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Total Asset Utilization (TAU) :

An Overview of a Productivity Metric for Profitability Enhancement and Focused Cost Reduction

by

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Background

In the United States today, many companies are faced with the daunting prospect of responding to three concurrent and inter-related challenges :

(1) continuous demands from their customers to reduce the price of their products and/or services; while
(2) managing and reducing their costs in order to maintain profitability; and
(3) maintaining an adequate return on equity or assets to meet or exceed the expectations of stock market analysts and stockholders.

This pressure has been particularly acute on primary (e.g. steel and aluminum) and component manufacturing firms producing a complex product mix as first and second tier suppliers; and, most especially, in mature industries producing commodities. As these companies have struggled with meeting these externally-driven demands, the result of their efforts have been decidedly mixed. Re-engineering, often simply a not-so-subtle ‘code word’ for downsizing, and forced mergers have, in many cases, led to the sub-optimization of Key Performance Indicators (KPIs) in all three domains. Still other firms have attacked the problem through company-wide cost or quality initiatives which start with great fanfare, yet die slowly (and in some cases, excruciatingly), ultimately ending without adequate financial benefit.

A good deal of the failure of all of these approaches is that the effort to reduce cost and subsequently price, and ultimately control profitability, is that the attempts tend to take place with vertically rather than horizontally-integrated strategies. The quality department is assigned the responsibility for reducing scrap and loss; the sales and marketing department is assigned the task of increasing sales and hopefully margin; the finance personnel dedicate themselves to uncovering opportunities to reduce costs; and the process engineering and operations groups commit their time to increase productivity and efficiency. Unfortunately, each of the individual division or department efforts often tend to generate sub-optimal responses and solutions, so that the ultimate gain in profitability tends to be less than the sum of the individual parts.

The reason this occurs is that profitability and cost improvement is a horizontal versus vertical issue, and must be attacked with a uniform and horizontally-integrated effort. This means that two elements must generally be recognized by management.

(1) In mature industries with a diverse product mix, an Activity-Based Costing (ABC) system versus a Standard Costing system at some level of specificity will be required to successfully and comprehensively understand the true cost structure associated with each product manufactured and customer served. Without such a device in place, the knowledge of the actual cost and profitability of various product mix configurations will be elusive at best, and catastrophically deficient at worst[1]. While it is not the intention of this article to discuss the nature and benefit of ABC, it should be recognized that the benefit of asset utilization analysis, which is the major thrust of this article, will be significantly improved in the presence and with the integration of this system.

(2) A metric which allows for the analysis and improvement of productivity and efficiency on a horizontally-integrated basis, linked to maximizing *profitability* across the entire organization, must be deployed within the organization. Ideally, this measure will possess the following attributes:

- It should avoid the flaw in traditional measures of productivity and efficiency, which tend to assign ownership of productivity improvement to operations, engineering, and maintenance personnel; rather than to multiple process owners across all units of the organization.

- It should define productivity improvement on the basis of profit versus simple unit growth, avoiding the dynamic of a ‘feed-the-beast’ mentality prevalent in many commodity industries (such as Steel and Baking).

- It should be equally useful in measuring productivity at the corporate, plant, department, line, or individual equipment level.

- It should ultimately allow for the efficient analysis of improvement opportunities which will maximize the comprehensive reduction of costs for the organization as a whole.

These requirements, as well as a number of other benefits, may be realized through the introduction of a metric which allows for the assessment of *Total Asset Utilization (TAU).*

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[1] Rao, Srikumar *Overhead Can Kill You*, Forbes, February 10, 1997

Total Asset Utilization (TAU)

TAU may be defined as a measure of the degree to which an asset, such as a plant, production line, or piece of equipment, is being employed in profitable activity. The TAU metric has the following general form

TAU = Availability * Duty Cycle * Efficiency * Yield

where

> ***Availability*** is the proportion or percentage of time the system is available for producing goods or services. It may also be defined as *Percent Run Time* or *Uptime*. Conceptually, Availability will be equal to Total Time (the Base Period of Time selected for the analysis of TAU; e.g. day, shift or turn, week, or month) minus Total Downtime, divided by Total Time. In calculating TAU, it is essential to track the contributing sub-components of Downtime such as *Scheduled, Unscheduled, and Idle Time*; as well as the next level of contributing components such as *No Supply* and *No Demand* time in order to allocate improvement opportunities to process owners across the organization.
>
> ***Duty Cycle*** is the proportion or percentage of the Run Time or Uptime available for producing goods or services after subtracting *Setup Time* (e.g. a change in the product produced) and *Changeover Time* (e.g. label or packaging changes without a product change). Mathematically, it is equivalent to Run Time minus Setup and Changeover Time, divided by Run Time.
>
> ***Efficiency*** is the proportion or percentage of actual speed or output achieved versus the theoretical design speed or maximum output of the system. Of the four components in the TAU model, it is the value that is the most difficult to calculate correctly, and the most difficult for management to understand and accept. This is because for TAU purposes, based upon the premises advanced in the Background section of this article, Efficiency must be assessed in a different way than most traditional, engineering-based approaches dictate. This difference will be explained shortly.
>
> ***Yield (Recovery)*** is the simplest and most straightforward of the four components, representing the traditional proportion or percentage of 'good' or 'acceptable' units produced during a base period of time. Ideally, this component will allocate loss or reduction in units to the producing versus the harvesting department, division, or plant.

Although the applied and in-depth calculations of TAU will require the formulae to be modified on a company-by-company basis, the application of this model may be illustrated on a broad, conceptual basis with some sample calculations. Imagine that we were to apply the model for the measurement of a single production line dedicated to the manufacture of a mix of products. Assume further that the base period of time sensible for the TAU assessment was designated as daily (i.e. each day, 3 shifts).

Table I illustrates some common calculational components and potential process owners for the elements of the basic TAU model. This table is not intended to serve as a complete and comprehensive presentation of how the model should be deployed in all companies and conditions. Rather, it is intended to provide the reader with a basic and straightforward example of how the TAU model has been successfully and usefully structured in a number of companies with whom the author has worked.

Table I

Illustrative Elements of a TAU Model

TAU Component	Level I Sub-Component	Level II Sub-Component	Level III Sub-Component (where applicable)	Potential Process Owner(s)
Availability	Planned Downtime	Preventive Maintenance / Sanitation		*Maintenance Department *Sanitation Crew
		Lunches & Breaks		*Management
	Unplanned Downtime	Failure & Repair	Product-Related	*Product Engineering *Process Engineering *Operations Management
			Process-Related	
		No Demand	Lack of Sales	*Sales & Marketing
			Choose Not to Sell	
		No Supply	Internal (Upstream) Unit	*Operations Planning/ Scheduling
			External Supplier	*Operations Scheduling *Procurement/ Purchasing
	Choose Not To Run			*Operations Management *Operations Planning/ Scheduling
Duty Cycle	Set-Ups	Type/Model Change - Same Product		*Operations Management *Sales & Marketing
		Product Change		
	Changeovers	Label Change - Same Package		*Sales & Marketing *Operations Planning/ Scheduling
		Package Change		
Efficiency	Actual Within Product Manufactured			*Process Engineering *Operations Management
	Product/Process Selection Effect[1]			*Sales & Marketing *Operations Planning/ Scheduling
Yield (Recovery)	Acceptable Unit Count	{Count Maintained By Product Type/Model By Customer}		*Operations Management *Process Engineering *Product Engineering
	Unacceptable Unit Count	In-Process / Within Unit		
		End-of-Line		
		Shipped & Returned		

[1] A function of how Efficiency must be calculated for TAU purposes.

As previously stated, Efficiency is the most difficult component to calculate correctly for TAU purposes, as compared to standard or traditional methods employed for this factor. Two examples will be used to illustrate the difference in this model.

Imagine we are operating a Cold Mill in an Aluminum Products plant. Further, imagine that the maximum design speed for the mill is equivalent to 100 coils per day. Suppose that the actual number of coils produced in a given day was 95. The traditional method of calculating efficiency would be:

$$\text{Efficiency} = \frac{\text{Actual Speed or Output}}{\text{(Theoretical) Design Speed or Maximum Output}}$$

therefore

$$\text{Efficiency} = 95 / 100 = .95 \text{ (or 95\%)}$$

Referring back to our premises for the requirements of a TAU model/metric, we note that this traditional method of calculating Efficiency is unit- versus profit-based. The reason for this assertion is that the company in question is *paid by the pound*; **not** the coil. Therefore, the Efficiency calculation, to be valid for TAU purposes (and this will be absolutely critical when relative Efficiency values are integrated with an ABC system for portfolio analysis) **must** take into account the capacity of the mill as related to maximum or theoretical design ***weight***. Suppose, for example, the mill was capable of rolling finished coils 6 feet wide and 1 inch thick (gauge) at 1500 linear feet each. Suppose further the 95 coils in question were, in fact, 1500 linear feet each, but because of customer requirements or the alloy involved, each coil was 3 feet wide, and 0.5 inches thick. In this case, Efficiency is properly expressed (for TAU purposes) as:

$$\text{Efficiency} = \frac{\text{Actual Production}}{\text{Design Production}} \text{ x } \frac{\text{Actual Width}}{\text{Design Width}} \text{ x } \frac{\text{Actual Gauge}}{\text{Design Gauge}}$$

$$\text{Efficiency} = \frac{95}{100} \text{ x } \frac{3}{6} \text{ x } \frac{.5}{1.0} = .95 \text{ x } .5 \text{ x } .5 = .2375 = 23.75\%$$

not 95% ! At this point, managers trained in traditional metrics for Efficiency calculations will point out that perhaps the reduced efficiency was “a good idea”, because the firm gets more money for the narrower, thinner product. This may be true (although, without the application of an integrated TAU and ABC system, the author would assert that such a statement may or may not be true), but in no case does the calculational approach modeled above render such an assertion untrue. It simply reflects the true efficiency of the unit in the context of how the company is paid; that is, by weight, not number of units. The decision to sell and make a product that renders the mill 23.75% rather than 95% efficient may be a good financial decision, but it is irrelevant to the proper calculation of Efficiency for Asset Utilization purposes. The fact is, fewer pounds were produced off the mill during the base period than might have been if wider, thicker coils had been sold and manufactured.

This example illustrates one reason that the Operations Management / Production staff cannot be solely responsible for Total Asset Utilization as a measure of productivity, if it is to be truly linked to profitability. In the case of this component (i.e. Efficiency), Sales and Marketing would arguably have as much influence on Efficiency as the production staff.

Let us review a second example of this issue. The author was working with a company in Australia that was interested in using the TAU model with ABC to determine if they could enhance their profitability without downsizing, in the presence of revenue growth. One of the key production units in the manufacturing line was a die caster. The Efficiency of the die caster was assessed by the actual number of strokes per hour recorded for the caster; divided by the theoretical design speed (i.e. the theoretical maximum number of strokes per hour that the die caster was capable of running). It was not unusual to find periods during which the die caster ran at (ostensibly) 100% Efficiency for a given hour; with virtually all of the recorded Efficiency values running between 95% and 99%.

The problem was fundamentally that for TAU purposes, this traditional measure of Efficiency was inappropriate. The company was paid for the number of *units* (i.e. castings) that it produced, **not** the *number of strokes* on the caster. Because of the product mix, one stroke on the caster could be equivalent to 1 , 4, or 16 units in output. While the firm was paid a different price for the smaller (16 at a time) versus larger (1 at a time) units, the Efficiency calculation had to take the number of units per stroke into account. While management initially felt that the calculation “penalized” them for scheduling larger versus smaller units, the decision to produce 1 unit per stroke versus 16 units per stroke by definition must be structured to show a correct effect on Efficiency. Financially, it might be a defensible decision, but in TAU terms, it lowered the true Efficiency of the production unit. In the opinion and experience of the author, the failure to take this condition into account, combined with a flawed Standard Costing accounting system, is the primary reason many firms have experienced significant ‘improvements’ in productivity and efficiency; yet have concurrently watched their profit mysteriously degrade.

A final note on the calculation of Availability for TAU analysis purposes. The factor ‘Total Time’ should be based upon total calendar time. For example, suppose the Base Period for monitoring and analysis is one week. In this case, Total Time would equal 7 Days * 24 Hours/Day * 60 Minutes/Hour or 10,080 minutes (or units) as a Base Period for Availability. Some firms, set up to run for a single shift of 8 hours, with the remaining 16 hours per day allocated to Idle Time, often change the Base Period to 3,360 minutes or units (7 Days * 8 Hours * 60 Minutes). Unfortunately, this is incorrect for ***Total*** Asset Utilization purposes. While the staffing / scheduling decision may be financially defensible, the equipment and facility maintenance, rental and tax consequences exist on a 24 hour-a-day basis; and do not disappear because the equipment is not scheduled for production purposes. Therefore, the base period should be calculated on the basis of total calendar time for estimating Availability and Duty Cycle in a TAU analysis. It should be noted that many firms find it useful to use the scheduled calendar times in their calculations as well as Total Time. This calculation should be expressed as resulting in an *OAU*, or *Operational Asset Utilization*, value; and may be in certain circumstances be used in conjunction with, but never instead of, the TAU indices.

Table II, which follows, shows how sample data collected for a an actual production line in a single Base Period would result in the calculation of each of the four components of TAU, as well as the TAU index itself.

Table II

Illustrative Calculations (Minutes)

TAU Component **(Final Calculation)**	Level I Sub-Component **(Totals)**	Level II Sub-Component **(Sub-Totals)**	**Applicable** Values Obtained (Minutes)	Potential Process Owner(s)
Availability **(0.9062 =** 1305/1440)	Planned Downtime (55)	Preventive Maintenance/ Sanitation	**10**	*Maintenance Department *Sanitation Crew
		Lunches/Breaks	**45**	*Management
	Unplanned Downtime **(80)**	Failure & Repair **(25)**	Product-Related **25**	*Product Engineering *Process Engineering *Operations Management
			Process-Related **0**	
		No Demand **(40)**	Lack of Sales **40**	*Sales & Marketing
			Choose Not to Sell **0**	
		No Supply **(15)**	Internal (Upstream) Unit **15**	*Operations Planning/ Scheduling
			External Supplier **0**	*Operations Scheduling *Procurement/ Purchasing
	Choose Not To Run **(0)**		**0**	*Operations Management *Operations Planning/ Scheduling
Duty Cycle **(0.9693 =** 1265/1305)	Set-Ups **(25)**	Type/Model Change - Same Product **(10)**		*Operations Management *Sales & Marketing
		Product Change **(15)**		
	Changeovers **(15)**	Label Change - Same Package **(5)**		*Sales & Marketing *Operations Planning/ Scheduling
		Package Change **(10)**		
Efficiency **(0.4262)**	Actual Within Product Manufactured **(0.8525)**	**1300 Actual** 1525 Theoretical Maximum		*Process Engineering *Operations Management
	Product/Process Selection Effect **(0.500)**	**Portfolio Maximum: 3050**		*Sales & Marketing *Operations Planning/ Scheduling
Yield (Recovery) **(0.7731)**	Acceptable Unit Count	**1300-295 = 1005**		*Operations Management *Process Engineering *Product Engineering
	Unacceptable Unit Count **(295)**	In-Process / Within Unit	**0**	
		End-of-Line	**150**	
		Shipped & Returned	**145**	

TAU = 0.9062 * 0.9693 * 0.4262 * 0.7731 = 0.2894 = 28.94%

As shown by this example (Table II), the TAU index for this single Base Period was 28.94%. A critical factor to note related to this calculation is that the TAU value *may or may not* be directly related to ***throughput;*** or the number of units produced. This will be true even if Yield is relatively constant, noting that (for example)

0.90(Availability) * 0.60 (Duty Cycle) * 0.90 (Efficiency) * 0.60 (Yield)
is equal to
0.60(Availability) * 0.90 (Duty Cycle) * 0.90 (Efficiency) * 0.60 (Yield)
is equal to
0.90(Availability) * 0.90 (Duty Cycle) * 0.60 (Efficiency) * 0.60 (Yield)

in terms of a calculated value for TAU (29.16%); but it would be unlikely that the average number of units produced under these three conditions would be identical, or even nearly so.

As a result, it is critical to conduct a multiple regression analysis over data collected from multiple base periods through time to ascertain the critical component(s) associated with the throughput of the particular process. In some cases, expended costs will be substituted for units produced as a dependent variable in this analysis. As with all applications of this model, the selection of the dependent variable will be a function of the industry, company, and products for which the analysis is conducted.

Table III reflects an example of multiple period TAU data collected for an Electric Furnace and Caster. Note that the Base Period for these data is one month. Note also the Throughput data concurrently gathered for these Base Periods.

Table III

Actual TAU Calculations During Multiple Periods for An Electric Furnace / Caster Department

MONTH	AVAILABILITY	DUTY CYCLE	EFFICIENCY	YIELD	TAU	THROUGHPUT
January	57.01	86.48	60.30	96.71	28.75	55.92
February	53.94	85.08	58.70	95.99	25.86	51.44
March	57.04	87.75	58.90	96.43	28.43	56.44
April	57.56	88.10	64.30	97.85	31.91	56.78
May	60.37	88.28	61.90	97.66	32.22	60.26
June	60.34	86.19	60.80	96.54	30.53	57.45
July	65.78	87.61	63.80	96.22	35.38	64.55
August	61.06	86.35	55.10	96.37	28.00	59.92
September	57.40	83.41	52.90	94.64	23.97	49.74
Average	58.94	86.58	59.63	96.49	29.36	56.94
M.O.E.	65.78	88.28	64.30	97.85	36.54	65.06[1]
M.O.E. Gap	6.84	1.70	4.67	1.36	7.18	8.11 (14% vs Average)

[1] Based On Multiple Regression Analysis

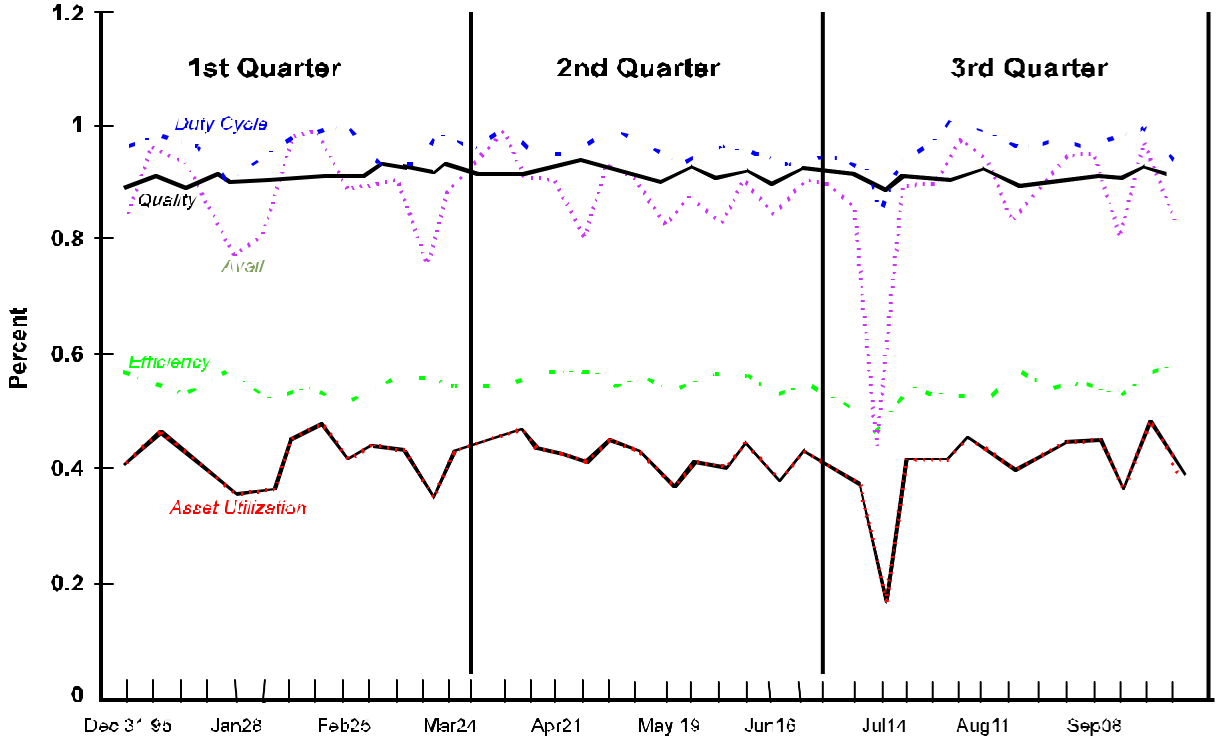
Table III shows component and TAU values at performance levels that are relatively common when initiating the use of the TAU model in most companies. An additional feature introduced in this Table is the identification of the *Moment of Excellence* (M.O.E.). This value represents the highest observed actual value achieved within each component, for the Base Periods analyzed. Note that for the Furnace data (Table III), these values do not all occur within the same Base Time Period.

The *M.O.E. Gap*, which represents the difference between the average and individual M.O.E. values in each component column, reflect the difference between how the facility generally operates (i.e. on the average), and the facility's potential under current capital conditions. The M.O.E. Gap for Throughput shows the additional output that this facility would produce versus its monthly average output if the Asset Utilization Index could be raised to its M.O.E. performance level. It is important to note that the predicted M.O.E. value for Throughput is obtained through the use of a multiple regression equation as described earlier, as opposed to using a single observed maximum value.

In most cases, it is most helpful to display these data through time on a Run or Control Chart. Illustration I reflects these type of data for a Bakery production line generating a mix of Buns and Pastries.

Illustration I

Sample Run Chart for TAU Data



As shown by the data on the Run Chart, Efficiency is the primary ‘driver’ for the resultant TAU Index. It is interesting to note, incidentally, that based on the Bakery data displayed on the Run Chart, as well as the summary data for the Furnace/Caster displayed on Table III, in neither case would improvements in Yield provide the primary or maximum impact on the TAU value for the facility evaluated. This is not an unusual finding in the experience of the author, but it does explain why many companies depending solely on Quality or Yield improvements to reduce costs and increase profitability may have ultimately been disappointed.

Next Steps : Planning for Improvement Utilizing the TAU Data

For many industries, a World Class estimate or milestone for TAU would be identified as 85%. This goal, of course, would require that the four components (if performance on each were equal) would each be operating at an average performance level of approximately 96.1% (since $.961^4$ = 85.3%). This objective would not necessarily be obtainable for all industries; and, in fact, could be a counter-productive goal. What we are truly interested in is the maximization of the Throughput or Output dependent variable, which in turn will be tracked by improvements in the TAU index; not the reverse.

Toward this end, the procedure which would be used at this point would generally consist of the following steps.

1. Establish the capability of the process evaluated in TAU terms while it is operating under a state of statistical control.
2. Using the data from stable (in control) conditions, conduct a multiple regression analysis to determine the critical components, and sub-components, associated with the maximum improvement opportunities associated with Throughput (or its surrogate variable or variables).
3. Based upon the results of the Multiple Regression Analysis, identify the process owners in the organization responsible for improving the associated conditions and metrics. Set up an ongoing monitoring effort in the Daily Management system of the firm.
4. Provide each designated process owner with a fault tree showing the potential root causes for the applicable performance metrics requiring improvement[1].
5. Once these internal improvements are underway, stratify the data by Customer; by Product; and by Customer by Product. Reanalyze the TAU and TAU-related data within these categories. Combine the results with the financial data available (hopefully, an ABC system), and conduct a *Customer-Product Rationalization analysis*[1]. This analysis will provide the Sales and Marketing group with many of the tools necessary to reallocate resources to maximize *the richness of the customer/product mix,* rather than the number of units sold, on a 'go forward' basis.

The use of these data, integrated with appropriate cost and profitability analyses, has the potential to swiftly improve the profitability of most firms. This will be particularly true if the results of these analyses can be integrated with the goals, objectives, and incentive systems associated with the Sales and Marketing personnel.

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[1] Luftig, J. *An Overview of Total Asset Utilization.* Seminar Manual presented to the American Association of Industrial Managers (AAIM), St. Louis Regional Quality Institute, Distributed by Luftig & Warren International, June 4, 1997

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NETWORKER

For more detailed information on creating industry-dedicated metrics for TAU and its associated components; or on how to conduct a Customer/Product Rationalization analysis; or any other information related to this article, contact Dr. Luftig directly at Jeffrey.Luftig@Colorado.Edu through the Internet.