



TITLE

MEASURING THE COST OF CAPACITY

CREDITS

This statement was approved for issuance as a Statement on Management Accounting by the Management Accounting Committee (MAC) of the Institute of Management Accountants (IMA). IMA appreciates the collaborative efforts of The Society of Management Accountants of Canada (SMAC) and the Consortium for Advanced Manufacturing—International (CAM-I). Appreciation also is extended to C.J. McNair, Babson College, and Richard Vangermeersch, University of Rhode Island, authors of the manuscript.

Special thanks go to Randolph Holst, SMAC Manager, Management Accounting Guidelines, for his continuing project supervision and to the members of the focus group for their suggestions that improved the document. IMA representatives on the focus group were MAC Chairman Alfred King, MAC members Sally Claybourn-Evans and Dennis Daly, and Lou Jones, trustee of the Foundation for Applied Research, Inc. Alan Vercio represented CAM-I on the focus group.



MEASURING THE COST OF CAPACITY

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I. RATIONALE

Every organization has a capacity, or potential, to do work. No matter what resources a company has or what types of goods or services it provides, maximizing the utilization of this capacity is a necessity, not an option. In the demanding global marketplace, eliminating all forms of waste is the key to gaining and maintaining a sustainable competitive advantage.

Maximizing the value created within an organization starts with understanding the nature and capability of all the company's resources. Never before has this understanding been so difficult to gain. Competition, capital decay and a technological explosion are forcing more rapid change in the processes used to deliver value, even as product life cycles shorten. Given these forces, and given advances in engineering and general business practices, the survival—let alone prosperity—of a company depends on the effective deployment of its physical assets, people and processes.

Effectively managing the cost of capacity is a key to unlocking the value-creating potential of a company's resources. The concept focuses on identifying improvement opportunities. Consisting of a set of action-based tools for making products and providing better, faster and cheaper services to customers, the development of capacity management systems is synonymous with best management practice in management accounting. Reaching this goal is a journey, not a destination; there is no one, universally correct model, measure or approach to capacity management and measurement in complex, modern organizations.

II. SCOPE

This guideline is intended to accomplish several purposes. First, it has been written to increase awareness and understanding of the wide variety of capacity cost measurement practices.

Second, it defines capacity from several different perspectives while describing various approaches that organizations use to better determine their cost of capacity utilization.

Third, the guideline provides an overview of implementation issues, and the organizational and management accounting challenges embodied in capacity cost measurement.

The concepts, tools, techniques and examples contained in this guideline are structured to apply to all organizations that produce and sell a product or service including:

- large and small organizations;
- enterprises in all business sectors; and
- all managerial or organizational levels.

This guideline will help management accountants and others:

- understand the relationship of capacity cost measurement to the organization's goals, strategies and objectives;
- appreciate the organizational and management accounting challenges inherent in measuring the cost of capacity; and
- broaden employee awareness and obtain buy-in for more effectively measuring and reporting the cost of capacity.



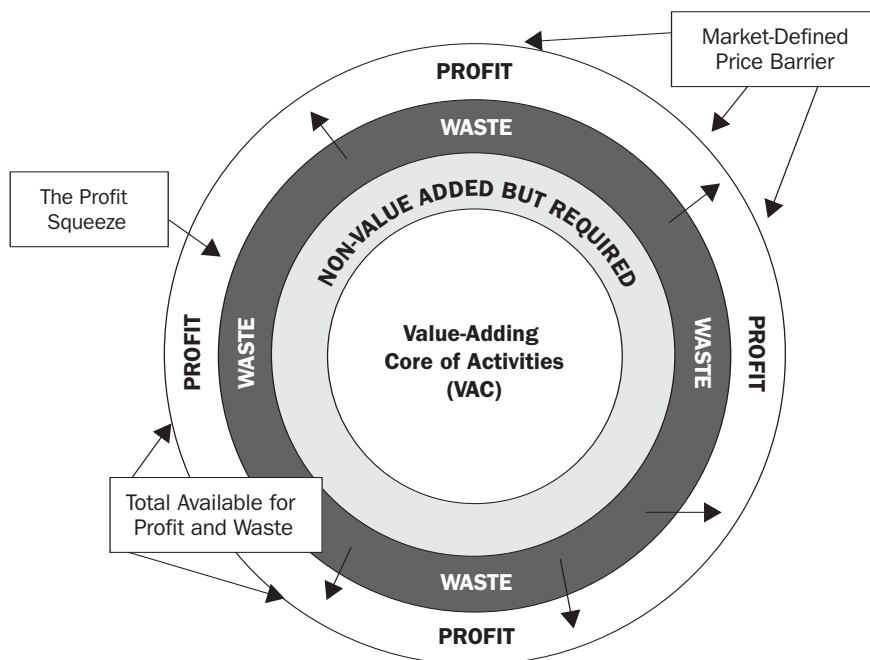
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III.DEFINING CAPACITY COST MANAGEMENT

This guideline is based on the underlying belief that capacity, and capacity cost management, is an essentially elusive concept. No single tool or single view of capacity cost management is best. No single, magical capacity number will work in all companies, all settings or all decision contexts. Rather, an overall philosophy or approach to capacity supports a company's efforts to improve performance through better management and utilization of its resources.

As a starting point, capacity cost management incorporates the basic economics of the marketplace. *Market price* is heavily influenced by the customer's willingness to pay for the perceived value delivered by a product or service. As suggested in Exhibit 1, the market price represents an upper boundary on the amount of resources a company can use in providing goods and services to its customers. If the company uses excess resources, then it suffers a loss. The logic of the market dominates, whether the organization operates in the public or private sector.¹

EXHIBIT 1. THE BASIC ECONOMIES OF BUSINESS



Source: McNair, 1995.

1 In applying Exhibit 1 to the public sector, the concept of a market-defined barrier for the total resources consumed by an activity remains. Instead of "price," though, the willingness of the populace to pay the taxes and support the individuals and programs that constitute the bulk of government services becomes the constraining factor. Regardless of the source of the funds used to finance the activities of an organization, it is subject to the ongoing assessment and demands of the "market."



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Exhibit 1 also illustrates that market price is based on a core set of *value-adding activities* (VAC) and attributes of a product or service. If this value-adding core is reduced, market price may fall. Increasing the size and quality of the VAC has the opposite effect: market price may increase. Thus, understanding the VAC is the essential first step in ensuring a company's long-term success. (In employing this logic, it is crucial to note that value to the customer does not, and should not, be equated to cost to the seller).

Profit, waste and non-value-adding activities fill the area between the VAC and market price. Effectively managing the utilization of all elements of the organization and the greater value chain—their capacity—adds to profit. Ineffectiveness and waste reduce profit.

From this perspective, the essence of capacity cost management is:

To profitably manage the value-generating competencies, processes and capacities of an organization in ways that support the strategic direction of the business.

A company achieves this objective by pursuing the following goal:

To minimize the unit cost of production within the VAC and to minimize waste by establishing appropriate benchmarks, improving related processes and utilizing resources more effectively.

Managing capacity cost starts when a product or process is first envisioned, and continues through the subsequent disposal or reassignment of resources downstream. Effective capacity cost management requires:

- in the short run, optimizing capital decisions and the effective and flexible use of investments that have already been made;
- maximizing the value delivered to customers;
- helping minimize requirements for future investment;
- supporting effective matching of a firm's resources with current and future market opportunities;
- closing any gap between market demands and a firm's capabilities. At times, the firm may have excess capabilities; at others, shortages may exist. These capabilities may be physical (i.e., bricks and mortar), labor, technology or capital;
- eliminating waste in the short, intermediate and long run;
- providing useful costing information on current process costs versus those proposed in current or future investment proposals (e.g., the opportunity cost of not investing in a new asset which could provide better capacity/cost results);
- supporting the establishment of capacity utilization measurements that identify the cost of capacity and its impact on business cycles and overall company performance;
- identifying the capacity required to meet strategic and operational objectives, and to estimate current available capacity;
- detailing the opportunity cost of unused capacity and suggesting ways to account for that cost;
- supporting change efforts, providing pre-decision information and analysis on the potential resource and cost implications of a planned change; and
- creating a common language for, and understanding of, capacity cost management.

Capacity cost management creates a number of challenges, at all levels of the enterprise. Organizations must redefine capacity and focus



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their capacity management efforts so that the actual costs and implications of current utilization levels and idleness are understood and acted upon. Only utilized capacity results in profits; all other states of capacity reduce the firm's potential profits. The capacity cost measurement system must make this basic economic fact visible.

IV. THE ROLE OF MANAGEMENT ACCOUNTANTS

Management accountants collaborate with others on a cross-functional basis in creating, implementing and monitoring capacity cost measurement and reporting policies and practices. Because management accountants have in-depth knowledge of costs and their behavior under various operating conditions, they can provide essential information and estimates of the value-creating potential of a company's resources.

Management accountants can advocate programs to improve capacity utilization, providing solid economic and strategic analysis of the risks and returns of various plans to enhance or modify existing capacity. By defining and reporting the costs and causes of idle and nonproductive capacity, management accountants can direct attention and activity toward improving overall organizational performance.

Management accountants should assist in defining and developing a comprehensive capacity cost measurement and reporting system that provides vital information about current utilization rates, the costs by cause of idle and nonproductive capacity, and the current available capacity of the company by operating unit and process.

Management accountants can instigate strategic planning involving the critical reappraisal of product life/market growth and market share through a

forecast of capacity costs and limits.

These efforts can enhance the role of management accountants in the organization, allowing them to help in improving profitability in the short, intermediate and long term.

V. A COMMON LANGUAGE FOR CAPACITY COST MEASUREMENT

It is difficult to accomplish the essence of capacity cost measurement without a common language for discussing and measuring capacity utilization. While different contexts or settings may shift the focus and critical elements of success in capacity cost measurement, the basic definitions and concepts that guide best management practice in this area remain unchanged.

Six key issues that combine to create the basic language of capacity cost measurement are:

- resource capability;
- baseline capacity measures;
- capacity deployment;
- capacity utilization measures;
- time frame of analysis; and
- organizational focus.

Resource Capability

A business requires enabling resources and an organization ready to use them. These resources provide the capability to produce revenue. The flexibility of resources and the ability to match them to the specific needs of the organization and its customers set the limits for capacity management. Specific concepts and definitions of resources include:

- *resource*—the potential for creating value that an organization buys and uses to support its activities and outputs;



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- **resource capability**—the amount and type of work that a resource can support; the storability, flexibility and useful life of a resource;
- **cost of preparedness**—the initial and continuing costs of readying resources for activity or use;
- **estimated cost**—the total economic value of all resources consumed in performing an activity over a predetermined period of time, or:

$$\text{estimated cost per activity completed} = \frac{\text{total cost of required resources}}{\text{maximum number of activities supported}}$$

- **behavior of costs**—the patterned matching of inputs (resources) to the outputs (activities, products and services) that they support;
- **cost variability**—the relationship between the amount of work that is done and the units or amount of resources consumed, stated in either physical units or time; the change in total cost that occurs when a firm makes one more unit of output or provides one more unit of service to a customer; and
- **relevant range**—the range of output volume, assumptions or practices over which a cost estimate is reasonably accurate.

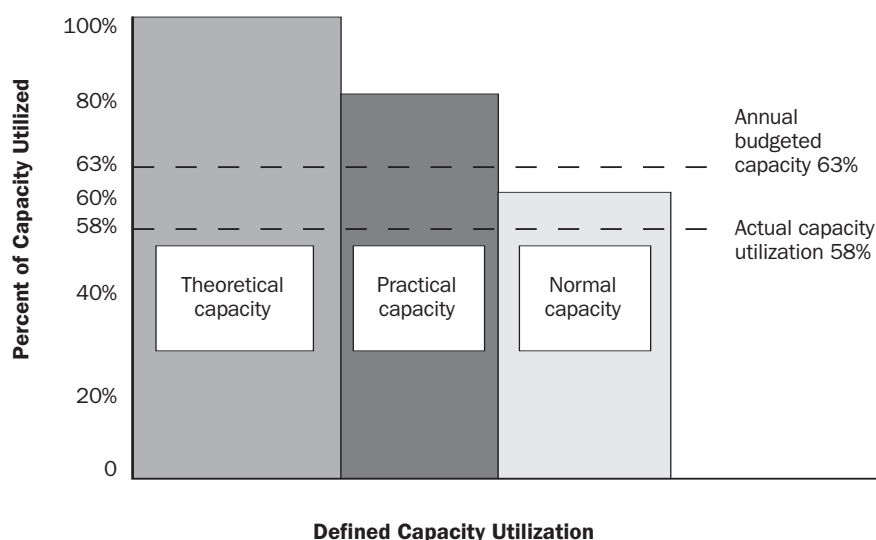
Resources, and their capability to support value creation, lie at the heart of capacity cost management. The ultimate goal is to ensure that every resource is effectively and efficiently used. The benefits of preparedness must outweigh its costs.

Baseline Capacity Measures

Resources represent the capability to do work. Applying resources to specific processes and outputs determines how much of that capability can be converted to profits. Just as important as the size or total cost of preparedness is the assumption about how much work or output these resources can support. The total expected work, or baseline capacity measure, for a capacity management system consists of one or more of the following measures, as illustrated in Exhibit 2:

- theoretical capacity;
- practical capacity;
- normal capacity;
- annual/budgeted capacity; and
- actual capacity utilization.

EXHIBIT 2. BASELINE CAPACITY MEASURES





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- *theoretical capacity*—the optimal amount of work that a process or plant can complete using a 24-hour, seven-day operation with zero waste, i.e., the maximum output capability, allowing no adjustment for preventive maintenance, unplanned downtime, shutdown, etc. Because theoretical capacity by definition has zero nonproductive capacity, this is the only situation in which productive capacity can equal 100 percent of total capacity. All other definitions of capacity consist of both productive and nonproductive capacity;
- *practical capacity*—the level of output generally attainable by a process, i.e., theoretical capacity adjusted downward for unavoidable nonproductive time: such as set-ups, maintenance or breakdowns;
- *normal capacity*—the average, expected, utilized capacity of a machine, process or plant/unit over a defined period of time (day, week, month, year, etc.);
- *annual budgeted capacity*—the planned utilization of a machine, process or plant/unit for the coming year, often stated as earned hours, machine hours, units of output or percentage of normal capacity; and
- *actual capacity utilization*—the capacity actually used for period production, often stated as earned hours, machine hours, units of output or percentage of budgeted or normal capacity.

The choice of the baseline capacity measure has a significant impact on the calculated cost of capacity and on overall management policies and procedures. While companies use each of these baselines, it is best practice to define and utilize *theoretical capacity* for management reporting. Theoretical capacity baselines ensure that all value-creating potential is actively managed, reducing the potential for unneeded plant expansions and for incurring other forms of waste.²

These basic definitions establish the nature and magnitude of the reported cost of capacity. Representing the rated, or baseline, capacity for a process, this measure provides a framework for identifying and valuing various forms of capacity deployment and their impact on overall utilization.

Capacity Deployment

Having established the baseline capacity of a process, capacity cost management turns to planning, assessing and managing the deployment of a firm's value-creating potential to meet customer needs³. Effective capacity deployment requires an understanding of the following:

- *productive capacity*—capacity that provides value to the customer. Productive capacity is used to produce a product or provide a service. It must be based on the theoretical, or maximum, value-creating ability of the company's resources;
- *nonproductive capacity*—capacity neither in a productive state nor in one of the defined idle states. Nonproductive capacity includes setups, maintenance and scrap;

2 Several issues need to be recognized in developing and using theoretical capacity baselines. First, in service industries it may be very difficult to pinpoint the "maximum" work an individual can do in the allotted time. In addition, the recognition that "24 hour-7 day, the best you can be" is not a concept that can be applied to one individual, but rather the entire team and process.

A second, and equally important, issue revolves around the fact that, while easy to talk about "in theory," theoretical capacity is difficult to isolate in any setting due to the constantly changing nature of work and resources. New concepts, such as "fuzzy set theory," promise to provide a way to recognize the uncertain nature of capacity (see Siegel, 1995).

3 A company's value-creating ability should not be equated, at any time, with its cost of doing business, given the current assets and processes at its command. The objective of capacity cost management is to ensure the minimization of waste, and through improved management awareness and techniques, to increase the cost-to-value ratio reflected in a company's profitability and marketability.



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- *planned nonproductive capacity*—capacity planned for use that is temporarily out of use due to process variability, such as the lack of materials, machine or process breakdown, or delays;
- *planned idle capacity*—capacity not currently scheduled for use; planned idle capacity might be planning for preventive maintenance; and
- *excess capacity*—permanently idle capacity that is not marketable or usable under existing operating or market or policy conditions.

Through effective deployment and design of work and daily management processes, organizations can productively use much capacity that had been reserved for contingencies. This opportunity to adjust capacity is the most attractive from a cost management viewpoint because it utilizes the inherent flexibility in existing capacity. For example, by reducing process flow time, an organization effectively increases its available capacity without any investment in fixed assets.

The best time to control capacity costs comes during the initial decision and design of the capacity. Design dictates the cost of capacity. Reserving capacity also dictates the cost, not just when that capacity is used to meet heightened demand but long afterward. If demand slackens or the nature of the product's ability to generate customer value changes, excess or reserve capacity increases the burden that the organization must carry.

Assessing specific capacity investments begins after the organization has eliminated all options for capacity realignment and reduced capacity requirements. It is important to evaluate whether the capacity that is put into place is the appropriate investment and whether or not the risk associated with achieving the investment's objective is acceptable. This risk is driven by the situations that organizations encounter outside the

traditional boundaries of capital investment analysis, and include economic, commercial, technological and implementation issues.

Underestimating, or failing to estimate, the impact of risk can completely eliminate any gain sought in managing the capacity. Organizational risk can include aspects such as training, synchronization with ongoing production and organizational performance responsibilities.

When making capacity decisions, organizations must balance the impact of the decision on customer value measurements, such as defect escapes, product delivery performance and product prices. Decisions to alter capacity utilization should match the company's ability to alter its capacity utilization according to current and future market demands.

Capacity Utilization Measures

Once a process or system has been deployed, or placed into one of the key productive states, the focus of capacity cost management turns to tracking and reporting current capacity utilization and its profit and cost implications. The key factors in assessing capacity utilization include:

- *throughput*—the total value obtained from a process during a specified time period; the rate at which a system generates revenues through sales;
- *activation*—the amount of time that a process is physically used or is active during a period, whether or not the resulting output is required to meet customer needs (e.g., rework represents activation, not utilization);
- *waste*—nonproductive use of a company's resources;
- *efficiency*—total utilization as a percentage of baseline capacity;



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- *standby capacity*—excess capacity that is used as a buffer to absorb unplanned shifts in total activity and the impact of other forms of variation on a process;
- *actionable capacity*—capacity utilization that can be affected by a specific manager or management group, resulting in higher or lower total resource requirements; and
- *cost of capacity*—the total economic value of all resources needed to keep a process at a specific stage of deployment or preparedness.

Capacity utilization costs are not limited to machine or asset depreciation charges. They include all of the indirect resources, or overhead, that are consumed in order to keep a process in a state of preparedness. Theoretical capacity is derived from those physical assets, tools and resources that can sustain round-the-clock operation. Because people cannot achieve this sustained level of operation, they should be considered as a variable contribution to the theoretical capacity. The separation of *committed capacity costs* (unavoidable costs in the short to intermediate term) and *managed capacity costs* (avoidable in the short to intermediate term) is critical in developing an effective capacity cost management system.

The estimated cost of capacity for a process that is in a planned idle mode should be lower than that experienced during its productive periods. The cost estimates developed for capacity cost management should reflect actual resource implications of current capacity deployment as well as the opportunity cost (i.e., forgone profits) of planned idle and excess capacity.

Reflecting actual performance and its effectiveness, capacity utilization measures are the raw data for constructing management reports and

the basis for future planning and deployment of a firm's total capacity.

When matched with the appropriate cost of capacity estimate, utilization measures provide management with detailed information on the efficiency and effectiveness of current operations as well as the potential for short-term, intermediate and long-term profit improvements.

Organizations should assess the impact of supporting a capacity cost measurement system. Such an assessment includes what information is required continuously rather than on an ad hoc basis. The assessment should also include why the company would force the accounting system to continually collect data if spot checks would suffice. This analysis alone can save resources, thereby increasing a firm's capacity to meet customer requirements.

Time Frame of Analysis

The time frame of decision analysis has a major impact on a company's ability to change the cost of its capacity and the critical issues addressed by the capacity cost management system.

In the *short run*, theoretical capacity is constant; very little can be done to change the theoretical capacity of a process. Capacity cost management focuses on improving the utilization of existing resources and processes (e.g., elimination of waste).

As the period of time, or time frame, extends to the *intermediate term*, a company can act to change how the process operates. These changes can impact the theoretical capacity of the process. In the intermediate term, however, the physical structure of the process cannot be changed. In the *long run*, the entire process can be restructured. Here, theoretical capacity can



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be entirely changed, resulting in a new process structure, a new flow and a new level of potential output. The focus of capacity cost management shifts to maximizing the flexibility of existing processes in order to decrease future investment requirements.

In the long run, it is possible to employ a wide range of techniques and costing approaches to support management's efforts to adjust capacity and its utilization. These techniques may include options to acquire new capacity, outsource, sell excess capacity, lease plant and personnel, license redesign existing products and processes, and related methods to improve current and future utilization.

The second element of a capacity cost estimate is the resources required to support the process. With most costs fixed over the short run, it is difficult to change the type and amount of resources needed to make a product or provide a service. Into the intermediate period, a company can begin to change the type and amount of resources it uses; as the process is modified, so are the demands for resources. Finally, in the long run, all costs are variable. In the same way that the entire capacity of the line can be affected, all of the resources used to provide this capacity can be changed.

Organizational Focus

Another important dimension of capacity cost management is organizational focus. The issues impacting capacity cost management at the process level often differ from those faced in examining the entire industry value chain.⁴ Four specific levels are typically considered, including:

- process level;
- plant or sub-unit level;

- company level; and
- value chain.

The first three levels are defined by an organization and its existing structure and capabilities. The *process level*, which can range from one task to an assembly line, focuses on individual units of output. The *plant* or *sub-unit level* suggests several processes and several unique types of outputs (e.g., different product lines). At the *company level* or *strategic unit*, many different plants or sub-units (e.g., strategic business units) combine to create a complex organization that serves many markets with many different types of products and services.

Finally, the *value chain level* returns to a product or product line focus, but shifts its attention to all of the activities and resources of all organizations used to bring a good to the consumer.

VI. CAPACITY COST MEASUREMENT TOOLS AND TECHNIQUES

Combining the issues of baseline capacity measures, timeframe of analysis and organizational focus creates a framework for analyzing capacity cost management issues and for sorting and choosing from among various capacity cost measurement models as illustrated in Exhibit 3. These models are grouped according to which particular capacity baseline measure they emphasize: *theoretical*, *practical* or *normal* capacity. Each cost measurement tool, or model listed, takes a different view of the capacity cost measurement problem.

⁴ The term "value chain" refers to the complete value-creating process from the time the raw materials are pulled from the ground until a final product or service is delivered to its ultimate consumer. This approach is that taken in Michael Porter's work on organizations. When this analysis is conducted over the life cycle of a product, it expands to include a product's cost and performance profiles from "cradle to grave," or from initial design until ultimate disposal.



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EXHIBIT 3. TOOLS AND TECHNIQUES FOR MEASURING THE COST OF CAPACITY

Model \ Features	Capacity Baseline Emphasized	Primary Time Frame of Analysis	Organizational Focus
<i>Resource Effectiveness Model</i>	Theoretical Capacity	Short- to Long-Term	Process/Plant/ Company Levels
<i>Capacity Utilization Model</i>	Theoretical Capacity	Short- to Intermediate-Term	Process/Plant/ Company Levels
<i>Capacity Variance Model</i>	Theoretical Capacity	Short- to Intermediate-Term	Process/Plant Levels
<i>CAM-I Capacity Model</i>	Theoretical Capacity	Short- to Long-Term	All Levels (Potential)
<i>CUBES Model</i>	Theoretical Capacity	Short- to Intermediate-Term	Process/Plant/ Company Levels
<i>Cost Containment Model</i>	Implicit Theoretical Capacity	Intermediate-Term	All Levels (Potential)
<i>Gantt Idleness Charts</i>	Practical Capacity	Short-Term	Process Levels
<i>Supplemental Rate Method</i>	Practical Capacity	Short-Term	Process/Plant Levels
<i>Theory of Constraints Capacity Model</i>	Practical Capacity (Marketable)	Short- to Intermediate-Term	Process/Plant/ Company Levels
<i>Normalized Costing Approach</i>	Normal Capacity	Intermediate-Term	Process/Plant Levels
<i>ABC and Capacity Cost Measurement</i>	Normal Capacity	Short- to Intermediate-Term	Process/Plant/ Company Levels
<i>Integrated TOC-ABC Model</i>	Various	Short- to Intermediate-Term	Process/Plant/Value Chain Levels

These tools and techniques are not mutually exclusive; effective capacity cost management may require multiple models at the same time to assess current performance and plan future capacity deployment and utilization.⁵

⁵ It should be recognized that the 12 tools and techniques selected reflect the general state of the art as of this writing, and should by no means be seen as being the only approaches available to companies. Before embarking on a capacity cost measurement project, companies should analyze their current demands, their strategic objectives and constraints, and then search for other companies facing, and having solved, similar challenges or for an existing model that meets their needs. With the increased interest in capacity cost management, the number of tools and models can be expected to multiply in the coming years.



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Managing the cost of capacity involves more than applying a certain capacity measurement model to understand existing capacity utilization. It encompasses the entire strategic planning process. While the tools and techniques discussed in this guideline can be simply applied to track current capacity utilization and costs, they are more beneficial if incorporated as part of the intermediate- and long-term planning process. In addition, the models, while presented in light of machine or process capacity, can be applied to the performance of the entire value chain.

Under this approach, organizations could use these models to assess how well the capacity meets their original objectives and the subsequent impact on business risk. A statistical process control run chart that tracks how the capacity of the process responds to the risk factors used in the original investment is one way to apply these capacity cost management models in a broader setting.

The information provided by these models can be used to influence future decisions, to control past ones, or to provide management with the ability to analyze the impact of various alternative ways to increase or decrease utilization before a decision is made. Capacity cost management is a set of living techniques, consistently applied at all stages of the life cycle for a process, product or value chain.

Theoretical Capacity Focused Models

Resource Effectiveness Model

A capacity cost measurement model that analyzes the economic impact of capacity management decisions on company performance is the Resource Effectiveness Model. Primarily concerned with supporting planning and analysis of current and future capacity investments, the Resource Effectiveness Model is used by Hill's

Pet Food to support its short-, intermediate-, and long-term capacity decisions.

Four key measures are tracked by this model as illustrated in Exhibit 4: *resource effectiveness*, *asset utilization*, *operating efficiency* and *runtime efficiency*. Standard runtime is examined as a percentage of total available time under different operating assumptions. For instance, resource effectiveness compares standard runtime against pure theoretical capacity, while asset utilization adjusts this equation for reductions in theoretical capacity due to management policies to get plant available time.

The results of this time-based analysis are easily translated into dollars through a process costing model defined on minutes of process time consumed rather than equivalent units of production. Combining operational and financial data creates a powerful basis for analysis and decision-making that can be easily placed into capital investment models.

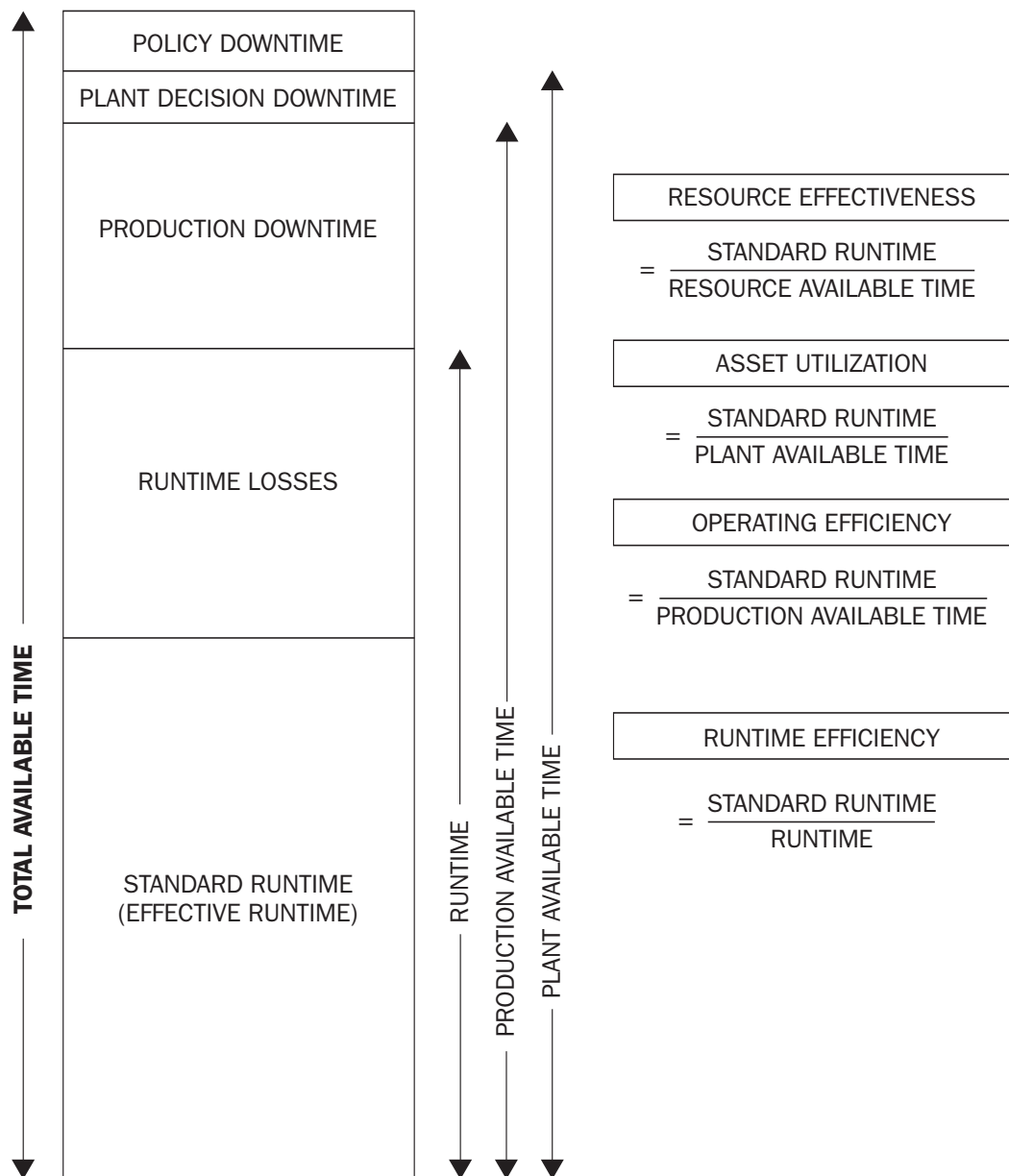
The key features of the Resource Effectiveness Model are:

- analyzes economic impact of capacity management decisions;
- supports decisions across all time frames;
- assumes that “zero waste” is the goal; and
- provides an integrated financial and operational analysis of resource decisions.

If an organization combines the information in this model with real-time data collection and reporting on the plant floor, it can gain capacity information that spans all organizational levels and time frames.



EXHIBIT 4. RESOURCE EFFECTIVENESS MODEL





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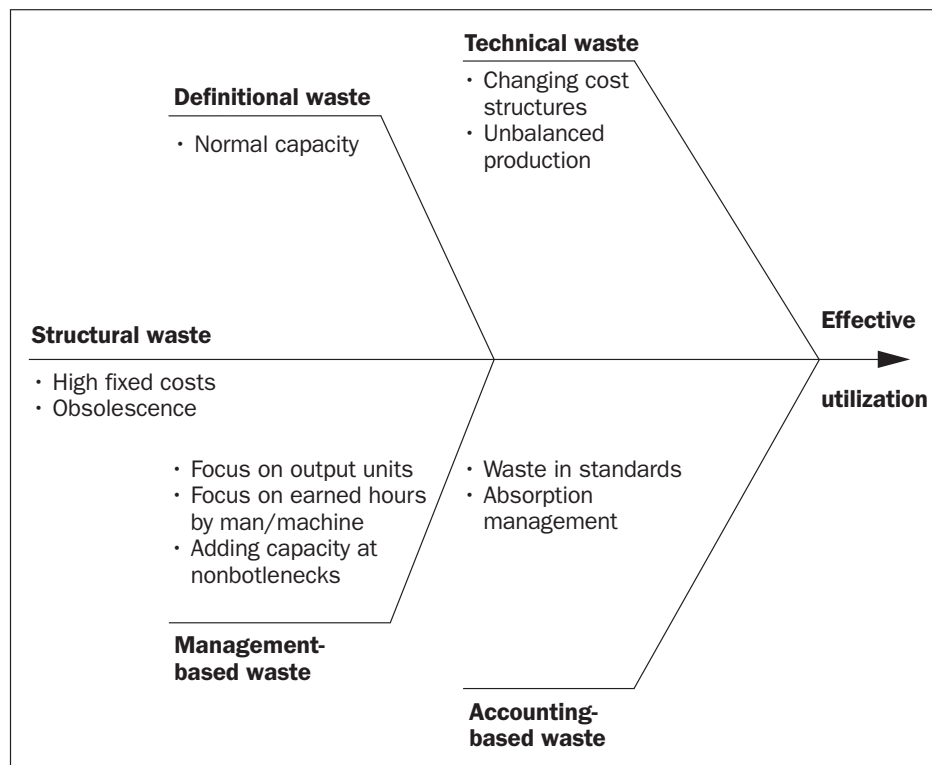
Like several new approaches to capacity cost management, the Resource Effectiveness Model recognizes that a firm should make new capital investments only if it makes full use of its current resources. The approach is recommended for all firms that use process, cellular or assembly-line manufacturing methods.

Capacity Utilization Model

Maximizing capacity utilization under the continuous improvement philosophy is based on the belief that unused resources, or resources used in ways that do not increase the value delivered to the customer, are waste. The Capacity Utilization Model focuses on identifying specific types of capacity waste using an Ishikawa fish-bone diagram as illustrated in Exhibit 5.

- *structural waste*—results from a mismatch between a company's actual capacity and that required to most effectively meet demand. It is excess capacity that should be eliminated or redeployed to other products or services in the intermediate to long term.
- *definitional waste*—results from choosing a capacity baseline measure other than theoretical capacity.
- *technical waste*—is caused by mix variation or unbalanced production.
- *accounting-based waste*—focuses on the excess inventory, standards that include scrap or waste, and related measurement problems that affect behavior and decisions in organizations.
- *management-based waste*—is driven by existing policies (e.g., five-day, two-shift operation

EXHIBIT 5. DIAGNOSING CAPACITY UTILIZATION





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versus a seven-day, 24-hour approach). It can be affected by decisions in the short to intermediate run.

The important features of the Capacity Utilization Model are:

- focuses on waste as key capacity measure;
- separates causes of capacity waste by time frames and actionability;
- supports analysis and prioritization of key capacity issues; and
- consists of systemic capacity measures.

While many capacity cost tracking models focus on linking financial and non-financial measures, the Capacity Utilization Model focuses on the waste embedded in a process or system. Waste is a systemic, or total organization, measure that emphasizes the resources lost to the company rather than the work it currently completes.

Helene Curtis is one company using this model to better understand its capacity utilization and opportunities for improvement. As part of a total

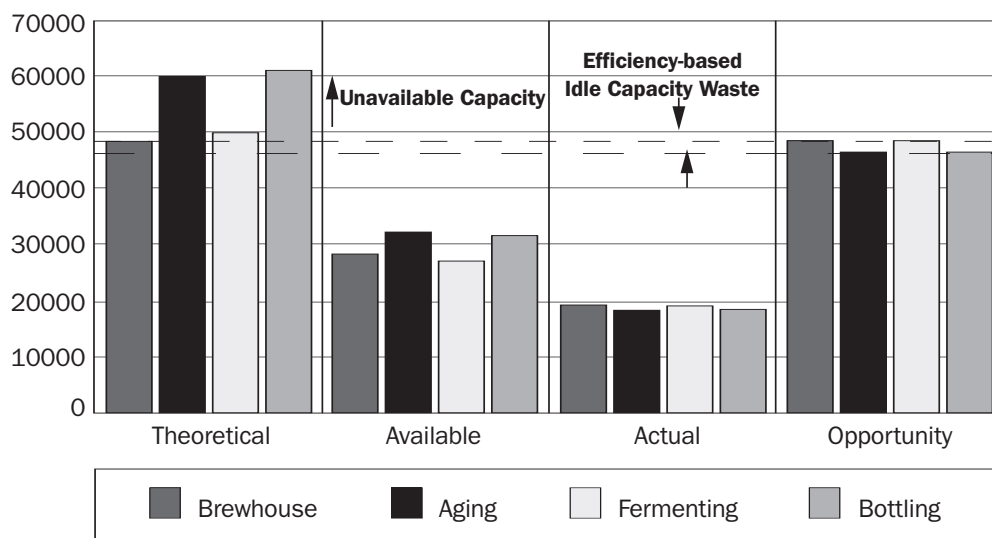
set of waste-based measures, the model provides a unique view of the capacity management issue. It is recommended for use in conjunction with other continuous improvement-supporting capacity models, such as Theory of Constraints.

Capacity Variance Model

The Capacity Variance Model emphasizes the differences between potential throughput or production and actual results. The traditional variance analysis approach is a natural one for accountants, but it often means less to users of accounting data. Exhibit 6 suggests an alternative way to present capacity variance information. Four different segments of a brewery's operations (brewhouse, aging, fermenting and bottling) are combined into one report.

The first set of measures reflects the theoretical capacity of these four interlocked components. This graph shows that the entire plant is constrained by the output capacity of the brewhouse. Excess capacity exists in aging, fermenting and bottling that cannot be utilized unless brewhouse capacity is expanded.

EXHIBIT 6. CAPACITY VARIANCE ANALYSIS





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A second critical point is made by Exhibit 6: efficiency-based capacity waste is a loss against theoretical capacity. No matter how long the plant runs, efficiency losses will take their toll on total throughput. As shown by the graphical version of variance analysis, management decisions to run the plant for less than 24 hours, seven days a week, show up clearly in the drop-off from theoretical to available capacity. Actual capacity utilization is interesting in that a “leveling-off” of throughput in the four major parts of the brewery appears for the first time. In the end, the plant is constrained not by the brew-house, but by fermenting.

Finally, the last grid details the opportunity, or potential production, of the balanced system.

The key features of the Capacity Variance Model are:

- details actual performance against theoretical capacity;
- identifies causes of capacity losses;
- supports opportunity cost analysis; and
- can be tracked against improvement goals.

Capacity variance analysis is easily combined with existing monthly or quarterly reports to provide information on ongoing performance against theoretical standards. While this model is primarily focussed on short-run, control-driven reporting, the measures created can be tracked over time as part of a continuous improvement program.

This approach is recommended for companies that wish to add some level of capacity cost management reporting to existing management report packages. Anheuser-Busch is exploring the use of this model as a supplement to its existing reporting package.

CAM-I Capacity Model

The CAM-I Capacity Model is primarily a strategic communication tool. It is designed to support the strategic decision process by helping managers understand and define the many states of capacity, measure these states, and then communicate them in a simple format.

The CAM-I Capacity Model can be used in the annual planning process and during interim quarterly update processes. Management can use this model to assess current capacity status, identify trends and plan changes in capacity. Manufacturing can use the model to communicate and sell new business initiatives requiring investment and operating changes. It can also be used to access the cost, causes and responsibility for capacity performance levels.

The CAM-I Capacity Model is built from activities at the operational level that can be reported using several different formats. Developed by CAM-I⁶ in conjunction with Texas Instruments, this model is a collection of capacity data that includes the supply of capacity, the demand on that capacity by specific products, and the constraint within a process that limits the production of good units.

The model is implemented through a series of templates that form the backbone of the capacity cost management database. The basic CAM-I model is captured in a simple formula as illustrated in Exhibit 7:

$$\text{rated capacity} = \text{idle capacity} + \text{nonproductive capacity} + \text{productive capacity}$$

⁶ Consortium for Advanced Manufacturing-International (CAM-I) is a not-for-profit, cooperative membership organization established to support research and development in areas of strategic importance to the manufacturing industries. Its Headquarters are located in Arlington, Texas.



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EXHIBIT 7. CAM-I CAPACITY MODEL

Rated Capacity	Summary Model	Industry Specific Model	Strategy Specific Model	Traditional Model
Rated Capacity	Idle	Not Marketable	Excess Not Usable	Theoretical
		Off Limits	Management Policy	
			Contractual	
			Legal	
		Marketable	Idle But Usable	Practical
	Non-productive	Standby	Process Balance	Scheduled
			Variability	
		Waste	Scrap Rework Yield Loss	
		Maintenance	Scheduled Unscheduled	
		Setups	Time Volume Change-Over	
	Productive	Process Development		
		Product Development		
		Good Products		

Source: CAM-I, 1995.

- *idle capacity*: Capacity not currently scheduled for use. The CAM-I Model breaks idle capacity into three specific classes: not marketable (no market exists or management made a strategic decision to exit the market), off limits (capacity unavailable for use) and marketable (a market exists but capacity is idle).
- *nonproductive capacity*: Capacity not in a productive state or not in one of the defined idle states. Nonproductive capacity includes setups, maintenance standby, scheduled downtime, unscheduled downtime, rework and scrap. Variability is the primary cause of non-productive capacity.
- *productive capacity*: Capacity that provides value to the customer. Productive capacity is used to change a product or provide a service. Productive capacity results in the delivery of good products or services. It may also represent the use of capacity for process or product development.



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The key features of the CAM-I Capacity Model are:

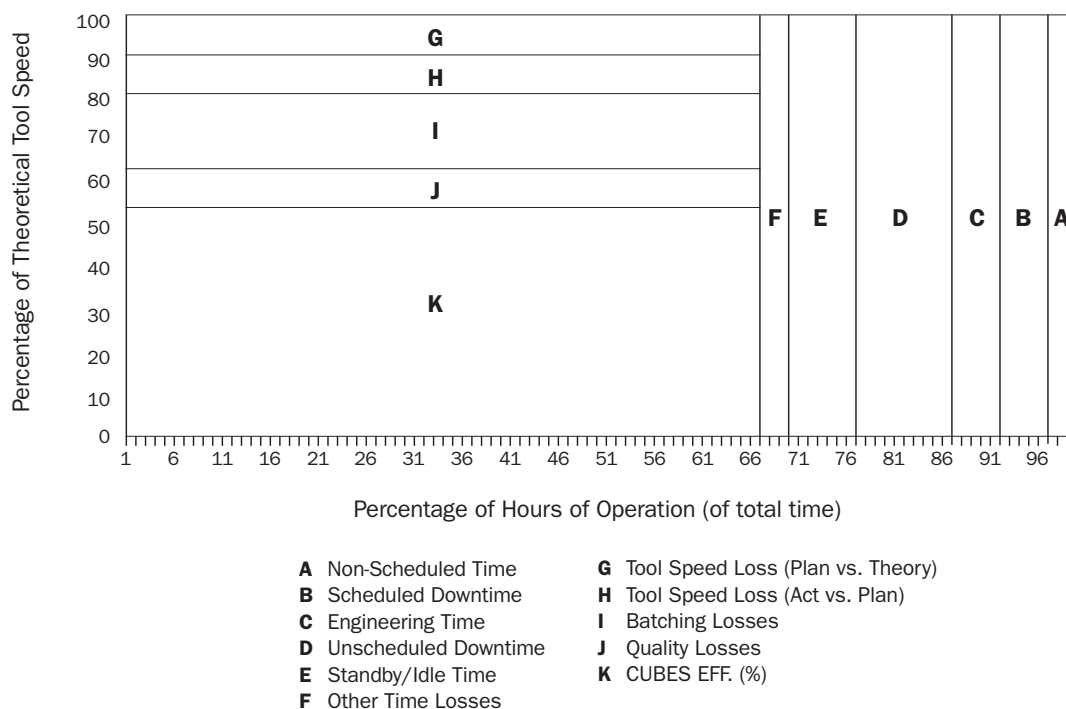
- integrates capacity data across many dimensions;
- ties to the financial reporting system;
- details responsibility for capacity losses; and
- uses time as a unifying measure.

The CAM-I Model uses a comprehensive capacity analysis approach. It can be utilized in simple settings, relying on a small, focused relational database structure. At a more elaborate level, it can allow a company to obtain the maximum benefit from its data warehouse/database capabilities to provide an integrated, flexible reporting package to be used across an organization.

CUBES Model

The Capacity Utilization Bottleneck Efficiency System (CUBES) has been developed by John Konopka while at SEMATECH, a consortium of semiconductor manufacturers in the United States. Developed for a capital-intensive environment, this model focuses on both capacity planning and identifying/implementing continuous improvement efforts in capacity utilization. CUBES combines the logic of cycle time analysis and activity-based analysis to generate an integrated view of capacity cost management issues that moves beyond the process level to incorporate key opportunities across the entire industry value chain.

**EXHIBIT 8. CUBES ANALYSIS OF POTENTIAL CAPACITY UTILIZATION
CUBES (E10 TEMPLATE) EFFICIENCY ANALYSIS GRAPH**



Source: Konopka, John M. 1995. Capacity utilization bottleneck efficiency systems—CUBES, *IEEE Transactions on Components, Packaging, and Manufacturing Technology* (18 September): 484-91.



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Building from the rich database required to run semiconductor processes effectively, the model combines static capacity measures and models with a dynamic simulation that predicts capacity utilization under various assumptions and operating conditions.

Exhibit 8 illustrates a CUBES analysis of potential capacity utilization. Management policies, defined on several key dimensions (unscheduled, standby, etc.), as well as the existing capabilities of the process (e.g., theoretical tool speed), are inputs that form a constraint on the potential throughput of the system. Given this potential throughput, the model then analyzes the utilization of available capacity. CUBES efficiency is determined by multiplying the percentage of theoretical tool speed by the percentage of hours of operation (e.g., $.58 \times .67 = .39$ efficiency rating).

The results are stated as outputs of the current operating plan and the relative impact on various forms of productive, nonproductive, idle and waste element of capacity. The model allows companies to chart their overall efficiency, breaking down the causes for efficiency losses by category.

The key features of the CUBES model are:

- integrates financial and nonfinancial data;
- builds from activity-based costs;
- uses Theory of Constraints, or constraint, logic; and
- provides a dynamic analysis and least-cost solution.

The CUBES and the CAM-I models are comparable approaches to the capacity cost management problem. While CUBES builds more directly from activity-based logic and provides a simulation capability, the CAM-I Capacity Model emphasizes responsibility accounting issues and communication

in a static model. The CUBES Model is recommended for companies facing challenges similar to the semiconductor industry (high capital investment with short product life cycles).

Cost Containment Model

Several of the models presented in this guideline can be adapted for use in service companies, or for analyzing capacity utilization in service or support areas of a manufacturing business. Occasionally, however, the unique characteristics of a process or activity make it difficult to accurately assess the baseline capacity measure or the actual utilization made of this capacity. In this situation, companies might focus on the total resources dedicated to certain activities or the effectiveness of total spending. In addition, it is often much easier to control or contain the growth of service costs than it is to eliminate these costs downstream.

The objective of the Cost Containment Model is to analyze and control future spending, not by enacting across-the-board cost reduction mandates, but by isolating the non-value-adding activities from those that are value-adding. Spending guidelines serve as the basis for implementing the cost containment approach. These guidelines can be based on internal analysis, best-in-class benchmarking, customer survey or management judgment.

Exhibit 9 illustrates the impact of this type of logic. An analysis of the value-adding, or priority 1, activities in this shipping example suggests that the company is spending too few resources on value-adding work. In order to maintain the current total costs of serving a customer, the 7 percent shortfall in spending on value-added work must be offset by reductions in spending on non-value-adding activities. The most obvious place to look for these savings is in the level 3 and level 4 activities that are not valued by the customer.



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EXHIBIT 9. SPENDING EFFECTIVENESS: COST CONTAINMENT IN ACTION

Mail Order Business

Step One: Detail the Value Chain

Customer calls in order	Inventory and Credit Check Done on-line	Order processed/ Packing slip printed	Items picked by Storeroom	Backorders noted with expected shipping dates	Order packed	Box sealed and labelled	Box weighed and paper-work done	Moved to pick-up area	Ship to Customer	Invoice	Collect Cash
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Step Two: Attach Resources to the Activities and then evaluate these spending levels against customer-defined value

Activity	Annual Resources Used	% of Total	Customer-Defined Value
1. Answer phone	\$ 25,000	Less than 1%	1 (Priority activity)
2. Take order/check credit and inventory	500,000	11.6%	1 (Priority activity)
3. Process order/send to storeroom	150,000	3.5%	3 (Low value)
4. Pick items on order	750,000	17.4%	1 (Priority activity)
5. Note backorders and expected ship dates	750,000	17.4%	2 (Low value; should be done right)
6. Pack order	500,000	11.6%	1 (Priority activity)
7. Seal and label box	125,000	2.9%	2 (Low value; should be done right)
8. Weigh and complete paperwork	125,000	2.9%	3 (Low value)
9. Move	75,000	1.7%	4 (No value)
10. Ship	500,000	11.6%	1 (Priority activity)
11. Invoice	350,000	8.1%	2 (Low value; should be done right)
12. Collect cash	450,000	10.5%	2 (Low value; should be done right)
	\$4,300,000	100.0%	

Step Three: Determine Spending Gap

Total resources used:	\$4,300,000
% spent on priority 1 activities:	\$2,275,000 / \$4,300,000 = 53%
Desired spending on priority 1 activities:	60%, or \$2,580,000
Spending gap: 7%, or	\$305,000

Source: McNair, 1995.



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In Exhibit 9, these items account for \$350,000 of the total cost of the process, which is sufficient to meet the \$305,000 shortfall in spending on priority 1 activities and possibly permit a \$45,000 spending reduction overall.

The key features of the Cost Containment Model are:

- focuses on support/service costs;
- supports/integrates with activity-based costing;
- builds on value-added, market-based models; and
- supports analysis and cost containment across many settings.

This model has been used by companies like Apple Computer and Stratus Computer to identify where they fail to spend enough money to meet customer needs, and to determine where to shift resources from non-value-adding work to value-adding activities.

Containing service capacity costs is typically an ongoing process of negotiation, compromise, reflection and analysis. This model is recommended for companies that are embarking on competitive bidding for internal services; that are conducting benchmarking studies that focus on costs per process/activity as a key data point; and that seek to continuously improve the quality of service delivered while reducing or containing the total cost of providing this service level.

Practical Capacity Focused Models

Gantt Idleness Charts

Henry Gantt, an early 20th-century industrial engineer, developed one of the earliest tools for capacity cost measurement. The objective of his idleness chart was to identify and eliminate avoidable idle time at the machine or process level. Gantt's approach focuses on operations and translates into financial terms using standard cost estimates.

Exhibit 10 illustrates a Gantt Idleness Chart. Idle capacity is reported by department or machine class, focusing first on physical capacity utilization both in percentage and bar chart terms. The next segment of the chart details the expense of idleness due to various common causes, such as lack of labor, repairs and poor planning. The expense of idleness is then classified into avoidable and unavoidable components, allowing the company to act to improve performance.

The key features of Gantt Idleness Charts are:

- efficiently highlight key capacity issues;
- summarize performance in operational and financial terms;
- detail costs and causes of idleness; and
- easy to implement and use.

Gantt's Idleness Chart contains a tremendous amount of information for managers. While the chart was designed more than 75 years ago, it can easily be adapted to a modern factory using departmental or cellular manufacturing approaches. As designed, this chart is a useful addition to the measurements maintained by workers on the plant floor. Its value in this setting is to underscore the cost of variation, or unplanned idleness, at the point of action.

Supplemental Rate Method

The Supplemental Rate Method was initially developed in the early 1900s by A.H. Church as part of a comprehensive system of cost accounting. Focused on serving the needs of both internal and external reporting with the same set of numbers, the supplemental rate method provides a useful model for a company that is just beginning to explore the issue of idle capacity and its costs on a local, or plant/process, level.



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EXHIBIT 10. GANTT IDLENESS CHART

Working Period 4 Weeks 22 Days 192.0 Hours _____ Period Ending May 28 1927

Weaving (Inc.) Total Machine Expense Used 56713.46 Total Unused 16112.21

Total Capacity Used 77.9% Total Credit .092%

Symbol	Department or Mach. Class	% Capacity to Attain	% of Capacity used on Day Turn							Details of Expense of Idleness Due to			
			10	20	30	40	50	60	70	80	90	Lack of Orders	Lack of Help
B	200 - 45" Looms	80									F47 32 2892 31	136 10	
C	687 - 54" & 58" Looms	80									F267 80 854 76	1473 52	
D	136 - 65" & 68" Looms	80									F142 62 432 83	441 94	
E	9 - 58" Looms	70									F5 53 376 19	24 95	
F	111 - 68" & 72" Looms	70									F194 68 1088 22	725 36	
G	1 - 72" Loom	80									c52 82		
H	1 - 58" Loom	80									C30 12	10 90	

Symbol	Details of Expense of Idleness Due to			Expenses of Idleness				
	Lack of Worked Material	Repairs	Poor Planning	Total	Unavoidable		Increase in Expense of Products %	Avoidable
					%	Amount		
B	19 40	20 92	6 39	3122 44	20	868 31	18.2	2254 12
C	A 15 54 194 14	493.89	136 42	3436 07	20	5646 65	18.2	2210 58
D	A 1 28 3 55	41 32	6 30	42 39 1069 83	20	7 71 1151 66	18.2	50 10 81 83
E	4 65	14 30	38 99	463 67	30	207 02	36.0	256 65
F	A 84 319 57	288 53	271 15	24 77 2888 35	30	8 92 3895 80	36.0	33 69 1007 45
G		1 95		54 78	20	9 92	18.2	44 86
H		48		41 50	20	3 10	18.2	38 40

The key features of Gantt Idleness Charts are:

- efficiently highlight key capacity issues;
- summarize performance in operational and financial terms;
- detail costs and causes of idleness; and
- easy to implement and use.

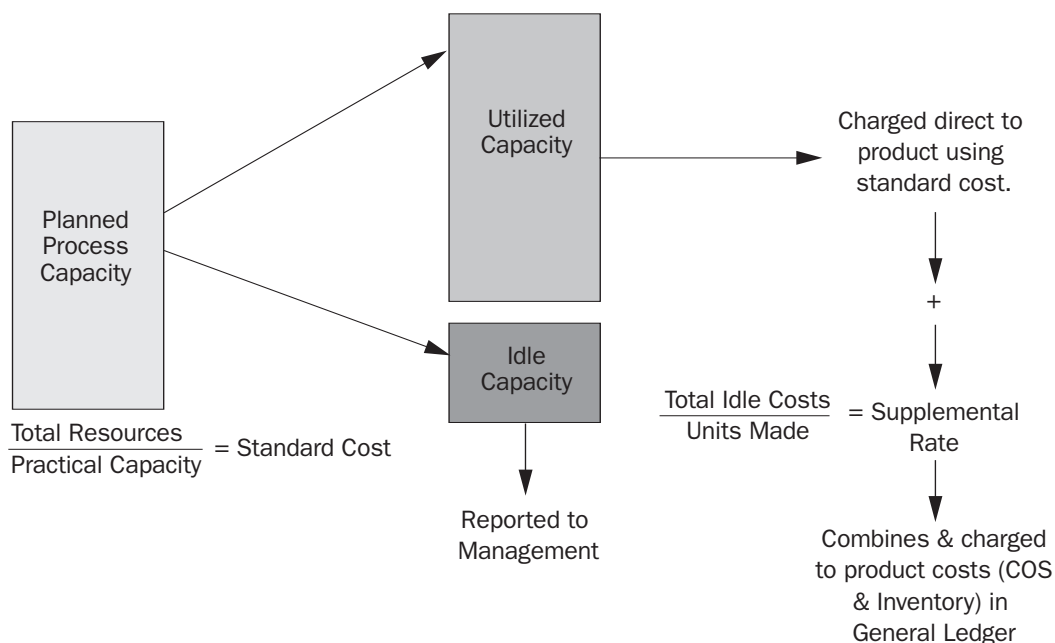
This model uses two overhead rates: one rate for the plant or department operating at its baseline capacity, and a supplemental rate for charging idle capacity costs to current production as illustrated in Exhibit 11. This approach yields a

fully absorbed cost for external reporting while providing a useful measure of the magnitude of idle capacity costs and their impact on company profits for management's use.



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EXHIBIT 11. SUPPLEMENTAL RATE METHOD



The key features of the Supplemental Rate Method are:

- supports internal and external reporting;
- easy to implement in existing systems;
- focuses on profit impact of idleness; and
- provides summary statement of the total cost of idleness in a period.

Church's approach is a small variation on the existing accounting practices of tracking volume variances, and then charging those variances against current output. The approach differs from conventional accounting practice in its adherence to *practical capacity* as its baseline capacity measure; most conventional accounting systems use *budgeted capacity* for this purpose.

For a small company with easily defined capacity costs and issues, the Supplemental Rate Method provides a low-cost means of identifying and assessing the impact of idle capacity costs on overall performance.

Theory of Constraints Capacity Model

The objective of the Theory of Constraints (TOC) model is to support continuous improvement throughout an organization. Several key principles underpin the TOC model:

- throughput capacity is defined by the underlying constraints of a system, which may be physical (i.e., a bottleneck) or invisible (i.e., policy, measurement, training) in nature;



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- “the goal” is to increase throughput while simultaneously decreasing investment (inventory) and operating expense, subject to meeting the needs of employees and customers;
- capacity of the organization is infinite. In order to enable an organization to move closer to its goal, TOC focuses on removing the root problems that prevent improvement; and
- the cost of idle capacity is not an opportunity cost unless customer orders exist that are not being filled.

Exhibit 12 details one type of report that can be used in a TOC setting. Based on the costing approach promoted by TOC, emphasis is placed on the contribution made by an order (its throughput) and the relationship of this contribution to the order's impact on the constraining resource. The objective is to maximize throughput and, hence, profit by actively and effectively managing bottleneck resources.

The key features of the TOC Capacity Model are:

- emphasizes company profitability over keeping people/machines busy;
- highlights key constraints inhibiting process performance;
- useful in plants or processes using TOC in their management processes;
- provides solid baseline for action; and
- strong track record of effectiveness.

The TOC Model provides unique strengths for companies that are managed under systemic, or process flow, approaches. By focusing attention on the primary process constraint, or bottleneck, TOC seeks to prevent the waste caused when resources are activated without any real demand for the subsequent output. It is recommended for companies using TOC approaches elsewhere in the organization, especially if existing information systems can support traditional, external and TOC-based management reporting. The TOC model is used extensively at Champion Paper.

EXHIBIT 12. TOC CONTRIBUTION REPORT

Order Contribution Report for 06/21/93 through 06/21/93 Report date 06/21/93					
Order Number	Gross Sales	Variable Costs	Throughput	Constraint Hours	Throughput per Hour
Cutting tools					
41631	796	394	402	N/A	N/A
41910	156	40	116	.51	227
42424	306	41	265	1.50	177
42659	262	79	183	.66	278
42692	288	61	227	.34	668
43227	422	63	359	.50	718

Source: Noreen et al, 1995.



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Normal Capacity Focused Models

Normalized Costing Approach

Normalized Costing is a capacity cost measurement model that uses average performance over time, adjusted for abnormal events, in its calculations. The key elements of the Normalized Costing Approach are:

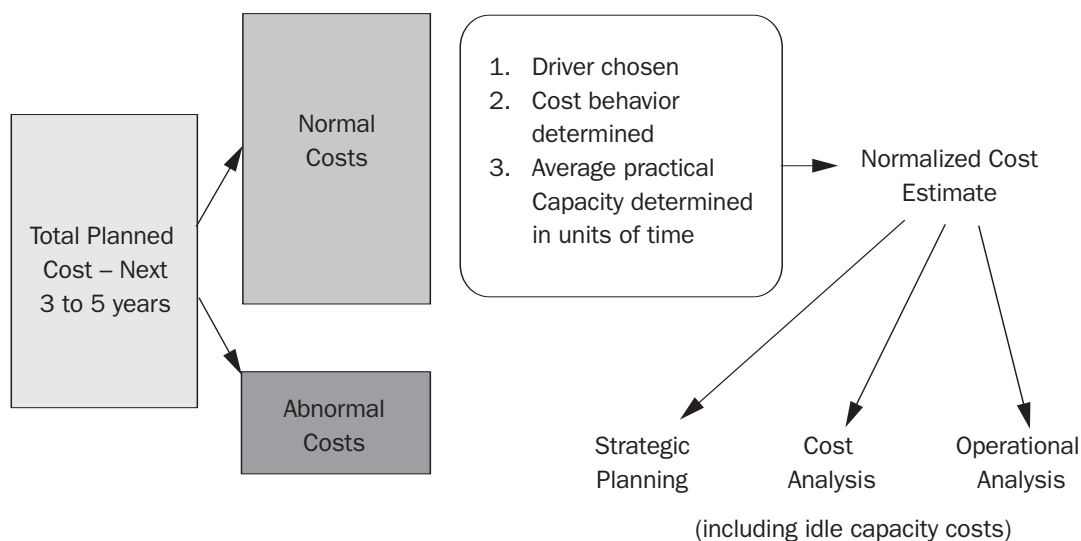
- asset depreciation is calculated on hours of machine use;
- abnormal expenses are eliminated from operational cost pools (e.g., plant modernization costs);
- the behavior of costs within a process is determined and defined within a formula that recognizes key elements affecting the cost of capacity within a process;
- the capacity of the process is then determined, using practical capacity baselines set over a three- to five-year period; and

- normalized cost is then determined by combining cost and capacity information to create a cost estimate under a given set of operating conditions.

The resulting capacity cost measure represents a multi-year average that does not charge idle capacity costs to current production as illustrated in Exhibit 13. Idleness costs are summarized in a separate account, which becomes management's responsibility to eliminate or redeploy.

Caterpillar finds this approach to be a viable basis for constructing management accounting information. Incorporated within an elaborate, detailed, and highly flexible management information system, normalized costing is used for all management reports at Caterpillar. It is recommended for complex manufacturing companies.

EXHIBIT 13. NORMALIZED COST APPROACH





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ABC and Capacity Cost Measurement

Activity-Based Costing (ABC) is a major innovation in costing methods being implemented in many large, medium-sized and small companies in North America and Europe. As described by key proponents R. Cooper and R. Kaplan (1992), "Activity-based cost systems estimate the cost of resources used in organizational processes to produce outputs." Idle, or unused capacity, is the key link in activity-based cost models and the general ledger system used for external reporting. Specifically:

$$\text{Activity Availability} = \text{Activity Usage} + \text{Unused Capacity}$$

According to this equation, unused capacity represents the difference between the cost of resources actually used to complete various activities and the cost of resources supplied or available to do that work. Unused, or idle, capacity is the gap between what could have been done and the work actually accomplished, stated in financial terms.

The information developed under ABC can be presented in a format similar to that in Exhibit 14. The sorting of costs between used and unused categories indicates that excess resources are being consumed. The exhibit also highlights the impact of unused activity capacity on operating

EXHIBIT 14. ABC INCOME STATEMENT

SALES				<u>\$20,000</u>
Less: EXPENSES OF RESOURCES SUPPLIED AS USED				
Materials		7,600		
Energy		600		
Short-term labor		900		<u>9,100</u>
CONTRIBUTION MARGIN				<u>10,900</u>
Less: ACTIVITY EXPENSES:COMMITTED RESOURCES		Used	Unused	
		Capacity	Capacity	
Permanent direct labor		1,400	200	
Machine run-time		3,200		
Purchasing		700	100	
Receiving/Inventory		450	50	
Production runs		1,000	100	
Customer administration		700	200	
Engineering changes		800	(100)	
Parts administration		<u>750</u>	<u>150</u>	
TOTAL EXPENSES OF COMMITTED RESOURCES		9,000	700	9,700
OPERATING PROFIT				<u><u>\$1,200</u></u>

Source: Cooper and Kaplan, 1992.



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profits. Combined with other forms of reporting, this model can be used to highlight the often-overlooked components of sub-unit or organizational capacity.

In using this model, organizations can track the capacity costs related to resources directly consumed by an activity. They can also better manage assets not directly used by their core activities.

The key features of the ABC capacity approach are:

- fits into activity-based cost model;
- reports both the quantity and cost of idle capacity;
- supports analysis of alternative solutions to capacity issues; and
- strong emphasis on resources.

ABC helps managers predict the impact of changes in volume and mix, process changes and improvements, introduction of new technology, and product and process design changes on activity costs. Serving as a useful bridge between more conventional views of capacity cost management and ABC, this model is useful in any company using or implementing ABC. Hewlett-Packard Corp. is an example of a firm that makes extensive use of this model.

Integrated TOC-ABC Model

Robert Kee recently developed a new capacity model that integrates the basic concepts of TOC and ABC models to generate a mathematical, least-cost solution to the capacity utilization issue.⁷ Utilizing a mixed-integer programming approach, this model gives the optimal production mix subject to the capacity of the individual activities comprising the firm's production structure.

In this model, unit-level costs and resources are treated as continuous variables, while batch- and

product-related costs are represented as discrete variables. The resulting equations and model capture the interactions among the cost, physical resources and capacity of production activities, which effectively integrate the ABC and TOC approaches as illustrated in Exhibit 15.

The solution resulting from the mathematical combination of ABC and TOC captures the best of both worlds in terms of assumptions and treatment of the firm's economic realities. Specifically, the opportunity cost of the resources is used to determine an optimal product mix, one that allows a company to select products with the highest contribution margin per unit and highest profit per unit for a bottleneck activity. The opportunity cost from using the resources of the bottleneck activity is reflected in the relative profitability computed for each product.

The key features of the Integrated TOC-ABC Model are:

- uses mathematical modeling to solve for optimal capacity utilization;
- effectively combines both operational and financial views of the capacity problem;
- can be easily added to existing ABC applications;
- when at least one bottleneck operation exists, provides a superior solution to a pure TOC or pure ABC methodology; and
- uses marginal revenue as its decision basis.

VII. SELECTING A CAPACITY COST MEASUREMENT MODEL

Choosing a capacity cost measurement model from those presented in this guideline is a second-level decision in deploying capacity cost management practices. Only after a strategy for the total value chain's efforts has been developed—



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EXHIBIT 15. COMPARATIVE ANALYSIS OF ABC, TOC AND INTEGRATED MODELS

	ABC Model	TOC Model	Expanded ABC Model
Product Mix:			
X ₁	-0	50,000	30,000
X ₂	-0	100,000	100,000
X ₃	-0	25,000	30,000
X ₄	20,000	-0	-0
Excess Resources:			
Assembly (labor hours)	100,000	-0	10,000
Finishing (labor hours)	100,000	55,000	55,000
Set-up (hours)	-0	-0	-0
Purchasing (orders)	200	235	200
Engineering (drawings)	500	500	500
Profit:			
Projected Income	\$3,180,000	\$2,280,000	\$4,620,000
Cost Saving Available			
From Excess Resources*	-0	2,307,000	-0
Available Income	\$3,180,000	\$4,587,000	\$4,620,000
* The cost savings from excess resources was computed by multiplying the excess capacity of each activity by its respective cost driver rate. The cost of excess resources are excluded from income under ABC and the expanded ABC models.			

Source: Kee, 1995.

one that ensures maximization of performance against customer-defined components of value—should management attention turn to current utilization patterns.

The 12 models described in this guideline can be used alone, or in combination, to underpin an organization's capacity cost management system. No single model will work under all conditions nor will one model serve all of management's needs for capacity cost analysis. In choosing a model, companies should address the following issues:

- What is the overriding goal or focus of the capacity cost measurement system?
- Is a short-, intermediate- or long-term perspective required? (Some models work very well in the short run, but provide little guidance for strategic decision-making. Other capacity cost measurement models are most informative in the intermediate to long term but provide little guidance for short-term operational decision-making.)
- Do the critical capacity questions apply at the level of process, unit, company or value chain?
- What other programs (i.e., TOC, continuous improvement, ABC) is the company engaged in?
- What are the company's information processing capabilities?

7 Kee, 1995.



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- What type and amount of data already exist to support the capacity cost measurement system?
- How many resources are available to support the development and maintenance of the capacity cost measurement system?
- Is capacity cost measurement primarily a planning tool, or will it become part of the management control system?
- How important is it to tie capacity costs to existing financial and operational reports and performance measures?

The answers to these questions will narrow the list of available models to a few that will most effectively address the specific capacity cost management issues for a company as illustrated in Exhibit 16. In addition, as a company gains more knowledge about its cost of capacity, it can substitute or add more sophisticated models.

The best capacity cost measurement model in any setting is that which facilitates management's efforts to continuously improve against customer expectations. Enhancing customer-defined value is the key objective, not simply improving internal efficiencies. As such, capacity decisions that create no additional costs but rather improve the company's performance against customer expectations increase the firm's value-creating ability, and hence capacity.

VIII. DETERMINING THE COST OF IDLE CAPACITY

The choice of a capacity model leaves still unaddressed the critical issue of determining the cost of idle capacity. High costs caused by too much idle capacity may render the firm unable to compete. Traditional measures usually fail to provide management or operating personnel with significant useful information about the amount and cost of idle capacity.

Key factors influencing the cost of idle capacity are:

- total resources required to keep the process in the various states of preparedness;
- the cost behavior of these resources in the short and intermediate term;
- the incremental cost of moving from one level of preparedness or total available capacity to another; and
- the flexibility/storability of affected resources.

The type, quantity and overall flexibility of resources differs markedly from one company to another. Determining the specific cost of idle capacity is based on a few overarching rules:

- all resource usage caused by, or driven by, process capacity and its activation should be placed into the capacity cost pool;
- the denominator or activity level chosen for the pool should be theoretical capacity (24 hours, seven days);
- resources that are flexible, storable (e.g., can be retained for future use with no loss of value-creating potential) or variable (purchased and consumed only as needed) should be identified;
- in periods of planned idleness, no matter what the reason for this idleness, only unavoidable costs (fixed, inflexible and/or nonstorable resources) should be charged to idle capacity; and
- in periods of production and unplanned idleness (regardless of cause for this nonproductive time), idle capacity will be charged at the "full cost" per minute of time available.

The objective in assessing the impact of idle capacity on company performance is to match resource consumption to the various states of preparedness and utilization to meet customer needs.



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EXHIBIT 16. COMPARISON OF CAPACITY COST MEASUREMENT MODELS

<i>Features/Model</i>	<i>Baseline Capacity Measure Emphasized</i>	<i>Primary Focus of Mtd.</i>	<i>Suggested Treatment of Idleness Costs</i>	<i>Other Programs Suppl.</i>	<i>Required I/S Capabili.</i>	<i>Data Requirements</i>	<i>Resources Required</i>	<i>Planning or Control?</i>	<i>Strong Tie of Financial, Operational Suggests</i>
<i>Resource Effectiveness Model</i>	Theoretical Capacity	Resource Utilization	Change to Profit & Loss	Continuous Improvement TOC & ABC	Moderate	Moderate	Moderate	Planning	Yes
<i>Capacity Utilization Model</i>	Theoretical Capacity	Capacity Utilization	Change to Profit & Loss	Continuous Improvement & ABC	Moderate	Moderate	Moderate	Both	Yes
<i>Capacity Variance Model</i>	Theoretical Capacity	Analysis of Performance	None Suggested	Continuous Improvement	Minimal	Low	Minimal	Control	Yes
<i>CAM-I Capacity Model</i>	Theoretical Capacity	Communication	Change to Profit & Loss	Continuous Improvement & ABC	Sophisticated	High	Moderate to High	Both	Yes
<i>CUBES Model</i>	Theoretical Capacity	Process Utilization	None Suggested	Continuous Improvement & ABC	Sophisticated	High	Moderate to High	Both	Yes
<i>Cost Containment Model</i>	Implicit Theoretical Capacity	Total Cost/ Activity	None Suggested	Continuous Improvement & ABC	Moderate	Low	Minimal	Planning	No
<i>Gantt Idleness Charts</i>	Practical Capacity	Efficiency	Change to Profit & Loss	Continuous Improvement	Minimal	Moderate	Minimal	Control	No
<i>Supplemental Rate Method</i>	Practical Capacity	Supporting both internal & external reporting	Change to Product	Continuous Improvement	Minimal	Low	Minimal	Control	Yes
<i>Theory of Constraints Capacity Model</i>	Practical (Marketable) Capacity	Throughput	None Suggested	Continuous Improvement	Minimal	Low	Minimal	Both	No
<i>Normalized Costing Approach</i>	Normal Capacity	Decision Analysis	Change to Profit & Loss	Continuous Improvement & ABC	Moderate	High	Moderate to High	Both	No
<i>ABC & Capacity Cost Management</i>	Normal Capacity	Resource cost per activity	Change to Profit & Loss	Continuous Improvement	Moderate	Moderate	Moderate	Planning	Yes
<i>Integrated TOC-ABC Model</i>	Various	Minimize marginal cost	None Suggested	Continuous Improvement & ABC	Moderate	Moderate	Minimal	Both	Yes



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In reporting this information, a company recognizes that the various forms of idle capacity costs are controllable, or can be acted upon, at different management levels. A decision to maintain standby capacity is strategic in nature; changing these costs requires action by top management.

Conversely, planned nonproductive capacity due to equipment breakdowns is an operational issue that is best addressed on the plant floor, at least in the short term. In order to be relevant, capacity cost management data, including the cost of idle capacity, must be actionable and focused on identifying opportunities for improvement.⁸

IX. ASSESSING THE IMPACT OF CAPACITY COST MEASUREMENT ON ORGANIZATIONAL BEHAVIOR

Capacity measurement and segregated accounting and reporting of capacity costs are necessary for improved product costing, maximizing the utilization of capacity, eliminating waste, and gaining and maintaining a sustainable competitive advantage.

However, measures impact behavior in organizations. If these measures are used as part of the performance evaluation process, their impact can be profound. In designing and using capacity cost measurement systems, it is critical to assess the impact of various types of metrics and reports on the decisions and behavior of individual managers. For instance, labor efficiency-based measures of capacity can drive a company to produce work-in-process even if no current or future demand for this product exists. In this setting, the capacity measurements drive people to keep busy, not necessarily to create value.

The key behavioral factors to consider when choosing a specific capacity measurement model include:

- If this measure were made available to me, or one of my key managers, what response would it likely create?
- Does the measure reinforce and reward continuous improvement and learning?
- What dysfunctional behaviors might the measure create?
- Will the measure be used in the performance evaluation process? If yes, is it fair and objective?
- Is the measure actionable? If so, by whom?
- In the long term, what would be the implication of always doing well against this measure?
- Will the measure support, or work against, other management programs and objectives?

The goal of capacity cost management is to support efforts to improve the profitability and capability of a process or organization.

Attaining this goal requires careful attention to specific capacity cost measures and reporting formats. In the end, “firms get what they measure and reward.”

X. ORGANIZATIONAL AND MANAGEMENT ACCOUNTING CHALLENGES

The primary organizational challenges in implementing effective capacity cost measurement practices are those common to all change efforts. Top management must support the effort, ensuring that required resources are made available and viable solutions are implemented. The change process should be completed with minimal politics and personal maneuvering; everyone wins if capacity utilization is improved. Finally, the recommendations and changes made as a result of implementing and using a capacity cost management system must be reinforced through incentive and reward systems that encourage effective resource utilization.

⁸ Global idle capacity is very different from local idle capacity. Global idle capacity becomes marketable, policy or abandonment opportunities. Local idle capacity may not be available for marketing, policy, or abandonment options.



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The management accounting challenge embodied in capacity cost measurement is to design and implement an effective cost accounting system to meet the internal needs of the organization while retaining the requisite records and systems needed to comply with GAAP-based external financial and legal entity tax accounting requirements.

Management accountants must recognize and change the misconception that GAAP requires full absorption product costing and prohibits the charging of idle capacity costs directly to the income statement. The GAAP guiding capacity reporting is actually based solely on accepted practice. In the United States, Financial Accounting Standards Board (FASB), the Internal Revenue Service (IRS)⁹ and the various Securities Exchange Commission (SEC) mandates do not require full absorption product costing in any of their promulgations except as noted below.¹⁰ Companies with U.S. Government contracts will have to comply with Federal Acquisition Regulations (FAR) and may be subject to Cost Accounting Standards Board (CASB) requirements. These companies should discuss with their government representatives the impact on the allowability of the costs allocated to government contracts before selecting a cost method other than full absorption.

Nor does any regulation affecting Canadian enterprises require this extreme treatment of cost. Full absorption costing is not required; it is simply a habit. As such, it poses no barrier to implementing more effective, relevant capacity cost measurement systems. U.S. Government contracts represent the only major exception to this blanket statement. U.S. Government contract regulations require full absorption costing for negotiating contract prices. In order to apply relevant capacity cost measurement systems when pricing these contracts, special contractual arrangements (such as separate

contracts or contract line item pricing for the costs of capacity) will be necessary.

Management accountants need to reopen the debate of “best practice” in capacity cost management—debates which led to elaborate idle capacity reporting practices early in this century. Management accountants need to recognize and address current misconceptions about GAAP and its implication for capacity reporting practices, and openly search for ways to better reflect economic reality in their reporting practices.

Where they will be effective, major changes in common reporting practices required to support capacity cost measurement include:

- use of theoretical rather than annual budgeted capacity as the capacity baseline measure;

9 In 1987, the U.S. Internal Revenue Service passed a regulation preventing the use of practical capacity (and implicitly theoretical capacity) as a capacity baseline. Given that most companies already maintain separate inventory and cost records for tax and financial/managerial purposes, the impact of this regulation is minimal. While cash flow, on an after-tax basis, is impacted through the increased capitalization of overhead costs inherent in choosing normal or budgeted capacity as the baseline measure, the ongoing movement to minimize work-in-process and finished goods inventory suggests that this impact can be addressed.

10 The most applicable accounting standard is ARB 43, which deals with inventory pricing. Key comments in this document are: As applied to inventories, cost means in principle the sum of the applicable expenditures and charges directly or indirectly incurred in bringing an article to its existing condition and location (28); ...under some circumstances, items such as idle facility expense... may be so abnormal as to require treatment as current period charges rather than as a portion of inventory cost (29); It should also be recognized that the exclusion of all overheads from inventory costs does not constitute an accepted accounting procedure. (29) The key element in this analysis is the concept of “abnormal.” Paton and Littleton’s (1941) monograph, the seminal work in accounting theory, clarifies the language of ARB 43 by noting that abnormal is defined by existing management policy, and that accounting records should NOT attempt to hide the cost of inefficiencies due to management decisions. In the end, the management accountant has to determine what interpretation of these guidelines best serves management and supports their decisions, regardless of how these costs are handled for external financial reporting.



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- elimination of idle capacity costs from product costs; when excess and idle capacity costs are charged to product, these expenses and their implications for long-term growth are hidden;
- analysis and reporting of the cost of capacity in different states of preparedness;
- reporting of all idle, nonproductive and productive uses of capacity and their costs: While many nonproductive costs, such as set-up time, are logically caused by, and should be attached to, products made, the current cost of these activities must be carefully tracked and presented to management. While a necessary part of doing business, nonproductive costs can be minimized only if the organization recognizes their impact on effective capacity utilization, and hence company profitability;
- recognition that the cost of capacity exceeds the depreciation or fixed charges to support a machine. Capacity costs include all costs driven or caused by the decision to maintain a process in a certain state of preparedness;
- adoption of new types of capacity cost measures, including realistic depreciation methods which fairly assign cost to all products which use the capacity and all uses of capacity should be considered. Current accelerated rates of depreciation with very conservative lives is acceptable for financial accounting but not for managerial accounting or capacity cost management. Managerial accounting's objective is to mirror capacity modeling which uses "average and fair" values;
- development of non-traditional reporting formats that highlight key capacity issues in non-numerical formats. Numbers are the backup data that support different types and forms of reports;
- enhancement of cost reporting to incorporate factors and operational issues that more effectively capture the organization's key processes, constraints and activities; and

- increasing the emphasis on analysis and assessment of potential costs and opportunity costs of future capacity decisions.

XI. CONCLUSION

In the race to gain a sustainable competitive advantage, companies need ways to better use their resources. Value creation does not mean throwing all the resources the company can muster at the productive process; rather, it means achieving long-term improvements in products and services while reducing the long-term average cost of providing these products and services to the customer.

Capacity cost management is a vital part of a company's arsenal of strategic and operational tools and models. Focused on improving existing capacity utilization and reducing the need for future investments, capacity cost management enables the company to improve its use of resources to meet customer requirements.

Dynamic capacity cost measurement focuses management's attention on opportunities for improvement either through using existing process capacity or through reducing the total resources required to provide the requisite level of preparedness. Capacity cost measurement addresses the critical element in the profit equation: the amount and type of resources consumed to generate a dollar of revenue. It addresses this issue in a precise and focused way by identifying and supporting the elimination of non-value-added uses of resources

In the fiercely competitive global marketplace, a company requires sound facts about its actual performance and its value-creating processes. Effective reporting of capacity utilization and the waste of this essential value-creating ability is a critical element in a company's drive to attain a sustainable competitive advantage. In the end, effective capacity cost management is a journey, not a destination.



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GLOSSARY

Accounting-based waste – scrap, downtime, inefficiency and waste built into standards; idle capacity costs charged to product.

Activated capacity – capacity that is being used to meet an order or customer requirement.

Baseline capacity measure – company-defined capacity of a process.

Behavior of costs – the patterned matching of inputs (resources) to the outputs (activities, products and services) they support.

Capacity – the potential of a process to do work; the value-creating potential of a process.

Capacity cost information – cost data that detail the economic impact of using or idling various types of capacity in a plant or process.

Capacity cost management – the profitable management of the value-generating competencies, processes and capacities of an organization in ways that support the strategic direction of the business.

Capacity flexibility – the ability of a plant, process or machine to be quickly and efficiently adapted to other value-added activities or uses.

Capacity model – a predefined and focused approach to measuring and managing capacity at the level of the process, unit, company or value chain.

Capacity planning – analysis of upcoming business in terms of its impact on the cost, level and effectiveness of capacity utilization.

Definitional waste – capacity waste that is caused by a failure to use theoretical capacity as the baseline capacity measure.

Full absorption product cost – a cost accounting system that includes fixed manufacturing overhead costs in the unit product cost. Idle capacity can be and should be excluded from these calculations for managerial product costing.

Idle capacity costs – the economic value of resources not utilized to make products or provide services.

Management-based waste – wasted capacity due to management policies regarding operating hours, shifts, breaks, etc.

Marketable idle capacity – capacity for which a product or other forms of market demand exists.

Nonproductive capacity – capacity not in a productive state nor in one of the defined idle states. Nonproductive capacity includes setups, maintenance, and scrap.

Off-limits capacity – in the CAM-I capacity model, this capacity is unavailable for use. Examples include government regulations, management policy and contractual arrangements.

Planned nonproductive capacity – capacity planned for use that is temporarily out of use due to process variability, such as the lack of materials or machine or process breakdowns or delays.

Preparedness – the capability of a process to complete the type and amount of work for which it was designed.

Rated capacity – manufacturer or industrial engineering estimate of the output capacity of a machine or process. The rated capacity is equal to hours available x efficiency x utilization. In Theory of Constraints (TOC) rated capacity = hours available x efficiency x activation, where activation is a function of scheduled production and availability is a function of uptime.

Required capacity – the amount of capacity needed to meet current production schedules/plans or to respond to customer requirements.

Service capacity – the amount of work a service or support system can provide before needing additional resources.



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Standby capacity – in the CAM-I capacity model, this capacity is buffer capacity required to deal with variability, such as the arrival of materials or the distribution of capacity downtime. It also includes capacity caused by areas of process/factory that can produce at higher output rates than the process/factory constraint.

Structural waste – waste embedded in a system or process due to a lack of balance or the inherent nature/capability of the resources used.

Supplemental rate – a second, end-of-period, overhead charge used to allocate unabsorbed overhead to products.

Value-adding (creating) activities – work or activities that generate products or services the customer is willing to pay for; many activities remain essential for the effective management of the business (e.g., non-value-added but required), but are not seen as directly value-creating by the customer.

Waste – resources consumed that do not add value to customers; costs incurred for unnecessary work, capacity or outputs.



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