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INSTITUTE FOR DEFENSE ANALYSES

Reengineering the Product Assurance Function in DoD

Karen J. Richter, Project Leader
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PREFACE

This paper documents the work performed by the Institute for Defense Analyses on the task entitled "Reengineering the Quality Assurance Function in DoD." The work was sponsored by the Office of the Director, Test, Systems Engineering, and Evaluation (DTSE&E).

The authors wish to thank the reviewers, Frederick Riddell and Louis Simpleman, for their insightful comments.

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SUMMARY

This report examines the future of Quality Assurance (QA) organizations in the Department of Defense (DoD) in the midst of the quality revolution underway in American industry. With respect to quality assurance functions themselves, the report explores whether they are still necessary, whether they have changed, and where the emphasis should be. And if QA functions are necessary, where should they be in the organization—in an independent QA organization or imbedded throughout the organization? Finally, the report examines the advantages and disadvantages of each organizational structure.

BACKGROUND

In the quality revolution beginning in the 1980s, slogans such as "quality is everybody's business" began to occur throughout industry. And industry took it to heart. Engineers started using Quality Function Deployment (QFD) to determine customer requirements and Design of Experiments (DOE) and robust design techniques to design quality into the product. Manufacturing engineers and shop floor operators took responsibility for their processes and worked to reduce variability using statistical process control (SPC) techniques. The need for end-item inspection greatly decreased and, in some cases, disappeared completely. The very existence of a separate Quality Assurance organization, responsible for this inspection, was called into question.

Today, quality assurance professionals recognize the changing requirements of their jobs. In fact, the July 1996 issue of *Quality Progress* focused on "The Future of the Quality Profession." QA has evolved from an after-the-fact policing action to a vital, integral part of the entire life cycle. In many manufacturing operations, personnel can and do take on the responsibilities formerly charged to inspectors, assuring quality throughout production. Quality of each individual's work is largely accepted, making oversight less of a priority. Commercial enterprises are using improved processes in their reengineering efforts that focus on customer requirements and are therefore achieving greater customer satisfaction.

IDA APPROACH

Given that different companies, and indeed different industries, are reengineering in different ways, IDA initially examined the principles and issues of reengineering in general. These issues are described in Chapter I of this report. IDA then contacted best practice companies to establish benchmark reengineering models with various types of QA organizations as a basis for further analysis (Chapter II). In most product (as opposed to process) industries, most of the functions previously performed by a separate QA organization are dispersed throughout the company among Engineering and Production in an integrated product and process development (IPPD) environment with integrated product teams (IPTs). The remaining Quality organization consists of a few people whose responsibility is the ISO 9000 quality system and customer relations. These companies have shown the value of "centers of excellence" (CoEs), or "home bases," for training personnel assigned to IPTs, providing career paths, and maintaining a critical mass for the skills.

Popular trends notwithstanding, the benchmark models show that there is no universal solution to determining the correct mix to perform all the QA functions. In particular, process industries such as pharmaceutical and nuclear power, have retained large, strong QA organizations to perform the independent assessment function deemed critical to their operations. One reason might be that their operating processes are under strict government regulatory control. Another reason could be safety and reliability issues. This is not to say that other industries, such as aerospace, don't also have demanding safety and reliability problems, but they have successfully integrated their QA functions into their engineering and production operations. In general, the study of industry and government organizations found that successful reengineering efforts need to be tailored to the specific mission of the organization involved. This must be kept in mind in considering DoD organizations, since they generally contract out much of the final engineering and production processes for their weapon systems.

In the case study of the Army Armament Research, Development, and Engineering Center (ARDEC) Product Assurance Directorate (PAD) (Chapter III), IDA found that the functions performed by PAD could be broken into two categories: (1) technology and assessment functions best performed by an independent group, and (2) IPPD activities best integrated into the engineering/production process. In this case, preference for a strong, independent PAD entity for assuring product quality through independent assessment came from past and present commanding generals (CGs) who have relied on the independence and objectivity of PAD to ensure the safety of the armaments and ammunition to be released. The CGs believe this function is essential for the ARDEC mission of delivering munitions to all the armed forces. The remaining issue was where the personnel assigned to IPPD activities should have a home base—in PAD or in Engineering.

The emerging, popular, Lean Enterprise model (Chapter IV) provides an alternating home base model for performance ratings and career path planning. This model also combines Quality Assurance with Industrial Engineering (functions within production, such as modeling, painting, assembly) into a new process-management function. The model is similar to what we found in industry where Quality Assurance and Production were combined into "Operations" for the quality *control* aspect of the function. In this model, work is performed in IPTs in an IPPD environment and the separate functions themselves become schools and policymakers that provide training for the workers (see Figure S-1).

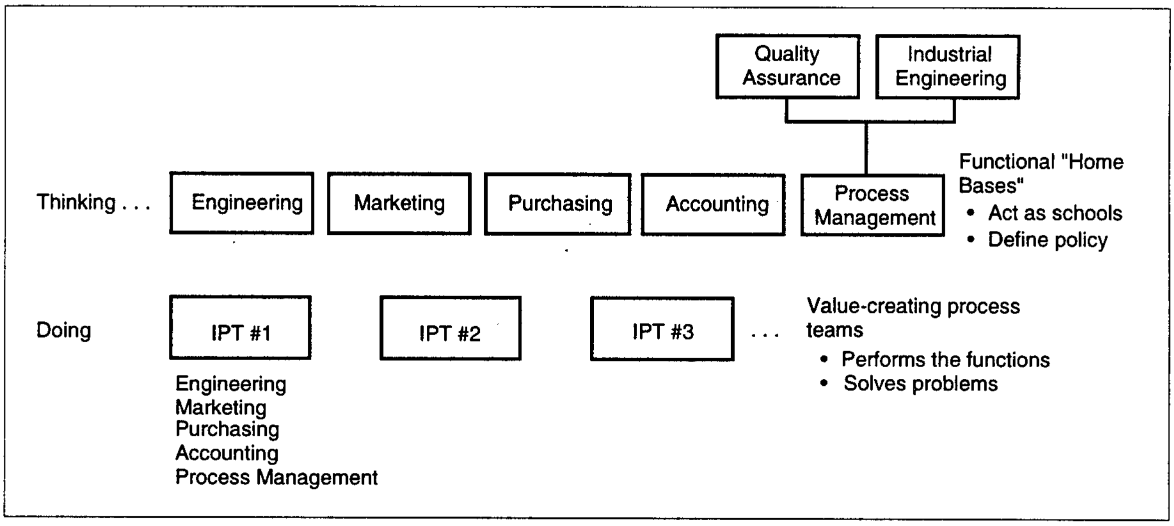

Figure S-1. Lean Enterprise Model

This was not the total model that could be recommended for the ARDEC, because it has no resident industrial engineering functions. ARDEC is a research and engineering function—products are actually produced at contractors' facilities. One alternative structure is shown in Figure S-2, where PAD consists of the Technology and Assessment Division and PAD Commodity Division IPT members. Both major elements report to a single director, who in turn reports to the commanding general. PAD assigns personnel to allocated teams aligned to the mission commodities, and the teams then provide staffing to product IPTs as required.

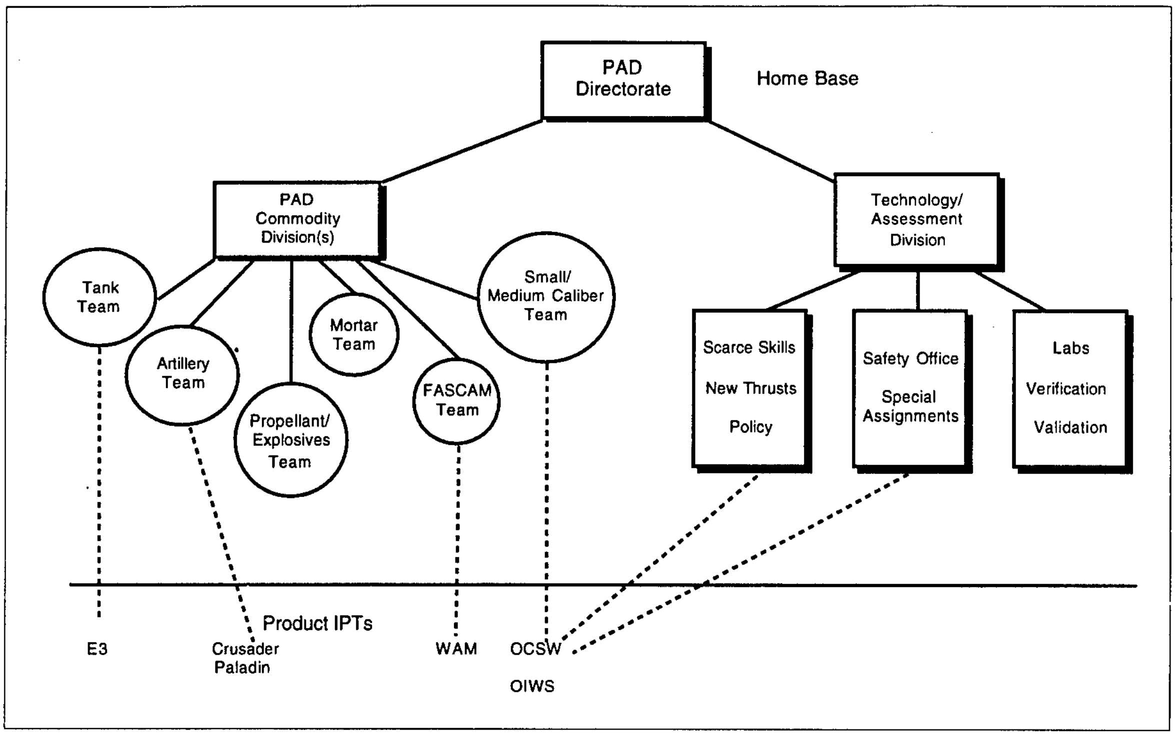

Figure S-2. PAD Organization Structure Alternative

We deem the Lean Enterprise model to be exemplary, but its application within DoD must be tailored. Just as the QA functions changed within the benchmarked industry models of Chapter II when we got to the pharmaceutical companies, the safety and liability issues within DoD organizations vary widely from low risk to high risk. Since the QA organization often provides the independent assessment so important to the safety issues, a different approach may be required in DoD for high risk products than for low risk items.

Also, the combination of Quality Assurance and Industrial Engineering is not appropriate for DoD organizations that are not arsenals or that do not do production functions. In the majority of cases, the DoD organization is doing basic research, science and technology, and development work, and the contractor is doing the production. Still, it is appropriate for the quality *engineers* to be combined with manufacturing and other engineers. The Lean Enterprise model does provide excellent options for performance ratings and offers a new viability for functional organizations as schools and policymakers.

I. INTRODUCTION

The objective of this research effort was to identify, develop, and evaluate methodologies for reengineering the Quality Assurance (QA) function within the Department of Defense. State-of-the-art companies in the defense and commercial sectors are reengineering their quality and product assurance functions to shorten cycle time, reduce risk and costs, improve quality, and gain a competitive edge in the global marketplace. Doing so requires the implementation of best practices in process and supply chain management, including alternatives to inspection-based acceptance of product based on process controls and capabilities, supplier quality certification, and integrated product and process development (IPPD). In the DoD community, however, there is no overall approach to exploiting best practices and their implementation in industry. This report is a step toward providing such an approach.

The IDA study team began this task by researching and evaluating Quality Assurance missions and structures in identified world-class companies and within DoD. The IDA team first interviewed members of the Advanced Quality Practices team of the Government & Industry Quality Liaison Panel. Other contacts were made and telephone interviews conducted with people from, for example, Malcolm Baldrige award-winning companies. The team attempted to cover a wide variety of types of industries, both commercial and defense, with varying degrees of risk levels associated with their products.

A great deal of material—surveys, past studies—was collected from the Army Armament Research, Development, and Engineering Center (ARDEC) at Picatinny Arsenal. ARDEC was undergoing a major reengineering effort, so it was an opportunity to observe and help configure the restructuring of their Product Assurance Directorate (PAD). The IDA team first met with the ARDEC Technical Director responsible for the reengineering effort. Many people at ARDEC, including the commanding general, were also interviewed. During this case study, other Army Centers that had undergone a restructuring were contacted, and a visit was made to one. Preliminary results of this study were presented at the Army's Product Assurance Directors' Conference in Detroit on 22 June 1996.

To provide a foundation for our more detailed analysis, this first chapter discusses reengineering in general and gives some definition to the QA functions. Chapter II then gives models from industry and the Army to serve as benchmarks against which the case study can be compared. The case study in Chapter III considers the PAD at the Army ARDEC. Chapter IV discusses recommended models.

A. REENGINEERING DEFINED

In the book *Reengineering the Corporation: A Manifesto for Business Revolution*, by Michael Hammer and James Champy, reengineering is formally defined as "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed." [1] Reengineering first determines what a company must do and then how to do it, ignoring how it has been done in the past. It disregards all existing structures and procedures and invents completely new ways of doing work. Reengineering is not about making incremental, marginal, or superficial changes. It aims to discard the old and replace it with something entirely new. It focuses on processes—not tasks, jobs, people, or structures.

Hammer and Champy list the five major elements that build a case for action:

- Business context—what is changing, what is newly important in the environment?
- Business problem—what is the source of the company's concern?
- Marketplace demands—what are the new performance requirements that the company can't meet?
- Diagnostics—why can't the company meet these new performance requirements?
- Costs of inaction—what are the consequences of not reengineering?

Clearly, as the book title indicates, reengineering and the five major elements were designed for a corporation. Applying these to the Quality Assurance functions within the Department of Defense (DoD) is a little different. Here we examine the five elements for DoD.

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1 Michael Hammer and James Champy, *Reengineering the Corporation: A Manifesto for Business Revoultion*, Harper Business.

1. Business Context—the New Environment

A recent Defense Science Board (DSB) study recognized that changes in the world security environment had wrought changes in the defense and commercial business environments. It said the following:

> The change from a bipolar, well-defined threat to a diffuse, uncertain threat has dramatically altered the worldwide national security environment and reduced and changed U.S. defense materiel requirements. This new environment calls for high technology products to be produced with steeply declining procurement budgets. This change affecting DoD and its defense industry is occurring at the same time that U.S. commercial industry is responding to a competitive and dynamic world economic situation in which a significant emphasis is being placed on improving product value, process yield, quality, and performance. The survivors in these environments will be firms that deliver high quality products with the correct performance features at low cost and on time, which requires profound changes in behaviors, procedures, practices, systems, and policies. [2]

The Honorable Mr. Noel Longuemare, who is now the Principal Deputy for Acquisition and Technology in the Office of the Secretary of Defense (OSD), was co-chair of the DSB study cited; hence many of the recommendations made in that report are being put into place. In an environment of restructuring and downsizing due to the rapidly declining defense budget, DoD is trying to implement the best practices of commercial world-class companies through initiatives such as the following:

- Single processes facilities[3]
- Performance-based specifications[4]
- Making extensive use of integrated product teams (IPTs) [5]

The downsizing of the Defense Department has caused the recent rash of mergers and acquisitions in the defense industry. In the future, DoD will be operating with fewer government people and dealing with fewer contractors. There will be less production of new weapons systems and more upgrading of existing systems. However, following

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2 Defense Science Board, *Engineering in the Manufacturing Process*, Department of Defense, March 1993, page 3.

3 Use of Common Processes at Contractor Facilities, Memorandum signed by the acting Under Secretary of Defense for Acquistion and Technology, Noel Longuemare, on 14 May 1995.

4 See DoD Initiatives 5000.1 and DoD 5000.2-R.

5 Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition, Memorandum signed by Secretary of Defense William J. Perry on 10 May 1995.

DoD's firm policy of technological advantage, these new systems will tend to be more complex and sophisticated.

2. Business Problem

In DoD, as in industry, it is increasingly necessary to meet requirements of supporting the warfighter with drastically fewer resources—both people and money. For the QA functions, this means maintaining or even increasing product quality at a lower cost with fewer people and ultimately protecting the safety of the warfighter.

3. Marketplace Demands

For DoD, the new performance-based specifications are driven by the downsizing and budget requirements that the Services must meet. However, the new performance-based environment requires skills in translating user needs into measurable and affordable product validation techniques. Quality Function Deployment (QFD) is one of the tools that may be needed to aid in the decomposition of requirements. Processes will be stressed for affordability reasons, and Statistical Process Control (SPC) may be important for control of these processes. Audits of contractor engineering and management processes may become critical as well.

4. Diagnostics

Can the QA function meet its new performance requirements? If the new performance requirements include downsizing to a restricted budget, then the size of the organization is the limiting factor. If the new performance requirements include SPC and audits of processes, then the QA functions are poised to meet these requirements, which traditionally have been in their domain.

5. Costs of Inaction

There is no question that some form of reengineering will be required to deal with downsizing and budget constraints. The goal is to do it wisely, so that all engineering functions within DoD can consistently deliver safe, reliable, and quality products to support the warfighter. The QA functions have always played a vital role in that delivery.

B. REENGINEERING ISSUES

An organization is defined by many parameters, such as the type of product produced, fiscal standing (a leading driver for DoD), skills mix, mission, and degree of independence. These parameters, as well as intra-organizational issues, must be considered before an organization can be effectively reengineered. Of prime importance is the customer's view. Understanding the gap between customers' needs and desires and an organization's capabilities should be the foundation of any strategic improvement effort. Proper qualification and quantification of this gap results in an easily communicated vision, a sense of urgency, and a viable framework for chartering cross-functional teams.[6] Integrating the voice of the customer with reengineering avoids the pitfalls of the "program of the month" mentalities, competing initiatives, and employee fragmentation. Still, the idea that an organization should organize around outcomes and not tasks is radical and difficult for people to accept.[7]

1. Downsizing and Core Competencies

During any reengineering process, especially when accompanied by downsizing, the organization has to be cognizant of its core capabilities. An organization's core capabilities are those functions that the organization does so well or that are so organizationally important that it would be unwise to outsource them. A recent study from the Massachusetts Institute of Technology (MIT) suggests that the skills required to do outsourcing competently are precisely the skills of systems engineering—a core competency that needs to be protected. This study found that outsourcing creates two different types of dependencies:

- Dependency for capacity
- Dependency for knowledge

Dependency for capacity is a less risky situation than dependency for knowledge. The degree of risk is influenced by the degree to which the dependent (outsourced) item is decomposable from other items and activities. In a recent study of the DoD Laboratories, IDA found that being a smart buyer is somewhat of a core competency. Can you really satisfactorily outsource that ability? In the era of performance-based specifications, this

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6 Ibid.

7 K. Patel, Integrated Business Process Improvement Model for the Department of Defense, Business Reengineering, Directorate of Defense Information.

capability may become even more important. In any reengineering effort, the dangers of losing key knowledge within an organization must be carefully examined.

2. Effective, Efficient Organization

[This section is adapted from the Defense Science Board study, *Engineering in the Manufacturing Process*, March 1993. The authors, one of whom participated on the DSB study, thought these comments were very relevant for the study reported on in this paper.]

One of the more difficult, but potentially significant, characteristics of a world-class company to assess is its organization. In the past, many firms have fallen to the temptation to organize themselves in a very traditional, hierarchical fashion with layers of managers. This approach is costly and incompatible with efficient or fast-reacting operating postures. About the only thing that can be said for it is that it is reasonably efficient as a watchdog organization. If you don't trust your employees, a hierarchical organization allows more people to watch others and thus keep bad things from happening. However, it frequently keeps good things from happening as well. Progressive firms have frequently replaced a hierarchical organization with flatter, shallower organizations that are designed around an important business characteristic or competitive advantage that the firm wishes to achieve.

Another fairly frequently used technique is to base the organization on the information flow that must occur for the firm to be successful. A popular organizational design centers on small operating units. These units are given a unique single charter, such as for a single product line, and the responsibility for all aspects of that product (i.e., manufacturing, engineering, marketing, and finance). This is not to say that smaller operating units are always affordable or the best way of doing business, but they certainly offer significant advantages of flexibility and focus.

Thus, when analyzing a supplier, the customer needs to consider whether the supplier's organization makes sense for the task at hand. For instance, in using small organization units, manufacturing companies frequently give the responsibility for all the production steps (fabrication through assembly, test, and shipment) for one product to a small group of people. Thus, these employees understand very well that their responsibility is toward that single product. This type of organization doesn't always work, however, if a very expensive process is needed in the manufacture of products across several production units. Each production line, for instance, cannot have its own integrated circuit fabrication activity. It would simply be too expensive to replicate several times throughout a plant. Thus, more expensive processes are frequently centralized with the attendant disadvantage of losing people's focus on the end product. In the interest of economy, however, centralization is sometimes the only sensible approach.

These organizational considerations apply not only to the physical processes in manufacturing but also to the organization of such important departments as Research and Development. A significant question is, Should the lab be organized around products or technical expertise? For example, should there be a power supply department that invents power supplies for all products in the lab, or should there simply be a team of engineers (including a power supply engineer) working on Product A, another on Product B, and so on. This latter organization has the technical inefficiencies of having the power supply people scattered throughout the entire organization. Inefficiencies can occur (1) because power supply engineers can't exchange ideas and problem solutions nearly as freely and (2) the products with the poorest power supply engineers will have the poorest power supplies. These problems would be substantially mitigated if all power supply engineers were located together. However, experience has shown that a great deal of enthusiasm and product loyalty can more than make up for the dilution of some levels of technical expertise.

In discussing this quandary between product concentration and functional concentration, the intention here is not to suggest which is correct but simply to indicate that there are times and places for each. A supplier that chooses one predominantly over the other is not guided by a complete understanding of the company mission but rather by tradition and will likely be poorly served.

3. Challenges of Organization

Industry—commercial and defense—is having great success implementing integrated product and process development (IPPD). However, there are some pitfalls to avoid and lessons to learn. The processes must be sufficiently characterized so that an integrated, parallel effort of process development can be undertaken along with the product development. Team members need tools to enable the efficient flow of communication among them. And companies implementing IPPD need to ensure that their people are not on too many teams. Even if assigned to one product team, teams from other initiatives—TQM, etc.—can cut into team members' time. Perhaps the most important lesson is that the organization cannot survive with everyone on product teams unless they have some home base to return to for upgrade training to maintain core capabilities and for cross training between team assignments. This home base must also be responsible for recruiting new individuals into the organizations and providing the career paths. As organizations become "flatter," however, career paths often take on a horizontal character.

The home base, or Center of Excellence (CoE) as it is sometimes called, is not organized along old functional lines. There may be one CoE for all engineering (designers and all the "ility" engineers), another for operations (manufacturing, inspection and test, etc.), and another for administration (the business side). The responsibility of the CoEs is training and recruiting, not performance appraisals. Industry has found that appraisals should be done by the team leaders alone or jointly with the CoE.

One interesting point to remember is about lines of responsibility. Say an employee has a solid line responsibility for reporting to a team leader, but maintains an administrative dotted line to some functional group where the group leader is in charge of promotions among his functional people. The employees over which he has dotted line authority may get RIF'ed before those who have a solid line responsibility to him.

4. Overcoming the Barriers

Recent studies have shown that between 50 and 70 percent of reengineering efforts don't succeed. Costs are often reduced 15 to 50 percent, but in half of the cases, actual improvement is less than 5 percent. Such disappointing results are attributable to—

- Ineffective identification of processes
- Ineffective and insufficient up-front study and analysis of the current processes
- Failure to emphasize core competencies
- Failure to understand and integrate customer needs in the reengineering
- Insufficient mobilization of resources
- Insufficient time allowed to achieve results. [8]

Moreover, in DoD the culture and reward system have been cited as high-level management problems that may impede any reengineering effort:

> There is a strong belief that the DoD culture and reward system is an impediment to process improvement implementation. Management compensation (in both DoD and private sectors) is often a funciton of the number of employees who report to the manager. Thus, a manager's status (i.e., level within the organization) may be diminished by the elimination of people that can be a consequence of functional process improvement. In

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8 Alan Leeds, First Reengineer Your Thinking, *The Business Journal*, Week of 6 June 1994.

> one of our interviews the question was asked: What motivates the manager to reduce the workforce and increase efficiency? The difficulty in answering centers around the fact that the people who should increase efficiency are the ones who are likely to lose, either due to a reduction in the number of people who report to them (potential grade drop) or in the elimination of their own position.[9]

The difference in culture existing between industry and government was very evident throughout this study. Although industry QA professionals were very supportive of the trends, such as IPPD, their government counterparts were very skeptical and much more protective of their having a large, strong, separate organization.

C. THE QUALITY ASSURANCE FUNCTIONS IN DoD

Quality assurance is "the activity of providing the evidence needed to establish confidence, among all concerned, that the quality function is being effectively performed." Quality Assurance (initial caps) is the title of a "broad-based department that is concerned with many quality-related activities, such as quality planning, quality control, quality improvement, quality audit, and reliability." [10]

The Quality Assurance organization provides a support—not a core—function within DoD. At arsenals, labs, depots—all of acquisition—the core function is producing the weapon system for the warfighter. That said, there are core functions within the overall support functions of Quality Assurance.

A review of the new DoD 5000.2-R gives the following excerpts on the types of activities required by a contractor. Although Quality Assurance, or Product Assurance, are not called out per se, many paragraphs seem to apply. Under paragraph 4.3.2, Quality:

> The PM shall allow contractors the flexibility to define and use their preferred quality management process that meets program objectives. Third party certification or registration of a supplier's quality system shall not be required. The quality management process shall include the following key quality activities:

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9 Thomas R. Gulledge, David H. Hill, and Edgar H. Sibley, Public Sector Reengineering: Applying Lessons Learned in the Private Sector to the U.S. Department of Defense, in Varun Grover and William J. Kettinger, *Business Process Change: Reengineering Concepts, Methods, and Technologies,* Idea Group Publishing, Harrisburg, PA, 1995, page 533.

10 Frank M. Gryna, Quality Assurance, Section 9.1 in J. M. Juran and Frank M. Gryna, eds., *Juran's Quality control Handbook,* Fourth Edition, McGraw-Hill Book Co., New York, NY, 1988.

1. Establishment of capable processes
2. Monitoring and control of critical processes and product variation
3. Establishment of mechanisms for feedback of field product performance
4. Implementation of an effective root cause analysis and corrective action system
5. Continuous process improvement

Related activities, such as reliability and safety, are also described. Paragraph 4.3.6, Reliability, Maintainability and Availability, states the following:

> The PM shall ensure that reliability, maintainability, and availability activities are established early in the acquisition cycle to assure meeting operational requirements and reduced life-cycle ownership cost. Reliability, maintainability, and availability requirements shall be based on operational requirements and life-cycle cost considerations; stated in quantifiable, operational terms; measurable during developmental and operational test and evaluation; and defined for all elements of the system, including support and training equipment. They shall be derived from and directly support system readiness objectives. Reliability requirements shall address both mission reliability and logistic reliability. Maintainability requirements shall address servicing, preventive, and corrective maintenance. Availability requirements shall address the readiness of the system.
>
> The PM shall plan and execute reliability, maintainability, and availability design, manufacturing development and test activities such that equipment used to demonstrate system performance prior to production reflects the mature design. Demonstrations shall use production representative systems (or as near as possible) and actual operational procedures (e.g., actual technical orders, spare parts, tools, support equipment, and personnel with representative skill levels).

And paragraph 4.3.7, Environment, Safety, and Health, states

> Environmental, safety, and health (ESH) analyses shall be conducted, as described below, to integrate ESH issues into the systems engineering process and to support development of the Programmatic ESH Evaluation (see 3.3.6).

More detail is given in paragraph 4.3.7.3, System Safety and Health,

> The PM shall identify and evaluate system safety and health hazards, define risk levels, and establish a program that manages the probability and severity of all hazards associated with development, use, and disposal of the system. All safety and health hazards shall be managed consistent with mission requirements and shall be cost-effective. Health hazards include conditions that create significant risks of death, injury, or acute chronic illness, disability, and/or reduced job performance of personnel who produce, test, operate, maintain, or support the system.

Note that this regulation defines the responsibility to do things but does not describe how to do them. How the PM should be organized to accomplish these tasks other than through IPPD is not addressed.

> The Secretary of Defense has directed that the Department perform as many acquisition functions as possible, including oversight and review, using IPTs. These IPTs shall function in a spirit of teamwork with participants empowered and authorized, to the maximum extent possible, to make commitments for the organization or the functional area they represent. IPTs are composed of representatives from all appropriate functional disciplines working together to build successful programs and enabling decision-makers to make the right decisions at the right time.
>
> The PM shall employ the concept of Integrated Product and Process Development (IPPD) throughout the program design process to the maximum extent practicable. The use of Integrated Product Teams (IPTs) is a key tenet of IPPD.
>
> The IPPD management process shall integrate all activities from product concept through production and field support, using multidisciplinary teams to simultaneously optimize the product and its manufacturing and supportability to meet cost and performance objectives. It is critical that the processes used to manage, develop, manufacture, verify, test, deploy, operate, support, train people, and eventually dispose of the system be considered during program design.

DoDI 5000.1 does discuss the use of independent assessments, which are separate from the independent Operational Test and Evaluation assessments.

> <u>Independent Assessments</u>. Assessments, independent of the developer and the user, are extremely important to ensure an impartial evaluation of program status. Consistent with statutory requirements and good management practice, DoD shall use independent assessments of program status. Senior acquisition officials shall consider these assessments when making decisions. Staff offices that provide independent assessments shall support the orderly progression of programs through the acquisition process. Independent assessments shall be shared with the Integrated Product Team so that there is a full and open discussion of issues with no secrets.

The next chapter benchmarks how reengineering the Quality Assurance organizations is working within industry and at some DoD facilities.

II. INDUSTRY AND ARMY BENCHMARKING

This chapter looks at several models of how various companies have reengineered their QA organizations. We selected organizations with a reputation for good quality, many of whom have won awards for quality. We included both defense and commercial companies and attempted to cover a wide range of product types. A few examples from the Army are also included. All examples are given fictitious names, as more information was forthcoming when IDA promised nonattribution.

A. ABC COMPANY

The ABC Company is a large defense electronics producer ($1.7 billion in 1994). Today, the company has significantly fewer people in product quality assurance (QA) activities than it had 5 years ago. The role of QA professionals in this firm has changed from policing activities to Statistical Process Control (SPC) and Design of Experiments (DoE). QA workers are involved in up-front activities, participating proactively rather than reactively and focusing on prevention rather than correction. The responsibility for product verification in this company shifted from quality assurance to operations. Increasing use of certification programs for operators limits the amount of independent product inspection and testing.

Until late 1991, the product quality assurance functions were the responsibility of a separate division in each business entity within the Company. The Quality Division manager reported to the business entity manager with a dotted line relationship to the vice president for Quality. The Quality Division manager was responsible for Quality Engineering, Reliability Engineering, Software QA Engineering, Inspection, and Product Acceptance Test. In late 1991, an evolutionary reorganization/reengineering process began which has resulted in the current organization structure. This structure has replaced the business entities with product divisions. These product divisions are supported by personnel from an engineering division, an operations division, a quality assurance division, a finance division, etc.

The product divisions' quality manager now reports to the vice president for quality but also serves as a member of the product division manager's Leadership Team. This team consists of the product division manager, each of the product department managers, and the division's operations manager, engineering manager, etc. In each of the product divisions, only quality engineers report to the quality manager. Reliability engineers and software quality engineers are now part of the engineering division.

Inspection and test is now a function of the Operations Division. Within each of the product divisions, the supporting personnel (quality, operations, engineering, etc.) are typically members of a department, project, or product team with day to day assignments and responsibilities to that team, but they are tied administratively back to their parent organization (engineering, quality, operations, etc.).

There are very few, if any, totally overhead quality functions. Most quality professionals now charge directly against program budgets; thus, they must make an effort to determine what portion of their duties can be directly attributed as contributing to a product and charge accordingly. Quality professionals are now more accepted as a value-added member of the product team.

In the spirit of continuous improvement, this evolutionary process is still underway. Figures II-1 and II-2 illustrate the change in organization that ABC Company underwent.

B. DEF COMPANY

The DEF aerospace company produces space technologies for both DoD and NASA. In reengineering, the company has reduced emphasis on in-process inspection and test witnessing. The emphasis is now on process improvement and the elimination of non-value-added steps.

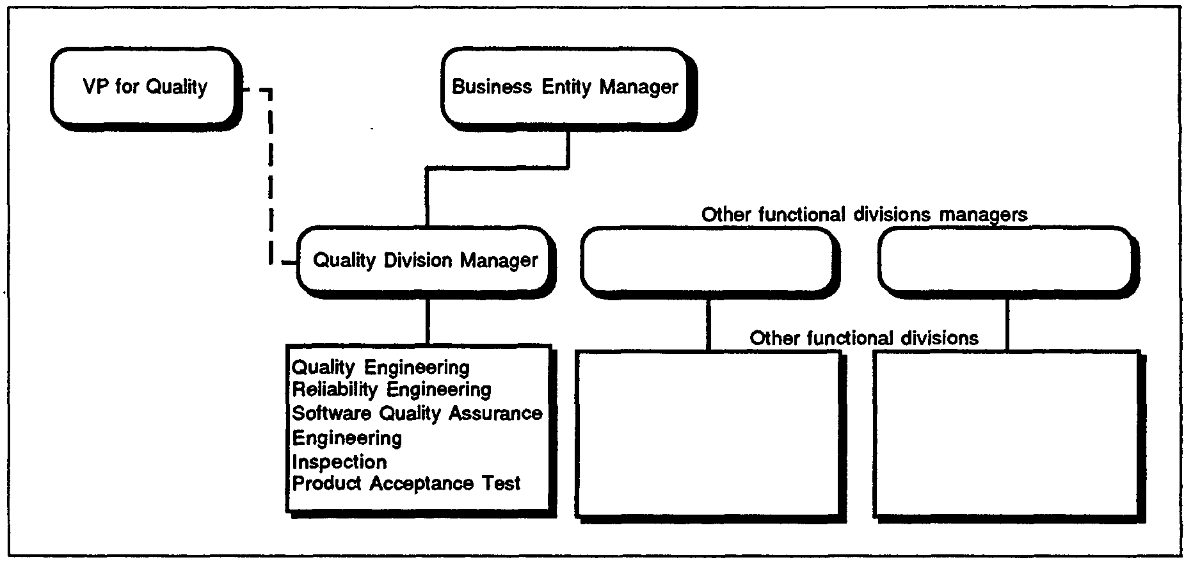

Figure II-1. ABC Company Organization Chart, Old Way of Doing Business

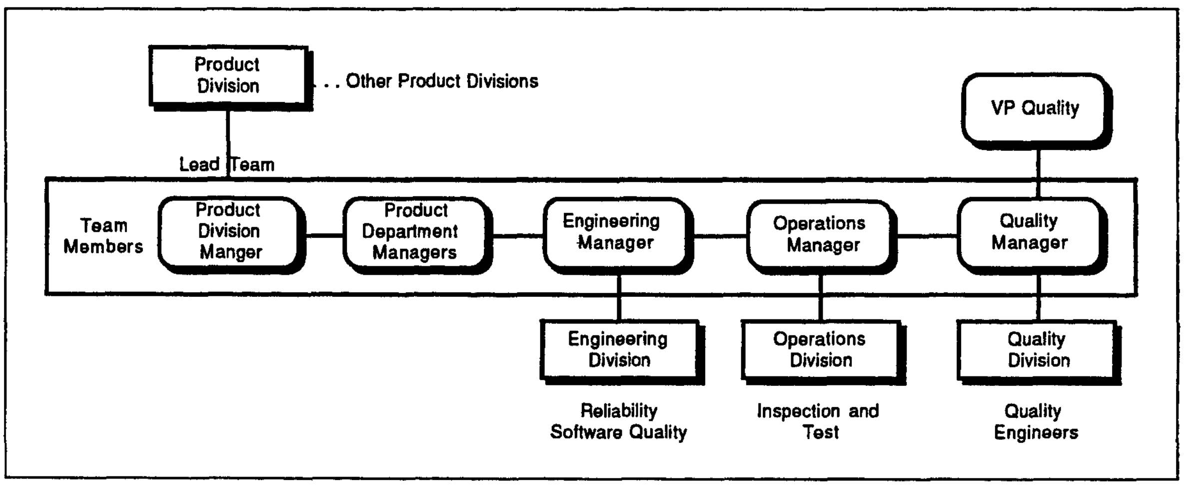

Figure II-2. ABC Company Organization Chart, New Way of Doing Business

The company's QA professionals serve as representatives on IPPD teams and report to the team leader. Their administrative requirements—time cards, appraisals—stay with the QA manager. The quality engineers and the manufacturing engineers were combined into one Operations Engineering function, thus reducing redundant tasks by 20 percent. The level of education of these engineers has increased dramatically over the last 10 years. Currently, 90 percent of the "Operations Engineers" are degreed, many with masters degrees, and some are certified by the American Society of Quality Control (ASQC).

In this company, the QA professionals, minus the Quality Engineers, remain in a clearly defined and independent organization. IDA was told, however, that this organization was driven by their DoD and NASA customers and is "not like in the commercial world." Figure II-3 shows DEF Company's current QA organization.

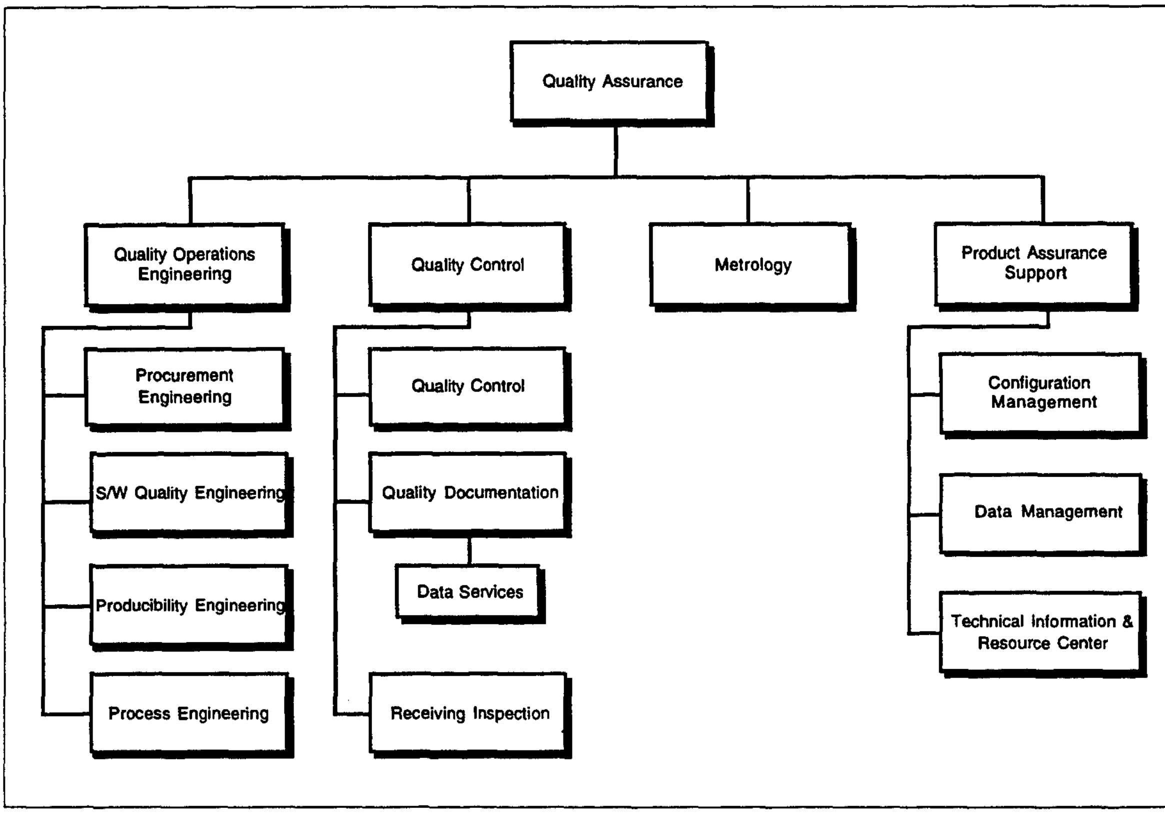

Figure II-3. DEF Company Organization Chart for Quality Assurance

C. JKL COMPANY

The JKL Company produces high technology mechanical and electronic products and services for the military, the government, and commercial customers. Its products include munitions and electronic ordnance devices. Sales were $175.5 million in 1994.

Over the past several years, the JKL Company's QA organization has become prevention oriented rather than inspection oriented. Emphasis is now on process improvement including audits, planning information analysis, design control, and supplier control. The Company is moving from detailed inspection operations to inspection audits. Quality's goal in manufacturing is to be part of the team and help operations improve their processes with 100 percent first-pass yield.

Partially due to the Company's ISO 9000 efforts, its efforts have expanded to involve all organizations. Not only is Total Quality and Quality Assurance one organization, but this company has a separate Horizontal Team, the Quality Council, which includes management from all organizations within the company.

Although manpower in the QA unit has decreased by 78 percent over the past 8 years, the remaining employees are more versatile. The organization accomplishes the same activities as it did 8 years ago plus additional responsibilities. In the past, QA had managers in charge of training procedures, quality information systems, quality engineering, software quality, supplier control, in-plant and receiving inspection, and audits. Now, the QA staff is more versatile with few managers and a variety of people accomplishing many different tasks. Inspectors are also more versatile and many have had cross-training, so they can work in all inspection areas including mechanical and electronics in-plant and receiving inspection.

The Company's audit function in 1986 was accomplished by supervisors and managers conducting audits and reporting to Quality Engineering. Now there is an audit manager reporting to the director of Total Quality, the company's ISO 9000 management representative.

The JKL company is organized into strategic business units, functional support units, and horizontal teams, as shown in Figure II-4. Today, the QA organization, with six supervisory personnel, is under the director of Total Quality, as shown in Figure II-5. Figure II-6 illustrates the complexity of the organization in 1989, when it had 18 supervisory positions.

D. UVW COMPANY

The UVW company develops technology, including hardware and software, and integrates it into the manufacture of tracked vehicles for DoD and allied governments. It is the largest manufacturer of tracked, armored combat vehicles in the United States. Figure II-7 shows the Company's QA organization and the functions it performs.

E. XYZ COMPANY

The XYZ company is a large aerospace company that produces missiles, engines, and avionics. Company sales amounted to $4.6 billion in 1994.

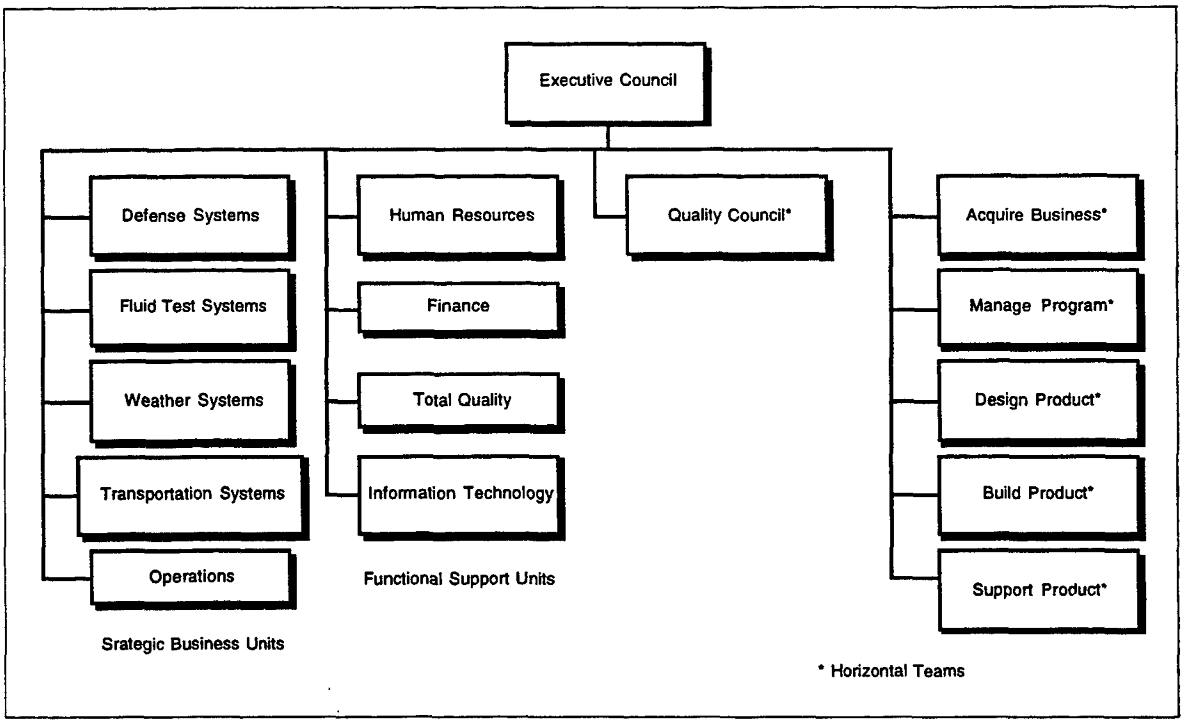

Figure II-4. JKL Company Organization Chart

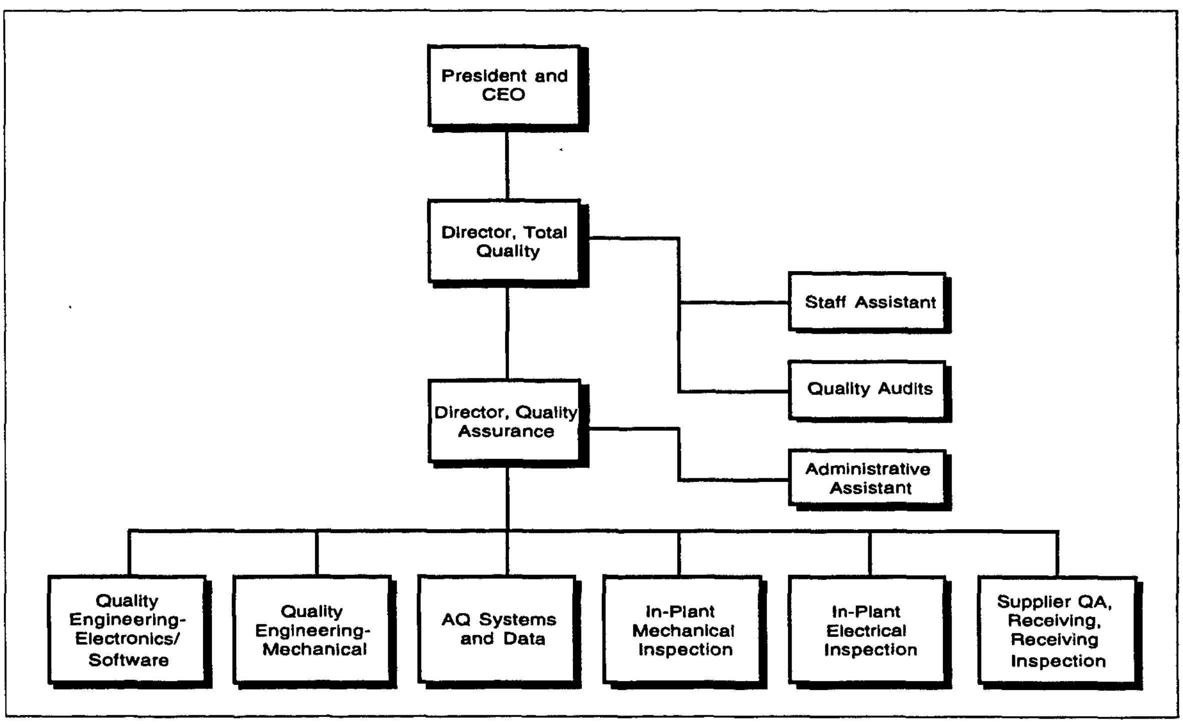

Figure II-5. JKL Company Organization Chart, Quality Assurance, 1996

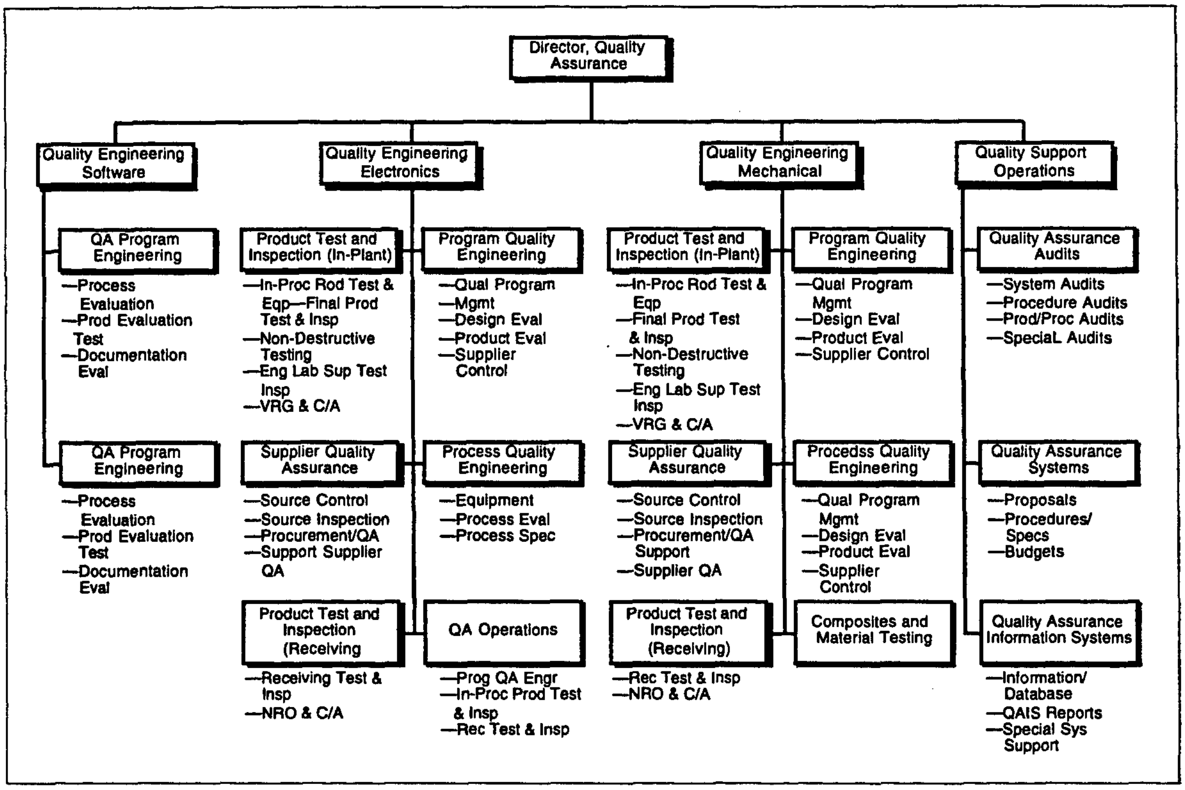

Figure II-6. JKL Company Organization Chart, Quality Assurance, 1989

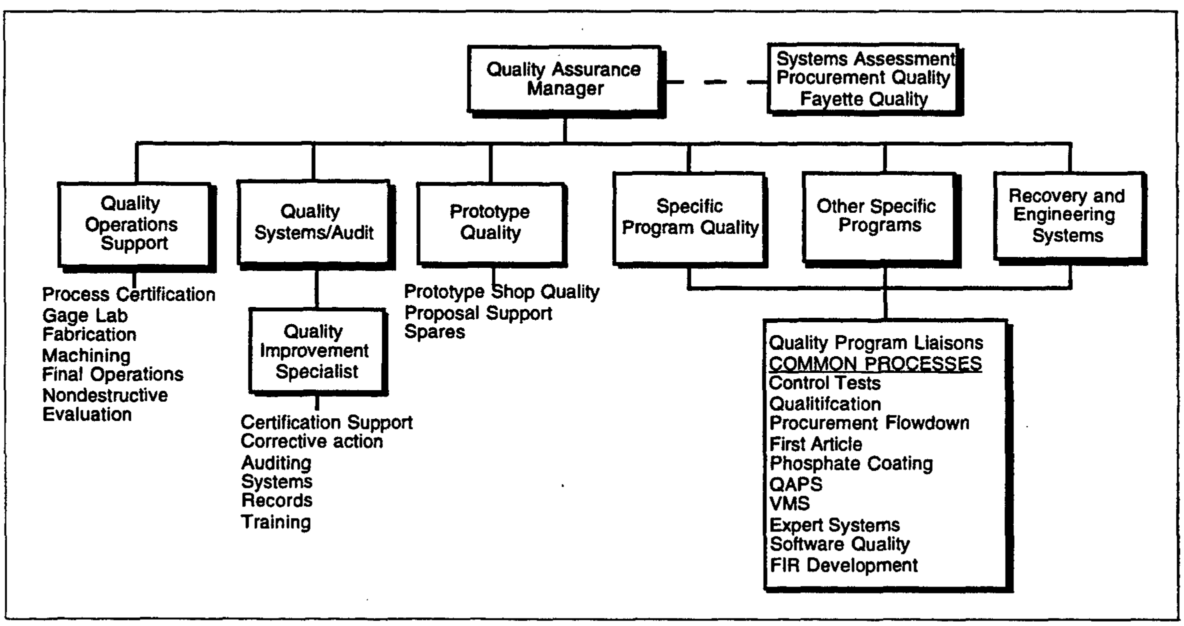

Figure II-7. UVW Company Organization Chart, Quality Assurance

XYZ Company has begun reengineering efforts and thus far has decreased QA personnel from 12 to 15 percent of census down to 3 percent. The Company's goal is to get down to 1 percent. The QA function has changed from being an independent assessment group to an audit and oversight group. Responsibility for the quality manuals moved from the Quality department to the site level. Quality control—inspection, verification and validation (V&V), test—moved from the QA department to the engineering process owners. Internal audits, managing corrective action, and representing customers stayed within Quality Assurance. There is a quality assurance presence on all integrated product teams, often giving the customer perspective.

Examples of the Company's reengineering efforts include:

- Software Quality Assurance
  - Quality control function moved to engineering, where a Software Engineering Institute (SEI)-type model is used for self-assessment and V&V across projects.
  - Quality assurance function needs only one or two people to ensure that customer requirements are addressed correctly throughout the process.
- Procurement Quality Assurance personnel
  - Solid line responsibility to procurement manager, who performs their performance reviews. This company feels strongly about the appropriateness of this arrangement.
  - Dotted line responsibility to QA manager. QA personnel attend staff meetings and the QA manager determines their career path if they stay in the quality assurance line of work.
- Quality and manufacturing engineers combined into one function—Process Engineers.
- Quality director is staff position, whose job it is to be champion of the integrated quality system.

F. COMMERCIAL WEAPONS COMPANIES

IDA spoke with two commercial weapons companies—called Company A and Company B here—about their Quality Assurance organizations. Each company's approach is described below.

Company A has a fire arms division with three primary directorates operating under the plant manager: Engineering, Production and Quality. There are approximately 30 engineers, 14 technicians, and 12 quality staff. The Quality Directorate is cross-functional. It consists of a core group of 12 people, and an additional 12 to 13 technical people are on loan from the other groups. These additional staff report administratively to their home manager but take direction from and report functionally to the Quality Manager. Their performance appraisals are written jointly by both the Quality Manager and their home manager.

The employees are empowered and everyone is responsible for quality. Much of the quality function is embedded in the production team. Figure II-8 shows the organization.

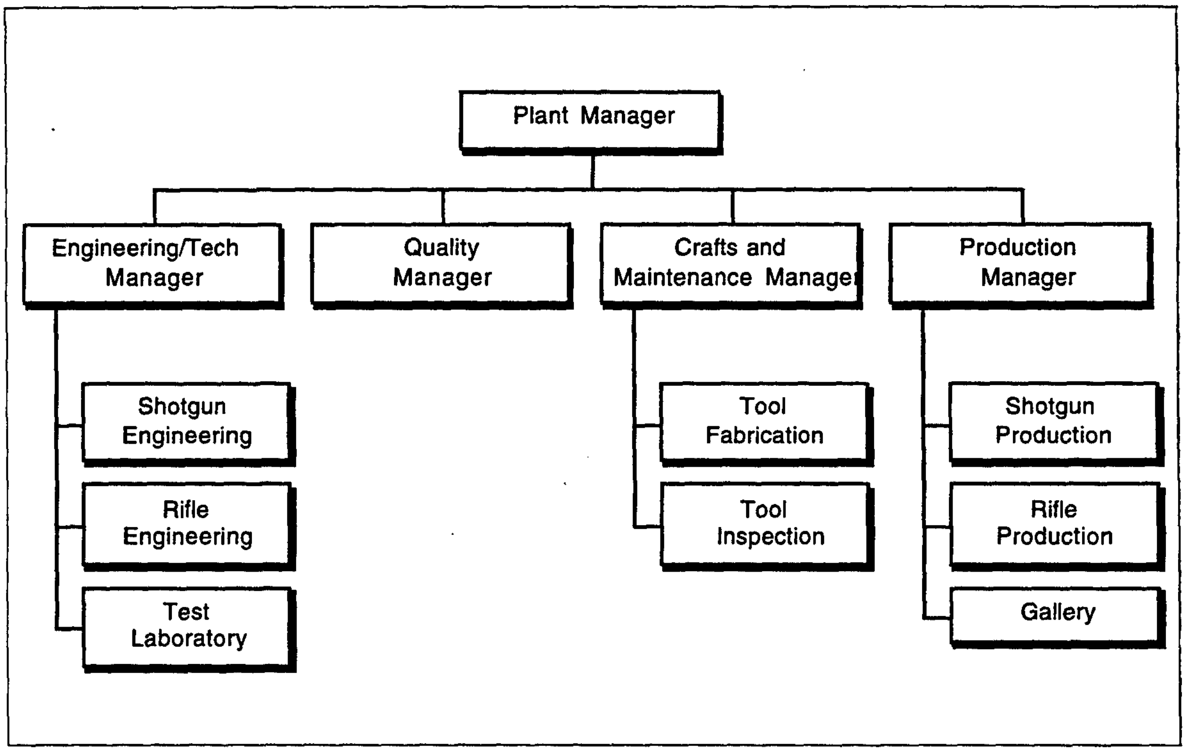

Figure II-8. Organization Chart of Commercial Weapons Company A

The standard production testing of each gun is done by the Gallery, which is part of the Production Directorate. Each fire arm part is tested during assembly; then every completed fire arm goes through function and target testing prior to shipping (each model has different requirements). The Gallery has complete cross-product functionality—it tests all products. The same is true for inspection—the only product-specific teams are the assembly teams and the engineering teams, which are split into rifle and shotgun categories.

The Test Lab primarily conducts field tests on current and new products, not production tests, unless there is an exceptional problem.

The Quality Group interacts continuously with Engineering, Test, and Purchasing. The basic responsibilities of the core group are to—

- Provide statistical analysis
- Develop quality standards for new models and modify existing standards when necessary
- Set up process plans and develop characteristics for new products
- Support engineering process study capabilities
- Resolve production problems
- Monitor incoming material product quality
- Monitor (and respond to) warranty reports submitted by the contract warranty houses

Most field failures that are covered by warranty are repaired by contract warranty houses. The Quality Group monitors these reports and conducts a weekly or monthly analysis to look for trends. This information is then fed back into the production line and changes are made accordingly.

Company B is an organization of approximately 1,200 people. Between 30 and 60 of those are technical staff. Three or 4 years ago, this company had a staff of 85 in the QA department (prior to that the census was as high as 300). Management realized that it didn't make sense for the inspectors to check the production people who had control and knowledge of their own processes. The Company now follows ISO 9001 and has a five-member ISO 9001 audit group, which audits the processes, not finished products. If the process is good then the finished product will be good. The corporate quality credo is "prevention"—with the proper training, equipment, tools, and documentation the product must be of high quality. Under this new system the quality has improved significantly and the customers are happier.

There is a check and balance system within the organization. The production process is divided by product line and type of part, for example, Pistol Barrels, Revolver Barrels, Pistol Small Parts and Revolver Small Parts. Each division is treated as an internal customer and/or supplier. Each customer has the right to reject parts from a supplier if they are inferior. By design, parts that are not right will not fit together and function—thus, defective parts become obvious. However, every finished weapon is tested (fired) before leaving the factory. Failure analysis is done by the testing team. Nonconforming products are segregated for corrective action and sent back to the appropriate production team, which is then responsible for finding a solution to eliminate the problem.

Under the old system, production line workers had a "separate organization" mentality—they believed that the inspectors would catch defects, so they didn't have to worry about quality. Now, the philosophy is that the customers will find the defects and that is not acceptable. The responsibility for product quality has shifted from the inspector to the production worker.

The organization utilizes Just-In-Time (JIT) inventory principles when scheduling the production of parts. It produces only what is needed for immediate assembly. If there is a problem with the quality of a part, they will know quickly. In the past, the Company would hold large inventories of parts. If there was a problem with a production run, a long time could pass before the defect was known, and the company would incur significant inventory production time and losses.

Management has learned that it takes a tremendous amount of courage to implement radical changes. At the beginning of the change process, employees expressed a lot of concern. Management found that the most effective ways to allay the concerns were to openly assure the employees that they would not lose their jobs and to implement the change slowly. The company re-trained the inspectors to be production workers and implemented the new processes in phases.

Company B knows the new system is working by the steady decline of customer complaints and returns and by the reduction of warranty repairs. The company provides a lifetime warranty with each hand gun, so the improved quality saves money for the company and customers are happier with the products. Figure II-9 illustrates how Company B sees its organization.

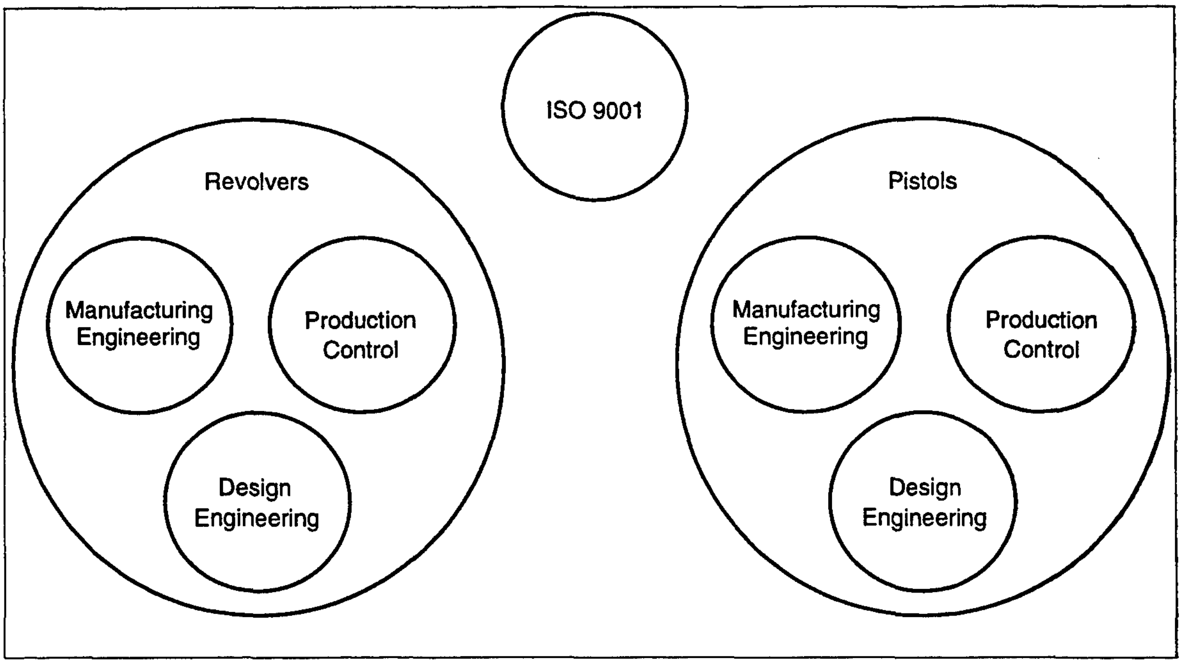

Figure II-9. Conceptual Organization of Commercial Weapons Company B

G. UTILITY COMPANIES

IDA also spoke with two utility companies. At the first company, the quality function is performed by the Quality Control (QC) department, which has a staff of 15 and is augmented by contract help as needed. The QC responsibilities are centered on the generation side of the business:

- Boiler repairs
- Testing equipment and performing repair or replacement
- Monitoring contractor performance
- Conducting supplier qualification
- Review equipment specifications to ensure that quality requirements are met
- Work with procurement and inspect new equipment to be sure it meets specifications
- Conduct non-destructive testing
- Write inspection checklist for the inspectors

The department previously included reliability, but the Engineering staff is now responsible for reliability and failure analysis. This group tracks equipment failures to determine the root cause and develop long-term solutions. Shifting reliability from QC to

Engineering has yielded positive results. In some areas, such as boiler tube failures, there has been a major positive impact.

The QC department's objective is to identify critical equipment and the activities related to that equipment and to direct resources accordingly. Inspection is essential to maintaining quality, but QC does not spend resources on non-critical areas. QC management found that "you only get what you measure."

Figure II-10 shows the overall organization.

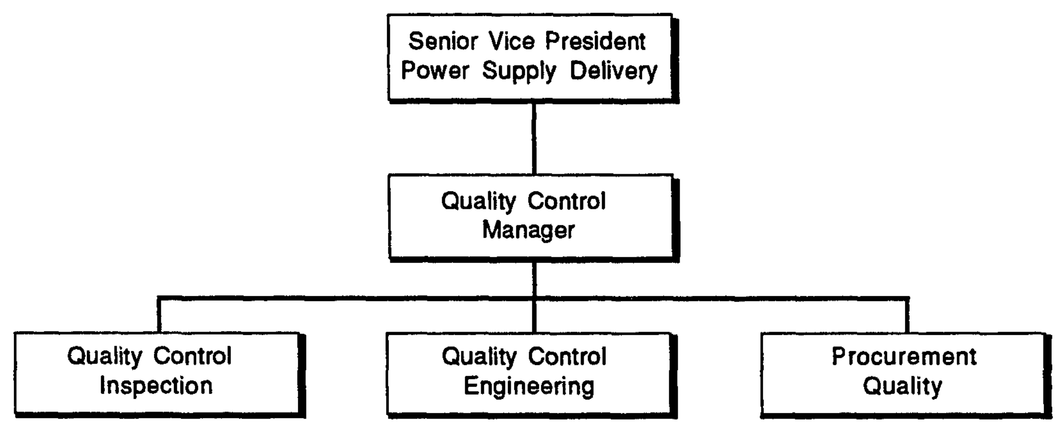

Figure II-10. Utility Company's Quality Organization

IDA spoke with the QA manager of a second utility company that has two nuclear power generators. Nuclear power plants are highly regulated by the Nuclear Regulatory Commission (NRC). There are 18 elements to the regulation that prescribe the quality and safety standards for nuclear power plants. Included in the regulation is a mandate to have an independent, internal quality organization consistently review the plant performance. Hence, this company's Quality Assurance group consists of 75 people; the overall plant census is 1500, half of which are technical staff. In addition, the NRC has three full time auditors on site. Figure II-11 shows this organization.

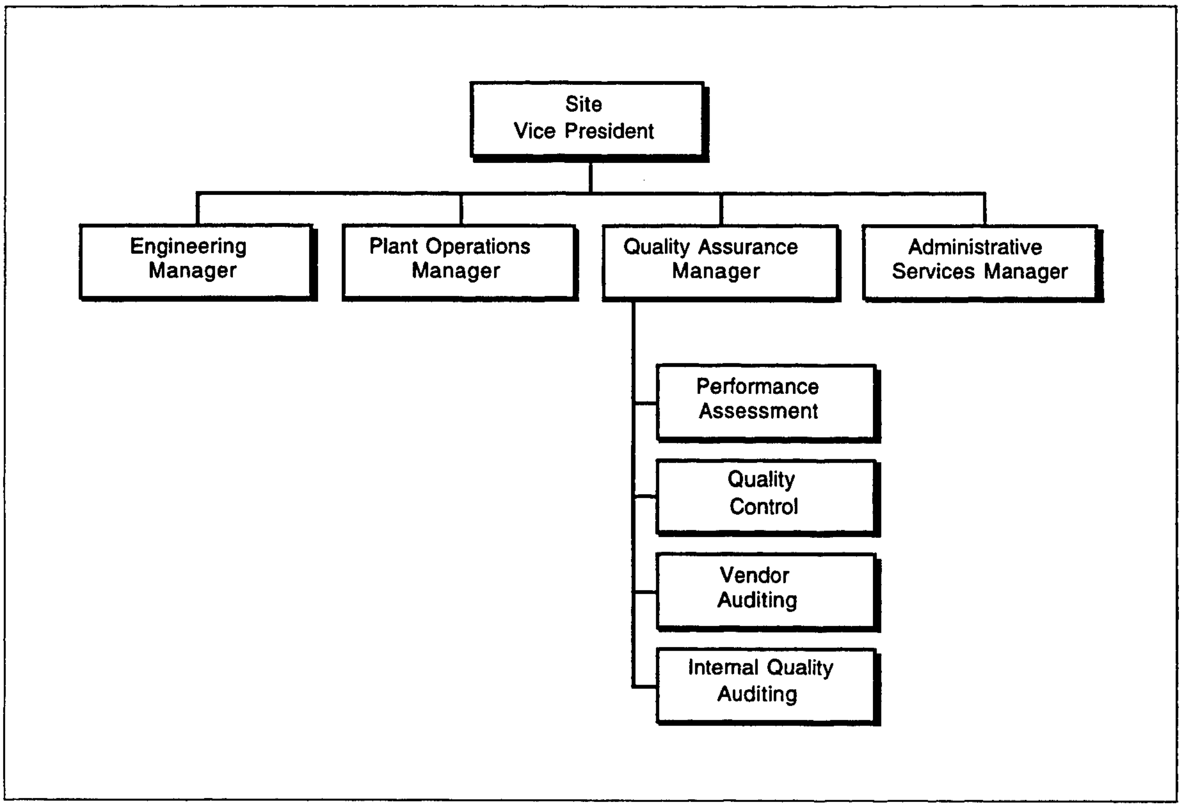

Figure II-11. Quality Assurance at a Nuclear Utility Site

There are two types of internal quality audit groups at this facility. The first type reviews the programs for conformance with written procedures; the second type verifies the critical maintenance activities. There are four quality groups operating under the manager of Quality Assurance: Performance Assessment (15 people); Quality Control (35 people); Vendor Auditing (10 people); Internal Quality Auditing (10 people). The QC group observes the operations personnel and checks their performance against the specifications. The Vendor Auditing group visits vendor facilities to verify that their quality systems are in compliance with the regulations. The Internal Auditing group is responsible for reviewing the regulations and assuring they are being followed.

The NRC regulations are very compliance oriented. They require extensive checking of activities vis-à-vis written procedures; thus, the process is very paper intensive. The QA manager expressed a need to move toward a performance-based method of evaluation, but change is slow due to the heavy regulation and high hazard factor.

In 1991, the NRC recognized that there were no rules for reliability. As a result, a new performance-based rule went into effect on 10 July 1996. This new rule requires the maintenance department to determine and prescribe the reliability standards. This rule is unique and represents a step toward changing the prescriptive method of regulation. The rule does not specify how to meet the standard. For example, a feed pump may be required to be 98 percent available; therefore, it can be down only 2 percent of the hours of operation. If the feed pump performance is not meeting the requirement, then the technical staff must determine the cause and implement a long-term solution.

H. PHARMACEUTICAL COMPANIES

IDA spoke with two pharmaceutical companies, C and D for purposes of this discussion. These companies were very different than the previous "product" companies. Each had strong, separate organizations for Quality Assurance.

In Company C, the QA function operates as a separate entity and is not cross-functional. The vice president of Quality is on the same level as the VP of Production; both report to the president. Management wants complete assurance that there is no conflict of interest. With this organization structure, they are confident that the QA group provides unbiased and independent analyses.

Because of its massive size (50,000 people), Company C is organized by geographical region. We spoke with one regional director of QA at a facility where 6000 people are located. Of these 6000 people, 230 are QA personnel. This group is responsible for proactive quality audits, regulation compliance, and product recalls. Figure II-12 shows an excerpt of the organization structure, focusing on the quality function.

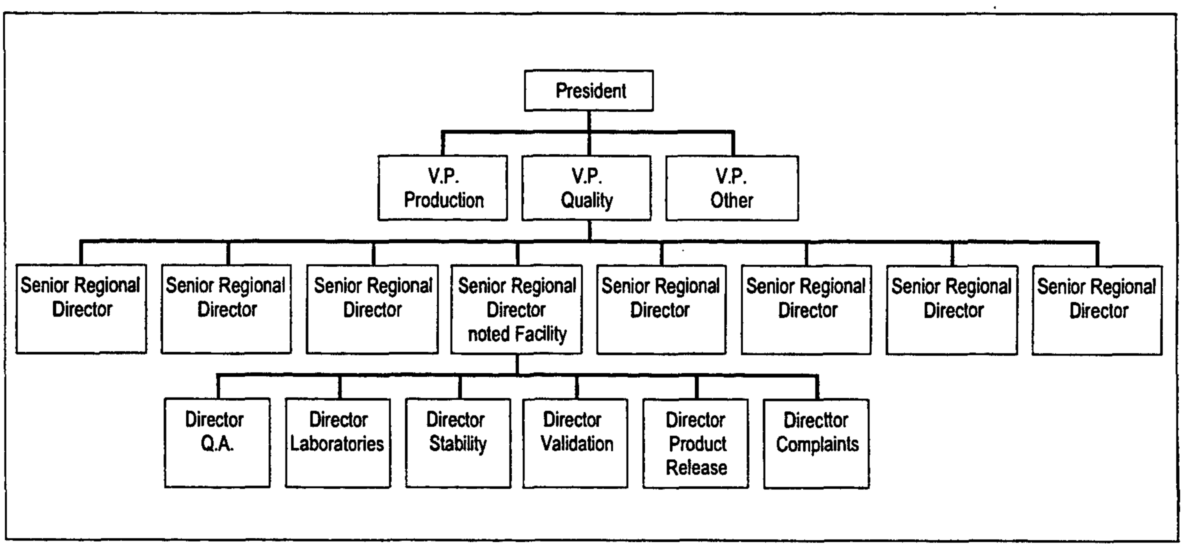

Figure II-12. Quality Assurance at Pharmaceutical Company C

At the second company, D, IDA spoke with the VP for Quality Control and Quality Assurance in North America and Mexico/Latin America. About 4 years ago, the company reorganized and completely separated the QC/QA function from the manufacturing function (Figure II-13). This VP has 14 regional QC/QA directors reporting to him. The directors are located at the various manufacturing facilities, but they report directly to the VP at headquarters—not the site manager, as in the past. The results of this reorganization—separating the quality function from manufacturing—have been positive. There is complete independence and objectivity in the testing. There is no opportunity for the plant manager to attempt to influence the QC/QA staff findings and compromise quality for the sake of profit. Product quality and profit goals are completely separate.

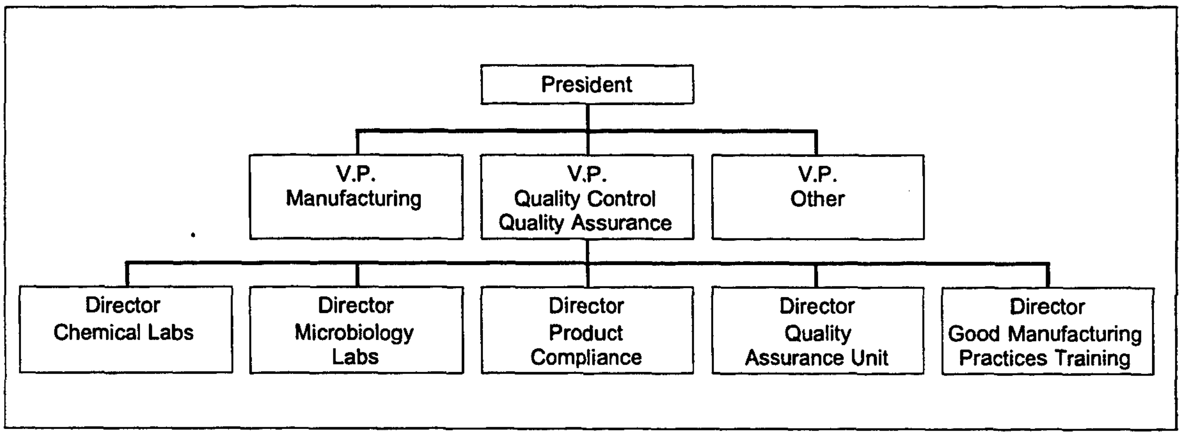

Figure II-13. Quality Assurance at Pharmaceutical Company D

The Chemical and Microbiology Labs perform various product tests, such as stability and potency. The Quality Assurance Unit is responsible for independent investigations during manufacturing, acting as liaison with the Food and Drug Administration (FDA) inspectors, addressing customer complaints, and performing vendor audits. The Compliance Directorate reviews the batch records and test results prior to product release. The Good Manufacturing Practices Training Directorate provides factory-wide training in proper procedures and methods, as required by law.

I. ARMY EXAMPLES

During the course of this study, IDA visited or contacted two U.S. Army Material Command (AMC) Major Subordinate Commands (MSC) that are included here as data points from non-industry sites. Since the case study (Chapter III) focuses on an Army organization, we focused on some other Army organizations. Regrettably, IDA did not have the resources to analyze the other Services during this study.

1. ABC Command

ABC Command develops products that are essential for the safety of the warfighter in hostile physical environments. In 1993, its Product Assurance organization was totally dispersed (Figure II-14).[1] Since then, there have been two modifications (Figures II-15 and II-16) in which more centrally controlled quality functions and responsibilities have been re-assigned to the director of Quality. However, Quality Engineering functions—quality engineering, product quality management, software quality assurance, and reliability, availability, and maintainability (QE/PQM/SQA/RAM)—have remained part of the Engineering Directorate, with personnel serving on integrated product teams (IPTs).

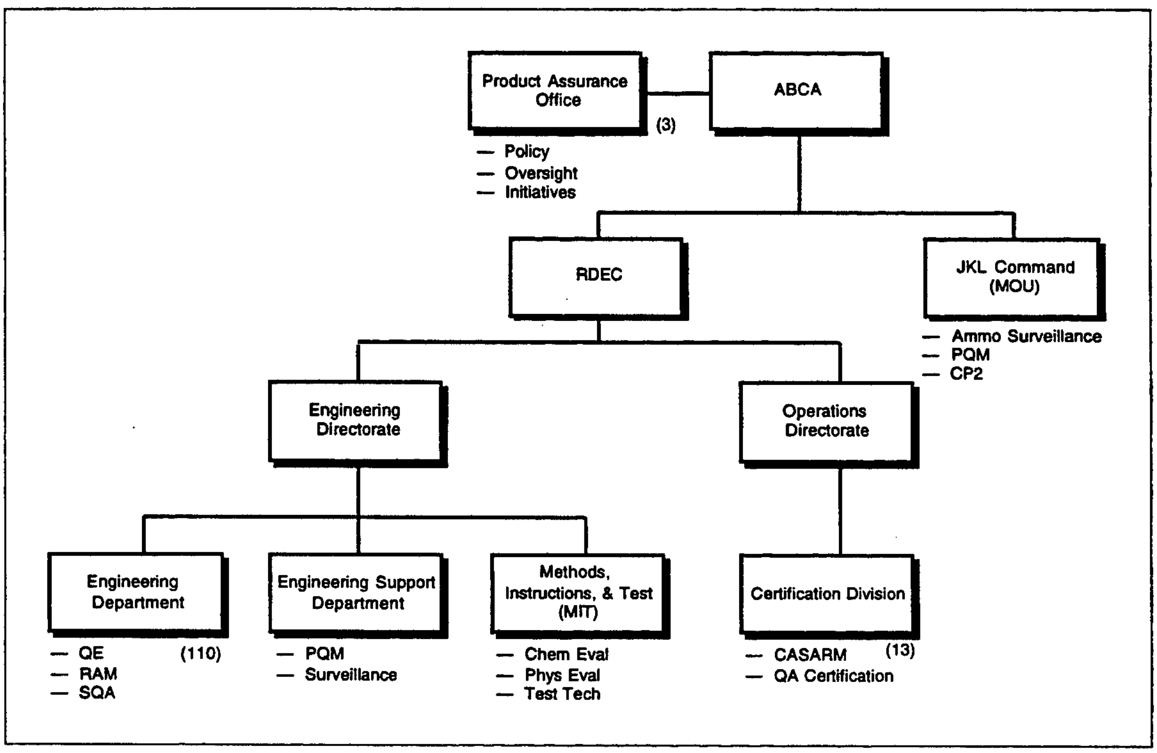

Figure II-14. ABC Command, FY 93

1 In these military organizations, the term Product Assurance often encompasses more than the Quality Assurance functions in the industry examples.

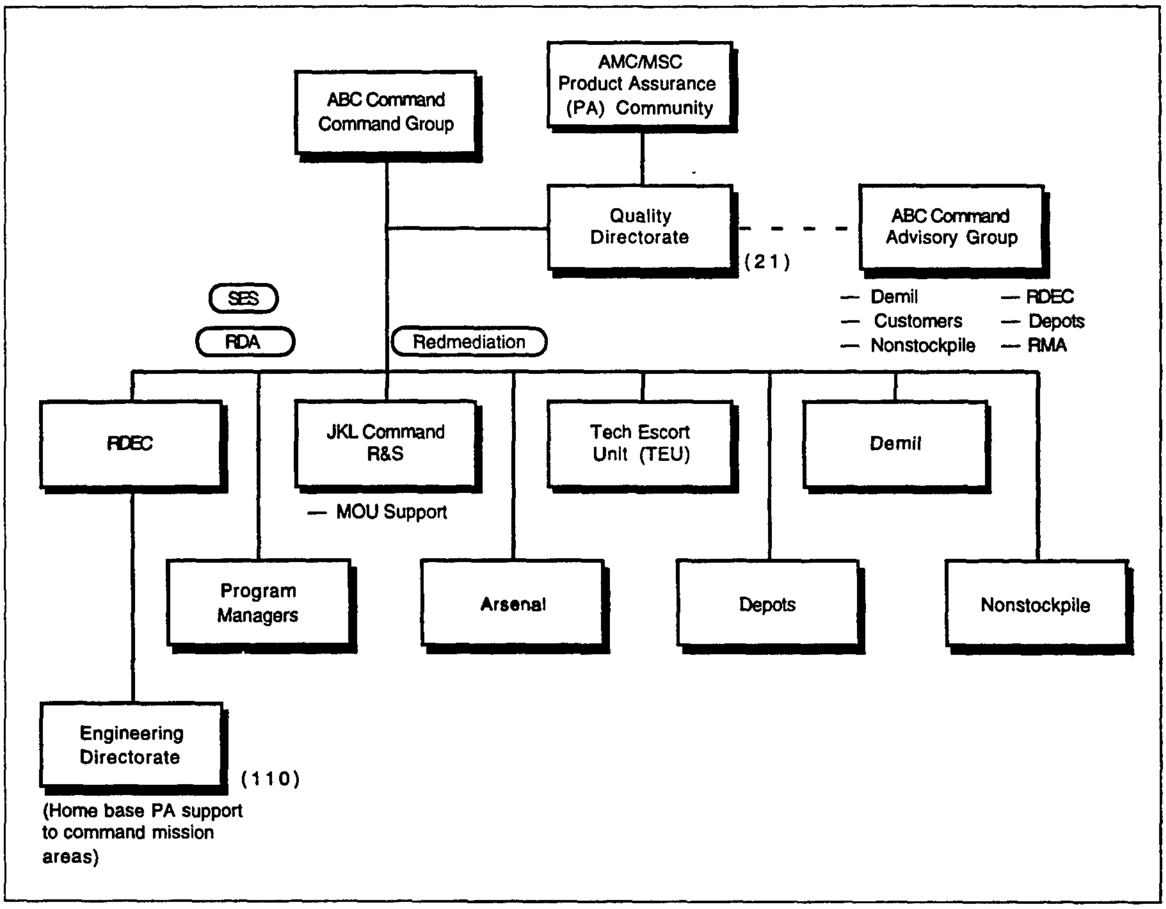

Figure II-15. ABC Command, FY 95

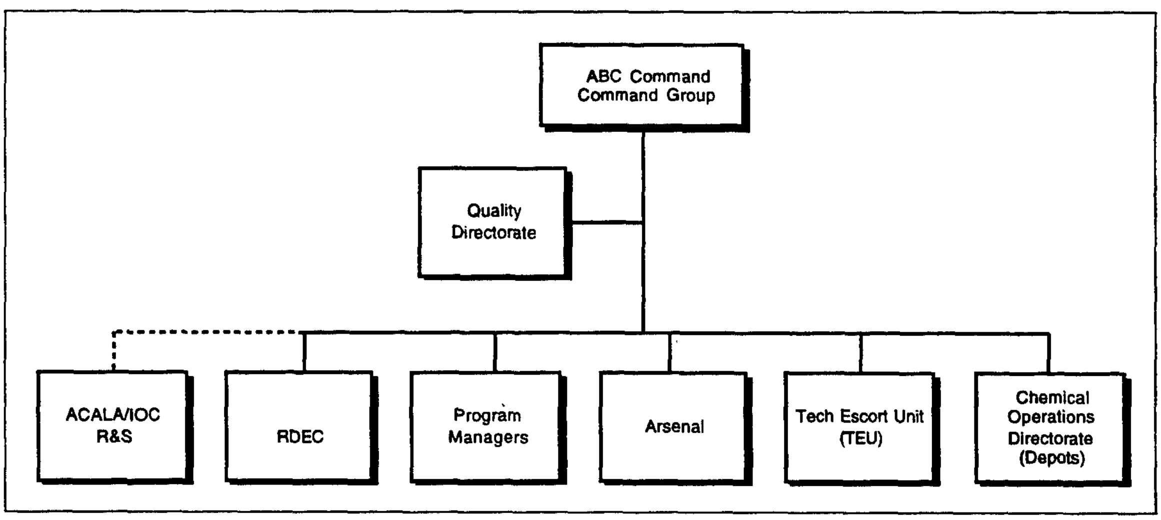

Figure II-16. ABC Command, FY 96

With a smaller quality organization and the reassignment of many of the quality functions, many of the quality initiatives lost focus, we were told. Quality function personnel assigned to the IPTs said they were experiencing difficulty because cost and schedule pressures had led the IPTs to disregard concerns about product quality. They said that more emphasis must be on training and that mentoring of the quality assurance personnel is essential. ABC Command is addressing this problem by emphasizing home bases, whose responsibilities would be skill base maintenance, professional growth and development, and career management.

2. XYZ Command

XYZ Command develops airborne platforms. Recent organizational changes within this Command have been designed to maintain a separate Product Assurance organization to "nurture the special skills and emphasis that quality and reliability personnel bring to the acquisition business." The most significant change was to bring the separate Product Assurance organization essentially intact under the Research, Development, and Engineering Center (RDEC). Additionally, to preserve the "special advisor to the Commanding General for Quality," the director of Product Assurance was dual-hatted as an associate director of the RDEC.

The Quality or Product Assurance function therefore remains intact as a separate organization. Through IPPD, Product Assurance provides

- A home base, allowing the workforce to increase and contract with Program Management demand as people move from IPTs to general support assignments.
- Corporate memory from a variety of systems, to bring to bear a distinct specialty engineering focus on current problem areas.
- Training for the specialists in particular technologies of critical importance to product quality.

J. BENCHMARKING SUMMARY—PROS AND CONS OF DIFFERENT ORGANIZATIONAL STRUCTURES

It is clear that in most companies over the past years, the QA functions have shifted from defect detection to defect prevention. Quality control types of activities have shifted to the manufacturing process owners, and quality engineers are often combined with other engineers. Reliability no longer seems to be a QA function, but is an engineering function as well.

Until we contacted the pharmaceutical companies, we would have said that the trend in both defense and commercial companies is to move away from having a strong, independent quality organization. Even in another "process" type of industry (a chemical company) that we contacted in a related study, the Quality Department consisted of only three people—a benchmarking expert, an ISO 9000 expert, and the VP of Quality and Health, Safety and Environment.

There may be various reasons for this dichotomy between industry sectors. One explanation may be that the more the hazard or product liability increases, the more the need for a strong QA organization increases. This relationship is not clear, however, since the aerospace and weapons companies certainly have product liability concerns, and they are following the trend that "quality is everyone's responsibility" and dispersing the traditional QA functions throughout the organization. Another reason could be that the more regulated the industry is, the greater the need for a strong QA function.

In the beginning of this task, IDA did various literature and World Wide Web (WWW) searches for information. It is interesting to note that in one search on "Quality Assurance" with 50 articles, the vast majority were in the health care field. There were 18 hits for health care and the next highest categories—software and waste testing/hazardous waste—had only four. Marketing and construction followed with three each, and food processing, accounting control, and instrument inspection had two each. In a random selection of companies with home pages on the WWW, the only company that really promoted their strong Quality Assurance organization was J. C. Penney. Although many companies tout their product quality, it did not appear that they also touted their QA organization.

A brief summary of the lessons learned from studying these industry and Army models:

- Industry
  - Companies support IPPD and IPT concepts.
  - Quality engineers and manufacturing engineers become combined into "Producibility Engineering."

- Quality control and production personnel become combined into "Operations."
- Quality staff functions generally remain TQM, ISO 9000 focused.
- There is a strong tendency to create home bases or centers of excellence.
- The strength of an independent QA organization is related to the type of product—strongest in medical and pharmaceutical organizations.

• Army

- IPPD and IPTs are commonly used in DoD Programs.
- The strength of independent QA organization does not seem to be related to the type of product or risk level.
- There is no consistent implementation of home bases or centers of excellence.

III. ARDEC CASE STUDY

During the course of this study, the Armament Research, Development, and Engineering Center (ARDEC) was undergoing a major reengineering effort. So IDA had an opportunity to observe the process and help configure the restructuring of their Product Assurance Directorate (PAD).

ARDEC is the Army's life cycle engineering center for weapons, ammunition, and related items. To optimize life cycle performance, they use a variety of tools such as predictive technology, Taguchi methods, and Quality Function Deployment (QFD). To guarantee performance to their customers, they provide 48-hour field support anywhere in the world for major malfunctions.

The Product Assurance Directorate (PAD) at ARDEC has responsibility for the safety and integration of all items ARDEC supplies to the armed forces. The first approach taken in this case study was to review and analyze previous PAD organizational studies. Internal PAD studies included:

- Evaluation of Potential Contractability of ARRADCOM-PAD Functions (PATEN study), 1978—what missions are essential by law, regulation, etc.
- Strategic Plan for the Year 2004, 1984.
- Feedback Analysis Network, 1986.
- PAD Initiatives/Thrusts in Quality, 1987.
- Taminent Study, 1993.

External studies included:

- Kerwin Report, 1982.
- PAD Customer Surveys, 1984, 1994.
- Productivity Enhancement Group (PEG) V, 1994.
- AMC Core Competencies, 1995.
- Presidential Quality Award Application, 1996.

A. CURRENT ORGANIZATION AND FUNCTIONS

The mission statement of ARDEC PAD is as follows:

> To act as staff advisor to the Commanding General on all ARDEC product assurance and test matters; to develop policy and procedures for the life cycle product assurance functions; provide the command's product assurance interface with other commands, higher headquarters, and other government and non-government activities. Provide the ARDEC Test and Evaluation, Materiel Release and Corrosion Prevention and Control Managers. Plan, develop, direct and manage life-cycle product assurance programs for all ARDEC managed materiel. Establish policy and procedures for research and development technology and methodology to improve effectiveness of product assurance for ARDEC mission materiel. Manage product assurance engineering and technical support in the areas of system safety, reliability, availability, maintainability, inspectability, testability, predictive technology, quality engineering, test and evaluation, software quality assurance/independent verification and validation (IV&V) assessment and root cause/red team investigations. Provide product assurance support in acquisition quality assurance and product quality management. Direct the independent assessment program for ARDEC materiel. Serve as the primary ARDEC action point for matrix support to PEOs/PMs with respect to product quality assurance functions. The Administrative Office provides administrative support to the Product Assurance Director for Armament Systems.[1]

Figure III-1 shows the organizational design of PAD. Figure III-2 illustrates how the changing mission of DoD and reduced resources have affected the PAD functions within the various parent organizations.

Figure III-3 shows the functions within each of the offices and divisions in today's PAD. Table III-1 lists the primary ARDEC activities and the PAD activities associated with them, for which PAD is reimbursed for its matrixed support. This list, refined from background material, gives an indication of what PAD's customers—the Program Managers (PMs) and Program Executive Officers (PEOs)—want PAD to do.

B. SURVEYS

An integral part of this case study was to review and conduct several surveys of the PAD work force and its customers—PEOs and PMs—and present and past Commanding Generals (CGs) at ARDEC. A 1984 PAD customer survey was used as a baseline.

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1 This mission statement appeared on the ARDEC's home page on the World Wide Web in the summer of 1996, when we were conducting this study. Since their reorganization, the mission statement has changed. The new mission statement can be found in Appendix A.

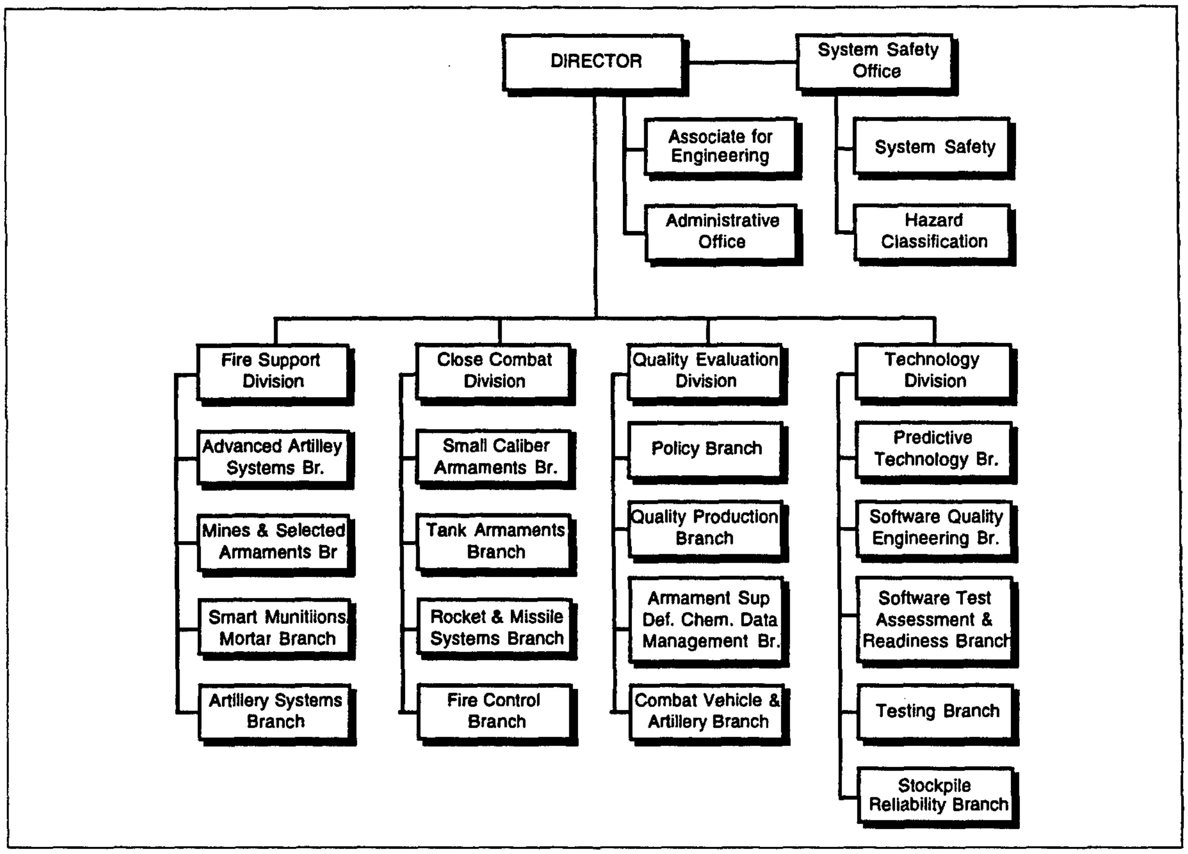

Figure III-1. Current Organization Chart for ARDEC's PAD

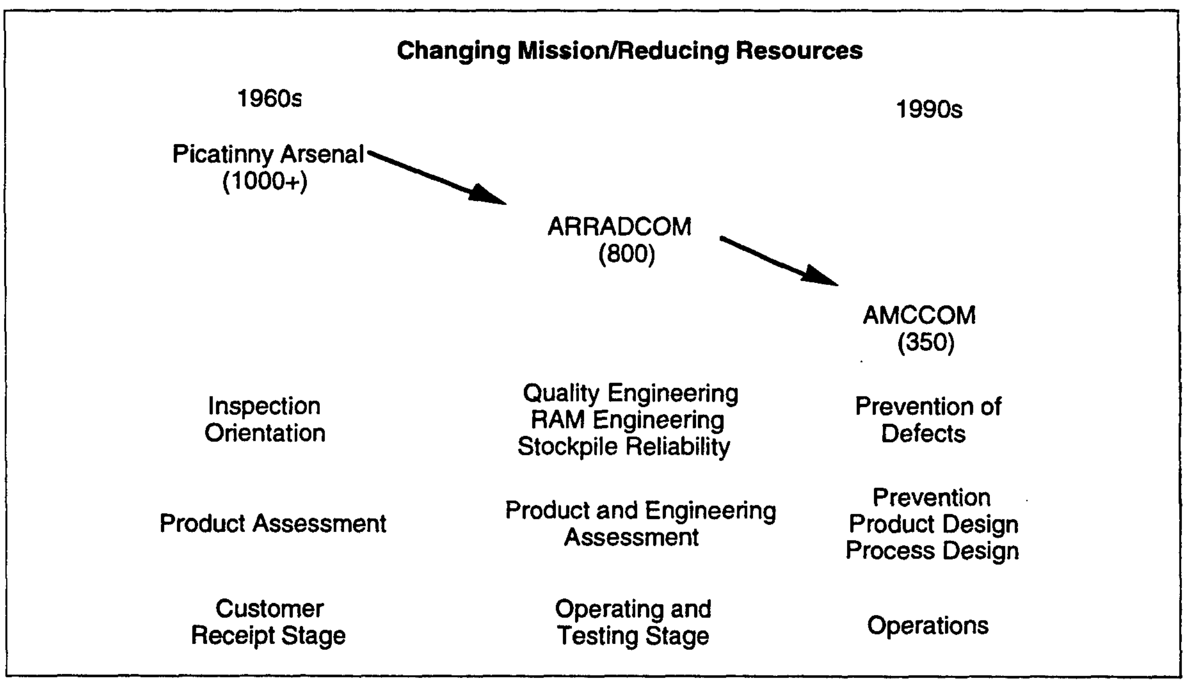

Figure III-2. Restructuring Over the Last Decades

Functions of the PAD

System Safety Office

- Explosive hazard classification
- Surface danger zone
- Radiation safety
- System Safety Hazard Analysis (SSHA)
- Army Fuze Safety Review Board
- Safety Assessment Report (SAR)
- System Safety Management Plan (SSMP)

Quality Evaluation Division

- (CP)2
- CPC/RAM
- Failure/root cause analysis
- First article test
- Material release
- Mathematics/ Statistics
- Policy/warranty
- PQMs
- Scratch and digs
- Standardization

Technology Division

- Packaging
- Physical test
- Predictive technology
- Propellant and explosives
- Software quality assurance
- Soldering
- Stockpile reliability
- Test instrumentation engineering
- Acceptance inspection equipment
- Nondestructive testing
- Testing technology

Fire Support Division & Close Coombat Divsion

Quality Engineering:

- Program-unique and performance specs.
- Statistical Process Control (SPC)
- Design of experiments (Taguchi)
- First Article Test (FAT) & Lot Acceptance Test (LAT)
- Procurement quality assurance (QALI, QDR, etc.)
- Contract SOW and for solicitation
- Source Selection Evaluation Board (SSEB)
- Acceptance sampling

RAM Engineering:

- Materiel Developer Analysis (MDA)
- Reliability prediction
- Failure Modes, Effects and Criticality Analysis (FMECA)
- Sneak Circuit Analysis (SCA)
- Fault Tree Analysis (FTA)
- Failure analysis

Figure III-3. Functions of the PAD Offices and Divisions

Table III-1. Reimbursable Matrix Support to Program Managers (Primary Activities Only)

Activity	Phase	RDTE Funds	Procurement Funds
Reliability, Availability, Maintainability-Durability (RAM-D)			
Develop RAM rationale reports	Development	X	
	Production		X
Independent verification and validation	Development	X	
	Production		X
Prepare/approve reliability growth plans/tracking	Development	X	
	Production		X
Conduct predictive technology programs for total life cycle requirements	Development	X	
	Production		X
Review/investigate contractor hardware critical item (HCI) specifications and control processes	Development	X	
	Production		X
Evaluate the performance of devices	Development	X	
	Production		X
Integrated Logistics Support (ILS)			
Implement stockpile reliability programs	Development	X	
	Production		X
Materiel Change Management			
Provide hardware/software support to TDP development	Development	X	
	Production		X
Design Engineering			
Generate performance specifications	Development	X	
	Production		X
Attend TIWGS	Development	X	
	Production		X
Review test equipment requirements	Development	X	
	Production		X
Producibility Engineering in Design			
Assist in failure definition development	Development	X	
	Production		X
Contractual			
Input quality assurance provisions in contractor proposals	Development	X	
	Production		X
Provide liaison support with DLC Plant Representative Offices (PROS)	Development	X	
	Production		X
	Fielding		X

Table III-1. Reimbursable Matrix Support to Program Managers (Primary Activities Only) (Continued)

Activity	Phase	RDTE Funds	Procurement Funds
Contractual, continued			
Participate in contract negotiations as technical representative	Development	X	X
	Production		X
	Fielding		
Contractor certification	Development	X	
	Production		X
	Fielding		X
Quality system reviews	Development	X	
	Production		X
Participate in pre-award and post-award meetings	Development	X	
	Production		X
	Fielding		X
TDPs/Development of Documents			
Prepare safety assessment reports	Development	X	
	Production		X
	Fielding		X
Prepare specifications	Development	X	
	Production		X
Prepare quality assurance and test provisions	Development	X	
	Production		X
Provide provisions for materiel release	Development	X	
	Production		X
Test Plans/Testing			
Forecast/establish test needs for hardware programs	Development	X	
	Production		X
Initiative/execute MMT and MTT projects to advance testing and inspection technology	Development	X	
	Production		X
Review/approve contractor test and inspection plans per SOWs	Development	X	
	Production		X
Approve instrumentation used at non-Government PGs	Development	X	
	Production		X
Conduct/assist in failure analysis	Development	X	
	Production		X
Conduct predictive technology test programs	Development	X	
	Production		X
Develop stockpile reliability test requirements	Development	X	
	Production		X
Review test plans/test results	Development	X	
	Production		X

Table III-1. Reimbursable Matrix Support to Program Managers (Primary Activities Only) (Continued)

Activity	Phase	RDTE Funds	Procurement Funds
Independent Evaluations			
Provide RAM assessments for design reviews	Development	X	
	Production		X
Prepare safety assessments and health hazard analyses	Development	X	
	Production		X
Safety Engineering/Releases			
Prepare RAM assessments for IPRS/other reviews	Development	X	
	Production		X
Prepare/approve safety assessment reports and health hazard analyses	Development	X	
	Production		X
	Fielding		X
Input QA safety provisions into SOWs	Production		X
	Fielding		X
Serve on safety boards for PM-managed programs	Development	X	
	Production		X
	Fielding		X
Materiel release actions	Development	X	
	Production		X
Establish/develop System Safety Working Group (SSWG) charter	Development	X	
	Production		X
	Fielding		X
Attend SSWG meetings	Development	X	
	Production		X
	Fielding		X
Provide safety review and comment to O&O and ROC	Development	X	
	Production		X
	Fielding		X
Provide safety input to SOW and CDRLs	Development	X	
	Production		X
	Fielding		X
Provide safety review and comment to specification	Development	X	
	Production		X
	Fielding		X
Provide safety input to RFP	Development	X	
	Production		X
	Fielding		X
Represent safety in TIWGs	Development	X	
	Production		X
Review TIRs for safety issues	Development	X	
	Production		X

Table III-1. Reimbursable Matrix Support to Program Managers (Primary Activities Only) (Concluded)

Activity	Phase	RDTE Funds	Procurement Funds
Safety Engineering/Releases, continued			
Participate on TIR close-out review board	Development	X	
	Production		X
Review comment on contract data, e.g., Safety Assessment Report (SAR), System Safety Program Plan (SSPP), and system safety analyses	Development	X	
	Production		X
Prepare safety positions for system safety risk assessments	Development	X	
	Production		X
	Fielding		X
Production Readiness Reviews (PRRs)/ In-Process Reviews (IPRs)			
Manufacturing methods and controls (including statistical process controls)	Development	X	
	Production		X
Engineering in Support of Items in Production (ESIP)			
Reestablish, on a one-time basis, the reliability of stored items which have become suspect due to malfunctions of like items issued to users.	Development	X	
	Production		X
In-House Software Development (Life Cycle software Engineering)			
Software quality assurance	Development	X	
	Production		X
Software error data compilation and development of utilization methodology	Development	X	
	Production		X
Interoperability Support	Development	X	
	Production		X
Perform analysis and evaluate problem reports			
Define deficiencies and recommend solutions			
Participate in TIWGs, TEMPs, TDPs, and CMTWGs			
Provide support on NATO and FMS and joint programs			

1. Commanding Generals' Expectations

The commanding generals (CGs) at ARDEC have strongly voiced their views and expectations for the PAD in any restructure plan. First, General Boddie, the current CG, gave the following responses to IDA:

- A strong, independent PAD is needed.
- Early involvement of PAD is important.
- PAD has the capability to address production and fielding issues.
- Collocation of personnel on IPTs is important, but it is a business decision.
- The need for facilities is recognized, but outsourcing alternatives should be explored.

The former CG, General Holmes, gave these responses:

- A strong, independent PAD is essential.
- If PAD personnel are collocated on an IPT, they must have a strong home base and a direct performance rating link.
- In industry, collocating on single IPTs may be viable.

Obviously, both CGs thought that ARDEC needs a strong, independent, PAD organization.

2. Customer Expectations

In her paper Integrated Business Process Improvement Model for the Department of Defense, K. Patel asserts that in any reengineering effort, one must look at how the organization adds value to the product's customers, not to the customers of the services performed.[2] In the case of ARDEC, the product customer would be the warfighter. In the surveys analyzed in this section, we look at the customers of the services performed by PAD. IDA did not have the resources or the available background material to actually interview the warfighter on these issues. We suspect that safety would be paramount.

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2 K. Patel, Integrated Business Process Improvement Model for the Department of Defense, Business Reengineering, Directorate of Defense Information.

a. Formal Survey

In September 1994, the PAD sponsored a survey of customers primarily from Picatinny and Rock Island Arsenals. The overall response rate was 60 percent. The survey was constructed to assess what the customers viewed as PAD's strengths and weaknesses and which functions were most important and least important to them.

In Section 1 of the survey, respondents rated each of the listed 28 functions as a strength (S), weakness (W), or not familiar with the area (left blank). Space was provided for comments at the end.

In Section 2, respondents wrote in what they believed to be the three most important and the three least important support areas to their organizations. Most respondents selected from support areas listed in Section 1.

In Section 3, the respondents were asked to write in recommendations or suggestions as to how PAD could improve its service to their organization. Thirty-eight of the 75 respondents left this section blank.

Section 4 asked respondents to rate the overall quality of support received from PAD. The response choices were *excellent*, *good*, *average*, or *poor*. The results for overall performance are shown in Table III-2 and Figures III-4 and III-5.

Table III-2. Results of Overall Performance

Category	Picatinny[a]	Rock Island[a]	Total	% Total
Excellent	16	3	19	25
Good	31	9	40	53
Average	5	5	10	13
Poor	1	1	2	3
Not Rated	1	3	4	6
Total	54	21	75	100

[a] See Figures III-4 and III-5 on following page.

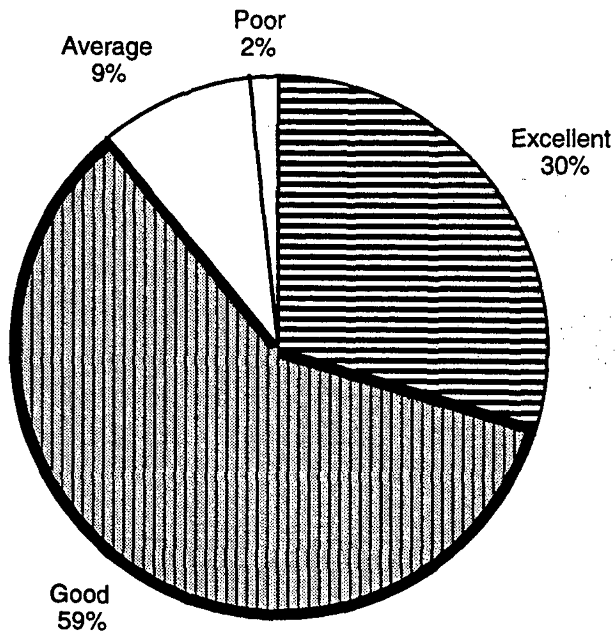

Figure III-4. Overall Ratings by Picatinny Customers

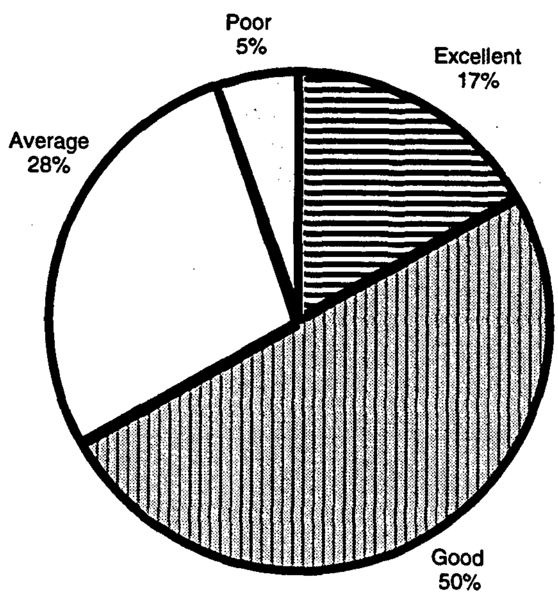

Figure III-5. Overall Ratings by Rock Island Customers

These results indicate that more than three quarters of the respondents believe that PAD provides good support or better.

Two critical pieces of information are necessary to assess the quality of services provided in any given industry: supplier performance and importance to the customer. It is important to know not only how well PAD is performing, but also how valuable that effort is to the customers. Of course, a low performance rating in an area that is very important to the customer raises a red flag and calls for correction. But equally important is the situation where an organization performs exceptionally well in an area that is of little value to the customer. In this case, management can shift resources and focus its efforts on areas that are important to the customer. With that in mind, we analyzed the survey results and determined that Section 1 of the questionnaire evaluates PAD's performance and Section 2 identifies which services are important to the customer.

The preferable methodology for structuring the questionnaire is to simultaneously measure performance in a particular area and the importance of that area to the customer. Unfortunately, this survey was not structured that way. Section 1 lists the support areas and the respondent has three responses to choose from. Section 2, however, is presented in an open-ended fashion, allowing the respondent to fill-in any response, and in some cases, no response at all. This created a statistical problem when we analyzed and compared the results from the two sections.

To compensate for the difference in the methodologies, IDA developed a similar formula to score each of the support areas (as listed in Section 1) for Performance and Importance. The formula for determining Performance for each area is:

> The number of respondents that said the area was a STRENGTH, plus the number who had NO OPINION, divided by the number who said it was a WEAKNESS, plus the number who had NO OPINION.

$$Performance = (S+NO)/(W+NO)$$

A response of NO OPINION is defined in the survey as "not familiar with the area." If a customer is not familiar with the area, then it clearly is not important to them; similarly, they cannot rate it as a strength or weakness. This is important information and must have an effect on the score so we included NO OPINION responses in both the numerator and the denominator of the equation.

The formula for determining the Importance to the customer for each area is:

> The number of respondents that identified the area as MOST IMPORTANT, plus the number who had NO OPINION, divided by the number who said it was LEAST IMPORTANT, plus the number who had NO OPINION.

$$Importance = (MI+NO)/(LI+NO)$$

The Performance scores ranged from 2.3 to 1; the Importance scores ranged from 1.75 to .76. The discrepancy between the two ranges is due to the different methodologies used in each section, as mentioned above. To account for this difference and still get a meaningful comparison of the two scores in each area, we rank ordered the areas according to their Performance score and then according to their Importance score. There are 28 areas evaluated, so each category received two relative place values; one for Performance and one for Importance (28 represents the best, 1 is the worst). The results are shown in Table III-3.

By graphing the place value rankings side by side, it is easy to see how PAD is performing in each area and if that performance is important to the customer. Looking at the bar chart (Figure III-6), we see that First Article Test obtained the highest Performance score; e.g., PAD does it well. The Importance to the customer ranked 22. The areas of concern are those with significant discrepancies in the rankings between Performance and Importance, such as Document Review. The Performance score ranking is 26, but the Importance is only a 14. This could indicate that efforts should be put in another area where the outcome is reversed. Product Quality, for example, has a Performance ranking score of 20 and 26 for Importance.

This analysis provides an opportunity to look at the support areas relative to one another as a tool to help management assess the directorate's effectiveness. It is a useful "sanity check" when considering organizational changes.

In general, the Performance vs. Importance chart indicates that PAD has only a few significant discrepancies to be considered in any reengineering effort. The eight most important functions to the customers are Quality Assurance, Material Release, Product Quality, Failure Investigation, Configuration Management, Technical Data Package, First Article Test, and System Safety. Of these, only one, First Article Test, had a ranking for Performance higher than for Importance. On the other hand, Document Review, which the customers thought PAD does extremely well, was valued at only about one-half its Performance rating. The three least important areas are Contractor Performance

Table III-3. Support Area Customer Survey Summary

Area (in order of importance ranking)	Number of Responses			Total Respond-ents	Performance Score (S+NO)(W+NO)	Performance Rank Order (28 is High Score)	Number of Responses			Importance Score (MI+NP)(LI+NP)	Importance Rank Order (28 is High Score)
	W	W	NO				Most Important	Least Important	Not Picked		
Quality Assurance	40	1	34	75	2.114	27	20	1	54	1.345	28
Material Release	35	7	33	75	1.700	23	15	1	59	1.233	27
Product Quality	31	8	36	75	1.523	20	13	0	62	1.210	26
Failure Investigations	37	7	31	75	1.789	25	12	1	62	1.175	25
Configuration Management	30	9	36	75	1.467	18	13	4	58	1.145	24
Technical Data Packages	33	9	33	75	1.571	22	11	2	62	1.141	23
First Article Tests	43	1	31	75	2.313	28	9	1	65	1.121	22
System Safety	27	4	44	75	1.479	19	11	4	60	1.109	21
Test and Evaluation	27	6	42	75	1.438	16	9	2	64	1.106	20
Test Support	33	0	42	75	1.786	24	9	2	64	1.106	19
Procurement Actions	25	9	41	75	1.320	13	8	1	66	1.104	18
Reliability	20	6	49	75	1.255	11	7	0	68	1.103	17
Test Plans	30	6	39	75	1.533	21	8	3	64	1.075	16
Safety Assessment Reports	24	3	48	75	1.412	14	4	1	70	1.042	15
Document Review	35	3	37	75	1.800	26	3	1	71	1.028	14
SSEB Support	18	1	56	75	1.298	12	2	1	72	1.014	13

S = Strength, W = Weakness, NO = No Opinion

Table III-3. Support Area Customer Survey Summary (Continued)

Area (in order of importance ranking)	Number of Responses			Total Respond-ents	Performance Score (S+NO)(W+NO)	Performance Rank Order (28 is High Score)	Number of Responses			Importance Score (MI+NP)(LI+NP)	Importance Rank Order (28 is High Score)
	W	W	NO				Most Important	Least Important	Not Picked		
Special Teams/Boards	23	1	51	75	1.423	15	0	2	73	0.973	11
Contractor Liaison	22	10	44	75	1.222	10	2	5	68	0.959	10
Statistical Process Control	27	6	42	75	1.438	17	2	5	68	0.959	9
Software QA	13	3	59	75	1.161	8	3	7	65	0.944	8
Predictive Technology	15	7	53	75	0.107	4	2	8	65	0.918	7
DPRO Liaison	13	6	56	75	0.093	2	0	7	68	0.907	6
Maintainability	6	6	63	75	0.000	1	1	8	66	0.905	5
Audits	13	4	58	75	0.120	5	1	9	65	0.892	4
Soldering	18	2	55	75	0.213	7	1	15	59	0.811	3
SOW Inputs	18	2	55	75	0.213	6	1	15	59	0.811	2
Contractor Performance Cert. Prog.	17	10	48	75	0.093	3	0	18	57	0.760	1

Note: There are a total of 28 areas rated plus one category called *Other*. *Other* was not considered in this analysis. *No Opinion* means that the respondent was not familiar with the area.

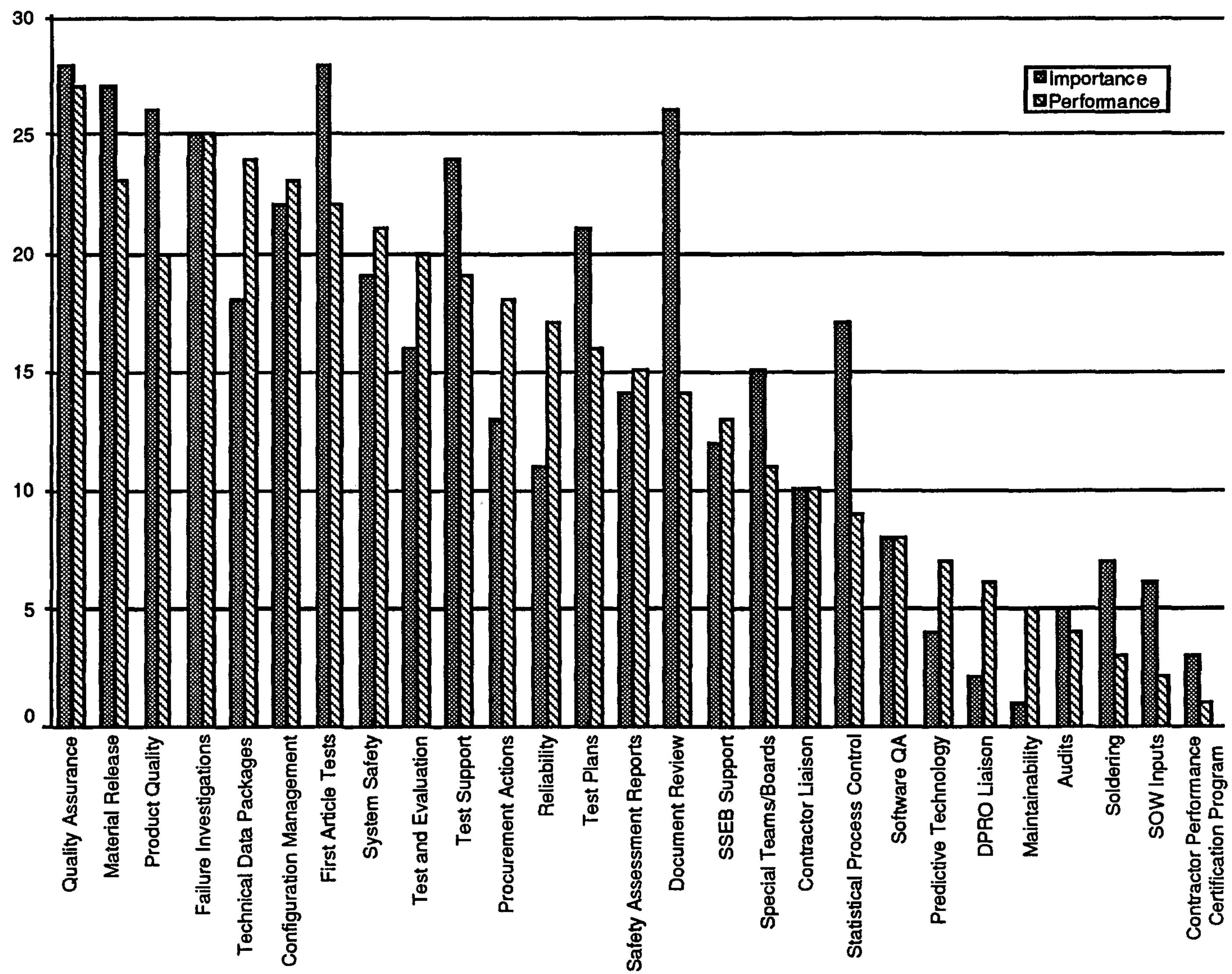

Figure III-6. Importance vs. Performance Customer Survey Results

Certification, SOW Inputs, and Soldering. In each of these areas PAD's performance exceeds the importance to the customer. Since customer success is one of PAD's objectives, the results indicate an opportunity to concentrate on other areas that are more important to the customer.

b. Informal Survey

In an informal survey conducted as part of this case study, the following questions were asked of the PMs and PEOs for which ARDEC does business:

- Does PAD provide a value added in its concurrent role?
- Does PAD provide a value added in its independent safety role?
- Does PAD maintain a program balance?

Their limited response is summarized as follows:

- Concurrent role—yes.
- Value added to safety—yes.
- Need visibility for independent safety assessment on team.

3. Work Force Expectations

Survey questions posed to the employees of PAD were:

- What is the main mission of PAD?
- How do you support that mission and what is your value added?
- What are the major problems you face in accomplishing your mission? (Do not include administrative burden.)
- From an organizational standpoint, how could you operate more efficiently?
  - — Collocate as a major group or part of PAD.
  - — Collocate in IPTs or as a part of PAD.
  - — Become part of the engineering laboratory as a major group.
  - — Become a part of the engineering laboratory integrated into IPTs.

The responses were poor, as the employees failed to address their value added. They did recognize the need to become part of a team, but they expressed a desire for collocation in large groups, not as individuals.

C. ANALYSIS OF FUNCTIONS, ACTIVITIES, AND ORGANIZATIONS

1. Analysis of Functions and Activities

This portion of the case study was directed at reviewing the functions performed by the ARDEC PAD to determine the essential core competencies of product assurance and how these functions could be restructured into IPPD operational concepts. Core competencies traditionally in Product Assurance, as identified by former Directors of PAD, are shown in Table III-4.

Table III-4. Traditional ARDEC Product Assurance Directorate Core Competencies

Technical	Management
Quality engineering	Smart buyer
RAM engineering	Materiel release
System safety	Certifications [(CP)2, etc.)]
Software quality assurance	
Verification and validation	
Nondestructive testing	
First article test	

Table III-5 summarizes the PAD's activities and marks them as being done independently (I) or concurrently (C) with other functions. Figure III-7 further delineates those functions that deal with technology and assessment—those for audit, policy, special assessments—and those functions that should be included in the IPPD teams.

2. Organizational Analysis

Having determined which functions were performed independently and which were best performed within IPPD teams, IDA then studied several potential organizational alignments. Industry and other government agency trends were balanced against the need for independent analysis and criticality of the organizational mission. The demonstrated need for home bases to retain skills, provide career paths, and maintain the smart buyer capability was also considered, as were the views of the current and former ARDEC CGs, who clearly voiced support for an independent organization.

Table III-5. PAD Activities Done Independently or Concurrently

I	Participate in materiel acquisition review board (MARB)
I	Participate in source selection and contract negotiation teams
C/I	Conduct contractor quality audits
C/I	Conduct/participate in readiness for test reviews (RFTR)
C/I	Develop plans/conduct FLA and PLA
C/I	Input to TMs, EOD procedures, and DMWRS II
C/I	Participate/provide input to formal development program review meetings (ASARC, IPRS, PZRs, management reviews)
C/I	Participate in blue teams, red teams, malfunction and deficiency investigations
C/I	Participate in fuze safety working group (FSWG) and fuze safety reliability group (FSRB)
C/I	Prepare/provide input to scope of work (SOW), independent government estimates (IGCE), data item description (DID), and DRL requirements
C/I	Prepare contract quality clauses
C/I	Prepare performance specifications
C/I	Provide technical support to full evaluation and user tests of fielded ammunition and weapons including PREPO
C/I	Develop RAM rationale and evaluation criteria
C/I	Participate in materiel release review
C/I	Perform/review reliability growth
C/I	Prepare system health hazards assessment and environmental impact
C/I	Prepare/review failure mode and effect analyses (FMEA)
C	Conduct/review reliability allocation and assessment
C	Develop nondestructive tests (NDT), review NDT applications
C	Participate in configuration control boards (RFW/RFD)
C	Participate in proving ground testing
C	Participate in TIWGS/provide input to Test and Evaluation Master Plans (TEMPs), TIRS
C	Perform/review first article tests (FAT)special tests/inspection support/LATS
C	Preparation/review gage/test design
C	Preparation/review/certification of specifications, SQAPS, quality evaluation plan (QEPS), QAPS
C	Prepare/review reliability/system safety fault trees
C	Prepare product assurance plan
C	Prepare quality assurance letters of instruction
C	Prepare safety assessment reports (SARs)
C	Prepare/provide input to ammunition stockpile test plan
C	Prepare/review ballistic test requests (BTRS) (production)
C	Prepare/review process control plans and SPC plans
C	Prepare/review system safety program plan
C	Prepare/review/comment on engineering change proposals and value engineering change proposals (VECPs)
C	Provide support to ammunition stockpile laboratory and firing test program
C	Provide/review data for interface control documents
C	Review/comment on requirements documents (ROCs, MNs)
C	Validate contractor's technology data

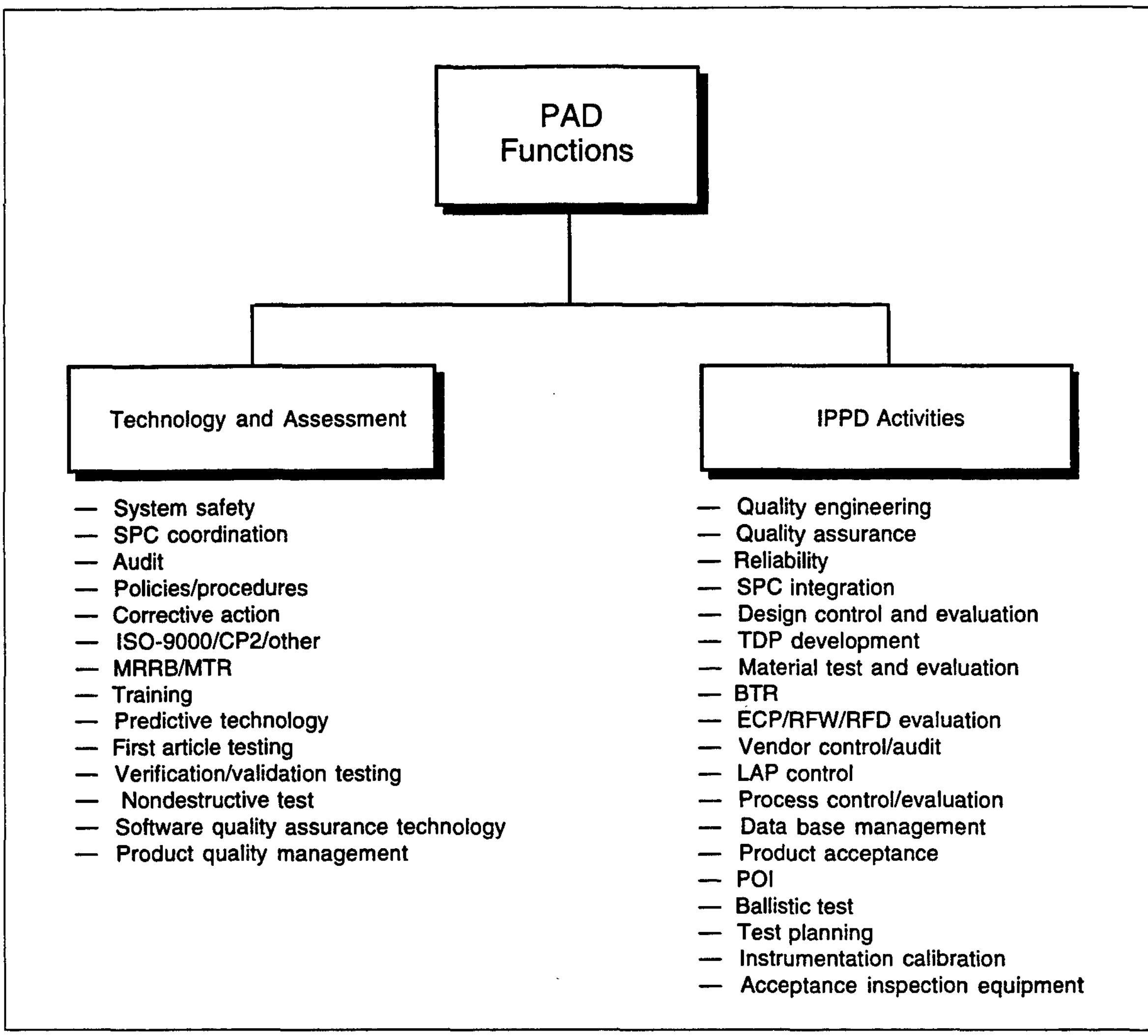

Figure III-7. Proposed Product Assurance Functional Responsibilities

As a result of this analysis, which considered the strengths and weaknesses of options ranging from totally dissolving the PAD to keeping the status quo, we identified two viable organizational structures for further consideration. Both structures involved collocating personnel providing the IPPD-related activities in Figure III-8 on the IPTs and a separate organization of technology and assessment PAD personnel to provide the centralized policy, training, technology development, and special assignments. Both structures provided for the organizational independence necessary to assure to the CG the safety, support stability, and reliability of armament systems being developed and produced for use in the field.

The major issue becomes where the personnel performing the IPPD activities should have a home base—in PAD or in Engineering. The major strength of having these personnel reporting to the director or chief of the engineering directorate was financial unity. It would take potentially fewer resources to perform the functions, as the engineers are direct program charges and not overhead. Industry has also had a lot of success with such arrangements.

Figure III-8 depicts the organizational structure that collocates PAD personnel with the commodity IPTs. Here, PAD consists of the Technology and Assessment Division and collocated PAD IPT members, both reporting to a single director who in turn reports directly to the CG. As shown, PAD further apportions its personnel into collocated teams aligned to the mission commodities, and the teams then provide the staffing to product IPTs as required. This organization provides a technology-specific functional home base for product assurance professionals who perform their roles in an IPT environment much like the XYZ Command discussed in Chapter II. This arrangement allows for greater worker comfort and appeases the problems discussed in Section I.B.1. The weaknesses are the cost of retaining a function-specific home base and the practice of having the IPT members reporting directly to the PAD director, which industry practice shies away from. The Lean Enterprise model, discussed in Chapter IV, provides an alternative practice.

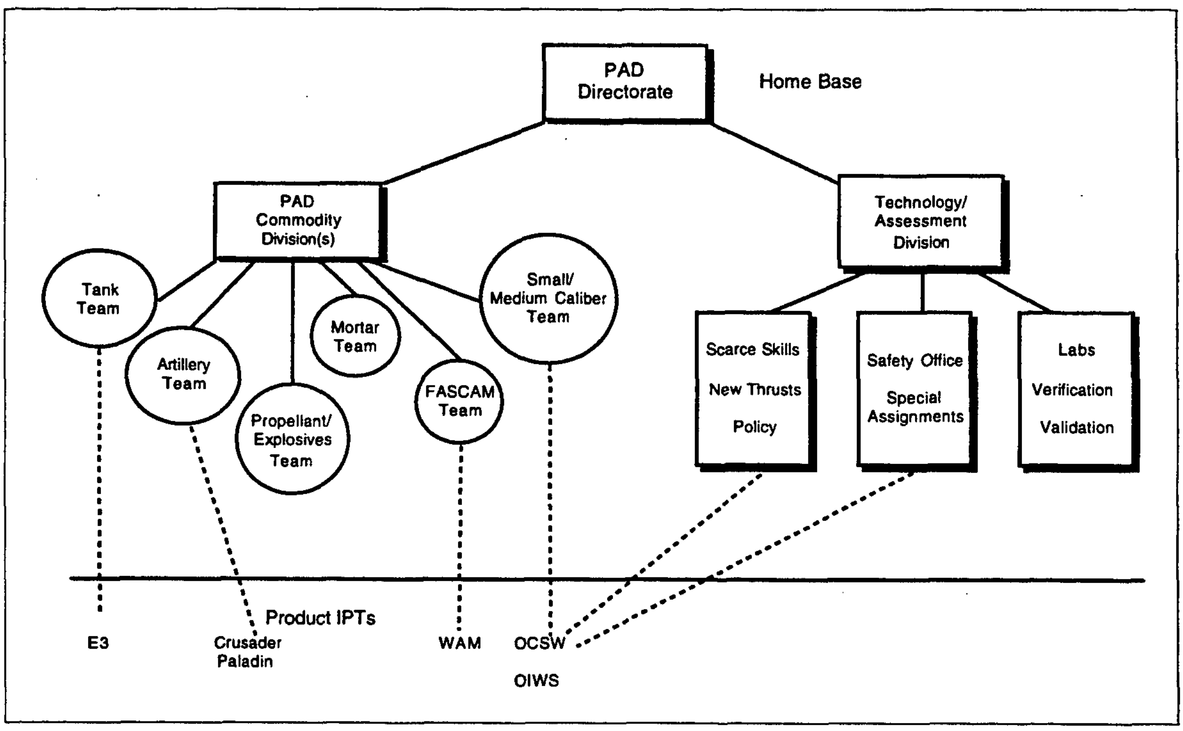

Figure III-8. PAD Organizational Structure Alternative

D. SUMMARY

Within the ARDEC, product assurance is a core competency, as deemed by the CGs. While it is considered a support and not a direct-charge function, product assurance does provide a vital link in the life cycle from early research through the prediction and assurance of stockpile reliability. Its technologies of Quality Function Deployment (QFD), statistics, reliability, failure analysis, fault trees, nondestructive testing, etc., are ever evolving, and their applications are becoming even more critical in the future environment where failure at any level cannot be tolerated. Whether these activities belong in an engineering directorate, as has been done in industry, or in a separate product assurance directorate, is the question. Regardless, past and present commanders rely on the independence and objectivity of product in releasing new material to the field, ensuring the safety of the armaments and ammunition to be released. Therefore, an independent technology and assessment division with the detailed skills and resources for these assessments is considered a viable solution for ARDEC, but certain functions could be outsourced (Figure III-9).

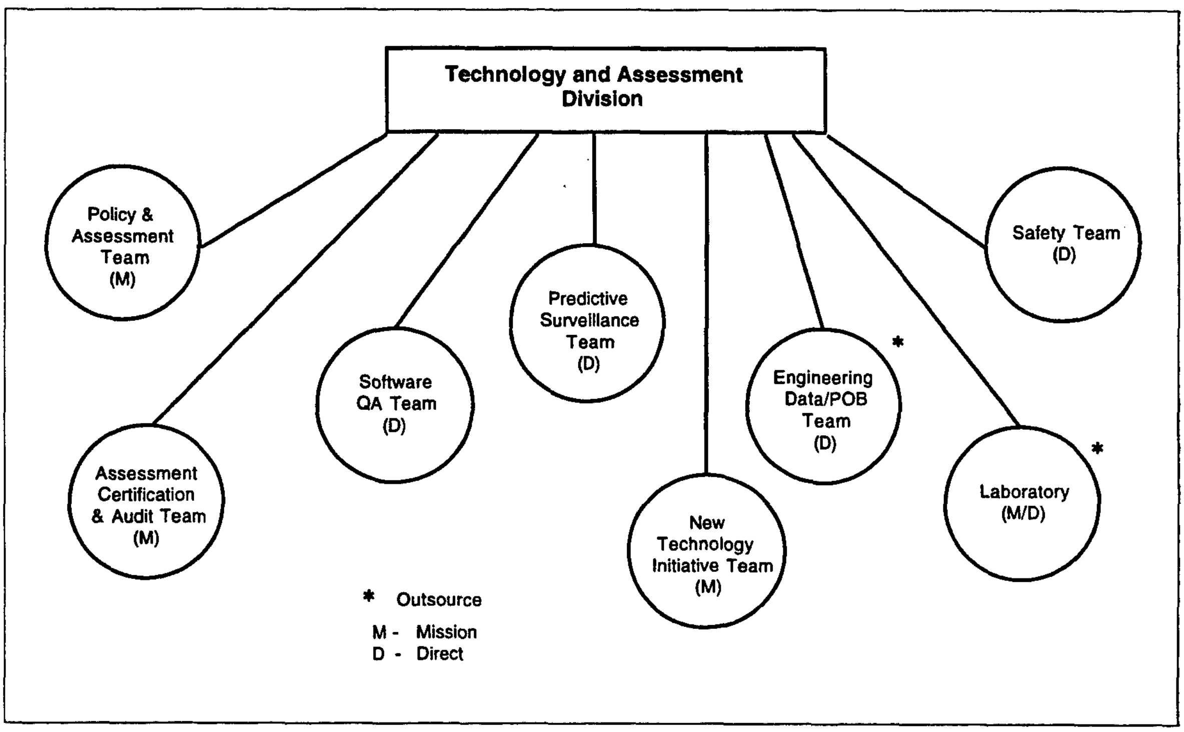

Figure III-9. Outsourcing Opportunities

IV. THE LEAN ENTERPRISE MODEL

Chapter I discusses the principles and issues of reengineering, citing relevant literature on the subject. Reengineering articles and books, however, do not readily give models for an organization; they focus on the process. For a model, IDA turned to the Lean Enterprise model.

A. MODEL CHARACTERISTICS

The book *The Machine That Changed The World* introduced the concept of "lean" manufacturing or production.[1] The "machine" is the automobile, but the revolutionary concept of "lean" is the manufacturing approach pioneered by Toyota. By eliminating waste, recombining labor into cross-functional teams that align all steps of an activity in a continuous flow, and striving for continuous improvement, Toyota found that companies can "develop, produce, and distribute products with *half or less* of the human effort, space, tools, time, and overall expense. They can also become vastly more flexible and responsive to customer desires."[2]

The massive study behind the book was led by the Massachusetts Institute of Technology (MIT), which continues to help North American and European companies implement lean production and is credited with turning around the U.S. automobile industry. That success attracted the attention of the Air Force's Manufacturing Technology (ManTech) organization, which is currently funding the Lean Aircraft Initiative (LAI) for the aerospace industry.

Authors Womack and Jones, in their follow-on article presenting the Lean Manufacturing Model,[3] maintain that an organization needs to form a continuous *value stream* that creates, sells, and services a family of products. In so doing, the organization must take into consideration the three needs:

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1 James Womack, Daniel Jones, and Daniel Roos, *The Machine That Changed the World*, Harper-Collins, New York, NY, 1991).

2 James P. Womack and Daniel T. Jones, "From Lean Production to the Lean Enterprise," *Harvard Business Review*, March-April 1994.

3 Womack and Jones, "From Lean Production."

- The needs of the individual—needing a job, a career, and a "home" that defines who one is in their work lives.
- The need of functions—to accumulate knowledge, teach knowledge, continually search for new knowledge.[4]
- The needs of companies—to calculate costs and benefits it generates within the value stream, and see the results of its improvement efforts.

The authors relate these three needs to the traditional cultures in the U.S., Germany, and Japan, respectively. The lean enterprise model satisfies all three needs.

1. Alternating Career Paths

On the subject of value streams, *The Machine* states that "individuals must be totally dedicated to a specific process" and that "functional specialists involved in product development must completely focus on their task in a team context."[5] But if an individual is permanently assigned to an Integrated Product Team (IPT), he or she faces abandoning their functional career path. Also, the loss of these individuals threatens key functions with loss of power and importance. When people feel threatened, streamlined reengineering will not be successful. The Lean Enterprise model addresses these issues by offering alternating career paths.

The idea is that an individual's career path alternates between concentration on a specific family of products and dedicated, intense knowledge-building within functions. The Human Resources function must provide career planners who are responsible for ensuring a coherent career for all workers. This is the key to attracting new employees.

In this model, performance raters also alternate. While the individual is working within the IPT, the team leader rates performance; when the individual is back within the function, the function head performs the rating. The function head, team leader, and career planner jointly decide where the individual goes within the alternating jobs of applying

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4 See Peter F. Senge, *The Fifth Discipline: The Art and Practice of the Leaning Organization,* Doubleday, New York, NY, 1990.

5 Womack and Jones, "From Lean Production."

knowledge and gaining knowledge. This seems to be the key to preventing the loss of skills from not having a home base, as observed at one of the Army installations.[6]

2. Functions Become Schools

In the lean enterprise model, the functional organization does two things:

- It serves as a school, systematically summarizing current knowledge, searching for new knowledge, and teaching this knowledge to the functional people who then go serve on value-creating process teams, or IPTs.
- It develops guidelines based on the best practices for the function, rules for how the function will work together with other functions, and behavioral codes.

But it is the IPT that actually performs the function. In this model, purchasing no longer purchases, for example:

> The traditional purchasing department should define the principles of enduring relationships with suppliers, draw up the roster of eligible suppliers, and strive to continuously improve the performance of every supplier. The IPT should perform the purchasing department's traditional job of deciding to obtain a specific amount of a specifc item at a target price from a specific supplier for the life of the product.[7]

3. Form a New Process-Management Function

In this model, the traditional industrial engineering and quality assurance functions are combined into a new process-management function. This function does the following three things:

- Defines the rules for managing IPTs and the continuous flow of production, including quality assurance

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6 The importance of these issues to the work force was demonstrated during our case study at ARDEC. During a teaming workshop held in February 1996 to help ARDEC become more customer focused using a team-based organization, the following issues were ranked second, third, sixth, and seventh among the work force participants:

- Provide for development of the future workforce
- Provide for hiring and training to offset the current aging workforce
- Preserve key functional expertise in support of our commodities
- Provide for the continual development and training of core commodity and technology capabilities to insure exptertise and up-to-date facilities exist to support IPTs and ARDEC's mission.

7 Womack and Jones, "From Lean Production."

- Teaches team leaders in product development and production how to apply these rules
- Constantly searches for better approaches.

The Lean Enterprise Model is illustrated in Figure IV-1.

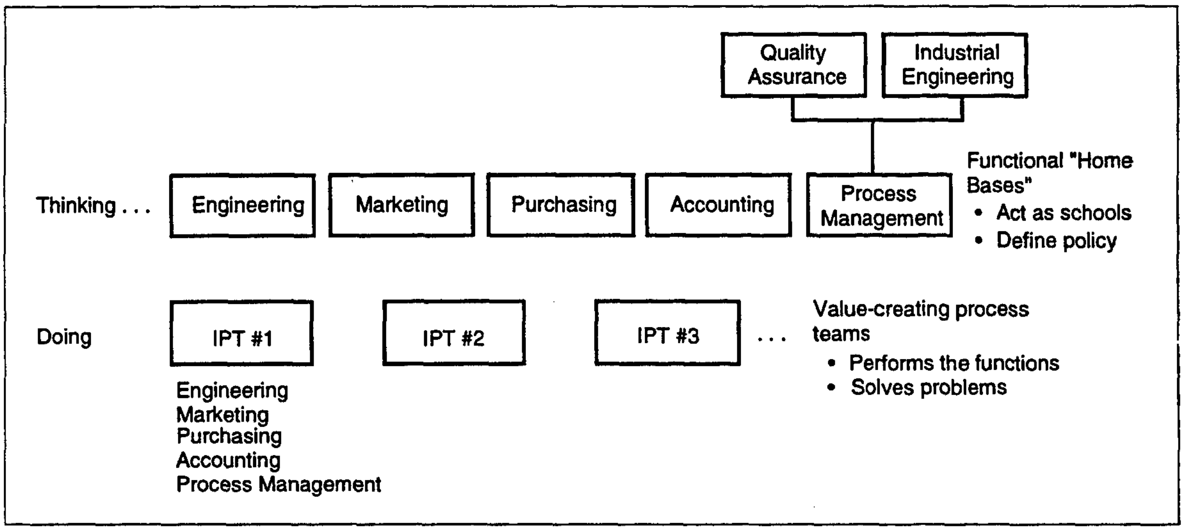


Figure IV-1. Lean Enterprise Model

B. APPLICATIONS WITHIN DoD

Just as reengineering books and articles are focused on companies, so is the Lean Enterprise model. Whereas we see this as an exemplary model, its application within DoD must be tailored. Just as the Quality Assurance functions changed within the benchmarked industry models of Chapter II when we got to the pharmaceutical companies, the safety and liability issues within DoD organizations vary widely from low risk to high risk. Since the QA organization provides the independent assessment so important to the safety issues, a different approach is required for high risk products than for low risk items. In the high risk cases, Quality Assurance would have to maintain an independent evaluation function.

Also, the Lean Enterprise model that combines Quality Assurance with Industrial Engineering (functions within production, such as modeling, painting, assembly) is not appropriate for DoD organizations that are not arsenals or do not do production functions. In the majority of cases, the DoD organization is doing basic research, science and technology, and development work, and the contractor is doing the production. The model is similar to what we found in industry where Quality Assurance and Production were combined into "Operations" for the quality *control* aspect of the function. Here it is still appropriate for the quality *engineering* functions to be combined with manufacturing and other engineers and be members of the IPTs.

The Lean Enterprise model provides excellent options for performance ratings and offers a new viability for functional organizations as schools.

APPENDIX A

NEW MISSION AND ORGANIZATION OF THE PRODUCT ASSURANCE DIRECTORATE OF THE ARMY'S ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER

Appendix A
NEW MISSION AND ORGANIZATION OF THE PRODUCT ASSURANCE DIRECTORATE OF THE ARMY'S ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER

The material in this appendix is taken from ARDEC's home page on the World Wide Web after their reengineering occurred (January 1977). The Mission of TACOM-ARDEC is to:

- Conduct or manage research, development and life cycle engineering, including product assurance, engineering in support of items in production and integrated logistics support for assigned armament, munitions systems and materiel;
- Provide procurement and management of initial production quantities and technical support to soldiers and equipment in the field;
- Maintain a technology base to facilitate the design, development, procurement, production and life-cycle support of assigned materiel or transitioned technologies.

PRODUCT ASSURANCE DIRECTORATE MISSION

To act as staff advisor to the Commanding General on all ARDEC product and test matters; to develop policy and procedures for the life cycle product assurance functions; provide the command's product assurance interface with other commands, higher headquarters, and other government and non-government activities. Provide the ARDEC Test and Evaluation, Materiel Release and Corrosion Prevention and Control Managers. Plan, develop, direct and manage life-cycle product assurance programs for all ARDEC managed materiel. Direct the independent assessment program for ARDEC materiel. Serve as the primary ARDEC action point for matrix support to PEOs/PMs with respect to product quality assurance functions.

PRODUCT ASSURANCE DIRECTORATE VISION

PAD will be an independent organization for providing product assurance and services to other organizations. PAD will establish itself as a Center of Excellence through (1) the innovative attainment and assurance of high quality materiel delivered to the soldier, (2) by increasing professional visibility through marketing improvements (e.g., customer perception) and (3) by attracting customers through confidence in our professional capabilities. PAD will measure and improve upon its expertise in unique functional support areas, to include SRAM and Failure Analyses and become a recognized leader in problem resolution (e.g., Red Teams), as well as problem prevention (e.g., Failure Analysis, et al.)

MESSAGE FROM THE DIRECTOR

Product Assurance is a partner with the Armament R&D Engineering Center (ARDEC) and provides quality, reliability and system safety support to assure that ARDEC's customers receive a world quality product.

In that regard we at Product Assurance have developed this Business Plan to lay down our objectives, identify our strengths, reflect how PAD integrates its strategic goals with ARDEC's system goals and identify our business thrusts in three primary thrust areas; ARDEC's commodity centers, the supplier base for our products, and the test technology needed to support PAD's functions.

It is a Business Plan designed to provide world class support to our customers, ensure a future capability by enhancement of PAD's work force and finally provide the vision necessary to help assure ARDEC's mission in the 21st century.

The Product Assurance Business Plan was designed for success. We, all of us in PAD, have dedicated ourselves to make that happen.

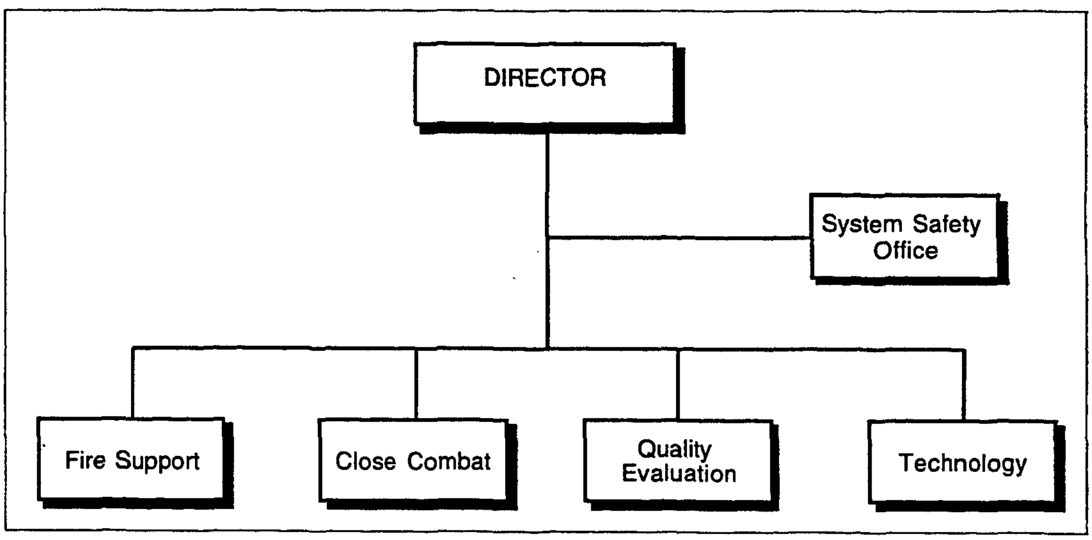
PAD BUSINESS PLAN

This plan represents the strategic business planning efforts of the Product Assurance Directorate (PAD) at the U.S. Army Armament Research, Development and Engineering Center (ARDEC) located at Picatinny Arsenal, New Jersey, and Rock Island Arsenal, Illinois.

ARDEC is part of a larger command structure reporting through the Tank-Automotive and Armaments Command (TACOM) to the Army Materiel Command (AMC). PAD is a multi-disciplined organization, providing independent research, development, and engineering capabilities in conjunction with other planning elements and program organizations at ARDEC, TACOM, ACALA, AMC, as well as the Department of the Army (DA) and Department of Defense (DoD). Our Customer Base includes the Program Executive Offices of Field Artillery Systems (PEO FAS) and Armored Systems Modernization (PEO ASM).

PAD's customer focus has paid dividends over the last decade. Fiscal soundness is evidenced by the consistent flow of RDT&E and PAA reimbursable dollars; the roughly $25M annual budget is projected to remain stable over the next 5 years. OMA is a sensitive area, and shortfalls like the stockpile program have reduced income in this sector by approximately one-half of the $15M fiscal year 1992 level. The Directorate has been able to adjust to the OMA decreases via mandated downsizing and self-initiated restructuring. PAD will continue to respond accordingly to changes in fiscal status, but expects to see a turnaround by 1999.

PAD ORGANIZATION



Product Assurance Directorate Organization

PAD KEY INDEPENDENT AREAS

Table A-1. Key Independent Functions by Organizational Element

Fire Support	Close Combat	Quality Evaluation	Technology
Indirect Fire	Direct Fire	Materiel Release	Stockpile/Bullet-A
Artillery Systems and Munitions/Fuzes	Tank Ammunition and Fuzes	Failure/Root-Cause Analysis	Non Destructive Test (NDT)
Mortar Systems and Munitions/Fuzes	Aircraft and Air Defense Systems	Policy Guidance and Warranties	Software Quality Assurance
Smart Munitions	Fire Control	First Article Test	Predictive Tech.
Mines	Cannon Caliber	Scratch and Digs	Explosives
Electro Armaments	Small Caliber	Standardization	Propellants
Grenades	Missile Warhead	(CP)2	Pyrotechnic
Demolition	2.75"	RAM/CPC	Physical Test
	Mechanized Vehicles	Reliability/Statistics	Environmental
	Land Warrior	Contract Management	Soldering
	Less Than Lethal		Packaging

KEY FUNCTIONAL AREAS

Table A-2. Key Independent Functions across Commodity Centers, Supplier Base, and Test Technology

Commodity Centers	Supplier Base	Test Technology
Fire Support	(CP)2	Non-Destructive Testing
Close Combat	First Article	Dimensional Testing
Materiel Release	Contract Management	Physical Properties
System Safety	Scratch and Digs	Predictive Technologies
Propellants and Explosives	Standardization	Stockpile Reliability
Software Quality Assurance	Soldering	Dual-Use Technologies
Failure Analysis		
Packaging		
Reliability/Statistics		
RAM/CPC		

APPENDIX B

THE FUTURE OF THE QUALITY PROFESSION

Appendix B
THE FUTURE OF THE QUALITY PROFESSION

The following excerpts were taken from articles included in the July 1996 volume of the ASQC *Quality Progress* journal, titled, "The Future of the Quality Profession."

A Look at the Past to Predict the Future, Mark Gershon, pp. 29-31.

> An important challenge faces the quality profession. Over the past 20 years, quality has been a major area of contention for companies. Better quality products have had an edge in the marketplace. But J.M. Juran and others have warned that a competitive strategy based on quality might no longer be possible. Essentially, they argue that quality professionals' success will lead to the satisfaction of the need in society for their services.[1] In other words, quality professionals will no longer be needed because extraordinary levels of quality are already being achieved across the board. [This result is seen in statements of corporate strategy. For example, Toyota no longer cites "quality" but "cost effectiveness" as its major goal.]
>
> Mark Gershon is a professor and the chairman of Department of Management Science and Operations Management at Temple University in Philadelphia, PA. He received a doctorate in systems and industrial engineering from the University of Arizona in Tucson. Gershon is a member of ASQC.

Where Will They Fit In?, Lori L. Silverman and Annabeth L. Propst, pp. 33-34.

> In today's business environment, an organization's survival is tied to its ability to provide value to its customers. Traditionally, organizations attempted to ensure value by monitoring and controlling quality. They created departments with titles such as quality assurance, continuous quality improvement, quality control, and quality systems. Often these departments were small empires, staffed with managers, supervisors, inspectors, technicians, and engineers. Recently, there has been a shift toward departments with titles such as business performance, organizational effectiveness, and strategy management. These new departments, however, may have only a handful of staff members, and it appears that traditional quality departments are becoming smaller or disbanded. As a result, quality professionals have found themselves unemployed or grouped into the general work force. This is fueled, in part, by the perception that staff positions—such as those in quality departments—add cost rather than value.

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1 J.M. Juran, editor in chief, *A History of Managing for Quality*, Milwaukee, WI, ASQC Quality Press, 1995.

This apparent trend away from quality extends to other arenas. For example, the 1996 version of the Malcolm Baldrige National Quality Award criteria states that the purpose of the award is "to recognize companies for business performance excellence and competitiveness improvement." The word "quality" is not mentioned here or in the titles of the seven award categories. Even ASQC is considering a name change based on the evolving focus of its members.

Quality departments that provide traditional quality assurance are becoming extinct in organizations that have been quick to transform into customer-sensitive, knowledge-creating, agile enterprises. In many firms, existing work groups assume some, if not all, of the quality department's responsibilities. As a result, quality professionals may be laid off or integrated into other areas of the organization. If a work group needs assistance with process redesign or measurement, there may be individuals designated to respond to these needs in addition to their regular responsibilities.

In other organizations, the quality department is given a new purpose, such as improving business performance, and a widely increased scope of responsibilities.

A third approach that is gaining more attention is the consolidation and integration of strategic planning, organizational development, human resources, industrial engineering, quality systems, training, and safety. A department staff by one or more internal consultants usually emerges. These individuals may provide the service themselves, tap into external or internal resources for specific needs, or focus on the skill and knowledge enhancement of existing leaders who can develop their employees.

Successful organizations of the future will provide value by maintaining quality as a paradigm, not a department. There will be more jobs for quality professionals, not fewer, but they will not be in quality departments, nor will job titles contain the word "quality." These positions will be directly linked to the value chain of the organization. Quality will become a way of life—not a job or a profession. At last it will be apparent that quality professionals are adding value rather than cost.

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Annabeth L. Propst is the owner of Quality Transformation Services in Chicago, IL. She has a master's degree in applied statistics from Northern Illinois University in DeKalb. Propst is a senior member of ASQC.

Rethinking Traditional Quality Assurance, Rick Sutter, pp. 40-41.

Before the fate of the quality profession can be determined, the functions, jobs, and tasks it includes must be established. In the past, the profession encompassed quality auditors, quality control inspectors, and quality engineers who ensured that design documents contained necessary and sufficient quality assurance and control criteria, and that organizations established appropriate procedural controls.

These quality disciplines resulted from the regulated mass-production processes of the World War II era. The heavily regulated commercial nuclear industry of the 1970s helped solidify the quality professional's role in business and government, and as overseas competition for manufactured goods increased, American business began to adopt these quality disciplines in an attempt to survive.

More recently, however, manufacturing has changed. The world economy has leveled the playing field on which the United States was once the dominant player. An example of this is the switch from mass production to mass customization, and from stable, long-term services to constantly changing and niche services. Mass customization can be seen everywhere—from coffee and blue jeans to automobiles land health insurance. Short production runs, customer input, short product life cycles, and innovations in computer-controlled and robotized manufacturing methods are causing businesses to rethink traditional quality assurance.

Formal quality assurance and quality control departments perpetuate the idea that conformance or compliance is the objective, rather than customer delight. Instead, companies must educate stakeholders on the vision and philosophy of the company, each stockholder's contribution, and what to expect from living that philosophy. Everyone must have a genuine desire to live the philosophy. This desire is created when policy and behavior are congruent, when all participants know their roles and value, and when all share visibly in the organization's success.

Rick Sutter is quality assurance manager at IT Hanford Co. In Richland, WA. He has a bachelor's degree in political science from the University at Albany, State University of New York. Sutter is a member of ASQC and a certified quality auditor.

The Darwinian Future Is Looming, Paul F. Wilson, pp. 45-48.

Designing newer process-centered tools. Throughout the quality profession's history, there has been a steady stream of new quality improvement programs. First, there were quality control (QC) programs, in which quality was inspected in. Then the achievement of quality was treated as a program that could be appended to a larger organizational system. Companies defined quality programs, devised suitable means to control them, and then made sure employees complied. In principle, these traditional quality assurance (QA) programs provided the necessary control that, in turn, assured quality products and services.

But quality programs based solely on this approach did not always produce the intended results. For example, consider the model for the QA program that was initially developed by the nuclear power plant construction industry but later used by many industries. In this model, an independent QA organization, which reported to the very highest level, set up and administered a corporate quality program. Redundancy was used as a proven way to improve reliability.

QA programs based on this model, however, unintentionally resulted in an overreliance on backup. QA personnel became de factor supervisors. This transfer of responsibility and the lack of perceived ownership for achieved quality were major problems of the model.

While quality professionals have been improving quality programs, they have also come to understand that these programs, by themselves, do not ensure quality. Many are only too painfully aware of companies pointing proudly to volumes of QA manuals that, in reality, only gather dust in managers' offices. On the other hand, most quality professionals can also come up with at least one example of a truly excellent company that does not have a formal quality program. These organizations seem to intuitively understand the true idea of quality products and services.

Will the quality profession itself survive? This is a tantalizing question. During its transformation, the function specifically identified as the "quality department" will probably fade and eventually disappear because everyone in the organization will need to be quality conscious and practice quality principles. But therein lies the future of the quality profession. Quality professionals will need to represent the collected body of knowledge. They can provide valuable direction and coordination, and they can become important team contributors. Taken in this context, the quality profession will grow dramatically.

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13. ABSTRACT (Maximum 200 words)

This paper presents concepts to help reengineer the Quality Assurance functions within DoD using the Army Armament Research, Development, and Engineering Center (ARDEC) as a case study. Models of the Quality Assurance organizations in various best-practice commercial and defense companies and some Army organizations are presented and their reengineering efforts discussed. Findings show that large, independent Quality Assurance organizations are becoming a thing of the past except in some highly regulated industries where product risk and liability are major concerns. The down-sizing of the Quality Assurance organizations is in keeping with the Quality movement of the past decade where product quality becomes the responsibility of all process owners. The Lean Manufacturing model is given as a recommended model for how career paths can be preserved in the new down-sizing environments.

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