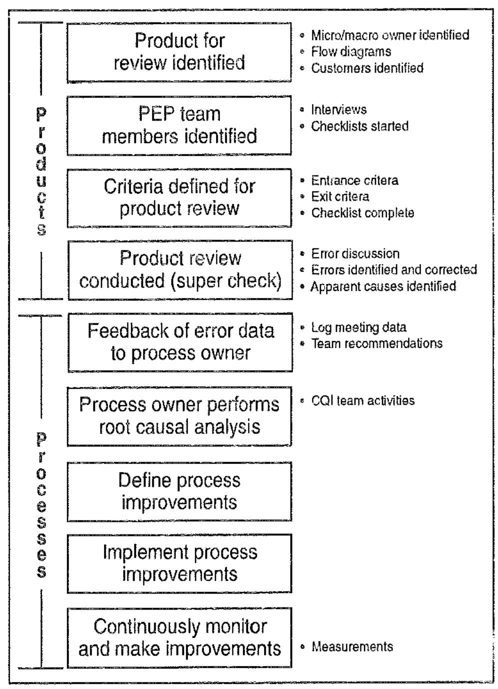


Figure 7. Process Error Prevention (PEP) Steps.

Process Error Prevention uses relevant data accumulated from our products to recognize problems with the related processes. Suppliers, authors, and customers of a product are assembled as a team to review existing requirements, standards, guidelines and methods governing how the product is made. The team then begins to investigate the product in great detail to determine if the end product was produced in compliance with the standards. If the product was produced within the set guidelines, then we ask: Were errors caused due to unclear or obsolete standards? Was variance caused by individual interpretation of training or guidelines? What are the common errors associated with the product? By identifying the root cause of errors or defects we are able to facilitate definition of process improvement and implementation plans at the process owner level. In conducting these error reviews, we have come to realize that many of our processes, while under control, have wide variation caused by unreliable methods. Additional benefits from PEP reviews add awareness of what types of recurring errors or defects we should be looking for in other like products. All processes must, however, be continuously monitored and improvements made as required to preclude falling back into old ways of conducting business.

We have just begun using the PEP tool, yet to date some 300 error-prevention and process improvement reviews have been conducted within our engineering organization resulting in 6,000+ errors being isolated, over 1,500 of which could have caused expensive downstream rework. Other benefits from use of this tool are improved communication between internal product customers and a comprehensive knowledge of the processes involved in the making of a product.

To further enhance error detection, our engineering organization has developed and implemented the Design Success Measurement System (DSMS), a tool for identifying chronic design producibility problems. Historically, producibility data, particularly involving vendors, have not been available to engineering. Producibility programs have been considered "factory problems" when in fact many are the result of poor engineering. Producibility data regarding aircraft component production exist on mainframe computers. With part rejection history readily accessible to engineering in structured report form, we have discernible information on recurring part and installation problems.

These reports are now regularly distributed to key personnel throughout our engineering department, providing visibility of chronic problem areas. Figure 8 shows a 12-month run of rejected components for an airplane system—a typical DSMS chart. Elements of these reports include installation background information, a narrative description of the difficulty, and statistical charts depicting associated installation problems. We use tools such as our PEP method discussed above to aid in identifying problem root cause(s), and corrective steps are then taken. Once improvements have been implemented, it is important to monitor the installation in subsequent computer reports to ensure that design changes have appropriately affected production.

In addition to scheduled reports, DSMS also has a number of expanded capabilities. For example, DSMS can provide overnight reports upon request for any aircraft assembly or installation. It can also provide complete narrative printouts of rejected parts, which can

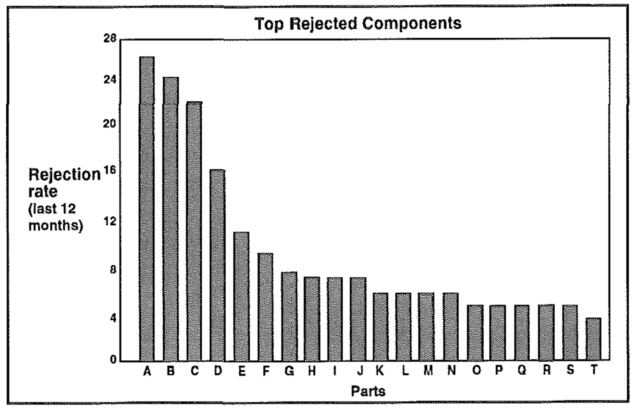
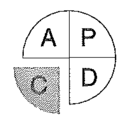


Figure 8. Typical Design Success Measurement Chart.

be used for problem investigations. This effective design producibility program ensures that our engineering is continually monitored for accuracy. Release of precise engineering design work greatly contributes to customer satisfaction by reducing costs while simultaneously cultivating technical excellence.



Check

"Those things that get measured, get done," a quote by Tom Peters, indicates the impact of a measuring or checking system. For the benefits of CQI to be seen, we must know where we have been, where we currently are, and where we are headed. By going back through data, processing it into usable form, and analyzing the statistics we can establish where we've been and where we are in relationship to technical excellence. The detailed CQI implementation plan will determine where we are headed. The plan includes measures and checks that evaluate consistency in the products, determine compliance to specifications, and most importantly determine if the product meets customer requirements.

It is not always easy to know where or when to perform a measurement/check or exactly what to measure. This is particularly true in the engineering design environment. Great care should be taken to secure measurements not just at the end of the process, but rather to determine where and when measurements will have the greatest indicator for improving the process as well as making the greatest impact on the process. As an example, if 1,000 engineering drawings were released in a week's time and 95% of those drawings were "on time" (a traditional type of measure), that would mean that there was a total of 50 late drawings. If 100 drawings were released the following week and 90% of those were "on time," that would mean that there were 10 late drawings. Do you think the customer (in this case manufacturing) would think that the 95% on time was better performance than the 90% on time, comparing the 50 late releases to only 10? Or would a system of measuring the start of a drawing instead of the release be better since that measure would give some time to resolve the problems causing the late releases? Even this measure is questionable because ultimately it's the quality of the drawing not the quantity (on time or not) that is the most important measure and of greatest importance to the customer.

Finding key quality indicators set the stage for genuine improvement to happen. Key quality indicators are:

- Measurable.
- Support decision-making and provide a basis for agreed-upon action.
- Are simple and understandable by those who need to review process improvement (including customers).
- Are expressed in terms that invite uniform interpretation.
- Involve data that are economical to gather.

Each process will have its own set of key quality indicators and relevant data.

We in engineering also use Departmental Task Analysis (DTA) as a means of checking the effectiveness of our operations. When using DTA we focus on the following questions:

- What is our product?
- Who supplies us?
- What is or is not value-added?
- Who is our customer?

We ask our customers and suppliers to address their perceptions of who we are and what we do. Results can be surprising. What one group believes to be their product is not necessarily what a customer believes they get. By answering the questions above, we continually define what we do, how well we do it, what our customers think of our products and where there is waste in our processes. Based on this definition we are able to implement department improvements where needed. As its name implies, DTA is departmental, that is within a specific department. See figure 9 for an example of a simple DTA chart (list of customers and suppliers has been omitted for clarity of chart).

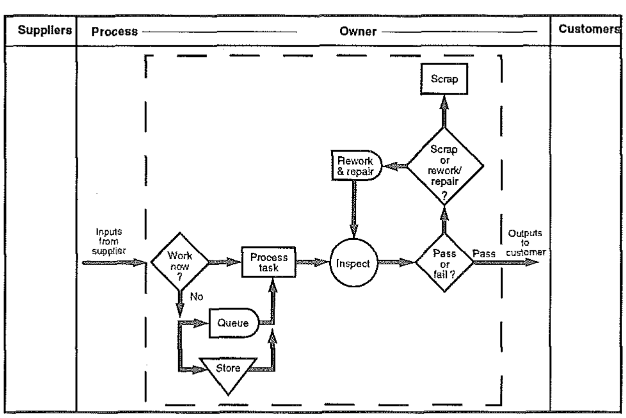


Figure 9. Departmental Task Analysis Chart.

Processes that cut across departments must also be understood, reviewed, and improved. We call these horizontal processes "Business Processes." While manufacturing business processes are fairly well understood, engineering processes are generally undefined and process owners are few and far between. As such, large-scale process improvement without definition or distinguished process owners is difficult to achieve. We in engineering are just breaking ground in our endeavor to understand cross-departmental processes at the macro level.

We must ensure that all improved processes are continually monitored and that data that indicate whether the process remains in control are gathered and reported. Periodic review of progress and performance should be conducted to ensure that the process has stabilized and not returned to its original state.

When necessary data are missing or overlooked, there is the possibility of having to invest tremendous expense and time to correct problems. As an example of incomplete data, an order was placed for a cargo version of one of our airplane models. Ensuing discussions with the customer led us to assume that the customer wanted only cargo containers installed on the aircraft. Costly redesign/rework of the plane was necessary because our customer's requirement was for cargo pallets as well as containers to be installed on the plane. Insufficient communication led to insufficient data that ultimately led to an unsatisfied customer and redesign of the aircraft to accommodate the customer's requirement. Comprehensive data and communication are needed to ensure that any product is made to meet, if not exceed, the customer's needs. One tool we are using to understand customer needs is Quality Function Deployment (QFD).

The basic approach used in QFD begins with the translation of customer requirements into design requirements. Often these requirements are expressed by the customer in nontechnical terms such, "looks good, feels good, comfortable, long lasting." Conversion of loosely stated requirements into an engineering design can be difficult, as multiple parts can make up the design and each part has to be considered for its effectiveness for design compatibility and ultimately satisfying the customer. Manufacturing must now be taken into consideration. Can the part design be manufactured? What tools are needed to produce the parts? Are tools currently in place or do they need to be acquired?

Once viable manufacturing requirements have been determined, manufacturing operations need to be defined. That is, a process for the making of the parts has to be developed. Once developed, there is a requirement to ensure the process is mistake proof. This necessitates establishing such measures as a preventive maintenance schedule on machinery, publishing an operator's guide, providing training, etc.

This established progression of customer and product requirements, from initial customer contact through final product manufacture, can have a high degree of success for ensuring delivery of a quality product only if the requirement translations are properly relayed from one process to another.

Feedback regarding any type of transition is essential and affords management the opportunity to candidly present its observations on continuing progress. As a means of disseminating feedback, our Continuous Quality Improvement Organization publishes and distributes to all employees an annual brochure highlighting quality success stories. These articles are authored and submitted by individuals and groups throughout Renton Engineering. This media vehicle is a means of advertising, promoting, and publicly broadcasting the relevance and importance of daily, ongoing quality improvement within our department.

After we have completed our planning phase, set the stage by empowering and training our employees, and checked our data, we will be ready for improvement implementation. But before a process can be improved, each method used in the process must be stabilized and made reliable; that is, the level of variation is predictable by ensuring that everyone and everything involved in the process is performing in a consistent manner. Variation, whether common or from a special cause, prevents us from producing a consistent, quality product. An example of special-cause variation might be the increased number of errors made during the vacation of a quality worker, when a temporary employee not as familiar with the process was asked to fill in. It is expected that all processes will have some minimal variation, since each process is affected by persons and events. Take for example a quality-conscious worker who consistently performs in a quality manner. But if that same worker had spent the previous night caring for a sick child, the daily work processes could easily be affected by the exhaustion or worry for the sick child. In a stabilized process, special-cause variation is easily detected as it falls outside normal upper and lower control limits. In the control chart of figure 10 we see only common-cause variation. Also by stabilizing our processes we establish a baseline from which we can measure progress, which includes things such as improvement in quality and cycle time reduction. The practice of stabilization is what keeps us from slipping back into use of old ways. In order to maintain the improvement, there is also a requirement to standardize the method by training everyone to do it the new way. By employing this standardization and stabilization methodology which is a refinement to the PDCA cycle, we are able to look for further improvement in the process. In summary, to set the stage for improvement we must have reliable methods that will lead us to stabilized, reliable, and predictable processes.

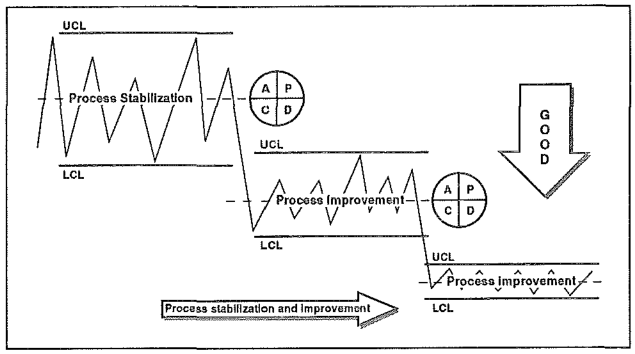
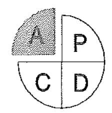


Figure 10. Achieving Reliable Processes.



Act

As we progress to the "Act" phase of the PDCA Cycle, there are three distinct steps we must act upon: (1) correct, (2) maintain and (3) improve.

Correct

Defects in products must quickly be corrected. Quick-fix remedial response action is designed to fight immediate "fires," and is not necessarily intended to be considered a permanent solution. Once a defect has been corrected and the existing faulty processes identified, the process must be examined in detail to determine the best possible action for preventing further similar deficiencies. An example of immediate corrective action is best related by reviewing a quality-conscious company's approach. When a defect is identified during assembly by a line worker, a conveniently placed cord is pulled that activates a loud whistle or light while simultaneously stopping the production line. Within seconds, many workers are on the spot to execute a fix. Once all defects have been corrected and a remedy implemented, the production line again begins operation. The defect, however, is not truly considered fixed, as the entire associated process must be examined to identify root cause.

Within the engineering environment finding and correcting the root cause of an engineering defect is not always easy. Transpositioning of numbers, writing an incorrect dimension on a drawing, or using incorrect variables in an equation, are examples of subtle human-caused errors that are difficult to prevent. We are investigating allowing additional time for projects, improved facilities and tools, additional training, check sheets, and feedback as means for improvement in these areas.

Maintain

Once the root cause of a defect has been identified and the process revised to incorporate required changes, it is essential that the new method is standardized to maintain the improvement. Failure to sustain this modified condition leads to a relapse of the process and setback in the improvement. This relapse reaction, or quick fix without a process change can best be depicted by figure 11. The end result for failure to maintain the quality gains is that no long-term, full-blown improvement occurs.

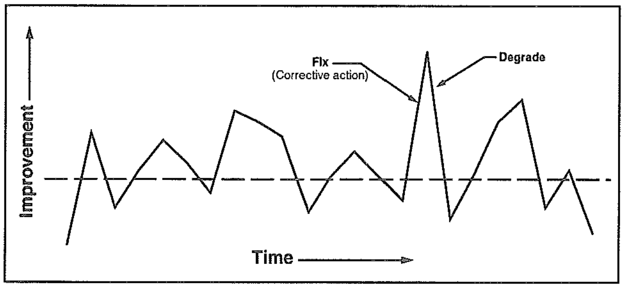


Figure 11. Failure To Sustain Improvements by Changing the Process Results in Relapse.

In looking at figure 11, it is evident that there exists no place from which incremental improvement occurs. That is why maintenance of corrections is critical, as it provides a foundation from which an upward improvement transition can develop. Figure 12 identifies a system where incremental improvements are maintained which allows for future improvement. It is obvious that improvement growth comes from processes that have been carefully monitored and maintained, which then allows continual improvement to happen.

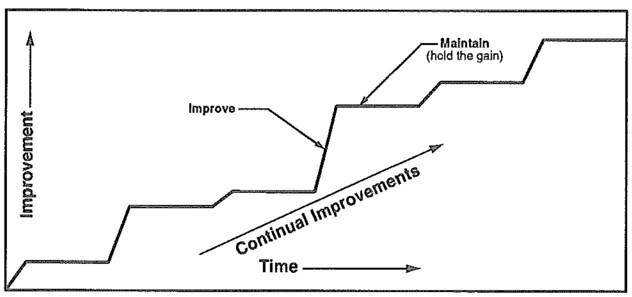


Figure 12. Maintaining the New Process Allows Incremental Improvements.

Furthermore, in order to maintain existing improvements and obtain future improvement data, we must review all the information collected during the improvement process, challenge the results, and isolate any difficulties experienced. Failure to consider unfavorable data acquired during our pursuit for total quality could interfere with subsequent improvements. The difficulties we encountered during the process are the indicators for further required improvement plans.

Our challenge now is to implement Continuous Quality Improvement by taking specific and required action on all that we have learned during the PDCA Cycle. The data indicate the best way to do business, and we must ensure that the old way is discarded and the new methods unilaterally employed. Only when we adopt these new, improved means of doing business, making decisions based on facts and data, can we say that genuine improvement has occurred.

The completion of the PDCA Cycle brings us back to the fundamental planning stage, as we formulate new ways to improve our processes. This methodology for achieving total quality is an endless opportunity to fulfill the immediate and changing needs and desires of our customers, as well as safeguarding success in our business future.

We understand that if these improvement concepts are not incorporated into our business philosophy and used as our foundation for success, in another 30 years Boeing may not be the world leader in the commercial aircraft industry. This realization is prompting a revolution in how we think about doing business, as well as an evolution in how we perform our jobs. Moreover, the CQI philosophies are leading us to the determination to become recognized worldwide as a truly technically excellent engineering department by the end of the decade. It is our firm belief that by applying the quality implementation methodology briefly described in this paper, we will achieve our objectives, as well as meet, if not exceed the desires of our global customers.

Credits

Research, composition draft, editing—Lisa Haas
Layout, editing, and graphics coordination—Vicki Wells