Activity 14. Review the Operations

"Most of the leaders of the excellent companies have come from operational backgrounds." Thomas J. Peters and Robert H. Waterman, Jr., "*In Search of Excellence – Lessons from America's Best-Run Companies,* New York: Harper and Row, Publishers, 1982, p. 288.

Introduction

Chaos pervades a small law office. Client files are everywhere; open on the lawyer's desk, stacked in piles on the floor; scattered on a "working" table, filed and mis-filed in the documents room. His receptionist-secretary is frazzled from answering the telephone, handling fax messages, responding to the whims and demands of the lawyer and being pleasant to clients, some of whom are anxious, others are angry and annoyed. Similar situations can be found in a wide range of sectors and sizes of service and production operations around the world.

In late 1997, Boeing Company, the world's largest manufacturer of aircraft, announced a third quarter loss of US$696 million on revenues of US$11.4 billion, a 26 percent increase from the US$9 billion in sales for the same three month period a year earlier. According to reports, the company was incapable of managing the "ramped up" operations and parts supplies required to produce the record number of commercial airplanes that had been ordered. Karen West, *Seattle Post-Intelligencer,* "Boeing posts loss of $696 million", in *The Globe and Mail,* October 27, 1997, B13. Work on the production line was being done out of sequence, costing about five times more for labor than when the work is done in sequence. At the end of September, 1997, the number of "out-of-sequence" assembly jobs peaked at 14,276 for the 747 models being produced, about five times what is considered to be normal in aircraft production. During the month, many 747s were moved down the final assembly line and rolled out the factory door but were left unfinished, waiting for parts. In early October, the company halted the final assembly of its 747-400 models and slowed down the production of its next-generation 737 models. Stopping the production lines allowed factory workers to complete planes that were missing parts and gave Boeing and its 3,000 sub-contractors time to catch up with production requirements.

Boeing was not unique with its dysfunctional operations. Just for added flavor of the problems that plague production operations, consider a further sprinkling of examples. A tractor plant in Minsk, Belarus had an assembly line that was so antiquated that it "breaks down" frequently and was unsafe. The line was disjunctive and the assembly did not flow continuously. Its' underpaid and de-motivated workers put together tractors at a pace that was slow and inefficient. Assembled tractors were pulled off the end of the line and towed to storage areas. While they were being towed, parts of the new tractors fell off and tools clattered to the ground. Another production plant in Tambov, Russia, had a product line that was so dissimilar it was unable to achieve any synergies, economies and efficiencies in its operations. It designed, produced and marketed gas masks, brass valves and plastic kitchenware. Hundreds of other plants and "enterprises" throughout the former Soviet Union struggle to survive with operations and management that became obsolete under the "communist system". Throughout the world the operations of business, government and non-governmental organizations suffer from

mismanagement, obsolescence, deficient production flows and numerous other inefficiencies and uneconomical processes and activities.

Whether an organization is a sole proprietorship, a professional partnership, a non-profit charity, a public sector agency, a giant manufacturing corporation or billion dollar shipping company in Poland*, operational challenges abound. Information and intelligence is inaccurate or incomplete. Pressures for "quality work" and greater productivity are omnipresent in most organizations, especially those businesses in competitive markets. Similarly, mangers are "under the gun" to achieve numerous other operational results, some of which are incompatible, like the Tambov plant's disparate product line and production processes. Operations managers face difficult challenges. They have to cut costs, satisfy customers demand for quality and value, keep their personnel productive, safe and satisfied, optimally utilize the plant, equipment and supplies, protect the environment, adhere to government laws and regulations and union rules, achieve the organization's goals and other aims as well as perform a myriad of other duties.

> Regardless of how careful the planning, few systems of any complexity can be expected to operate indefinitely without encountering some type of malfunction which must be corrected. Richard B. Chase and Nicholas J. Aquilano, *Production and operations management,* Homewood: Richard D. Irwin, Inc., 1973, p. 537.

Rare is the organization that does not have such on-going pressures and would not benefit appreciably from operations reviews, especially just prior to choosing and implementing new or innovative tactical and strategic alternatives as illustrated in Stages II and IV of the TSMP.

Nature of operations and their reviews

Operations involve the activities, processes and methods of performing productive tasks, duties and responsibilities. Operations generate the output and major costs of most organizations. Every active organization has some form of productive operations and their management. Businesses produce, distribute and sell goods and services. Government agencies produce policies, programs, processes, products, services and legislation. Charities and other NGOs solicit donations and provide personal care services, facilities, needed items and funding for suffering and deprived people at home and around the world. "Operations management has existed as a function since man first organized to hunt and gather food, and later to farm, trade and build." Chase and Aquilano, *ibid.,* p. 4. Over time, the Egyptians have built pyramids, the Chinese have constructed the Great Wall, the Romans developed a vast empire, the Americans and Russians have designed and produced space craft and sent them to the moon and into orbit as satellites. Every day, billions of people around the globe are employed in operations of a vast array.

Historically, most if not all of management's analytical capabilities and efforts were oriented toward the operations of their organizations. From Biblical times through the Industrial Revolution to current concerns about productivity, managers have been

* Activity 14 is a result of feedback from the CEO of a large shipping company in Poland who brought the omission of a review of operations to the author's attention.

evaluating operational performance in its infinite forms and environmental vagaries. A smattering of historical events exemplifies the ever-present and increasing demand for the review and improvement of operational processes, activities and methods. Adam Smith and Charles Babbage dealt with the division of labour. Various industrial economists advocated "economies of scale" and mass production. In the early 1900s, Henry Ford put such concepts and principles into practice. Frederick W. Taylor's "scientific approach to management" focussed on specialization of labour, production efficiencies and time and motion studies in manufacturing companies. The Western Electric studies of the 1930s were intended to evaluate scientifically the physical performance of workers and improve production. Instead, the studies provided early insights into the motivation of workers on the assembly line. World War II provided major impetuses for advancing the scientific analysis of productive (military) operations and mass production. Since then, re-orienting military production to industrial and consumer markets has required ever-advancing reviews of productive capabilities, both physical and human. Enterprises in the former Soviet Union and China are going through such processes of productive change with dramatic economic, social and political consequences. For a variety of reasons, e.g., socio-political transformations of economic systems, pressures to reduce costs, improve the quality of products and services as well as streamline their supply, managers worldwide are experiencing growing demands for the reviews and advancement of their operations. Ever more organizations are constantly evaluating their operations as an integral part of increasing productivity, remaining competitive and surviving in ever-changing and challenging environments, often driven by innovations and advances in technology, increasing global competition and expanding trade and markets.

Every organization and its management have their own unique set of problems, issues and areas of operations review. One common set for manufacturers includes:

* technology and design of products and services;
* production capacity, location and distribution;
* operations' processes, jobs and facility layout;
* inventory ordering, flows and levels;
* industrial scheduling;
* personnel scheduling; and
* product and service quality. Based on Elwood S. Buffa, *Modern Production Operations Management,* New York: John Wiley and Sons, Seventh edition, 1983, *in passim*.

Simply stated, operations reviews focus on the productive and non-productive activities of the organization and whether or not they are meeting prescribed measures of performance. Such measures may be well-justified, substantive and systematically researched and proven, e.g., metal tolerances in vehicles or percentages of chemicals in pharmaceutical products. Other norms may be intuitive and perceptual, like a marketing manager or client saying "this ad layout just doesn't do it for me" or a dentist asking a patient how the newly filled tooth feels. What a range of "measures".

While experienced managers may use perception and intuition for parts of their reviews of operations, applying more well-defined measures, techniques and methods of science in logical and systematic way is the essence of operations analysis. Since the

"floodgates" of computerization opened in the 1960s, numerous quantitative approaches, hardware and software programs have been developed for use in operations reviews. Computers have expanded the capacity of operations specialists and management to evaluate enormous amounts of data and comprehend the complexity, conditions and performance of their productive systems. Decision criteria have been programmed for managers and electronic systems to seek, if not achieve, optimal results in organizational operations.

Computer simulations have enabled managers and their staff to introduce the constants and variables of an operations situation, prepare alternative courses of action, to test, apply and validate reliable and verifiable measures and examine the results of the simulated tests. Operations techniques such as linear programming, queuing theory and Monte Carlo methods continue to have worthwhile applications but have been surpassed by specialized programs, many of which have been based on and evolved from previous operations research approaches. A variety of quantitative models have been facilitated by computers' increased power, capacity and range of applications. Physical models such as product prototypes, scale models of automobiles, airplanes and buildings have advanced dramatically with the use of computer graphics. Abstract schematic models as basic as breakeven charts, spread sheets and critical path methods and as advanced as space flights and laser surgery have been developed electronically. Advanced mathematical models, the ultimate in abstraction for the average manager, utilize computers to develop, test and manipulate formulae and equations that few other than Einstein-like geniuses understand and apply. At the other end of the quantitative-qualitative spectrum are the subjective factors such as human values, purposes, visions and objectives that managers consider and use to evaluate people-dependent systems, projects, programs, processes and activities. Heuristics, i.e., non-programmed, trial and error ways, are used often as a prior stage of programmed decision making.

Lest managers think that such approaches are only for scientists, engineers and computer geeks, they ought to remember that the overriding characteristics of operations analyses cum reviews is an *orderly process that is applied to operating situations for the purpose of solving problems and making decisions optimally*. Such characteristics are inherent in most management jobs throughout an organization. Having clear purposes and/or definitive objectives and goals as well as appropriate and orderly processes are essential for successful operations analyses. TSMP Activities1, 6 and 7 are particularly relevant. Other vital characteristics of such reviews include:

* a predominant concern about issues or problems, their identification, analysis and solution;
* the presence and application of model building, testing and application;
* endeavoring to predict the logical consequences of alternative courses of action, certainly appropriate for operations management; and
* the use of interdisciplinary teams and methods for solving operations problems.

For many managers, especially in retailing and services sectors, such reviews may seem esoteric and needless. A study in Australia indicated otherwise. It found that manufacturing, engineering, mining, data-processing, management consulting and

banking firms were all using full-time operations researchers. G. M. Marinoff, "Operational Research in Twenty Companies in Australian Private Industry", *Operational Research Quarterly,* vol. 26, Issue 2, 1975, p. 369. The predominant types of issues to which such research was applied included coordination (33%), forecasting (13%), production (10.5%), finance (10.5%), distribution (7%), marketing (6.5%), inventory ((5.5%) and miscellaneous other areas (14%). Clearly, a wide range of applications for operations research and evaluation was evident from the study.

Approaches for Operations Reviews

General approaches

In their most fundamental form, the review of operations can be as basic as "eyeballing". An experienced manager can walk around a plant, store or office and make astute and compelling observations about the *modus operandi* of the place. The floor manager of a retail store is able to see how many customers are just browsing, how many are interested in a display or assortments of merchandise, how many are handling and inspecting merchandise, conversing with sales personnel and, ultimately, making purchases. A plant manager can walk around a production facility and observe the flow of jobs being produced, the equipment that is idle, the employees who are working and/or talking and check production records to gain a clear sense of the operations' productivity. Service and aeronautical experts check vital operating parts and sub-systems of airplanes on the tarmac between flights while passengers are being off- and on-loaded. Deviations from specified standards are reported, often leading to more thorough inspections by teams of operations experts. Problems or difficulties in the work place are taken "back to the office" where they are evaluated more thoroughly, maybe discussed with other managers and specialists, including some "higher up the ladder". If the situations merit further examination, experts are retained, given specified terms of reference and directed to study, analyze and recommend optimal, including feasible, courses of action.

A "scientific" approach to operations reviews

While various scientific approaches may be taken to operations reviews, the following generic process serves most managers reasonably well, at least at a preliminary stage of evaluating operations. It includes a series of five steps or phases.

1. <u>identification and explication of the operations situation to be reviewed and analyzed, particularly its priority issues and/or other problematic factors.</u> Basically, identifying a problem involves some derivation from accepted norms or standards. Managers are cautioned to distinguish symptoms from the "root causes" and not to be distracted in their efforts to hone in on the basic problem(s). Return to the opening paragraph of this Activity. Is the "root cause" or core problem the chaotic state of the lawyer's office or its' mismanagement? Such situations commonly include managerial deficiencies as well as problems related to physical assets and their optimum utilization, e.g., production lines and equipment, inventory systems and electronic information systems. They also include strategic management situations similar to those encountered by Canada Post when it hired a management consultant to review its general management

and develop an operational strategic management process (SMP). Subsequently, the forerunner of the TSMP was developed.

2. formulating, elaborating or detailing and testing, the operations model. While discussing operations issues, managers often draw "doodles", little pictures or schematics of the situation which help them visualize the components and their interrelationships. If they have a systems orientation, the "little pictures" may show the interactions and interdependencies of the related operational components. Such "little pictures" often provide the basis of a model, albeit relatively primitive. To refine a model, hypotheses or sets of testable positive and/or negative statements of cause and effect may be developed. The more specific the statement, the easier it will be to determine ultimately if it is true or not. Organizations with the appropriate technological capabilities, e.g., vehicle manufacturers, industrial design companies and advertising agencies, utilize computer graphics to develop their models through various stages, ranging from preliminary to finished product. In the TSMP, Activities 5, 6 and 7 are the most pertinent, especially the quantitative targets in goal-setting. Developing the basic framework of the TSMP for Canada Post required months of study, discussion, design, evaluation, revision and refinement before it was presented to and accepted by senior management and ultimately used in its extensive operations.
3. gather relevant information and intelligence and apply the model. Adequate inputs into the model and hypotheses development processes are necessary if the review and its inherent analyses are to be substantive and useful. Activities 2, 3 and 4 of the TSMP are relevant. Once the hypotheses are accepted or rejected and the model is approved, they are usually introduced incrementally. In more practical terms, hypotheses formulation, testing and application will not be used. Instead, experienced managers will identify, evaluate and utilize proven models, frameworks or approaches incrementally and, typically, on an experimental, trial and error basis. Models are like maps which lay out the situation graphically and provide various routes to guide managers in resolving their issues. They are not to be used slavishly but rather intelligently and flexibly in pursuing courses of action to resolve problems and achieve the aims of the organization. At Canada Post, managers initially used the SMP for strategic planning purposes. Through refinement, it was expanded into a more complete strategic management process. Subsequent development lead to the integration of tactics into the process.
4. evaluating the results. Like most maps when they are first drawn and used, mixed results occur. By using various types of simulations, models and hypotheses operations can be applied, tested, refined and developed toward optimality. Even with such modifications in the model, implementation provides the "acid test". Like most programs, processes, activities and resource allocations, putting them into action is incremental thus allowing each increment to be evaluated for its impacts on performance. Deviations from standards raise alarms to which staff and managers are expected to react with timely, corrective actions. Canada Post managers needed a process that they could use for strategically planning their operations on an integrated, annual and rolling forward basis. Initially, the modelled approach lacked sufficient streams of current information and intelligence about critical changing environmental forces and conditions, notably

labour relations, some competitive services and customers' perceptions of service reliability. In the TSMP, Activities 8 through 13, 18 and 19 are the most relevant.

5. implementing the optimal program and process. Oftentimes, managers must make difficult decisions about the alternative courses of action. ("That's what they are paid the big bucks for.") If one or more option is justified, by rigorous analysis and sound judgment, then choices may be made based on a well-formulated set of critical and substantive criteria. Such norms can be prioritized by weighting them for relative importance. Choices will be made, action taken and the subsequent or consequential performance will be monitored. In the TSMP, Activities 20 through 27 are applicable. In the case of Canada Post, managers utilized the planning operations models and subsequently modified it based on the experience they derived from using it. Ultimately, the strategic planning process was implemented successfully and became the basis for the TSMP.

To varying degrees, a generic "scientific approach" provides a base for operations reviews. With the advancement of electronic systems and programs such methodology has been subsumed. Given the great selection and availability of software, either generic or customized for specific uses, the approaches that follow are intended to outline other generic approaches to performing the review of operations.

Optimization models

The adaptation of a basic "scientific approach" just outlined illustrates one project that was used to develop an incremental optimization model for strategic decision making. Such models are used by management in an effort to choose the best strategic and/or tactical alternative(s) in a situation characterized by various issues and complex problems. Such decision making efforts are often accomplished by the maximization of desired measures of utility or value. Richard J. Tersine, *Production Operations Management: Concepts, Structure and Analysis,* New York: Elsevier Science Publishing Co., Inc., Second Edition, 1985, p. 76. Among the many approaches taken to optimize operations are:

1. analytical optimization. The "best" alternative is arrived at by such direct, non-representative processes as economic order quantities, marginal analyses and differential and integral calculus; and
2. algorithmic optimization. With this approach, the "best" alternative is achieved by a repetitive, iterative process, e.g., integer or quadratic programming. *Linear programming* is an optimization methods used to allocate resources to competing alternatives, each of which has varying degrees of utility. It is intended to optimize a value system subject pragmatically to a set of scenario-based constraints, e.g., optimistic, pessimistic or realistic. For example, the *assignment method* is a linear program that is used to determine the optimal allocation of resources. It provides an efficient iterative technique that finds an optimal assignment schedule without explicit consideration of all the possible alternatives. The assignment method is a simple type of linear programming when *n* tasks can be performed by any one of *n* agents.

"Ethos" or "credo"

In the culture of many organizations, a characteristic set of values, beliefs and attitudes is present that includes the production and distribution of top quality products and/or services. Such a quality ethos is often manifested in a credo or slogan such as "Quality is Job One" or "Creative Excellence in Printing and Publishing". Managers and personnel throughout the organization are acculturated, even trained and conditioned, to sense, think and act in ways that achieve, maintain and progress incrementally to such ever-changing and progressive or advancing attributes that are desirable for their products, services and reputation or image.

Systematic monitoring

Such monitoring might be done simply by a manager taking an intelligent or sensible "walkabout" through the work place, be it a plant, store, office or other locale. The manager checks the work schedule for the day, observes the performance of the employees and their production processes, their work environment, equipment and availability of materials and supplies, talks to supervisors, workers and others who have intelligence and information about the operations and assesses such inputs "on the spot". In more complicated situations such as large organizations, such practices are much more difficult but not impossible nor ineffective. For decades, Adolph Coors would "visit the plant" every day, typically in the morning. Mr. Coors picked a different section of the plant to visit each day. He would talk to employees about their families, good fishing holes, their personal lives as well as anything related to their work and the corporation. For decades, Coors Brewing Company was an industry leaders in employee relations, production and profits. Another exponent of hands-on management was Ed Carlson, former CEO of United Airlines.

> "I'd get off an airplane, I'd shake hands with any United employees I could find. I wanted these people to identify me and to feel sufficiently comfortable to make suggestions or even argue with me if that's what they felt like doing." Peters and Waterman, *op. cit,* p. 290.

In the 21st century, and especially since "9/11", the capacities of electronics, sensors and other technologies have made systematic monitoring pervasive throughout organizations of all sectors and sizes. The justified concern that "Big Brother is watching" has spread from past dictatorships such as Hitler's Third Reich and the communistic Soviet Union to the Bush-Cheney Administration of the United States in 2005. Monitoring, even spying, has spread to government offices and agencies, plants, stores, banks and numerous other private and public sector operations. While such monitoring may be needed to optimize the operations of an organization, it must be guided and controlled by civil rights, other laws and regulations and moral codes.

"Exception"

The extent, size, speed, complexity and cost of monitoring have reached the level that "management by exception" has relevant and growing application. "It is impossible for management to maintain a personal check on all the happenings with such (complex)

systems." C.D. Lewis "Monitoring and Management by Exception", in C. D. Lewis *Operations Management in Practice,* New York: John Wiley and Sons, 1981, p. 429. Many Corporations monitor the performance of production lines, personnel, programs, activities and resource allocations based on samples. A pressman picks out a printed page or newspaper and inspects it quickly and expertly as hundreds or thousands of copies a minute roar through the multi-million dollar system of full color presses. Quality control is based typically on sampling and deciding if the operation is meeting standards ... or not. Where necessary, e.g., performance deviates unacceptably from established standards, then "exception reporting" is used.

Operations audits

One of the purposes of operations audits is to identify discrepancies between actual and desired performance benchmarks and goals. Such audits are derived from accounting practices and have been applied increasingly to a wide variety of operations, including manufacturing, marketing and financial activities. The use of valid and reliable check lists is basic to operations audits. They need to be adaptable to situations and include a variety of dimensions, standards and measures that are applicable to the unique circumstances being audited. Dimensions for evaluating operations are numerous but may include degrees of capital intensity, extent of equipment specialization and technological development, degree of worker flexibility, degree of vertical integration, extent of customer and work force involvement in the process and the frequency of process innovations. Krajewski and Ritzman, *op. cit.,* p. 778. The authors go on to present a more complete list of 43 vital signs for operations management that range from absenteeism to facility utilization, variation in monthly production rates and changes in sales and profit margins during the past year(s)

Control

Broadly defined, control is the process of monitoring, measuring, evaluating and adjusting the performance of the operating system so that it meets stipulated standards. For some managers, control is an essential responsibility (even a mania for "control freaks"). Control provides a primary purpose for the Review Stage of the TSMP. Control serves various purposes and aims, e.g., achieving or maintaining the quality of the operations and its resultant products and/or services, flow and level of finances and other resources and a general discipline for the organization and its people. One control process has been outline in five phases. Chase and Aquilano, *op. cit.,* p. 538.

Phases of Control

Sensing – Starting with the five human senses and organizational sources such as records, reports, charts, personal observations and mechanical devices, and then advancing to a growing number of technological sensors, managers are enabled to determine the status of the operations.

Comparing – For Chase and Aquilano, comparing involves matching operating data with pre-determined standards of performance. Such standards might include product specifications, desired output levels, customer requirements and other specified

norms of production and service. Once the control system is designed and used correctly, the "malfunctions" should be identified in this phase.

Analyzing – In the TSMP, comparing is considered to be the essence of analysis. For Chase and Aquilano, they are separate phases. To them analyzing is concerned with detecting the source(s) and cause(s) of the malfunction.

Decision making – Astute managers have alternative choices or alternative courses of action available that they can use in the event of changing circumstances, operational malfunctions, organizational opportunities, threats or other challenging situations. Such alternatives need to be well-developed responses to anticipated or actual forces and conditions such as developed in Activity 5, Forecasting Futures. Many of the forces and conditions are in the external environment and uncontrollable but operationally manageable to some extent.

Taking corrective action – This is the ultimate test of control. Actions need to be taken that will align performance with the organization's standards, goals and objectives. At least three generic courses of action are available: change the performance measures if they are unreasonable or unattainable; change the performance of the organization; or a combination of the previous two actions. Obviously, more situation-specific alternatives will likely be considered and acted upon. To achieve optimality in taking action, all relevant intelligence and information must be sought, all possible alternatives must be considered and sensitive factors such as time, costs and risks need to be evaluated. Using the TSMP as a reference framework, all or some of the first 21 Activities might be useful before taking corrective action.

Quality control

In some industries, some organizations and even some countries, quality control has been a major and specific focus of operations' evaluations. It has developed into a philosophy and set of principles aimed at continuously improving organizations and their operations. J. A. Swift, *Introduction to Modern Statistical Quality Control and Management,* Delray Beach: St. Lucie Press, 1995, p. 3. It has become so encompassing that it is commonly referred to as Total Quality Management (TQM). Some of the basic tenets of TQM are: management decisions are based on facts; quality is customer driven; quality improvements are proactive and focus on preventing problems; achieving process optimization; and TQM is a never-ending process of continuous improvement. Seven of the basic quality control tools are check lists, graphs, histograms, Pareto charts, cause and effect diagrams, scatter diagrams and control charts. *Ibid., p. 99.* These tenets and tools are merely a few among many that are available for managers and practitioners to use in quality control.

Trouble-shooting approaches

Following is a summary of diagnostics that provides additional and various approaches to identifying operational problems. Van Court Hare, *Systems Analysis: A Diagnostic Approach,* New York: Harcourt Brace and Jovanovich, 1967, pp. 259-72. Although some of these diagnostic approaches are out-dated, they still provide ways of thinking about and evaluating operations in an organization, usually in combination with other tools and techniques.

1. detection at a glance. This approach could be part of systemic monitoring, especially at the earliest, most rudimentary stage. Basically a manager, supervisor, employee or other person looks at the operation directly or reads meters, watches trouble lights, smoke detectors or other warning mechanisms. Miners check gas meters for toxic fumes in a mine shaft, mechanics listen to motors and physicians listen to their patients' hearts and lungs through their stethoscopes.

2. short and continuity checks. Interconnections and components of a system are checked one at a time. Plumbers and gas company employees check the connections in water and natural gas lines.

a. *signal tracing.* A standard signal is inserted into a multistage system. Successive components within the system are monitored for prescribed outputs.

b. *signal substitution.* A prescribed signal is inserted into a subsystem or independent component of a system. Then each stage of the system is monitored for prescribed outputs.

3. creating independence. Dependent components are tested independently of operating systems, according to separate test specifications.

4. binary splits. A system network or operational set is halved successively to reduce the number of checks that have to be made. For those who are mathematically inclined, a series of formulae are available to determine the number of check required.

5. stress tests. This approach is generally applied to avoid malfunctions. It involves the overloading or underloading of a system to identify and remedy weak components. Doctors use such tests when they check on the condition of a patient's heart. In a similar vein, automobile manufacturers and glass makers subject their products to stress tests to determine what their capacities are before they are sold.

6. block substitution. A block or a module, consisting of interrelated components, is tested by using successive replacement of components with a new block or module. This procedure enables simultaneous fault finding and corrections.

Although other approaches and methods are available, the selection provided enables managers to review operations from various perspectives and degrees of sophistication. From here, the Review Stage continues with Activity 15, the review of human resources and the organizational components of the TSMP.

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