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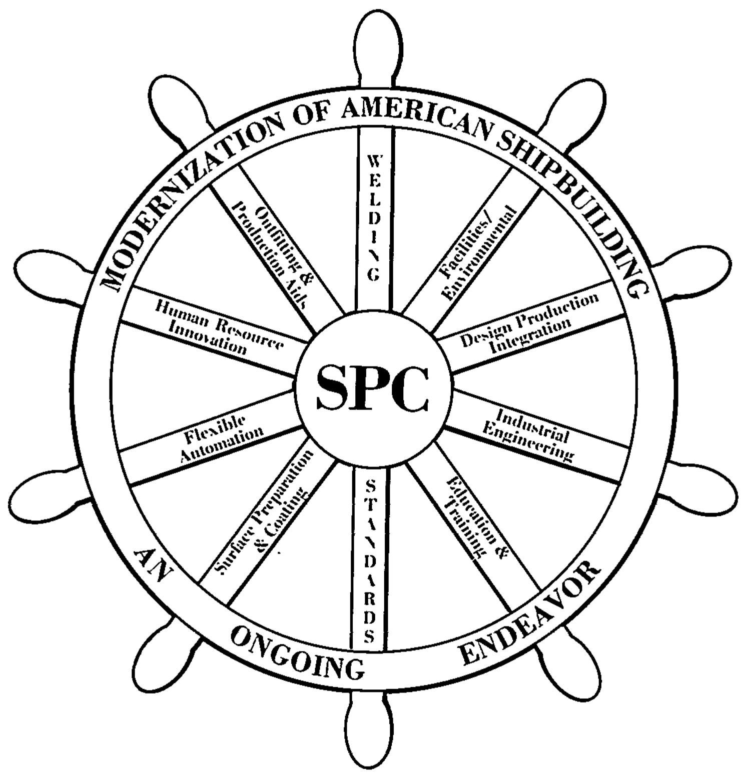

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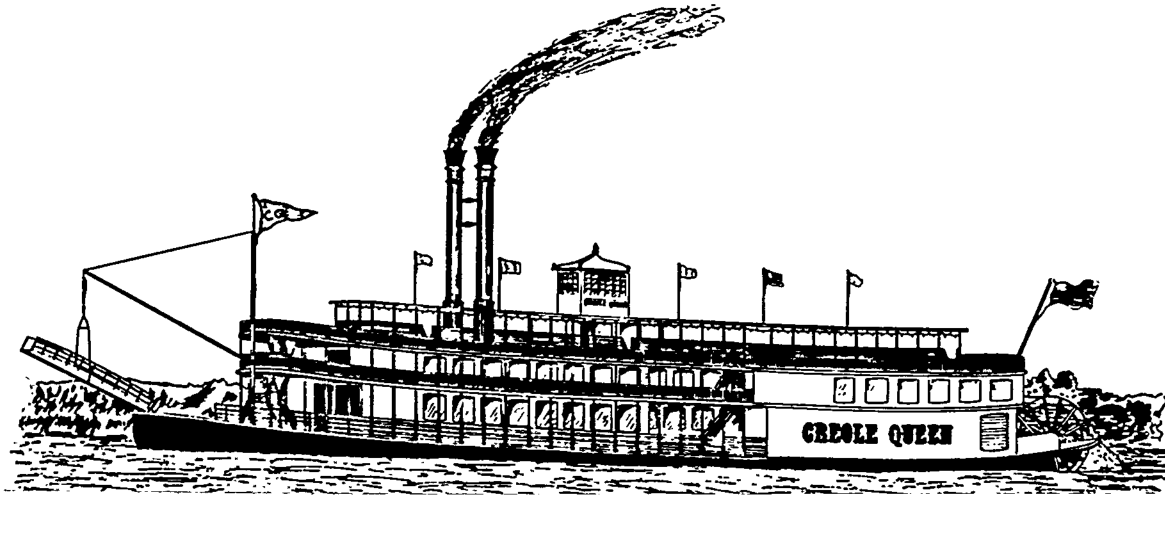

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
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Implementing Technology—Viewing Management's Task in Today's U.S. Shipbuilding Industry

No. 11

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ABSTRACT

Competitiveness (foreign and domestic) is continuing to present formidable challenges to management in the U.S. shipbuilding industry. The implementation of advanced technologies, especially software technologies, requires a special understanding by management. Based on material from two National Shipbuilding Research Program workshops, a view of the socio-technical goals and objectives for shipyard management are presented.

INTRODUCTION

This paper is based on work that was done by the author, and others, during two workshops held in Ann Arbor, Michigan in late summer and fall of 1986. The workshops, entitled *Implementation of Advanced Technology in the U.S. Shipbuilding Industry*, were based on the premise that the technology gap that exists today between U.S. shipyards and their overseas competitors is one that is caused primarily by software technologies. The direction and sponsorship of these workshops was provided by the Ship Production Committee's Design/Production Integration Panel (SP-4) and the Education and Training Panel (SP-9) of the National Shipbuilding Research Program. The process of implementing change, which was the focus of the workshops, provides a framework for viewing management's goals and objectives in dealing with the socio-technical organization of today.

Like other manufacturing industries in the U.S., the shipbuilding industry has had many advances in production techniques over the last twenty years. That period signalled the awakening of the shipbuilding industry to better methods of building the product and to the challenge of incorporating the associated technologies. Complicating this task, the new technology must be incorporated in a time of shrinking market demand that forces a compression of time and money resources.

It has therefore become the task of the entire organization, led by management, to deal with change. The goal is to transform the manufacturing process to promote market share growth while maintaining, and more ideally, enhancing the quality of the product. The technologies associated with this transformation have been identified as primarily "software" in nature.

A definition of software technology, the technology transfer process, and the structural elements of the production operation follow in the next two sections. Secondly, a discussion of resistance to change leads to modeling management's evolution toward the goal of being "externally supportive" to production operations. The emerging role of marketing and the product-oriented organizational structure are discussed. Finally, a road map for change is suggested through the development of company-wide quality control.

DEFINING SOFTWARE TECHNOLOGY

A global definition of technology (from anthropology) is that technology is the body of knowledge available to a civilization--knowledge that is of use in fashioning implements, practicing manual arts and skills, and extracting or collecting materials. A working definition of advanced technology (for the purposes of this paper) is that it is simply any existing process not commonly utilized, that improves production productivity: i.e., make it sooner, make it faster, make it better, reduce the cost, and meet legal requirements of work place safety and product liability.[1]

The subject of technology can be broken down a number of different ways. In discussing production manufacturing technology, it is most convenient to separate it into hardware and software.

Hardware
- Machines
- Tools
- Materials
- Facilities

Software
- Procedures
- Workers' Skills
- Techniques
- Organization of Work

New hardware technologies continue to become available (a new burning machine, CAD/CAM tools, etc.) and will continue to improve productivity; however, each piece of hardware must have its associated software interface into the production process. This supporting interface, which can be responsible for realizing the full benefits of a piece of hardware, is too often an after thought. It has been proposed that because software technologies have taken on a subordinate roll, they are considered to be the primary cause of the competitive gap between the U.S. shipbuilding industry and its foreign counterparts.[2] The advanced software technologies that must be brought into the mainstream of decisions include:

* quality control,
* planning,
* production control,
* production engineering,
* design for production,
* product work breakdown at the design stage,
* standardization of the product,
* progressive management techniques,
* standardization of procedures,
* material control, and
* management information systems.

THE TECHNOLOGY TRANSFER PROCESS

To survive in today's market, there must be a transfer of advanced technology. This transfer can be viewed as having four distinct stages:

1) Initial Awareness,
2) Evaluation,
3) Adoption, and
4) Implementation (including follow-up).

Fundamental changes resulting from the implementation of technology (hardware or software) affect the organizational structure, communication patterns, reporting relationships, work rules and job definitions, new attitudes and positions, etc., within the shipyard.

The introduction of a software technology (e.g., the move from viewing the ship as the product to the concept of group technology that requires an interim product focus) is especially difficult since it is less tangible then a new machine or building basin. Thus, it is often not clear what has changed and/or to what degree the organization has been affected. These unknowns typically retard the implementation process. The delay in realizing benefits from a project (or worse, the actual failure of a program) leads to management frustration with unrealized goals and objectives.

The resulting disruption from attempts at technology emplacement often has the most undesirable result of all: a "backlash" reaction against further endeavors at technology implementation and a deeper entrenchment of the traditionalists within the organization. The first three stages of technology transfer can happen with minimum disruption to the firm; however, to avoid the "backlash" reaction during or after stage 4, management must appreciate the extent to which a new production concept affects the structural elements of the production operation.

THE STRUCTURAL ELEMENTS OF PRODUCTION

A useful generalized framework for production operations has been outlined by Steven Wheelwright at the Stanford University Graduate School of Business[3] and is shown in Figure 1 below. This framework relates the organizational scope to the external and internal environment factors within which the firm must operate.

The Structural Elements of Production

	Structure ("Hardware")	Infrastructure ("Software")
MACRO (COUNTRY)	1. GOVERNMENT Fiscal/Tax Policies Monetary Policies Trade Policies Industrial Policies	2. SOCIETY Culture Traditions Religion Values Social Behavior
MICRO (COMPANY)	3. FACILITIES Plant & Equipment Decisions *Site, Location *Technology Vertical Integration	4. POLICY & PROCEDURES Workforce Policies Management Selection & Development Organization Structure

Figure 1: The Structural Elements of Production
Adapted from Wheelwright, Reference [3]

The first two quadrants represent the external environment that affects the organization. Quadrant 1 depicts the external "industrial policy" hardware, while quadrant 2 deals with the infrastructure software aspects (culture, traditions, and social behaviors) of workers and consumers.

The last two quadrants represent the more traditional company level (internal environment) view of production operations. Quadrants 3 and 4 divide the internal environment factors into the hardware and software resources of the production operation.

Management responds to change by controlling the resources in the internal and external environment depicted in all four quadrants. The management responsible for production operations within the company has control (for the most part) only over those hardware and software resources listed in quadrants 3 and 4. Quadrants 1 & 2 are not to be ignored (as they often are); they must be well defined by executive management to avoid conflicts between the macro- and micro-management of the organization.

Wheelwright states that there are usually three driving forces creating the necessity for change and for improvement of production operations: a need for

(1)greater capacity,
(2)new products, and
(3)profitability.

The short term solutions of yesterday signal a change in production hardware when one of the above forces is out of control: that is, pumping resources (typically in a reactionary mode) into quadrant 3.

However, the increased competition and higher cost of capital today requires long-term solutions that address all of the structural elements of the production operation. The changing of quadrants 3 and 4 in harmony requires that the organization use a "socio-technical systems" approach to management.

The Organization as a System

The term "socio-technical" system is used to describe the systems approach to the organization based on the theory that the technological system works only within the context of the worker's social system. A systems approach in general denotes an approach that recognizes that an alteration of a part of the system, alters the whole.[4]

When an organization uses the socio-technical systems management approach, analysis of the productivity of both the social system and the technical system must take place with a recognition of the interdependence of the two. The social system is examined to determine and improve organizational roles and their interrelationships. The technical system is analyzed to obtain maximum benefit from the machines, tools, materials, techniques, procedures, and skills used to do the work.

There is an increasing use of the socio-technical systems approach to organizations in the U.S. manufacturing industry. The fundamental change required by the traditional organization is a long, complex, and expensive procedure. The two major roadblocks to such change are the incongruous managerial system already in place, and the basic human tendency to resist change. The benefits of overcoming these roadblocks and implementing the change result in an organization that is flexible and highly motivated, and one which provides satisfaction to its work force.[5]

RESISTANCE TO CHANGE

Roadblock #1—The Incongruous Managerial System

The over-simplification of work, and the vertical orientation of departments that resulted from the management theory implemented in the early 1900s, left workers alienated from the organization. Productivity improvements traditionally focused on the technical system, as described earlier, without regard for necessary changes in the social system (e.g., in job roles or organization design).

The process of implementing change is an especially difficult one to accomplish in the traditional organization. The company is organized in a number of autonomous businesses, each with responsibility to its own results and its own contributions to the total company. Many firms have reached a point of dividing up the work so that they now suffer from communication blockage—analogous to the onset of osteoarthritis in the human body.[6] This is depicted in Figure 2 below: the horizontal lines represent the layers of management and the vertical lines the division of the functional departments. At each crossing, communication blockage occurs both vertically and horizontally.

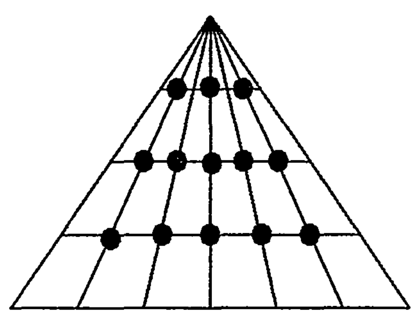

Figure 2: Communication Blocks

Workers in a traditional organization are living in their own narrowly defined "arthritic boxes"--at all levels of the organization, across departments, divisions, and segments of production. It has been programmed into these organizations that, if "I do my job - you do yours," the work of the company would get done. Over time, the functions and levels become so separated that they often send conflicting objectives or tasks up and down the "functional chimneys".[7]

For manufacturing and production organizations communication problems are compounded by this highly hierarchical organizational structure as two distinct levels have evolved: operations managers and technical specialists.[8] Add to this the complex product (such as a pre-outfitted ship subassembly) that must move across the functional departments, and the result is that everyone in production operations becomes protective and concerned about keeping track of his/her own "rice bowl", rather than the company as a whole.

The system itself, not the personnel, is at fault for creating this protectionist environment. Executive management directs the operations managers to meet certain requirements. Operations managers then specify to the technical specialists what needs to be done to meet these requirements. However, because of the evolution of specialization that has separated business administration from production, management is out of touch with production capabilities—yet it is directing what, when, and how to produce the product. (It should be noted that this separation has been supported to a large extent by academia teaching that "a good manager does not need to understand what he/she manages", and engineering curriculums that do not address management development skills).

The technical specialists in production (Production Engineering, Industrial Engineering, Materials, and Information Systems) work only toward meeting the requirements and expectations set forth from above. There is no encouragement or impetus to improve the system in general. Executive management vision focuses only on what has been presented to them. For the most part, these are problem areas where performance has fallen below expectations. There is no room for improvements to the system because of what Peter Drucker refers to as the lack of "entrepreneurial practices".

> "...problems have to be paid attention to...but if they are the only thing being discussed, opportunities will die of neglect. In fact the business and its managers, focusing on the "problems," are likely to brush aside the unexpected success [an innovation source] as an intrusion on their time and attention."[9]

The entrepreneurial organization is defined by Drucker as one capable of searching for change (new technologies), responding, and finally exploiting (implementing) the change as an opportunity. If the structure of the organization does not support entrepreneurship and innovation, ultimately, production will strive to maintain short-term flexibility and take a conservative stance on most issues.

Roadblock #2--Human Tendency to Resist Change

The second major roadblock to change is often referred to as the basic "human nature" tendency to resist any change. Rosabeth Kanter, author of "The Change Masters", describes the ten most common reasons for this resistance:[10]

1. **Loss of Control** - the feeling of "ownership" being threatened.
2. **Excess Uncertainty** - not knowing if the next step is into the abyss.
3. **Surprise, Surprise!** - decisions sprung on people without groundwork or preparation.
4. **The "Difference" Effect** - habits and routines are broken.
5. **Loss of Face** - admitting that the way things were done in the past was wrong.
6. **Concerns About Future Competence** - personnel questioning their skill levels and whether they will fit in.
7. **Ripple Effects** - impacts outside the project or even outside the job.
8. **More Work** - more work that is not usually recognized may be required.
9. **Past Resentments** - a past gripe against the organization may cause resistance to change regardless of what the change is.
10. **The Threat is Real** - change usually results in some winners and some losers.

Implementation of technology requires that these reasons for resistance to change be recognized and manipulated in such a way that the forces of change are all moving toward the organizational goal of transforming the production operation.

A model that describes the forces of fundamental change was developed by R. Beckard in the late 1960s. Paraphrasing his model[11], one can describe resistance to change (R) to be a function of three factors: dissatisfaction with the present (D), a vision of what is possible (V), and the first steps in reaching the vision (F). For change to occur, the product of these three factors must be greater than the resistance to change.

$$D \times V \times F > R$$

Although, dissatisfaction-with-the-present (D) can be of great magnitude in the traditional organization, its cause is usually not agreed upon. Additionally, the autocratic style of management that prevails in the traditional organization does not support team vision (V) and first steps (F).

Participative management within the socio-technically oriented organization is the means for developing factors that produce change in the right proportions (i.e., allowing for a common employee data base about: (1) how everyone in the organization sees the past and why a change is needed, (2) what the future could be and what is preferred, and (3) what steps can be agreed upon in order to effect change.)

However, as many U.S. manufacturing firms have discovered, using the words "socio-tech", "participative management", or "quality circle" is not enough. Organizational change (in terms of people, attitudes, and structure) must take place.

DIRECTIONS FOR MANAGEMENT

Managing the transition of organizational change requires the development of a strategy. A detailed examination of the external and internal environment must be made. The vision of where management thinking regarding where the production operation is headed must be visualized. A model of the evolution of management thinking provides basic goals and objectives for developing a transition strategy.

The evolution of management thinking regarding production operations is suggested in a four-stage model[12] and depicted in Figure 3.

In stage 1, executive management is considered internally neutral. "Fire-fighting" is the order of the day as problems that stem from current production operations are minimized, and the function of management is to be flexible and in a reactive mode.

Management Evolution

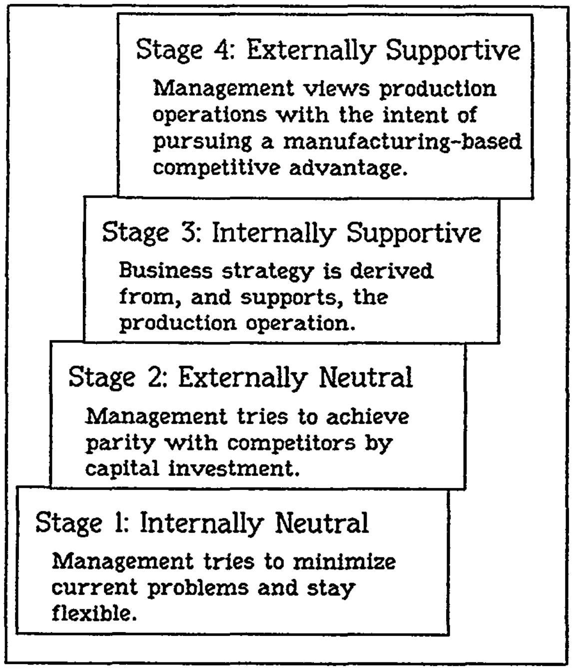

Figure 3: Stages of Management Evolution Regarding the Production Operation

In stage 2, management is externally neutral. Capital investment is used to try to achieve parity with competitors, and the role of production (as in stage 1) is essentially neutral.

In stage 3, management has moved into being internally supportive. Production operations has direct input into the business strategy by providing a screening of the decisions that are to be made. The role of production, however, is one that is derived after the other functions have developed their strategies and determined the macro-direction of the enterprise. The black books of estimating and planning are still intact.

The similarity between stages 1-3 is that production operations management itself is responsible for any improvements in moving from one stage to the next. As stated earlier, the lack of "entrepreneurial practices" does not provide the impetus to change. Production maintains a subordinate voice within the organization.

The final and fourth stage is referred to as externally supportive. At this level, general management changes its interface and views of the production operation with the intent of pursuing a manufacturing-based competitive advantage. Production operations now has a pro-active role in identifying and charting the course so that new technologies (hardware and software) can be applied in an integrated and systematic fashion.

The questions that management must answer for their particular organization are: "What is required to bring about a socio-technical system resulting in an externally supportive management?" "Is the functional organizational structure that has evolved, so backward that a drastic overhaul of the organizational chart is required?" If yes, "can the organization survive the impact of such change in today's shrinking shipbuilding market?" "Will such change only result in new lines and intersections for the communication 'arthritis' to take hold?" "What might be the alternatives and underlying objectives of needed change?"

THE ORGANIZATIONAL BINDER

One of the underlying objectives, as stated earlier, is the elimination of the communication blockages in the organization: i.e., the need for an organizational binder. In the following sections, three (not necessarily separate) directions for shipyard management are suggested: the emerging role of the marketing function, the product-oriented organization, and company-wide quality control.

The Role of Marketing

In support of the workshops that were the impetus for this paper, a Delphi survey was conducted to identify the major areas of change for the industry.[13] 74% percent of the survey respondents indicated that the functional role of marketing would change significantly in the next ten years. The following pro-active changes were stressed by the majority of these respondents:

* marketing will need to further develop the technical knowledge of ship production and shipyard capabilities,
* marketing will need to have intimate knowledge of customer performance requirements,
* marketing will be linked to technology development (R&D function) and strategic business planning,
* marketing will be more innovative and entrepreneurial.

Richard Bagozzi, Stanford University Graduate School of Business, explains this changing role of marketing as one of moving from a separate and parallel function to an integrative function that binds the rest of the organization together. In addition, marketing is taking on the role of providing strategic direction for the organization. This is a change from the mid-70s when finance, production, and engineering dictated strategy.

Marketing is assuming this emerging role as the forces driving the organization are changing--from financial and procurement considerations having center stage to fickle consumers, aggressive competitors, and an economy that no longer grows with prosperity unabated. A technically competent marketing department will allow the firm to impact these new driving forces.[14]

As will be discussed later in the section on company-wide quality control, the successful organization today is able to instill the "voice of the customer" throughout the organization. A marketing function that understands the firm's constraints allows for maximized opportunities by adapting these constraints to the customer requirements--something that has been lost in the specialization of the traditional organization.

Changing the Organizational Chart

Movement away from the functional organization is movement toward its counterpart: the product-oriented organization. R. Chirillo explains this in the NSRP report, "Shipyard Organization and Management Development":

> "Functional organizations, as an organization type, are best when a firm makes only one or a few products and where technology does not change. The traditionalists in shipbuilding look simplistically at the entire ship as the end product of the shipyard." The product-oriented organization, on the other hand is "...a structure based on a Product Work Breakdown Structure and Group Technology which permits diversification...aimed at interim products...that makes it possible for large firms to cope with technological change and multiple markets."[15]

The product-oriented organizational structure is depicted in Figure 4 for the IHI Kure Shipyard in Japan.

Choosing to shift to the product-oriented organization is dependent on many factors (product mix, volume, size, etc.) and the extent of the change will be different for each shipyard. The socio-technical systems approach to management suggests that the development of a shipyard's social system (the organizational chart) should complement the shipyard's technical system (the organization of work) for the full benefits of the technologies to be realized. The product-oriented system seems inevitable as the shipyards move into full implementation of group technology and zone-by-stage construction/repair.

The product-oriented organization provides a vision of what has worked. It is supported by a combination of the evolving management sciences; however, the key to realizing the full return on technology implementation will not be answered by change in the organizational chart alone. More fundamentally, full return is realized in the ability of the infrastructure to fully support what one IHI shipbuilding consultant referred to as the "passing of the baton."

Engineering does not redo what planning and estimating had guessed at. Production does not get the work done "in spite of engineering." The pay-off is in the elimination of the intangible rework that goes on everyday, rework that seems to be synonymous with a functional organization building a complex product.

This fundamental concept of the baton and the need for an organizational binder brings us to the newly established concept of quality that a manufacturing and production facility must understand to compete on the world market. The road map to the externally supportive management is clearly marked by what the Japanese refer to as company-wide quality control.

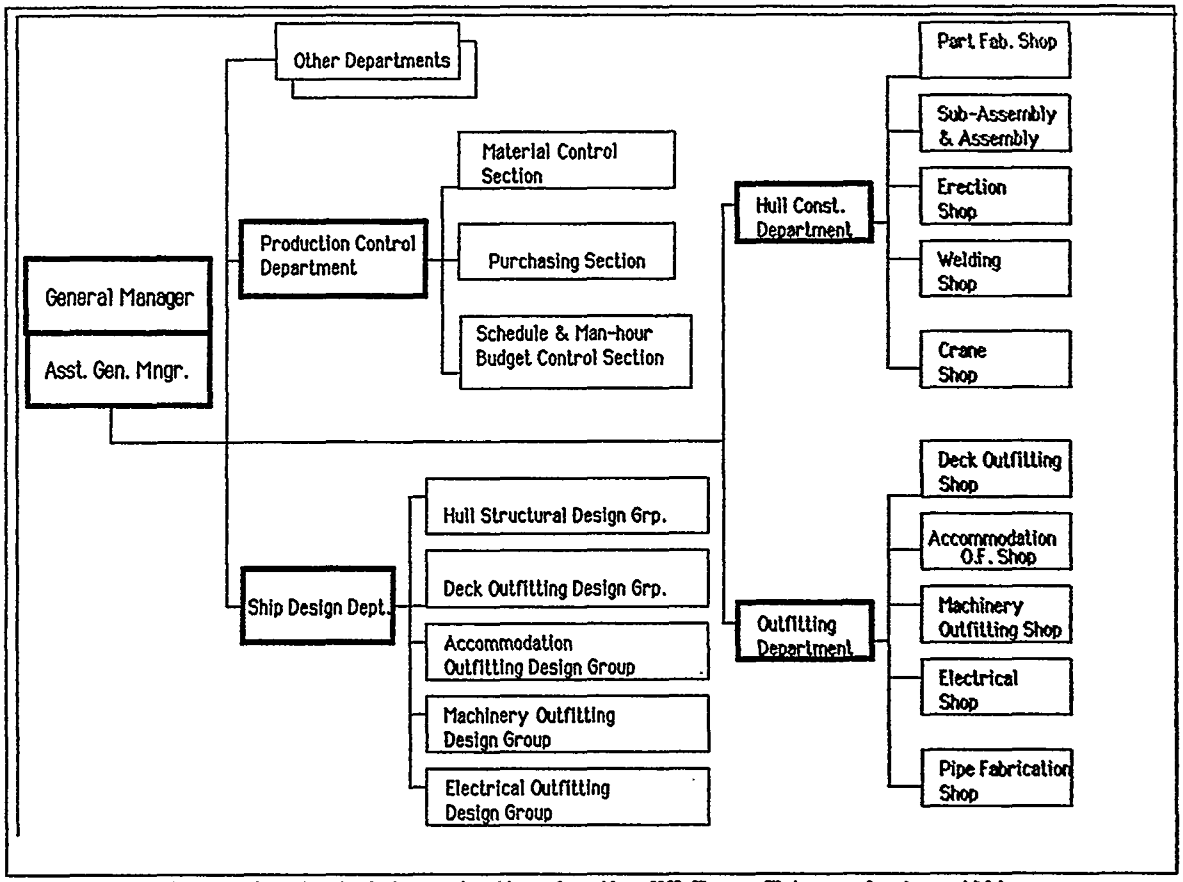

Figure 4: Product-oriented Organization for the IHI Kure Shipyard, circa 1982.
Source: Chirillo, Reference [14] page 21

COMPANY-WIDE QUALITY CONTROL

The Japanese Industrial Standard Z8101-1981 specifies quality control as: "a system of means to economically produce goods or services which satisfy customers' requirements...Implementing quality control effectively necessitates the cooperation of all people in the company, involving top management, managers, supervisors, and workers in all areas of corporate activities such as market research, research and development, product planning, design, preparations for production, purchasing, vendor management, manufacturing, inspection, sales and after-services, as well as financial control, personnel administration, and training and education. Quality control carried out in this manner is called *company-wide quality control*."[16]

The impact that company wide quality control (CWQC) has on the productivity of an organization is well documented, both inside and outside the shipbuilding industry. The evolution of the quality function has been modeled by L. Sullivan of the American Supplier Institute as having seven stages. This model is depicted in Figure 5.

Complete installation of CWQC refers to an organization that has moved from *manufacturing quality control* (inspection after production and/or statistical process control during production) to *product and process development quality control*. The result is that all operations are driven by the "voice of the customer". The impact on the organization is improved productivity and quality at reduced cost, and ultimately, competitiveness.

As depicted in Figure 5, Sullivan views U.S. manufacturing as somewhere in the first three stages of development. The U.S. shipbuilding industry, for the most part, can only be considered to be in stages 1 and 2.

It is the development of the humanistic side of quality that separates the U.S. concept of Total Quality Control and the Japanese style of CWQC:

"In traditional U.S. quality literature, 'cost of quality' refers to the cost of assuring conformance and of managing and correcting non-conforming material. In the CWQC definition, cost is the loss to society which is determined by design cost, efficiencies in manufacturing, assembly, sales, service, customer ownership, and the contribution to society."[17]

The stages of CWQC that go beyond the U.S. technologies provide the following:

* Statistical process control to separate common causes of variability from special causes in such a way that the process can be changed to reduce variability.

* Education of the workforce that changes the way people think and recognizes process improvement flowing automatically from personal improvement.

* Society-oriented product and process design that builds quality into the engineering process.

* Cost-oriented loss function allowing quality improvements that do not meet the traditional payback guidelines.

* Quality functional deployment to define the "voice of the customer" (internal and external) in operational terms.

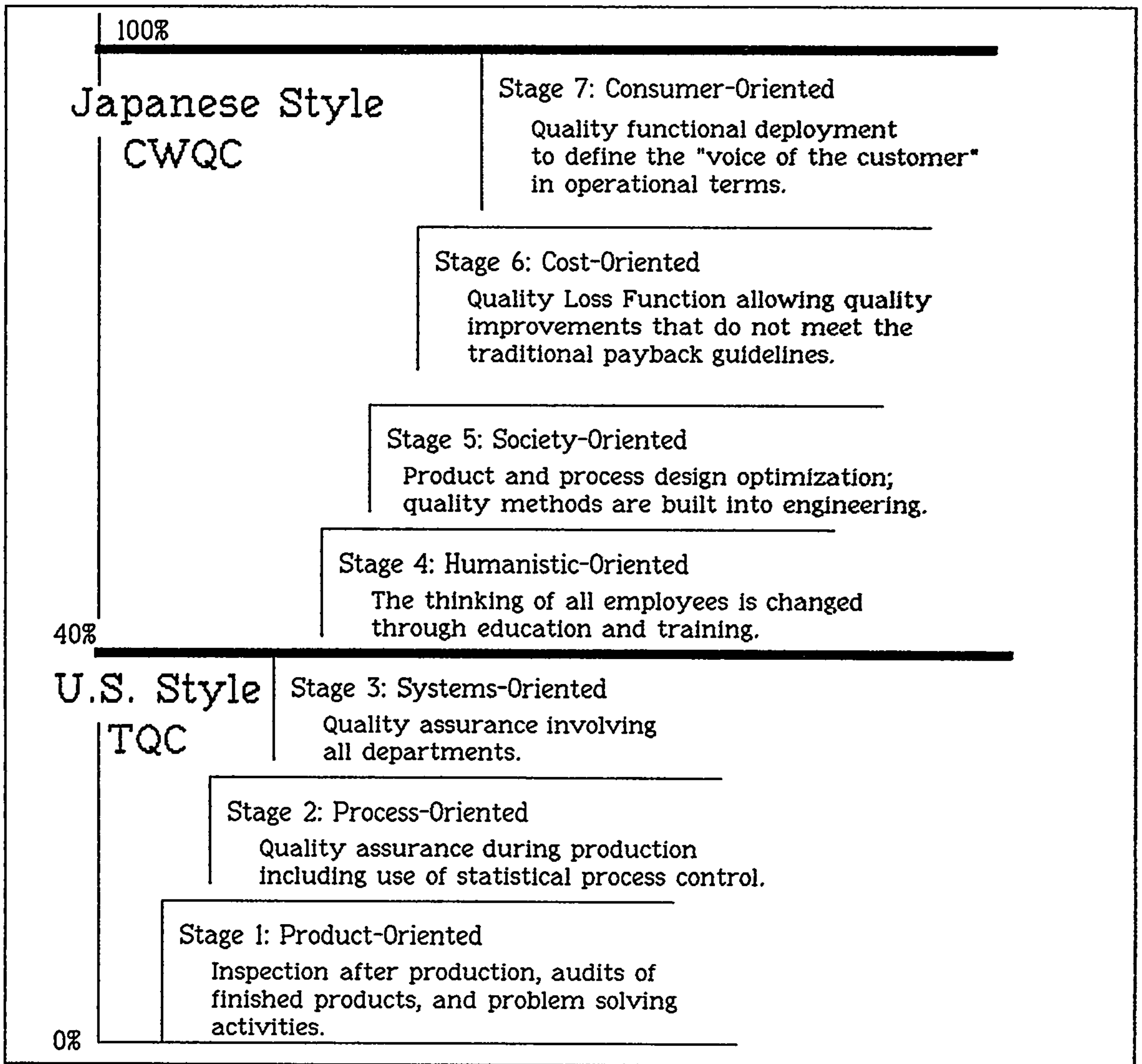

Figure 5: Stages of Quality Control

The management evolution model (depicted in Figure 3) and the socio-technical systems approach suggest that an externally supportive management is required so that new technologies can be applied in an integrated and systematic fashion. To get to this externally supportive stage, a breakdown of the product and process into an integrated mapping is necessary to provide continuous support for the shipyard in its development of organizational strategy. CWQC can provide such a framework through the systematic depiction of the "voice of the customer."

EPILOGUE

To the management on the front lines of today's shipbuilding industry the chord that may be struck by this discussion is that, "it is all easier said than done." This is no doubt true.

Steven Wheelwright notes that:

> "...whether one is looking at production planning and materials control, human resource management, or plant supervision, the critical tasks for the future are all very similar. These functions cannot be segmented and isolated, but must be integrated. Moreover, while these functions involve many small, seemingly minor day-to-day decisions, the cumulative effect of these decisions can indeed be substantial. Finally, it appears that when competitive advantage is based on such infrastructural arrangements in production operations, it becomes extremely difficult for competitors to imitate, because there are no short cuts to putting in place the infrastructures needed to realize these results."[18]

What is intended by this discussion is to affirm the need for top management's commitment, vision, planning and execution in the effective transformation of the the shipyard production process. In this continuous struggle to "get organized", new technology implementation must be done in a systematic fashion that avoids islands of efficiency. As stated by Peter Drucker, effectiveness and efficiency have a special relationship: "Efficiency means doing things right. Effectiveness means doing the right things. Doing the wrong thing efficiently is worse than useless. It can be very harmful."[19]

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