USING STRATEGIC PERFORMANCE MEASUREMENTS TO ACCELERATE LEAN PERFORMANCE

This article provides a "starter set" of performance measures that establish lean thinking conditions for many, if not most lean manufacturers. This is a good place to start to design more tailor made performance measures.

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All too often, successful lean manufacturing implementations cannot be sustained over the long term. Initial reductions in lead time and inventory levels that these companies achieved in the early days of the lean effort are not present when visiting the company three years later. Commonly, the companies continued to measure and evaluate operations based on their achievement of unit cost targets built into their standard costing systems. This recurrent problem might lead one to conclude that lean manufacturing cannot be sustained over the longer term without replacing these standard costing measurements. This article examines what is wrong about standard costing to measure operations in a lean company. It describes the characteristics of measures that support lean, and sets forth a set of measures that embody these characteristics. Finally, it describes a way to develop a set of performance measures that support lean performance.

The problem
The reason traditional standard costing measures don't work in a lean company is that they were created to support mass production. Mass production was created to achieve lowest unit product cost through long production runs at each operation. Under this theory the lowest unit cost for the product can be achieved when the unit cost produced by each operation is minimized. Using this measurement scheme, individual operations receive incentive to produce as many parts as possible per unit of time. Parts produced in excess of the amount demanded by customer orders were stored in work-in-process storerooms, to be used to support future demand.

Lean manufacturing, on the other hand, stresses making products one at a time, thereby eliminating the production of large work-in-process inventories, but leaving...
the operations with large amounts of unused machine and labor capacity as production volumes are reduced to support only those amounts needed to fill current customer orders. This reveals the basic conflict created by using mass-production measures to support lean: they reward maximum production and building work-in-process inventories and penalize the creation of unused capacity. If a company continues to use traditional performance measures, it will not be able to sustain lean manufacturing because the measurements will “push back” against the changes implemented by the lean program.

Solution to the problem
The solution to this problem gets cost measures out of the shop floor entirely and replaces them with measures designed to assess and motivate the causes of cost and performance. These new measures should thoroughly reflect the company’s strategies and goals at all levels. Consequently, as people seek to achieve individual performance targets, they also work to support more comprehensive endpoints.

Principles of effective lean performance measures
Just what should the new performance measures look like, and how does a company set them up?
1. They need to reflect the principles of lean thinking.
2. They should drive improvement of value stream results.
3. They should control adherence to standards in the lean cells.
4. They should link cell and value stream to corporate strategies and goals.

We can call these the principles of lean performance measurement. Individually and as a whole they represent a radical departure from traditional methods. Let’s examine each of these principles in turn.

The measures must reflect lean principles
Lean performance measures must measure an organization’s progress toward its desired lean state. In short they must embody the principles of lean thinking. Exhibit 1 depicts the five principles set forth by James Womack and Daniel Jones in their seminal book, Lean Thinking.1

Value to customers. The purpose of a lean enterprise is to provide value for customers. Lean performance measures must measure the extent to which the company is providing value to customers. From the point of view of the end customer, value includes the notions of quality, service responsiveness, and how well the features and characteristics of the product or service meets the needs of that customer. From the point of view of the process, it must measure how well the upstream process satisfies the needs of the downstream process in terms of quality and timeliness. This notion of value represents a significant departure from the “shareholder value” principle that drives the traditional performance measurement model. In the lean model, the enterprise exists to provide value to shareholders, which leads to a formulation of value based upon financial results.

Value stream. Lean operates in the context of a value stream. As Brian Maskell describes more thoroughly in his article in this issue of Cost Management, a value stream is simply all the processes that are performed to transform an order received from a customer to a delivered product or service. Therefore, lean performance measures must operate in this context. This “process” view of the organization represents the way the organization operates, but it is a radical departure from the traditional “departmental” view that undergirds traditional performance reporting.

Flow and pull. Lean operates in a just-in-time framework. Womack and Jones call this “flow” and flow is key to the achievement of lean. While people generally think of flow in terms of liquids and of certain process industries, lean adapts this concept to discrete materials that pass through the manufacturing process. The image is of material that moves at a constant rate through the process without stopping, and the lean company strives to attain perfect flow of its product from order to delivery. Lean also embodies the notion of “pull” which means that the rate of flow is determined by the rate at which customers demand (pull) products. So performance measures must calibrate the
EXHIBIT 1 The Framework—the Principles of Lean Thinking

Value Stream

Empowered People

Perfection

Flow & Pull

Extent to which the processes make products at this rate.

Perfection. The standard for lean is very stern indeed. It is not “budget” or performance within some statistical precision of the value but the flow and rate at which the customer wants the product or service. This means that measurement processes must be very good at measuring all instances of “non-value” and “non-flow” or “non-pull.” Measurements must also provide information that can be used to identify the causes of these conditions, so that these causes can be remedied rapidly.

Empowered people. Lean performance levels require people who can see what the process is not operating at perfection and who know what to do to correct the causes of problems that occur. In a lean process, which operates with very low inventory buffers, there is no time to get management permission to fix problems that arise. They must be fixed immediately by people who know what is wrong and can best ensure that the problems do not recur.

They should drive improvement of value stream results

Financial measures show the results of operations that occurred in the past. The fact that they are derived from operating data means that they are very difficult to interpret. At face value they show that results of operations were greater or less than expectations, but they provide no insight as to why this is so or what needs to be done to fix the problems that have caused this discrepancy. Consequently, they serve as a poor guide for action. If this were not bad enough, the results come many days after the problems occur. Lean companies cannot be managed by looking in the rearview mirror. They need the kind of measurement that focuses on the causes of desired results.

To achieve value stream performance goals like lower lead times and greater productivity, companies must undertake a program (a kaizen event if you will) that changes the causal factors that contribute to downstream goals. They must measure the achievement of these causal factors at the cell level in real time (hourly, daily), checking periodically whether the desired levels of value stream results have been achieved. If they have not, workers try to discern why the program has not been sufficient and modify it accordingly. In this way, companies create a program of continuous learning in which causal and result measures are linked to continuous program improvement. The weight-loss example described below and depicted in Exhibit 2 portrays the desired control process.

Let's say I go to my doctor for my annual physical, and he pronounces, "Bruce, you are too fat! You need to lose 20 pounds in four months!" I smartly reply that I am an accountant and know about measuring results; so I volunteer to weigh myself every day. To which he replies, "No, Bruce, if you are to lose the weight, you must understand the causes of weight gain and loss. Weight loss is caused by burning off more calories than you consume, and this means that you must undertake a program of limited intake and increased exercise sufficient to get your weight down. So starting tomorrow, I want you to start consuming only 2,000 calories and running three miles each and every day. I predict that if you do this you will lose a pound and one-half each week, which will enable you to reach your goal at the end of four months."

This identifies the critical factors for losing weight and sets up daily targets for each factor. So what do I measure? If I want to lose the weight I must measure the miles I run every day and the calories that I consume. Measuring my weight (the result mea-
sure) will not help me achieve my goal. I must measure the actions directly related to the causes of weight gain and loss. So, proceeding with the story, after having complied religiously with the regimen set forth and having faithfully recorded that fact, I get to the end of the first week, jump on the scale, and lo and behold! I have lost a grand total of only one pound for my efforts! Obviously my program needs to be altered. I must either eat less or run more—or both. So I alter my program, measure my adherence and record the results at the end of week two. I find that I have lost the pound and one-half I desired; so I maintain this routine throughout the remaining 14 weeks and reach my goal.

Applying this example to the lean value stream, the interplay among the desired value stream results, the continuous improvement program to establish new standards for critical factors used to achieve those results, and the monitoring of those critical factors constitute the lean performance measurement process that leads to continuous learning and desired results. But let's proceed with one other matter related to control.

**Measures control adherence to standards in the lean cells**

Performance measures should identify when the cell starts performing contrary to the standards set for the cell and trigger a process to get the cell back into control. This process can be likened to a thermostat that controls the temperature in a room.
This process is shown in Exhibit 3. Note that the important characteristics of this control process are that there is a rapid feedback response to the system’s performance outside the control limits for the critical factor, and second, that the control mechanism is related to the causal factor for maintaining control of the process. In the case of the furnace, the response is automatic and immediate. In the case of a lean cell, there must be performance measures that alert the cell team that there is a problem. The team must respond immediately to the problem with countermeasures so that the cell returns to goal oriented performance as soon as possible. This may mean stopping the cell to fix the problem.

Measures relate cell and value stream to corporate strategies and goals
Corporate strategy should cascade down to value stream and cell so that the continuous improvement program at every level is set with an eye to what is critical to achieving its goals. Exhibit 4 depicts the measurement framework for establishing such a set of goals and measures. The goals for the value stream are based upon critical ways that the value stream achieves corporate strategies and the cell achieves value stream goals. Performance measures calibrate the attainment of these goals and critical success factors. Causal measures become result measures moving from left to right across the exhibit. Thus, from the point of view of corporate strategy, the value stream measures are causal measures, but from the point of view of the value stream, they are the result measures. In this way the performance goals and measures are linked and cascade from strategy to value stream to cell. The same relationships apply between the value stream and cell. Because every company is different, each company should employ such a framework to design its unique set of performance measures to achieve its strategies and goals.

The starter set of lean performance measurements
Notwithstanding the uniqueness of manufacturing concerns, organizations can design a set of performance measurements derived from the principles of lean that conform to the needs of many, if not most, lean manufacturers by using the cascading perfor-
Thus, by linking the structure of goals, measures, and improvement kaizens properly at the cell level, the financial and business results will "take care of themselves." If this is not done, then no amount of managerial browbeating will cause it to be so. Proper use of the performance measurement framework and starter set of performance measures enables the achievement of financial goals and business strategy in most manufacturing companies.

The starter set measures
This section describes briefly each of the starter set measures for the cell and value stream levels of the lean company.

Cell Level measures enable the cell team to get done during a shift what has to be done that shift. The job of the cell is to make the takt (the rate of demand dictated by the customers), using prescribed standard work methods, and adhering to the kanban signals dictating what to make and when. In general, the measures flag problems achieving these goals, so that the focused attention of the value stream team can be brought to bear to fix the problem immediately and to apply temporary countermeasures to enable the cell to get done what it has to get done that shift. The earlier in the shift that this is known, obviously, the better chance there will be to achieve this objective. Cell level measures include:

- Day-by-the-Hour Report: This measurement board at the cell shows the volumes and products that need to be made each hour, how much has been made that hour, the problems encoun-
tered, and countermeasures employed. It provides the basis for cell team and supervisory management to get the cell the help it needs to fix the problems and get back on track.

- **Work-in-Process to Standard Work-in-Process:** This ratio shows the extent to which the amount of inventory at the cell is equal to the inventory levels specified when the cell was designed. Generally, it measures whether the cell is following the kanban signals concerning whether and what to make. If this is so the ratio will be “one.” A ratio greater than one generally signals that the cell is making products without getting a kanban signal to make. Examples might be making products ahead of schedule if a machine was down in a downstream work center or if materials for the scheduled production were not available. In such conditions, there is a great temptation to make product in violation of the kanban signals. But that avoids fixing the problem. The lean way is to stop and fix the problem so that it will not recur, and then proceed with the production. This measure serves to enforce this discipline.

- **First Time Through Quality:** This measures the capability of the cell to make good parts. It equals the ratio of parts made correctly the first time (without rework or scrap) to total parts made that hour. Lean seeks to alert workers when a process starts to make out-of-spec parts and to stop to fix the problem immediately so that no further bad parts will be made. Generally, quality problems signal that standard work has not been adhered to, or that there is need for a new standard. When the problem is fixed, the new standard should be developed and implemented in the cell. In that way problems are continually identified and quality enhanced.

- **Operational Equipment Effectiveness:** This measure identifies the ability of machine capacity to be improved. It is generally useful for a bottleneck machine that has to operate at as close to full capacity as possible, and it provides a guide to the improvement team regarding the highest priority initiatives to improve the capacity of the machine. The measure is calculated by multiplying the ratio of availability (time up) of the machine relative to total time, times the ratio of the actual run rate (actual parts per hour) relative to design (or ideal) rate, times the first time through ratio for that machine. Positing a scenario in which the bottleneck machine was up six

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**EXHIBIT 6 Value Stream Continuous Improvement Team Board**

<table>
<thead>
<tr>
<th>Productivity</th>
<th>Process Control</th>
<th>Quality</th>
<th>Material Flow</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales or Units per Person</td>
<td>On-Time Shipment</td>
<td>First Time Through</td>
<td>Dock-to-Dock Days</td>
<td>Average Cost</td>
</tr>
<tr>
<td>Pareto Chart (or other analysis)</td>
<td>Pareto Chart (or other analysis)</td>
<td>Pareto Chart (or other analysis)</td>
<td>Pareto Chart (or other analysis)</td>
<td>Pareto Chart (or other analysis)</td>
</tr>
<tr>
<td>Improvement Projects</td>
<td>Improvement Projects</td>
<td>Improvement Projects</td>
<td>Improvement Projects</td>
<td>Improvement Projects</td>
</tr>
<tr>
<td>Current Value Stream Map</td>
<td>Future Value Stream Map</td>
<td>Transition Plan</td>
<td>BOX SCORE</td>
<td>Value Stream Income Statement</td>
</tr>
</tbody>
</table>
hours of the eight it was supposed to be up (75 percent) due to one hour down for repairs and one for changeover; it was designed to make 100 parts per hour but it only made 80 (80 percent); and first time through quality was 80 percent. In this case, the operational equipment effectiveness is 0.75 X 0.8 X 0.8 = 0.48. This means that this machine is only operating at 48 percent of its potential capacity. It provides the basis for making improvements in this important dimension.

The cell team leader posts this data manually on prominent displays so that all who walk by the cell can see them. At the beginning and end of each shift the team leader meets with the cell team to review the performance during the proceeding and upcoming shift, identifies problems that need to be fixed, and assigns the problems to team members for further study and improvement. In an environment that aims to promote empowerment, this error is rather significant. Key problems and countermeasures are captured from the displays and submitted to the value stream continuous improvement team.

Value Stream measures calibrate how well the value stream is doing in proceeding towards the performance targets designed into the future state map. They are collected and analyzed weekly by the continuous improvement team as “result” measures from the point of view of making lean progress. They serve as a means of calibrating the effectiveness of ongoing continuous improvement measures and of designing future improvement initiatives. The following are the value stream measures:

• Sales per Person: This measures the productivity and throughput of the value stream during the past week. It is calculated by dividing the sales (or units) shipped from the value stream during the past week by the number of people in the value stream.

• On Time Delivery. This measures the extent to which the value stream is capable of making to schedule at the rate of customer demand. As such it is a measure of the ability to deliver customer value. Consequently it is important to use the amounts and terms requested by the customer, not those that they settled for because we couldn’t give them what they really wanted.

• Dock-to-Dock Time: This measure depicts the material flows through the value stream—the time it takes for material to flow from the receiving dock (or order entry point) to the shipping dock. It is thus a measure of the ability to deliver on time and is generally a good indicator of the effectiveness of lean initiatives to improve the lean flow. Computationally, it equals the number of days of average customer demand contained in all inventories (raw materials work in process and finished goods). It is a reliable indicator of the extent to which inventories are being reduced and cash flow improved.

• First Time Through Quality: This measures the percentage of total parts that are completed the first time without rework or scrap for the value stream. Computationally, it is the product of the first time through at the cells and answers the question as to how capable the value stream is as a system for making good parts.

• Average Cost per Unit: This measure the total cost of all the resources used by the value stream during the week, divided by the number of units shipped. Resources include production labor, engineering and operational support, supplies, outside processing, facilities, machine depreciation, and raw materials at their actual cost. The aim is to have as few allocations as possible, so that true costs are measured, so this measure should decline as lean improvements enhance throughput.

• Accounts Receivable Days Outstanding: This also measures the cash flow improvement of the value stream. It shows the extent to which account collection improves as sales and throughput increase.

These measures should be displayed in a value stream team area where the improvement team can meet, discuss progress shown toward lean goals, and design improvement initiatives to move lean progress forward. An examination of
the format for a measurement display showing trends, root cause analyses, improvement projects, and other analytical data is shown in Exhibit 6.

**Suggestions for implementation**

Here is a work plan for a kaizen event to implement these new measures:

1. Pick a value stream and cell to pilot the measures.
2. Decide whether the starter set will be used as is or tailored.
3. Teach all people in the company about the new measurements and measurement philosophy.
4. Design the measurements, measurement boards, data collection methods, and improvement methods using the methods.
5. Place the measures and new method in the value stream and cell.
6. Run the value stream and cell for one month using the new methods, discontinuing all other performance measures for those areas.
7. At the end of the month, review results of the test, modify measures, and implement.

This method of implementation allows companies to iron out problems in the measures before factory-wide implementation.

**Summary and conclusions**

This article has demonstrated that traditional performance measures will not work in a lean factory because they will only serve to work against lean progress. Lean companies need measures that motivate adherence to the principles of lean thinking, serve to drive continuous improvement, control adherence to standards in the cells, and link cell and value stream performance to business strategy. The starter set and implementations steps suggest ways to begin implementing lean principles. So now is the time to start implementation. Best of luck!

**NOTES**

2. Adapted from material presented at the Lean Accounting Summit, September 22, 2005, Dearborn, Michigan, in a presentation entitled, “Using Strategic Performance Measurements to Accelerate Lean Performance.”
3. See note 2.
4. See note 2.
5. See note 2.
7. See note 2.