CHAPTER II

THE FIVE BUSINESS EXCELLENCE MODELS

I. The ISO 9000 Model

Academic debate in management today discusses the changing market and industrial environments, which have such implications for business as shorter design cycles, shorter time to get to market, more stringent specifications, higher quality standards, and fewer suppliers, with whom one has deeper and more involved relations. Attention to these issues creates the need for new integrated and flexible management control systems.

ISO 9000 is a ready-made system for providing the kind of integrated but flexible quality management which can fit into an overall management information system and can also sit comfortably with production management systems of varying complexity, including MRP.

The outstanding characteristic of ISO 9000 for management is that it automatically simultaneously provides controls to ensure quality of production and delivery, and reduces waste, downtime, and labour inefficiencies, thereby increasing productivity.

ISO 9000 is a standard for quality management systems. Such systems will involve both individual product standards and calibration and measurement, but will in themselves be greater than both as they are overall systems for ensuring the continued operation of the whole process, from purchasing of materials to final delivery of finished goods (or services, as subsequently modified in the 2000 version) to a quality management standard.
Much of the origin of quality management systems can be found in the military and nuclear industries, where the concept of “vendor assessment” became common. This was where the large buyer carried out its own audit on the quality management systems of its vendors or suppliers. Some companies found themselves suffering multiple assessments from their many customers. Large customers began to reduce their numbers of suppliers to maintain quality and to ease the burden of assessment.

The International Standard is one of three International Standards dealing with quality system requirements that can be used for external quality assurance purposes. The quality assurance models, set out in the three International Standards listed below; represent three distinct forms of quality system requirements suitable for the purpose of a supplier demonstrating its capability, and for the assessment of the capability of a supplier by external parties.

a) ISO 9001, Quality Systems – Model for quality assurance in design, development, production, installation and servicing.
For use when conformance to specified requirements is to be assured by the supplier during design, development, production, installation and servicing.

b) ISO 9002, Quality systems – Model for quality assurance in production, installation and servicing.
For use when conformance to specified requirements is to be assured by the supplier during production, installation and servicing.

c) ISO 9003, Quality Systems – Model for quality assurance in final inspection
and test. For use when conformance to specified requirements is to be assured by the supplier solely at final inspection test.

It is intended that these International Standards will be adopted in their specified form, but on occasions they may need to be tailored by adding or deleting certain quality system requirements for specific contractual situations. ISO 9000 – 1 provides guidance on such tailoring as well as on selection of the appropriate quality assurance model, viz ISO 9001, ISO 9002 or ISO 9003.

It is emphasized that the quality system requirements specified in this International Standard, ISO 9001 and ISO 9003 are complementary (not alternative) to the technical (product) specified requirements. They specify requirements, which determine what elements quality systems have to encompass, but is not the purpose of these International Standards to enforce uniformity of quality systems. They are generic and independent of any specific industry or economic sector. The design and implementation of a quality system will be influenced by the varying needs of an organization, its particular objectives, the products and services supplied, and the processes and specific practices employed.

II. Total Quality Management (TQM) - An Accepted Definition

Total Quality Management (TQM) is a highly debated topic in business and academic circles. Business managers are fervently trying to figure out how to do it, while academicians are trying to determine what it is. None of them completely agree upon either

1According to Mary Walton (1990), the name “Total Quality Management” was first suggested by Nancy Warren, a behavioural scientist in the United States Navy.
the definition of TQM or how to put the concept into practice. This disagreement should be expected.

First, TQM is an evolving concept that is changing as new concepts and methods are developed. Second, different organizations are in different stages of transforming to TQM. Third, different organizations may require different forms of TQM.

One notable exception to this pervasive disagreement over the concept of TQM is the definition offered by the participants in the Total Quality Forum, a consortium of business and academic leaders who come together annually to study TQM and disseminate their learning’s. A study group of the 1992 Total Quality Forum defined Total Quality as:

“A people-focussed management system that aims at continual increase in customer satisfaction at continually lower real cost. TQ is a total system approach ( not a separate area or programme, and an integral part of high-level strategy. It works horizontally across functions and departments, involving all employees, top to bottom, and extends backwards and forwards to include the supply chain and the customer chain” ...

(Rampey and Roberts, 1992)

Not everyone will agree with this definition, although it seems general enough to cover many variations of TQM. Some people refuse to even talk about TQM. For example, when asked about Total Quality Management, W. Edwards Deming, who is widely regarded as a leading “quality guru,” (see Fig 2.1) responds that TQM is not in his vocabulary. “What is that?” he asks. Others who do talk about TQM may feel that this definition is not specific enough or that it leaves out important concepts.

Despite these reservations, the above definition is the most concise one available and agreeable to both business and academic leaders. It also separates the underlying principles
from the tools and techniques that are often mistaken for the concept. This separation reveals an important insight into the reason that many managers fail to achieve their expectations with TQM.

Looked at with greater elaboration,

*TQM is a management approach that strives for the following in any business environment:*

- Under strong top management leadership, establish clear mid- and long-term vision and strategies.
- Properly utilize the concepts, values, and scientific methods of TQM.
- Regard human resources and information as vital organizational infrastructures.
- Under an appropriate management system, effectively operate a quality assurance system and other cross-functional management systems such as cost, delivery, environment, and safety.
- Supported by fundamental organizational powers such as core technology, speed, and vitality, ensures sound relations with customers, employees, society, suppliers, and stockholders.
- Continuously realize corporate objectives in the form of achieving as organization’s mission, building an organization with a respectable presence, and continuously securing profits.

*The Role of Awards in TQM Implementation*

Many companies are using the criteria of one or the other Quality Award to guide their transformation into a TQM driven organization. Many
companies swear by it. Others criticize it. The critics have listed the following problems with Quality Awards:

- It requires too much time and money to follow the (generally) forty-page set of instructions, write an application (up to seventy-five pages), and support the requirements to disseminate or tell the story after winning.

- Bureaucracy can creep in and it can cost hundreds of thousands or even millions of rupees to apply and compete.

- Winners do it just to boast of the win in their advertisements.

- Companies get too caught up in winning rather than in achieving quality and solving their business problems (which is what any Quality Award is all about).

- The award doesn't guarantee that a company's products are superior, or that it will succeed financially. (For example, Baldrige Award winner Wallace Co., a Houston oil-supply company, filed for Chapter 11 bankruptcy protection.)

- The award does not address innovation, financial performance, or long-term planning (Fortune, "Is the Baldrige Overblown?" July 1, 1991, pp.62-65).

Total Quality Management was profoundly influenced by developments in Japan, but it is not a phenomenon that can be branded
“Made in Japan.” However Schmidt and Finnigan (1992) suggest that TQM’s roots include:

- Scientific Management: Finding the best one way to do a job.
- Group Dynamics: Enlisting and organizing the power of group experience.
- Achievement Motivation: People get satisfaction from accomplishment.
- Employee Involvement: Workers should have some influence in the organization.
- Socio technical Systems: Organizations operate as open systems.
- Organization Development (OD): Helping organizations to learn and change.
- Corporate Culture: Beliefs, myths, and values that guide the behavior of people throughout the organization.
- The New Leadership Theory: Inspiring and empowering others to act.
- The Linking -Pin Concept of Organizations: Creating cross-functional teams
- Strategic Planning: Determining where to take the organization, and how and when to get there
Schmidt and Finnigan also suggest that certain management theories and practices are dysfunctional and antithetical to TQM. These include:

1. **Bureaucratic Management**: Direction from the boss, compliance from the subordinate.

2. **Caveat Emptor**: Let the buyer beware.

3. **MBO and MBR**: Management by objectives and management by results.

4. **Internal Competition**: Encouraging each department to be number one.

5. **The Strategy of Organizational Stability**: “If it ain’t broke, don’t fix it”

6. **Antagonism toward Unions**: Workers’ interests are basically different from managers’ interests.

7. **Bottom-Line Driven**: Profit is the first test for every decision and action.

Those working in the field of TQM need to further establish underpinning theories that are consistent with TQM practice. Even the large-scale quality models such as for example, the Baldrige Business Excellence Model (BEM)) attract the attention of critical writers who question some of their underpinning philosophy regarding TQM principles. For example, Grint (1995) and Wilkinson and Willmott (1994) inquire if a coherent quality philosophy underpins these models. Wilson and Durant (1995) see theoretical weaknesses in that these TQM models can encourage a
Figure – 2.1

Deming’s “Condensation of the 14 Points for Management”

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Create and publish to all employees a statement of the aims and</td>
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<td></td>
<td>purposes of the company or other organization. The management</td>
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<tr>
<td></td>
<td>must demonstrate constantly their commitment to this statement.</td>
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<tr>
<td>2.</td>
<td>Learn the new philosophy, top management and everybody.</td>
</tr>
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<td>3.</td>
<td>Understand the purpose of inspection, for improvement of</td>
</tr>
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<td></td>
<td>processes and reduction of cost.</td>
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<tr>
<td>4.</td>
<td>End the practice of awarding business on the basis of price</td>
</tr>
<tr>
<td></td>
<td>tag alone.</td>
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<tr>
<td>5.</td>
<td>Improve constantly and forever the system of production and</td>
</tr>
<tr>
<td></td>
<td>service.</td>
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<tr>
<td>6.</td>
<td>Institute training.</td>
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<tr>
<td>7.</td>
<td>Teach and institute leadership.</td>
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<tr>
<td>8.</td>
<td>Drive out fear. Create trust. Create a climate for innovation.</td>
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<tr>
<td>9.</td>
<td>Optimize toward the aims and purposes of the company the</td>
</tr>
<tr>
<td></td>
<td>efforts of teams, groups, and staff areas.</td>
</tr>
<tr>
<td>10.</td>
<td>Eliminate exhortations for the work force.</td>
</tr>
<tr>
<td>11.</td>
<td>a. Eliminate numerical quotas for production. Instead, learn</td>
</tr>
<tr>
<td></td>
<td>and institute methods for improvement.</td>
</tr>
<tr>
<td></td>
<td>b. Eliminate M.B.O. Instead, learn the capabilities of</td>
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<td></td>
<td>processes, and how to improve them.</td>
</tr>
<tr>
<td>12.</td>
<td>Remove barriers that rob people of pride of workmanship.</td>
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<tr>
<td>14.</td>
<td>Take action to accomplish the transformation.</td>
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"motivational/directional effect," in other words, fulfilling award criteria is rewarded rather than achieving business goals. This is a form of goal
displacement where the award model criteria become pseudo business goals. Furthermore, the models encourage evaluation against a standard rather than evaluation of the standard. Many of these problems are identified by Carr and Littman (1990) as relating to TQM's lack of theory and definition. To avoid TQM being perceived as an "a theoretical black box," a systematic and rigorous approach to TQM theory building must be adopted.

The grounded theory approach to TQM theory building (Figure 2.2) has potential for further development. This methodology does not exclude practitioner insights and data, rather multiple sources of data are embraced.

Figure 2.2:

**Generic Grounded Theory Research Methodology**

*(Modified from Strauss and Carbine 1990 and Leonard and McAdam 2001)*

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and engaged in a recursive sense-making process. Thus, theory building by
grounded theory capitalizes on the rich practitioner-based knowledge base of
TQM. Sources of data can include TQM team meetings, interviews with
TQM managers, TQM case studies, and so on (Perry and Coote 1994).

**Grounded TQM Models**

The grounded theory research and analysis helped uncover a number of
key issues that explain and relate the various strategic applications and
dynamics of TQM. These are summarized using the various models
developed during the analysis of phases one and two of the research.

The models represent the TQM environment, the TQM life cycle, the
key points of TQM application, the strategic drivers, and the strategic
application of the BEM. These models were developed at different points of
the research and provide a rich and complex representation of TQM. Since
the models were developed through a natural progression of analysis using a
grounded approach, the models are interrelated. These models represent the
real-world models of what the quality managers and CEOs use in practice.

"Each manager's unique knowledge about the world ultimately gets filtered
into their rhetoric and actions; it is incorporated into everything she says
and does in the organization...these models or theories then inform her
future actions that in turn revise her base of knowledge. They make sense of
their environment by constructing meanings to which they attend, and these
constructions in turn guide action" (Eccles and Nohria 1992, 174).
The models created from this research provide what Eccles and Nohria (1992) believed managers needed. Namely, simple but robust concepts, models, frameworks, diagrams, words, and stories that reflect practice, represent their world and experiences in their language, and provide knowledge that can be applied to their circumstances to create action successfully.

When the models are placed together their interrelationship provides multifaceted picture of TQM. Although each model helps articulate the dynamics of TQM, viewing and considering each model together provides a more explanatory picture of TQM and its relationship with corporate strategy.

This combination of models is the strategic dynamics of TQM. This provides an overview of TQM dynamics in regard to quality awards, corporate strategy, and the wider business environment, down to the detailed considerations of selecting quality tools and techniques and measuring improvement activities.

From this overview the complex but basic issues that combine to create TQM can be related to each other. TQM consists of a range of philosophies, tools, and techniques. Figure – 2.3 allow the various issues that combine to create TQM to be distinguished. Each is then considered in its own regard and related to the others to consider TQM in a particular organizational context.
First, the founding principles need to be reflected upon. These relate directly to the philosophical issues underpinning TQM approaches and the organizational culture to be engendered. That is, what key principles will an organization use to base strategic decisions on, such as employee welfare or customer loyalty? These principles will guide the decision-making process and direction of the organization. If these principles are reflected upon and used to found strategic decision-making, it will link TQM principles to the corporate level and help to build senior management understanding and commitment.

Crucially, each organization needs to consider what its corporate strategy is, its aims and objectives, and its strategic intent. Seniors managers must be clear as to what they want the organization to achieve,
based on the corporate mission and philosophy. For example, is the ultimate aim increased profit or is there a willingness to temper this aim to consider the job security of employees or the price of the product or service. These key strategic drivers must be established. If such an awareness of the elements of the TQM environment and the true intent of the organization are not clearly established and used to determine the appropriate mix of TQM, then the true aim of the organization will not be sought. TQM and its management will be pulling in the wrong direction, systems will be established, and awards applied for simply for the sake of winning or to provide the facade of adopting TQM, which will add to the bureaucracy and ultimate disillusionment of employees and customers alike.

Once these founding issues have been considered and reconciled, the TQM tools and techniques can be reviewed and selected. These are problem-solving tools, ISO 9000, and any appropriate techniques that will create continuous improvement as part of an overall strategy.

Once these elements and their interaction are understood the next step is to understand the non-sequential nature of TQM. There is no universal method or sequence of TQM introduction. For example, many companies will have embraced downsizing as a result of economic hardships or as a means of rationalizing, ISO 9000 certification may have been the first application of TQM-related issues, and only after all of this have the wider aspects of TQM application been considered as a way forward. In other words, because of the nature of the industry, the company culture and its
immediate, medium, and long-term goals; the adoption of quality tools and techniques, and the views of senior management toward award models and TQM philosophy will be different in every case.

This stresses the need for strategic thinking as to what is best for the organization, what TQM can offer, and the unique pattern of TQM, which will be adopted. This non-sequential nature of TQM also needs to be appreciated in order to understand that one tool or technique will not necessarily lead sequentially to another. As the TQM life cycle shows, a number of tools, techniques, or initiatives will always operate in different stages of achievement or maturity (see Figure – 2.4). Each of these will have its own life cycle, that is, its own start date and projected completion or achievement date or goal that is a direct consequence of the organization’s strategic goals. The need for the regeneration (updating and continuing) or the ending of these initiatives or techniques is directly related to the degree to which the corporate strategy is being attained and the degree to which the tools or philosophies are influencing the formation of these strategies. Once this dynamic non-sequential nature of TQM is understood and used in tandem with the understanding of the TQM environment, the strategic structure of TQM will begin to form. This will allow the nature of TQM to be understood, the ideal form of TQM to be chosen for an organizational context, and the position and degree of success of the various tools and techniques mapped and positioned.
At this stage the corporate strategy and its relationship with TQM will have been established and the appropriate philosophies and tools selected. This will help determine the fundamental aspects that will create the dynamics of TQM within that particular organization. The next step is to appreciate where these dynamics function within the organization and the strategic process.

The key point of TQM application is determined having taken into consideration the corporate strategic process and assessing the strategic importance and role of TQM (see Fig.2.5). TQM will then fall into one of 4 roles; 1) as a method of improving operational effectiveness through the provision of tools and techniques 2) as catalyst for change 3) in leading the formation and characteristic of the corporate strategy by focusing on the
The profile represents the level of commitment and application of TQM. For example, if it is wider at the base or operational level and thinner at the top or corporate level, then this reflects limited corporate commitment, involvement, and strategic impact, with the majority of TQM application and commitment at the operational level.

The strategic drivers are the predominant factors that motivate and influence corporate decision-making. These could be profits, shareholder satisfaction, or market dominance, for example. These ultimately influence the strategic decision-making process and operation of the organization at all levels. These drivers need to be identified and their influence must be understood in regard to strategic functioning and TQM decision-making.

The key point of the application and the TQM profile relate directly to the strategic application of TQM (see Fig. 2.6). The strategic application of TQM highlights the relationship between TQM and the corporate strategy. It represents the operational application of TQM and the tools used in it functioning at this level, including the relationship this has through to the corporate level, as well as the tactical role of the strategic operational split that may exist in translating strategy and the appreciation of the degree to which TQM dictates or influences the corporate strategy. For example, to what degree does vision and philosophy truly dictate the practice of day-to-day operations and decision-making or influence in creating strategic intent? The TQM profile quickly reflects the degree to which each of these levels is given precedence. This can provide a realization of the application of TQM
and can prompt reevaluation by senior management. This then has direct association to the key points of TQM application and articulates the issues it highlights in more detail.

**Figure – 2.6:**

*Model 4: The Strategic Application of TQM*

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Model 5 (see Fig. 2.7) relates directly to the strategic, tactical, and operational levels explicit in the strategic application of TQM and the key points of TQM application. The decisions made related to these and in considering the role and impact of award models when considering the TQM
environment will have set the roles of its application. This has a direct link to the decisions made and depth of understanding gained when the TQM life cycle was evaluated and the various tools and techniques that were plotted upon it in their various stages of maturity and impact. The strategic application of the BEM represents in three layers the degree to which, for example, the BEM for business excellence would be applied as a conceptual model and how it would be used to deploy strategic goals. It also articulates the extent to which the BEM may assist in planning and structuring improvement by translating strategic direction into deliverable activities.

**Figure – 2.7:**

*Model 5: The Strategic Application of BEM*
Summary

When these five models are considered in concert the strategic dynamic of TQM can be represented and considered. Viewing all of the models together makes the impact and consequences of one decision on another more obvious. Not only does this provide a means by which the introduction of TQM can be considered graphically and strategically, but TQM can also be plotted in a longitudinal manner, providing a picture of its progress and development. This also provides a mechanism that can create discussion and provide a clear understanding of where TQM fits, not only within the wider business and theoretical environments where TQM’s meaning, influence, and definition are of importance, but also in regard to its profile within the organizational environment.

The models are not prescriptive; rather they show characteristics and behaviours displayed by organizations while using TQM. The models also provide an accurate picture of the dynamics of TQM as reflected by the practitioner. They provide a means of visualizing and understanding TQM using the language of the practitioner. The models emphasize the need for a strategic understanding of TQM and its dynamics and the need for a strategic-thinking approach. It is this characteristic that allows them to be used to reflect upon the potential impact of changes, and how they can be achieved, implemented, and recorded on the models. The strategic dynamics of TQM then can help one understand how changes and manipulations of TQM and strategy can be made to the ultimate advantage.
It is necessary to note that these models have been developed from the analysis of the larger samples of phases one and two and not from the simple longitudinal case study. This was to ensure that the models developed would be based upon a wide selection of views to provide generalizable models.

III. Total Productive Maintenance (TPM)

TPM had its genesis in the Japanese car industry in the 1970s. It evolved at Nippon Denso, a major supplier of the Toyota Car Company, as a necessary element of the newly developed Toyota Production System, which was originally thought to only incorporate Total Quality Control (TQC), Just in Time (JIT), and Total Employee Involvement (TEI). It was not until 1988, with the publication in English of the first of two authoritative texts on the subject by Seiichi Nakajima, that the western world recognized and started to understand the importance of TPM.

Suddenly it became obvious that TPM was a critical missing link in successfully achieving not only world class equipment performance to support TQC (variation reduction) and JIT (lead time reduction), but was a powerful new means to improving overall company performance. Hence it has only been since the early 90s that TPM has started to rapidly spread throughout the rest of the world, significantly improving the performance of manufacturing, processing, and mining companies. TPM is now having a major impact on bottom-line results by revitalizing and enhancing the quality management approach to substantially improve capacity while
significantly reducing not only maintenance costs but overall operational costs. Its successful implementation has also resulted in the creation of much safer and more environmentally sound workplaces.

The Evolution of TPM

Traditionally high buffer stocks were allowed to develop between major pieces of the plant and equipment to ensure that if there were a problem with one piece of the plant or equipment then it would not affect production from the rest of the plant. Hence the role of maintenance was to cost effectively ensure major pieces of plant and equipment were available for an agreed period of scheduled time, for example 90 percent.

Because of the accepted practice of retaining high buffer stocks, most items of equipment could be considered independent. If the equipment in a process was maintained such that it achieved 90 percent availability, the availability of the process was 90 percent Figure 2.8. If the equipment started to cause quality problems, these would probably be noticed in final quality inspection and the cause traced back to the offending piece of equipment and corrected by maintenance.

At Nippon Denso in 1970 with the introduction of the Toyota Production System, the buffer stocks were substantially reduced in their quest for shorter lead times and improved quality. Statistical Process Control (SPC) supported by “Quality at Source” was introduced to ensure right quality, first time so to provide maximum customer value through the highest quality at the lowest cost supported by quick responsiveness and
superior customer service. Hence in this quest for maximum customer value, buffer stocks were reduced to both reduce lead times and force the identification of cost generating problems. This resulted in individual equipment problems affecting the whole process.

**Figure – 2.8:**

*Equipment is ‘Independent’ due to the High Buffer Stocks*

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Equip #1</th>
<th>Equip #2</th>
<th>Stock</th>
<th>Equip #3</th>
<th>Stock</th>
<th>Equip #4</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90%</td>
<td>90%</td>
<td></td>
<td>90%</td>
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<td>90%</td>
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</tbody>
</table>

Equipment Availability – 90% Process Availability – 90%

If one piece of equipment stopped then shortly afterwards the whole process stopped. This made the equipment interdependent. Under these circumstances, the availability of the process became the product of the individual availabilities of each piece of equipment. Thus a process involving four pieces of equipment maintained at 90 percent no longer had an overall process availability of 90 percent, but an availability of 90 percent x 90 percent x 90 percent x 90 percent, or 66 percent! Figure 2.9.

**Figure – 2.9:**

*Equipment is ‘Interdependent’ due to Reduced Buffer Stocks*

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Equip #1</th>
<th>Equip #2</th>
<th>Equip #3</th>
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<th>Output</th>
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<tbody>
<tr>
<td></td>
<td>90%</td>
<td>90%</td>
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Equipment Availability – 90% Process Availability – 66%
Furthermore, as the quality approach changed to "Prevention at Source" by controlling process variables, equipment performance problems were identified much earlier. Conformance and reliability became much more important.

As buffer stocks reduced substantial pressure was placed on the maintenance department to improve process performance. From a maintenance perspective, the maintenance department's performance had not deteriorated, yet demand for the substantial improvement in equipment availability was overwhelming.

This caused friction between the production and maintenance departments. Production departments demanded former levels of process availability and quicker response times from maintenance, which were often unable to comply due to traditional organization structures, which keep maintenance as a separate function. After much conflict between maintenance and production, engineering were called in to find a solution. They soon realized that mathematically for the four pieces of equipment to achieve their original goal of 90 percent availability, their individual availabilities needed to increase from 90 percent to 97.5 percent.

The traditional view of maintenance was to balance maintenance cost with an acceptable level of availability and reliability often influenced by the level of buffer stocks, which hid the immediate impact of equipment problems. In traditional companies, maintenance is seen as an expense that can easily be reduced in relation to the overall business, particularly in the
short term. Conversely, maintenance managers have always argued that to increase the level of availability and reliability of the equipment, more expenditure needs to be committed to the maintenance budget. With the onset of substantial availability problems caused by the new way of running the plant, management soon realized that just providing more resources to the maintenance department was not going to produce a cost effective solution.

This conflict between maintenance cost and availability is similar to the old quality mind-set before the advent of Total Quality Control (TQC): that higher quality required more resources, and hence cost, for final inspection and rework. TQC emphasized “prevention at source” of the problem rather than by inspection at the end of the process. Instead of enlarging the inspection department, all employees were trained and motivated to be responsible for identifying problems at the earliest possible point in the process so as to minimize rectification costs. This did not mean disbanding the quality control department but having it now concentrate on more specialist quality activities such as variation reduction through process improvement. This new approach to quality demonstrated that getting quality right first time does not cost money but actually reduces the total cost of operating the business.

This new Quality approach of “prevention at source” was translated to the maintenance environment through the concept of Total Productive Maintenance (TPM) resulting in not only superior availability, reliability
and maintainability of equipment but also significant improvements in capacity with a substantial reduction in both maintenance costs and total operational costs. TPM is based on “prevention at source” and is focused on identifying and eliminating the source of equipment deterioration rather than the more traditional approach of either letting fail before repairing it, or applying preventive/predictive strategies to identify and repair equipment after the deterioration has taken hold and caused the need for expensive repairs.

TPM has developed over the years since its first introduction in 1970. Originally there were 5 Activities of TPM that is now referred to as 1st Generation TPM. It focused on improving equipment performance or effectiveness only. Late in the 80s it was realized that even if the shop floor were committed fully to TPM and the elimination or minimization of the “Six Big Losses” there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions. Hence the development of 2nd Generation TPM (Total Process Management) which focused on the whole production process.

Finally, in more recent times it has been recognized that the whole company must be involved it the full potential of the capacity gains and cost reductions are to be realized. Hence 3rd Generation TPM (Total Productive Manufacturing / Mining) has evolved which now encompasses the 8 Pillars of TPM with the focus on the 16 Major Losses incorporating the 4Ms – Man,
Machine, Methods, and Materials. Some practitioners add two more pillars to make it 10. These are:

1. Safety and Environmental Management
2. Focused Equipment and Process improvement
3. Work Area Management
4. Operator Equipment Management
5. Maintenance Excellence for TPM
6. Education and Training
8. Administration and Support Systems Improvement
9. New Equipment Management

An important outcome of this new approach to equipment management which is now supported by many success stories throughout the world in a variety of operational industries has been that senior management has realized that TPM is both strategically important for a world competitive business, and that TPM cannot be implemented by the maintenance department alone. TPM is a companywide improvement initiative involving all employees.

Although each enterprise may approach TPM in its own unique way, most approaches recognize the importance of measuring and improving
overall equipment effectiveness along with the need to reduce both operational and maintenance costs in an environment that promotes continuous improvement.

The Role of Total Productive Maintenance in Business Excellence

Many companies now participate in an international market, which offers huge opportunities for broadening the customer base, with the associated drawback of increased competition. To be successful, companies must draw up realistic business strategies. Market research to establish the extent of the demand for a product or service is essential. The company must deliver a reliable product, or service, on time and ensure that customer requirements are satisfied. Research and development are needed for the company to stay ahead of changing customer requirements. The price of the product or service must be kept low enough to be competitive whilst providing a sufficient margin for the business to be profitable and capable of funding research and development. In particular, the reduction and the eventual elimination of unnecessary costs associated with waste of time or materials should be one of a company's vital goals.

It follows that great attention should be paid to the reliability of the production lines in order to achieve the highest product quality at a minimum cost. In a typical manufacturing scenario, the desirable productivity, cost, inventory and quality all depend on the efficient functioning of the company's production facilities. It has been widely recognized that automation and even unmanned production might not
necessarily remove the need for strategic human intervention. In most cases it is true that only the manufacturing operations have been automated, and the maintenance activities still depend heavily on human input which in turn requires an appropriate maintenance organization for its effective and efficient application.

Total Productive Maintenance (TPM) is a programme for the fundamental improvement of the maintenance functions in an organization, which involves its entire human resources. When implemented fully, TPM dramatically improves productivity and quality, and reduces costs (Nakajima, 1988). TPM is productive maintenance carried out by all employees through well-planned small-group activities. For example, the machine operator is responsible for the maintenance of the machine, as well as its operation. The implementation of TPM can generate considerable cost savings through increased productivity of the machinery. The greater the degree of factory automation, the greater the cost reduction generated by TPM (Nakajima, 1988). One of the main aims of TPM is to increase the productivity of plant and equipment in such a way as to achieve maximum productivity with only a modest investment in maintenance. This is done by improving and maintaining equipment and facilities at an optimal performance level in order to reduce their life-cycle costs. Cost-effectiveness can be direct result of an organization’s ability to eliminate the causes of the reduction in equipment effectiveness.
**TPM as Part of the Business Process**

TPM has its roots in manufacturing industries, but has proved extremely valuable for the services sector, including hotels, education and finance. The most obvious examples of its application can be found in the caring for equipment, such as computers, copiers, communication systems and presentation aids. However, TPM can usefully be extended to transportation facilities, buildings and furniture, including ergonomic aspects. For example, the proper maintenance of seating, lighting and the general office environment could well be an essential ingredient for business excellence.

Mobley (1990) reported that from 15 to 40 percent of the total cost of finished goods could be attributed to maintenance activities in a factory, and as such it can be argued that they should be considered as an integral part of the business process. The costs associated with maintenance could be mainly due to labour and materials, including the need for spare parts and the cost due to loss of production. Furthermore, these costs are likely to increase at a higher rate in the future with the added complexities of factory equipment through the introduction of new technologies, large-scale automation and the ever-increasing use of robotics.

TPM has a double goal in ‘Zero Breakdowns’ and ‘Zero Defects’ (Nakajima, 1991) which would help organizations deliver what they have promised. When breakdowns and defects are eliminated, equipment downtime will be greatly reduced, together with its associated costs, and
work-in-progress inventory can then be minimized, and as a consequence overall productivity will increase (Nakajima, 1988). TPM is an innovative approach to maintenance, which optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous operator maintenance through day-to-day activities, which involve the total workforce. For example, Shirose (1992) described TPM as follows: “TPM is productive maintenance carried out by all employees and aims to maximize equipment effectiveness and prevent any unscheduled breakdown”. Roberts (1999) states that all employees must be empowered to initiate corrective action. Conversely, empowerment makes equipment effectiveness the responsibility of all.

**The Contribution of TPM to Business Excellence**

The modified EFQM model Figure – 2.10 shows that TPM plays an important role in each part of the model, either directly or indirectly. There is a strategic association between the eight fundamental development activities (Suzuki, 1994) that characterize the implementation of TPM and the business excellence model:

- *Leadership and TPM in Administration*: Support departments undertaking administrative functions should aim to create ‘information factories’ and apply process analysis to streamline information flow, while their production maintenance colleagues are engaged in TPM activities on the shop / floor. Administrative and support department can be regarded as process plants whose principal tasks are to collect,
departments, the maintenance training given to the production staff is carried out by their maintenance colleagues, which when successfully handled will help improve their relationship. The maintenance staff are removed from some of their more mundane responsibilities, and this enables them to concentrate on more complicated and time-consuming jobs, such as maintenance planning for ensuring equipment reliability.

- **Policy and Strategy and Early Management:** These activities include both early product management and early equipment management, the purpose being to achieve quickly and economically products that are easy to make and equipment that is easy to maintain and use. TPM is a good method to adopt in planning the strategy of an organization. A TPM-practicing company will have highly reliable equipment operating to maximum efficiency and hence will be in a position to give an accurate estimate of production times. This will help the company to formulate its plans and strategies to deliver the quantity of products needed at the right time.

- **Resources and Autonomous Maintenance (AM):** Teams of operators perform routine maintenance tasks and participate in improvement activities that halt accelerated deterioration, control contamination and maintain optimal conditions. AM is typically implemented in seven steps which can cover all available resources, ranging from the buildings to the machines and all equipment used in the organization.
for the purpose of staying in its intended markets. In TPM, the AM function empowers the production operators to look after the conditions and effectiveness of equipment within their care, and so the chance of sudden breakdown is very much reduced, leading to the most efficient use of resources.

- **Process and Planned Maintenance (PM):** PM embraces three forms of maintenance breakdown, preventive and predictive. PM activities emphasize Monitoring Mean Times Between Failures (MTBF) and using that analysis to specify the intervals for tasks in annual, monthly and weekly maintenance calendars. TPM requires a planned maintenance programme to be designed to look after the company’s processes. This is in fact where TPM starts from, before it is applied to other parts of the organization. Thus, if ‘business process’ were being taken in the widest context, TPM would be involved with all the core activities ever undertaken by a company.

- **People Satisfaction and Training and Education:** Implementing TPM is also a continuous learning process. Operators and maintenance personnel in particular must receive training to upgrade their equipment-related skills and knowledge. Plant managers and corporate managers must educate themselves about TPM and may even participate in model equipment restorations. When TPM is implemented, the resulting increase in productivity and quality, improved condition of the machines and factories, and reduction in
costs and waste, will all have a strong influence on people's satisfaction. The improvement of communication between departments and between individuals seeking to achieve maximum equipment efficiency will also have an indirect effect in increasing people's morale and satisfaction.

- **Customer Satisfaction and Quality Maintenance:** This is a set of activities designed to build in quality and prevent quality defects. In quality maintenance the equipment components that affect variability in a product quality characteristic will be identified and controlled. This in turn leads to high quality of the products, low costs and the products being delivered according to the planning target values, which would constitute the customers' main concerns.

- **Impact on Society and Safety and Environmental Management:** Assuring safety and preventing adverse environmental impacts are important priorities in any TPM effort. The implementation of TPM helps in reducing waste and improves health and safety conditions in the organization, specifically on the production line. All these have benefits to offer society.

**TPM Implementation and its Association with other Business Excellence Strategies**

The implementation of TPM is an organization-wide undertaking which demands commitment from senior management right through to
equipment operators. No one knows the conditions of equipment better than the operators, who spend the whole of their working hours running it and listening to the noises it makes under varying circumstances (Rheaume, 1997), or office workers operating computers and other office equipment. TPM cannot be implemented in the same way in all organizations because of differences in their culture and structure. It will thus take some organizations more time than others to complete the implementation of TPM. This will depend on the level of communication in the organization, the commitment from the management and the acceptance by the workforce of its implementation. It needs the co-operation of all people in the organization from the top management to the shop-floor worker. Without the co-operation the implementation will not succeed even after a very long time and much effort will have been wasted.

TPM is normally implemented in four phases: preparation, introduction, implementation and consolidation, which can be further organized into 12 steps (Suzuki, 1994). It is shown in Figure–2 how TPM can be associated with other essential strategies, which could help bring about business excellence. Figure–2.11 shows that some areas of total quality management (TQM), such as commitment, good communication between all levels; employee empowerment and benchmarking could be shared with TPM. However, TPM concentrates initially on equipment effectiveness, whereas TQM practitioners may not pay too much attention to detailed planned maintenance programme, which TPM demands.
Nevertheless, it is very helpful for the implementation of TPM if the organization has already implemented TQM because it will help in reducing the time and effort needed. On the contrary, if TQM has not been implemented, it will take great effort to change the culture of the organization.

Figure – 2.11:

*Business Excellence*

![Diagram](image)

Other techniques can also be associated with TPM, such as the well established just in time (Bassam Al-Najjar, 1996), statistical quality control (Miyake & Enkawa, 1999) and *kaizen*.

It is interesting to reflect that some of the more modern techniques, such as the ‘Six steps to six sigma’ (Bendell, 2000) procedures as practiced by Motorola, which bring about huge savings, could be further enhanced by TPM. The announcement by General Electric that it would save US$500
million in 1997, and their actual savings of US$1.2 billion by 1998 due to the application of 'six sigma', serve as reminder of the effectiveness of this method. The six-sigma approach when adopted as a long-term business strategy looks after the quality assurance aspect of the company's business. It seeks to minimize variations of product quality from the traditional three sigma (2700 parts per million) to the six sigma (3.4 parts per million or, more practically, a yield of 99.99966 percent if the process mean varies from the target by up to 1.5 sigma) limits. It can of course be argued that no matter how good the design of the product or the control and monitoring systems are, one would need a properly maintained production system to bring about the desirable performance level, which could promise such fantastic savings.

In today's highly competitive markets, TPM could be the only philosophy that makes the difference between success and failure for some organizations. It has already proved successful in helping to reduce costs and improve the quality of products and services in some areas. TPM brings the maintenance function into focus as a necessary and vitally important part of an organization, which aspires to achieve business excellence. It is no longer regarded as a non-profit activity. With TPM, downtime for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. It is no longer simply squeezed in whenever there is a break in material flow. The goal here is to limit emergency and unscheduled maintenance to minimum.
IV The Business Process Re-Engineering Model

Business Process Reengineering (BPR) is a popular term since the 1990s, especially after Hammer, Champy, and Davenport published books to elaborate BPR related issues and cases (Hammer and Champy, 1993; Davenport, 1993). Several companies and organizations report their successful experiences by applying revolutionary approaches to obtain dramatic, radical, and fundamental changes as Hammer and Champy (1993) suggested. However, people rethought the myths of BPR after recognizing that 70 percent of BPR's efforts failed (Davenport and Stoddard, 1994). One of these myths is that business process redesign does not come from a clean slate to build new processes from scratch.

Business Process Modelling (BPM) Methods

This section is aimed at introducing various BPM methods in literature. These methods are listed and discussed briefly below.

A business process consists of five elements:

a. A business process has its customers;

b. A business process is composed of activities;

c. These activities are aimed at creating value for customer;

d. Activities are operated by actors which may be humans or machines; and
e. A business process often involves several organizational units which are responsible for a whole process (Davenport, 1993; Hammer and Champy, 1993).


(1) Activity-oriented approaches tend to define a business process as a specific ordering of activities (sometimes referred to as tasks). They generally offer good support in refining process models. However, this mechanistic view may fail to represent the true complexity of work and in turn, fail to implement new business processes.

(2) Object-oriented approaches are associated with object orientation, such as encapsulation, inheritance, and specialization. The principles of object orientation are applicable to business process modeling. However, practitioners, such as process owners and team members, tend to describe their work by activities rather than by objects.

(3) Role-oriented approaches suggest that a role be involved in a set of activities, and carry our particular responsibilities (Ould, 1995). A group of primitive activities can be assigned to a particular role (i.e. actor or agent). However, they are not suitable to express an intricate sequencing logic.

(4) Speech – act oriented approaches, based on speech act theory under language/action perspective, view the communication process as four-phased loop: proposal, agreement, performance, and satisfaction
(Medina-Mora et al., 1992). Although business cases can be viewed as a communication between customers and performers, this modelling approach does not provide much help in analyzing existing processes or creating new processes.

**Modelling the Order Fulfillment Process (OFP) in Supply Chain Networks**

The generic process modelling approach with such properties as multiple layer of abstraction and separation of concerns facilitates the business process representation and analysis. They can be viewed as a grid, where y-axis denotes multiple layer of abstraction, and x-axis represents separation of concerns as shown in Figure 2.12. A target process can be represented by composing eight essential concepts in different levels of detail ranging from gross to fine-grained. A certain layer of abstraction may emphasize certain perspectives. The multiple layer of abstraction removes the barriers of process representation and model analysis by reusing and elaborating the details of process elements. That is, efforts of transferring process representation for model analysis are minimal. Therefore, the analysis including verification and validation can be embedded with the model, and the modelling procedure can be added to modelling activities. In order to illustrate such features, we apply this modelling approach to the order fulfilment process in supply chain networks.

The Order Fulfillment Process (OFP) starts from receiving orders from the customers and ends with having the finished goods delivered. The OFP
The generic BPM method with multiple layers of abstraction and separation of concerns

Involves the coordination of diverse activities such as sales commitment, credit checking, manufacturing, logistics, accounts receivable, and relationships with external suppliers from purchasing or shipping, which normally take place in several different functional units across business entities in Supply Chain Networks (SCNs) (Davenport, 1993; Lin, 1996). The OFP in SCNs have different functional units to support various activities for the OFP. The OFP in SCNs can be represented using the eight essential concepts of the generic modelling method as shown in the following.
(1) **Activity** – order management, production scheduling, capacity planning, material planning, and supplier management.

(2) **Resource** – materials, products and order.

(3) **Behaviour** – order committed decision (order management system), coordination among production scheduling, capacity planning and material planning (production scheduling, capacity planning, land material planning systems), bidding and contracting (supplier management system), and demand policy (business entities).

(4) **Event** – order arrival, material available, and product finished.

(5) **Information** – orders, production plan bill of materials, capacity plan, material requirement plan, and information infrastructure.

(6) **Relation** – relative relationship between business entities by linking with material and information flows or relation between entities.

(7) **Agent** – logical agents for processing information, such as order management, material requirement planning, capacity planning, production scheduling systems, and physical agents for processing materials, such as factory, production lines, and warehouse.

(8) **Entity** - objects containing attributes, such as products and orders.

*From Modelling to Design*

BPD is any planned change in a business process to permanently improve the functioning of that process. The change may involve redefining the steps in the process, applying new technology (including software and
hardware), redefining performance standards, improving the quality of inputs, training the personnel responsible for the process, enhancing management’s control over the process, and enhancing the alignment among processes.

Business Process Reengineering (BPR) was major trend in the 1990s. Boyle (1995) called it the “panacea of choice for an increasing array of organizational maladies.” Caldwell (1994) and Korchinsky (1997) estimated the billions spent on BPR projects and associated consulting services. Authors such as Hammer and Champy (1993), Leth (1994), and Eierman and Schultz (1995) described examples of dramatic improvement achieved through BPR.

There appear to be at least three schools of thought in the pursuit of process improvement: the total quality management (TQM) movement, business process reengineering (BPR), and what can be called the “eclectic approach” to the radical design of business processes.

TQM offers a variety of techniques for detecting and correcting process inefficiencies. While each change might result in only a small gain in process performance, the accumulation of many small improvements over time will enable dramatic improvement in process measurements. TQM is generally administered at low levels in the organization, with the work often done by production and clerical workers organized into quality improvement teams. The other two camps criticize TQM-driven change as too slow in achieving too little gain. TQM methods are said to be incapable of radical
change, and, further, enthusiasm and participation are difficult to sustain for more than a few years. Proponents say that TQM gets lot of people involved in managing and improving processes and, therefore, reflects a change in the organization’s culture, and a supportive culture is a prime requirement for sustaining process improvements. TQM proponents also argue that an organization cannot afford the substantial investments required for radical change in all of its business processes, and, therefore, a combination of TQM and radical change methods suits most organizations.

The brief discussion of TQM is presented because proponents of radical process improvement generally contrast their approaches to TQM. These approaches share certain features:

- The goal of radical change, that is, to enable the organization consistently to attain levels of performance never seen before by that organization
- Building the case for a major investment in process design by explaining how improved process performance will enable the organization to address a critical business issue
- Investment in information technology (IT) and systems architecture as a means for achieving radical change, sometimes called “breakthrough performance”
- Being very specific about process performance parameters before outlining the component steps of the new process
• The use of special techniques for flowcharting the new process design and possible for analyzing the old process design

• Recognition of a business process as a socio-technical system (Passmore 1988) in which technological elements must be integrated with the capabilities of the employees assigned to operate the process

• Attention to alignment and coordination issues between organizational units (or departments) that impact the functioning of the process

• Emphasis on quantitative measures of process functioning (for example, cycle time, operating costs) and of outputs (for example, product defect rates, sales volume)

• Testing prototypes of the process design by such techniques as computer simulation and trials at “beta” sites

• A project infrastructure that typically involves a sponsor, a project manager and design team, and steering team, and a consultant.

What Is Business Process Design?

BPD is not just one technique; it is a family of techniques with a common focus, namely, the improvement of a business process. Terms that overlap with BPD includes reengineering, process improvement, and process innovation. Proponents seem to coalesce into two camps: the “reengineers” and the practitioners, whom the author calls the “eclectics.”

The reengineering movement traces its roots to the seminal book, reengineering the Corporation: A Manifesto for Business Revolution by
Hammer and Champy (1993). Reengineering adherents see IT as the primary means for achieving breakthrough performance. They want systems that are faster, more flexible, more adaptable, more multipurpose, and easier to use than the obsolete technology that is in place. They see little value in studying the process in place because that might trap designers into trying to fix the current mess, which they believe can only lead to modest gains in performance. The project leader typically comes from the IT group. The decision-maker who chooses to use reengineering is usually someone at the top of the hierarchy, such as the President or Chief Operating Officer (COO).

The eclectic approach is represented by writers such as Harrington (1991) and Rummler and Brache (1995). The starting point for the eclectic group is the cross-functional or interdepartmental nature of almost all critical business processes. For example, the product development process may start with ideas generated by the sales force. These ideas are evaluated by the market research group, which recommends development projects to senior management who, in turn, directs the research and development department run, to design a prototype. Along the way, purchasing, engineering, and manufacturing may contribute information used in the development process. The eclectics are primarily concerned with the integration of people, work groups, and technology. Eclectics use a variety of techniques to improve process performance, including work elimination, benchmarking and "best practices" searches, training, statistical process
control, just-in-time inventory, restructuring, and so on. IT is an important contributor but not the leader. The project sponsor usually represents the department with the largest stake in the change. Part of the eclectic methodology is to examine the original process to determine the flaws and reasons for its inefficiency. This is done for two reasons: 1) to prompt thinking about how to improve the process and 2) to provide input to planning the implementation of the new design—where the issue is how to wean employees off the old way and transfer their commitment to the new process design.

Along with the advocates, however, have come the critics. A McKinsey team (Hall, Rosenthal, and Wade 1994) examined reengineering projects in more than 100 companies and concluded "too many companies squander management attention and other resources on projects that look like winners but fail to produce bottom line results for the business unit as a whole." Commenting on two surveys of Fortune 1000 companies, King (1994) concluded "Nearly 85 percent of top executives who have reengineered their operations are dissatisfied with the results of their efforts." In reviewing 10 years of published reports, Nissen (1998) wrote, "BPR or process redesign...has been tarnished by inefficiency, sporadic success, and pathological performance."

Why is BPD so difficult? Many writers have offered their opinions about the factors that facilitate or inhibit success, but only a few studies have tried to answer this question. Halt, Rosenthal, and Wade (1994)
examined reengineering projects in more than 100 companies and analyzed 20 projects in detail. They identified two factors, which they call “breadth” and “depth,” as critical to the long-term benefits of reengineering. Breadth refers to the extent to which the process maps onto the dimensions of the business, from a single activity in one function to a business system that spans the entire business unit.

Depth refers to how many of six “depth levers” are manipulated. The levers are structure, skills, IT systems, roles measurements/incentives, and shared values. From a survey on North American Information Officers, Boyle (1995) identified the top-10 barriers to and six critical success factors for reengineering success. Barriers included such variables as resistance to change and inadequate executive sponsorship. The list of success factors was headed by visible and involved sponsorship. Schultz and Eierman (1997) summarized the responses of 109 chief information officers and MIS department heads to a survey on BPR. They listed 18 factors affecting reengineering project success and the average ratings on a five-point scale (“not a problem” to “serious problem”). The factors were separately ranked for successful organizations, unsuccessful organizations, organizations achieving more than 100 percent process improvement, and organizations achieving less than 100 percent process improvement. Among the more important factors were the fear of change, unclear objectives, and the fear of job loss.
Raymond, Bergeron, and Rivard (1998) reported a study of process improvement efforts in 134 small and large Canadian companies. Their study analyzed relationships among five sets of constructs 1) the pay-offs (for example, greater market coverage), 2) measures of organizational support (such as supervision of the project by a steering committee), 3) compliance with BPR principles (for example, defining business processes around company objectives); 4) the diversity of human resources involved in the project (for example, users, information system specialists), and 5) methodological rigor for such techniques as the socio-technical approach (which includes structured interviews and prototyping). Raymond and his colleagues found that compliance with BPR principles, the diversity of human resources, and methodological rigor were correlated with the pay-off measures but only for large companies.

Finally, Elmuti and Kathawala (2002) reported a survey of 126 business executives and managers about their companies' reengineering efforts. Their data indicated that the most important contributors to reengineering success were a clear mission statement and a clear understanding of business reengineering definition, sponsorship, and the commitment of top management, and the availability of adequate resources to perform the work. Conversely, the most widespread contributors to failure were inadequate understanding of business reengineering, which many employees see as "mass chaos," lack of effective methodology to implement
reengineering plans, and lack of executive leadership, support and participation.

BPR is a commonly attempted type of organizational change, and it often occurs in combination with other types of change. This complexity may account for some of the difficulty in managing change. Only 23 percent of process change efforts generally attained breakthrough or near-breakthrough success. One key to successful change is to recognize the crucial role of middle management at the department, division, or business-unit level. The highest corporate officers perceived their sponsorship as more related to successful change than sponsorship. The most frequently cited reasons for undertaking BPR were cost, product problems, and the desire for greater control over the process. Successful BPR projects were supported by an array of quantitative performance measures, while unsuccessful projects were mainly described with subjective data, especially the opinions of people inside the organization.

Successful projects were characterized by variables that reflected strong sponsorship, a strong project team, and stakeholder management. A number of negative factors correlated with failure, but the strongest correlations had to do with breakdowns in leadership. The strength of the existing culture was also identified as a significant barrier to process change.

From these observations, the following requirements for managing BPR emerge:
1. Managers need guidance. BPR is difficult. Published estimates for success average about 23 percent. The degree of difficulty derives from managing change in support of, or in combination with, other types of organizational change over a period of time that may extend for two years (Carr, Hard, and Trahant 1996; and Rummler and Brache 1995, both suggest up to two years for complex process) and span a number of work groups.

2. The positive and negative factors suggest requirements for managing BPR. The role of the sponsor is pivotal. The sponsor should be versed in developing support for the change among key executives, organizing the project's infrastructure (for example, appointing a capable and dedicated project team), positioning the change initiative with stakeholders, protecting project commitments from other organizational priorities, and demonstrating continued support for the effort in ways that are visible to stakeholders.

3. Project planning and management also appear to be critical, as indicated by the need for a detailed plan, keeping the project small and manageable, and tracking and reporting progress.

4. Communication throughout the project is critical to developing and maintaining stakeholder support. As mentioned previously, the sponsor needs to communicate his or her support for the change, and progress should be tracked and publicized. It is also important that
people understand what they had to do to make the change successful. Conversely, failed efforts were characterized by vague goals and poor communication.

5. Executive and departmental (or business-unit) levels should be aligned in support of the change. There appear to be two focal points of power and leadership that need to coordinate their efforts: the executive leadership at the enterprise level and the middle rank of leadership at the department, division, or business unit level. Executives control strategy and resources, while middle management coordinates deployment of the resources to accomplish the strategic objectives.

6. Given the dismal rate of success, it seems reasonable to provide for the contingency of recovering from barriers that stymie a project. Tactics for revitalizing stalled projects should be defined. Planning should emphasize keeping the change manageable. The challenge is to achieve the change objectives without jeopardizing other strategic interests. There are tactics to accomplish this, such as: 1) phasing the change effort across business units; 2) cascading the change down the management hierarchy; and 3) successive approximations whereby the change is viewed as a learning curve with intermediate targets that gradually lead to the desired and state.

7. The implementation plan should provide for replacement of key players given the time span associated with process change and the normal turnover rates for senior and middle managers.
category, then the researchers as an aggregate believe that the most important functions are the design of the intervention, project management, and stakeholder management. The correlations reported in this study clearly indicate that the areas of leadership, project infrastructure, and contextual factors are also potentially important for the success of process design.

<table>
<thead>
<tr>
<th>Content Category</th>
<th>Boyle</th>
<th>Schultz &amp; Eierman</th>
<th>Raymond et al.</th>
<th>Elmuti &amp; Kathawala</th>
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Table 2.2:
Summary of success rates published for five types of organizational change (1990-2001)

<table>
<thead>
<tr>
<th>Type of Organizational Change</th>
<th>Number of Studies</th>
<th>Sum of Sample Sizes</th>
<th>Medium Success Rate (in %)</th>
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<tr>
<td>Restructuring and downsizing</td>
<td>9</td>
<td>4,830</td>
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<tr>
<td>Technology change</td>
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<tr>
<td>Mergers and acquisition</td>
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<tr>
<td>BPD (Reengineering)</td>
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V Enterprise Resource Planning

Computer systems to support manufacturing business processes have become widespread throughout manufacturing industries over the last thirty years. During this time the computer systems to support manufacturing resource planning have quickly evolved from basic Materials Requirement Planning (MRP) software to today’s sophisticated extended enterprise integration packages that reside on client/server computer architecture. The popularity of MRP-type systems is demonstrated by the many companies that have acquired manufacturing resource planning of “MRP II” systems (Anderson, Schroeder, Tupy, and White, 1982; Chase and Aquilano, 1995).
In 1996, the Institute of Industrial Engineers published a list of 94 MRP software vendors (MRP II Software, 1996)

MRP II computer systems are developed by nearly a hundred vendors (IIE Solutions, 1996) and quite possibly may not be identified within a company as a “MRP II” system. For example, MIS managers in many electronic manufacturing plants consider “ERP” or enterprise resource planning the new trend for manufacturing computer support systems. In 1997, it is still common to find manufacturing companies operating MRP systems on IBM AS400 minicomputers or other centralized data processing hardware systems. Many organizations are in the process of implementing enterprise resource planning computer systems on client/server network systems.

As organizations continue to seek ways to improve their overall performance, and new computer technology pressures industry to update and overhaul information systems, computer applications to support manufacturing have developed rapidly in recent years. Relatively simple materials requirement planning systems were first introduced in the 1960s. As the capabilities of computer technology continued to increase, more modules were added to integrate other organizational/business functions into manufacturing-support computer systems. These computer systems are more commonly known as manufacturing resource planning or MRP II. Today, some companies are upgrading and maintaining their current MRP II systems while others are installing new client/server networks within their
organization. The most common of the new MRP-type software is generally known as ERP, or Enterprise Resource Planning. These computer systems require a large financial investment as well as organizational commitment in training, changing processes, and adapting to the new technology.

The widespread use of computers in industry today presents a need for developing increased knowledge of how to effectively apply manufacturing resource planning, client/server systems, and computer applications in general. Quite often, computer applications change the way work is performed. Industrial engineers have traditionally been involved in “the design, improvement, and installation of integrated systems” which link people, materials, information, equipment and energy (Hodson, 1992). Within the field of industrial engineering, computers have long been used as decision making tools, but the overwhelming influence and potential of computer applications and computer support systems present a broad area in which knowledge of productivity and performance factors need to be developed.

The Development of Manufacturing Resource Planning

Definitions

MRP-1

Materials Requirement Planning, a computer-based system for managing inventory and production schedules. This approach to materials management applies to large job-shop situations in which many products are
manufactured in periodic lots in several processing steps. It does not apply to continuos-flow-type manufacturing systems. (Bedworth & Bailey, 1987)

**MRP-II**

Manufacturing Resource Planning, a system in which the entire production environment is evaluated to allow master schedules to be adjusted and created based on feedback from current production/purchase conditions. (Bedworth & Bailey, 1987)

Materials Requirements Planning (MRP, or MRP-I) was launched in the mid-1960s and quickly became popular for providing a logical, easily understood method for determining the number of parts, components, and materials needed for the assembly of each end item in production. As computer power grew and demands for software applications increased, MRP systems evolved to consider other resources besides materials. Software modules were added to include functions such as scheduling, inventory control, finance, accounting, and accounts payable.

As the materials requirements planning systems matured in the 1970s and 1980s, other portions of the productive systems were naturally added to the computer software system. One of the first functions to be included was purchasing. The software modules were expanded to handle cost data and selling price capabilities. Additional data about work center capacity limitations were also integrated into many systems as detailed scheduling for the shop floor was provided by the MRP systems. It was quickly becoming obvious that "material requirements planning" no longer was adequate to
describe the expanded systems. Oliver Wight is credited for introducing the name "manufacturing resource planning-MRP II" to reflect the idea that a larger part of the firm was becoming involved with the program. (Wight, 1981).

"The initial intent for MRP II was to plan and monitor all the resources of a manufacturing firm—manufacturing, marketing, finance, and engineering—through a closed-loop system generating financial figures." (Chase & Aquilano, 1995, 609) MRPII was also intended as a way to simulate the manufacturing system. The idea of the closed-loop system indicate that once the MRP program produce a initial production schedule, the output data is then sent to departments such as sales and operations to verify that the plans are realistic and attainable. Ideally, not only are many functions included in the output system, there is also feedback provided by the execution functions so that the planning can be kept valid at all times.

"For more than a decade, efforts continued in MRPII systems along the lines of adding some modules and making continuing small improvements. The basic system and its operating logic remained intact. IBM's Manufacturing Accounting and Production Information Control System (MAPICS), for example contains 19 interrelated modules." (Chase & Aquilano, 1995, 609) This is one of many MRP II systems that is still widely used.
MRP Functions, The Purpose of MRP Systems

According to Chase and Aquilano (1995), MRP computer systems serve the organization by providing the functions below:

In terms of Inventory, MRP systems:

i. Determine the number of parts, components, and materials needed to produce each end item.

ii. Determine the right part, right quantity, & right time to order parts. Provide time schedules for ordering materials & parts.

iii. Maintain a bill of materials sequencing the assembly parts of the final product ("schematic, product structure tree").

Priorities: Order for the right due date, keep the due date valid.

Capacity: Plan to optimize the use of plant & equipment capacity Plan an accurate load.

Theme of MRP (Chase & Aquilano, 1995):

“Getting the right materials to the right place at the right time.”

Objectives: (from Chase/Aquilano, 1995)

MRP has the same objectives as any inventory management system

1. To improve customer service
2. Minimize inventory investment
3. Maximize production operating efficiency
The Shortcomings of MRP-II Systems

"Since the 1970s, MRP has grown from its purpose of determining simple time schedules, to its present advanced types that can theoretically together all major functions of an organization. During its growth and its application, MRP's disadvantages as a scheduling mechanism have been well recognized. This is largely because MRP tries to do too much in light of the dynamic, often jumpy system in which it is trying to operate" (Chase & Aquilano, 1995, 596).

MRP-II systems do not allow material, time and capacity requirements to be determined until the system plans an actual lot size for a given run. In essence, the traditional systems cannot determine what products to build until the manufacturer receives an actual order specifying the required unique combination of parts. It is not uncommon for material schedulers force "dummy order" into computer production systems in order to minimize production inaccuracies due to inaccurate, forecasted demand. In today's competitive marketplace, suppliers who can quickly meet customer order win business. At times material schedulers will find that in order to start a production run without an actual order in hand, an estimate of an anticipated production order can be placed into the computer system that would meet the necessary checkpoints that are built into the software. Because MRP systems may not been tailored to meet the needs of "Just-in-Time" production, schedulers may choose to overlook the computer system or
"manipulate" it to accommodate priority customers who has specific needs and deadlines to be met.

The inaccuracy of the bill of materials and inventory database is a common problem with MRP systems. Inaccurate bills of materials mean inaccurate material and capacity plans providing a management system that will facilitate data accuracy will likely require major adjustments in strategic management approaches (Correll, 1995).

**Advanced MRP-Type Systems or Software changes from MRP II to ERP (Enterprise Resource Planning)**

For more than two decades, firms focused at the plant production level chose MRP systems to handle product demand, inventory levels, inventory order quantities, resource availability and production schedules. Since the mid-1980s industries have found themselves competing to meet product demands from a global marketplace; increasing subcontracting of products and parts; and managing more distributed, multiple-plant sites, both domestic as well as international sites. “In today’s environment, MRP users want instant access to information on customers’ needs, which plants can meet these needs, and company wide inventory levels and available capacity” (Chase & Aquilano, 1995). Rather than relying on historical data to predict inventory and sales levels, more efficient, more effective service could be provided by instantaneously accessing the latest data from inventory and sales figures on remote databases.
As industries find plant and organizational sites becoming more distributed, the capabilities of client-server architecture will be further developed. "From a technical standpoint, the acceptance of new computing concepts and advanced architectures has turned the MRP II software industry and its user community upside down..." (M.R. Rangaswami, quoted by Teresko, 1994). While many vendors are selling and maintaining existing MRP system, others are developing new advanced systems based on MRP logic. Accordingly, while some firms are modifying their current software programs, others are developing systems with major changes in the basic software programming logic and database structure.

"Today, manufacturing is re-evaluating departmentally oriented MRP II products in an attempt to plan and develop the next generation of enterprise oriented manufacturing solutions. In response, some MRP II vendors are scrambling to distribute modules of older software onto PCs and workstations, while others contemplate a strategic redesign of their products" (Teresko, 1994). Various names have been given to these advanced MRP-type systems. The Gartner Group introduced Enterprise Resource Planning (ERP) and Advanced Manufacturing Research (AMR) introduced a similar software, Customer-Oriented Manufacturing Management Systems (COMMS).

Advanced MRP systems are recognized for their databases and interdepartmental linkages. Their structure provides a natural basis for MRP systems to become an enterprise integration tool. Enterprise integration is
viewed as developing the availability and accessibility of information within an extended corporate system and using the information system to effectively coordinate both the decisions and actions of thousands of individuals (Enterprise Integration Laboratory, Univ. of Toronto, 1994).

To fully operate in an enterprise sense, there needs to be distributed applications for planning, scheduling, costing and so on to accommodate the multiple layers of the organization, its work centers, sites, divisions, and management levels. Multiple languages and currencies are also being included for global applications (Chase & Aquilano, 1995). Advanced MRP systems (also called ERP or next-generation MRP II) will include the following (Greene, 1992):

- Client/server architecture.
- Relational Database with SQL.
- Graphical User Interface
- Multiple Database Support
- Front-end systems for decision support.
- Automated Electronic Data Interchange (EDI) — for better communications with customers and suppliers.
- Interoperability with multiple platforms.
- Standard application programming interfaces.

**Distributed MRP Processing versus Centralized Processing**

Many companies have invested significant capital into MRP systems that reside on mainframe computers and centralized processing or “legacy”
computer systems. In order to provide users throughout the firm with reliable, real-time information, relational databases are being implemented on mainframe systems. Oracle Corp. has a widely used relational database system and fourth-generation language that is being incorporated to enhance existing MRP systems. Sequent Computers Systems, for example, is using Oracle's manufacturing software on its computer (Chase & Aquilano, 1995).

When using a mainframe computer hardware system, or centralized process operation, software features to support engineering, production scheduling, forecasting, order processing, purchasing, and materials planning are controlled at one central location, even if the system is used to control multiple plant sites. For different plant sites, a decentralized processing operation distributes the computer information processing responsibilities among the plants. A distributed processing operation uses a combination of centralized and decentralized controls to allocate resources where they are logically needed and where they can be executed most efficiently (Costello, 1992). A popular concept supporting distributed computer systems is that shifting to global manufacturing will encourage more decentralized MRP to allow more local control. However, the management and maintenance needs of distributed computer systems should not be underestimated. Distributed, client/server computer systems may allow for customization and information processing at the client site, but this architecture also introduces higher levels of system complexity and more complex control issues.
The cost of client server systems is far higher than managers expected. The tools and technologies for client/server systems have not fully evolved, and the need for implementation planning and personnel training were often underestimated (Rifkin, 1994). Early adopters of client/server technology found that the relative ease of developing client/server applications allowed them to build many applications using a wide mix of tools without much thought to the long-term overall results (Rick Martin, 1995). Later adopters are being more cautious, explicitly addressing architectural issues and standardization early in the process.

Contemporary Enterprise Integration Trends and SAP Systems

In manufacturing, client/server systems have the potential of providing essential data sharing between design engineers, production engineers, purchasing, the stockroom, and the factory floor. While the promise of open systems in manufacturing has yet to be realized, many of the systems are “in their infancy in terms of functionality” (Booker, 1994). In application development, formalizing consistency for screen views would be difficult considering each department has its own functional data requirements and “view” of the product. Client/server technology does suggest the likelihood that, in the future, a repair technician will be able to use a single identifier, e.g. a serial number, to query manufacturing, engineering and customer databases. A simple serial number for a part could access a database to provide the date of production, component part information, part suppliers, and a history of engineered design changes for the product. Such a tool
would be invaluable for customer service and for troubleshooting mechanical problems.

The need for enterprise integration tools is demonstrated by the current trend popularizing SAP R/3 software systems in large US corporations. SAP provides a software system that accommodates enterprise resource planning (Smith, 1996). Using a client/server network to access online databases, software systems such as SAP easily replaces traditional Materials Resource Planning (MRP) systems.

In the early 1990s, *Systeme, Produkte in der Datenverarbeitung* (German for Systems, Applications, and Products in Data Processing a.k.a. SAP AG Corporation, introduced their R/3 system to the US market. SAP R/3 provides an extensive spectrum of integrated business applications on client/server-distributed systems. The package runs on most versions of UNIX, Windows NT, IBM OS/2, DEC VMS, and Hewlett Packard MPE/IX, and supports a large variety of databases including Oracle, Informix, DB2, and Microsoft SQL Server 6.

In addition to traditional business computing functions such as financial accounting and asset management, the SAP R/3 system integrates modules in production planning, materials management, sales and distribution, business workflow, human resources, and plant maintenance. The ability of the SAP systems has been tested in the United States, but SAP’s development agreement with Microsoft and Intel exemplifies the potential clout of this software system. Because of SAP’s adaptability to
different types of industries, the software requires involved customization for each organization. Influential development of this client/server software can be expected in the future.

Many companies are justifiably reluctant to invest the capital required to install drastically new systems. Rather than adopting the R/3 package, many firms have installed SAP's earlier R/2 system that runs mostly on IBM 370- mainframe computers. As of 1994, more than 2,300 customers used SAP's R/2 system.

Traditional production companies such as and Cadbury were already using SAP R/3 for their enterprise resource planning (Smith, 1996). Consulting companies such as Price Waterhouse and Accenture are heavily involved in implementing SAP systems. Other companies who have implemented SAP include Proctor and Gamble, Apple Computers, General Motors and Intel.

Client/server systems provide a tool to assist in re-engineering business processes. In today's fast paced business environment, instant access to information is increasingly becoming a requirement to remaining competitive in the marketplace. Though the evolution of client/server software has not yet reached maturity, many organizations have already realized significant system improvements using client/server networks. Client/server systems will not only be an invaluable tool for future process improvement efforts, it is likely to be the "essential enabler" for large scale increases in organizational productivity.
The Enterprise Client/Server Model

From an organizational perspective, client/server architecture provides a model for extended enterprise integration. The technological capability of the system allows independent computers to be linked to the organizational network, enabling efficient communications to other client users and different databases. The network system has the ability to link products from different server types, whether the client uses IBM-PC, Macintosh, or Unix operating systems. The information access linkages also connect databases from different server types.

In a production-oriented organization, the extended enterprise client/server system links the departments involved in each phase of the product development process. Typically, product information will be initiated in marketing and design groups. The data can then be linked to the accounting department, manufacturing, the component purchasing group, the inventory control function, and production schedulers. This extended enterprise network links traditionally segmented organizational functions, allowing them to share data and customize information in a form that would be most useful for other internal customers in the organization.

In addition to linking functional departments, this model client/server system can also link employees in distant locations. The manufacturing and inventory groups within a large corporation are commonly located remotely from the design-engineering group. Thus, an integrated enterprise client/server system allows a mechanism for data coordination and accessible

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data sharing between these functional departments. Ideally, information from the design-engineering group can also be shared with marketing, thus providing an inter-connected matrix organization with a networked computerized system that allows for feedback at every stage.

This concept of this integrated enterprise client/server model is used in the structure of advanced MRP and enterprise resource planning computer software. Enterprise resource planning software package such as SAP have gained immense popularity in recent years. The enterprise client/server model provides a theoretical structure for applying client/server systems to encompass extended organizational – enterprise changes. In industry today many companies are working towards the integration of network systems, yet few organizations have developed client/server systems that have been integrated to this extent in the organization.