VITAL SIGNS OF MANUFACTURING COMPETIVENESS

10 Indicators of Performance Excellence

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SOS CONSULTING, LLC
Transforming Small-to-Medium Manufacturers to COMPETE in the Global Marketplace

VITAL SIGNS OF MANUFACTURING COMPETITIVENESS: 10 INDICATORS OF PERFORMANCE EXCELLENCE

This paper will introduce 10 indicators or "vital signs" of performance excellence that capture the essence of the six essentials for high levels of productivity and profitability leading to competitiveness.

US small-to- medium sized manufacturing organizations have borne the brunt of the recent economic recessions. 63,000 US factories have closed since 2000.[1]; employment has decreased by 21.8%[2] and wages have declined or stagnated[3]. While production moved offshore, US small manufacturers lost the capability to compete; they often have limited ability to design new products, serve customers, and solve problems. In addition, they typically have outdated equipment and a narrow product focus.

Many leaders in small to medium sized manufacturing organization want to manufacture in the US and provide steady living wage jobs in their communities. But performance is low – productivity, cost, time and quality are continually not meeting targets; customers are not satisfied and employees are not engaged.

These leaders awake at night thinking about the problems of the day and dread going to work every morning to the chaos, politics and conflict that surround these problems.

They've tried several improvement approaches over the years, but saw limited results. Their organizations cannot execute improvement in a way that is sustainable for the long-term. They question their leadership, knowledge and capabilities.

Six Essentials

Over decades of working in continuous quality improvement in manufacturing organizations of all sizes, SOS Consulting has identified six essential elements to competitiveness that leaders of small-to-medium manufacturers can use:

1) Cohesive leadership,
2) Strategic clarity
3) Communication
4) Process thinking
5) statistical thinking, and
6) Relationships.

The six essentials are depicted as a house and just like building a house requires all the right pieces to come together at the right time and place, the essentials are interdependent. See Figure 1 below.

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[1] Jennifer Alsever,"Smaller Businesses Struggle to make it in the U.S. A." Fortune, Nov 17, 2014.

[2] Michael Collins, "How American Workers Became Disengaged," IndustryWeek.com, May, 20, 2015

[3] Mark Matthews,"Manufacturing Employment by Education, 2000-2014," ASEE Capitol Shorts, July 10, 2015.

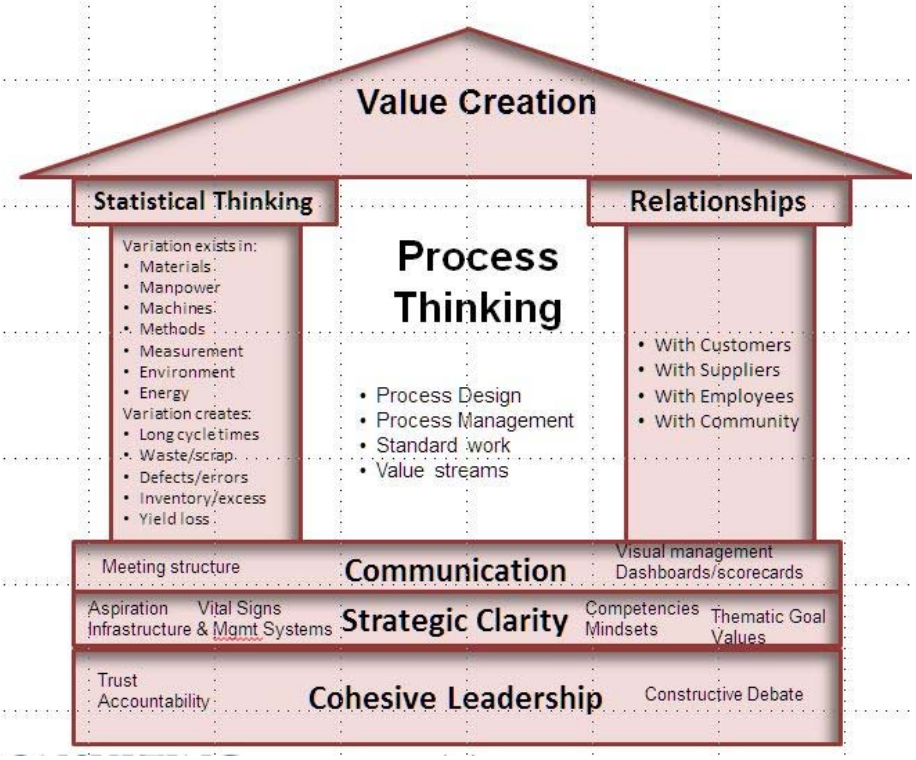


Figure 1: Six Essentials Depicted as a house

Objective of the Essentials

What makes an organization successful for the long-term? Beyond profit, what drives longevity? Let's agree that a successful organization is one that provides **value** to its customers/ clients/ volunteers/ members/community. A manufacturing organization that provides value to its customers through its products and/or services will provide good living wages to its employees and shared value to the community over time. A hospital that heals and prevents disease (value) will transform the health of the local community through its care for community members. This is our objective, what we are aiming for; **value creation forms the roof our house.**

The roof cannot stand on its own – it needs a foundation and load-bearing walls – things that synchronize the organization's internal systems with the external realities (market, government, technology, culture) they face. We at SOS Consulting, call this EXECUTION.

> ***EXECUTION*** *- the synchronization of the business processes with external realities*

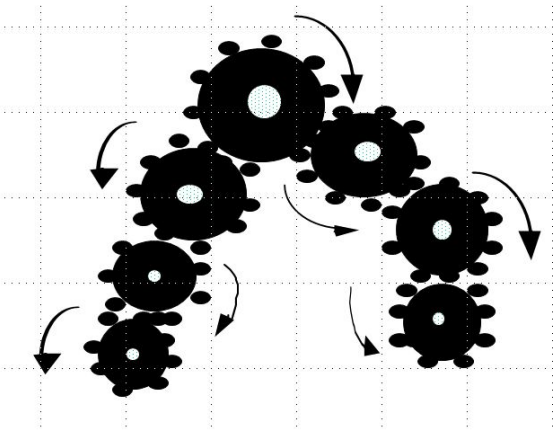
The 3 Foundational Essentials

So, how do you execute in a practical way be successful in today's rapidly changing world? Strategy? Technology? Training? Teambuilding? While these things are important and will probably be part of your path forward to some extent, the foundation to competitive advantage and longevity is **organization health.** No

strategy, technology, training, or improvement initiative alone can give leaders peace of mind and organization success without organization health. Organization health contributes **three of the six "essentials"** needed for organizations to execute consistently.

What is organization health? A healthy organization is one that practices four disciplines, the first three of which form the foundation of the house:

1) **Essential 1: A cohesive leadership team** –the leadership team trusts, constructively debates and holds one another accountable. If not, then that dysfunction will cascade throughout the rest of the organization. Think of an organization being composed of a series of gears where the senior leadership is the biggest gear and employees on the lowest level of the organization are the smallest gears[2]. One inconsistent communication or confusion about an activity's importance or refusal to provide resources by a leader will spin its way throughout the organization, faster and faster as it goes down the organization chart resulting in silos, turf wars and disengaged employees



2) **Essential 2: Strategic Clarity** – the leadership team is aligned around answers to strategic questions on organization purpose, how to deliver value, and what is the most important priority for the next 12 months. With this clarity, the leadership team can decide how to position their organization in the market/community[3] and the strategic brick & mortar and infrastructure decisions aligned with that position[4]. This clarity establishes unique competencies across the organization. Simply following industry practice or tradition instead of developing unique position and competencies through strategic clarity results in competitive neutrality[4]. Making strategic decisions without clarity/alignment across the organization leads to confusion throughout the organization and spending resources on infrastructure and brick and mortar not aligned with the purpose.

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[2] Brian L. Joiner. Fourth Generation Management: The New Business Consciousness. New York: McGraw-Hill, Inc., 1994.

[3] Tracey, Michael and Fred Wiersema. "Customer Intimacy and Other Value Disciplines," Harvard Business Review, January-February, 1993

[4]

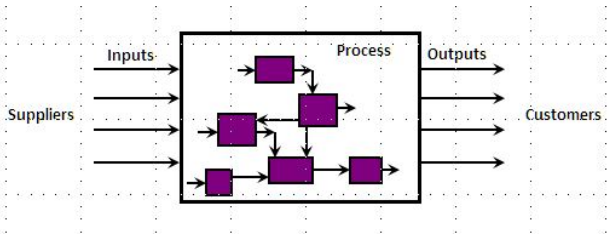
3) Essential 3: Over-communicate clarity – leaders constantly communicate the truth and what is most important; they are transparent to a fault. With this, employees two, three and more levels down know exactly what they should do/know in their daily work to make the organization successful. From daily check-ins to quarterly strategy reviews, meetings are structured to reinforce clarity and be productive (versus something to be dreaded). Tactical discussions and decisions are separated from strategic discussions and decisions to provide the focus needed.

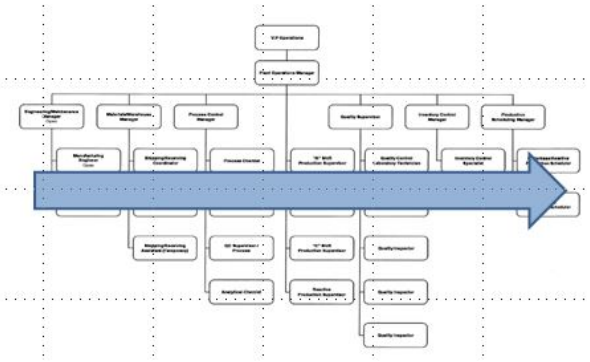
4) Reinforce clarity - Leaders reinforce clarity by constantly embedding the answers to the strategic questions into their managing systems / infrastructure (i.e., employee hiring & development, performance management, quality and safety systems).

Clear, Cohesive Leadership that Makes & Communicates Strategic Decisions throughout the organization form the strong foundation of our house of essentials for productivity and profitability.

Essential 4: Process Thinking

All work is a process. A process is a series of steps/activities that transform inputs (raw material, information, energy) into outputs (products /services) using labor, machines/tools and methods. Processes are the guts of how organizations make and deliver value (product/service) to the market – from supplier to customer - **hence processes fill the rooms of the house as our fourth essential**. (Yes, we have not yet provided the walls to support the roof, but understanding process thinking will help describe the remaining two essentials that support the roof.) We tend to think of organizations as they are depicted in the organizational chart – a hierarchy of vertical functions. The real work to fulfill a customer need, however, crosses multiple functions.[5]





Functional thinking results in people thinking more about what is best for their department than what creates value for the customer/community. If any of the functions is focused on anything other than that clarified and communicated by leadership, there will be a dis-connect: productivity/quality problems, confusion, turf wars, and disengaged employees.

Let's explore the impact of process thinking in a food manufacturer with a simple manufacturing process– the raw ingredients are added to a large tank and mixed for a specified amount of time and then dropped through a filling machine into metal cans, plastic jugs, and large totes with unique store-brand labelling. If R&D does not develop the recipe for the product taking into account the availability of the raw materials, material specifications, and/or operation of the equipment, the product may not be mixed or filled properly or at the scheduled time. If marketing does not get the labels with unique store-brand information designed in time for the print vendor to print and deliver them, the product cannot be filled and delivered to the customer per schedule. Typically everyone blames the manufacturing function for these failures; they do not understand that the manufacturing function is only one element of the **product fulfillment process;** the manufacturing function is dependent on the output of other functions (R&D, marketing, sales, shipping and distribution). The company has a functional versus process view of delivering value to the market. This lack of process thinking can create an environment of mistrust and conflict that undermines cohesive leadership.

Essential 5: Statistical Thinking

Variation exists in all processes. Manufacturing organizations experience variation in product, service, and process performance (yield, productivity, time, quantity, cost, product quality characteristics).[6] The more variation a process is experiencing, the more the process must adjust to account for this variation, creating waste (defects, over production, inventory, and/or excess processing); this waste in turn produces more

[5] Markovitz, Dan. "The Perils of Vertical Thinking." *Industry Week online*, Sept 22, 2015.
[6] Hoerl, Ron and Ronald Snee. *Statistical Thinking: Improving Business Performance*. Pacific Grove, CA: Duxbury, 2002.

variation in the process. Variation can enter a process through its inputs (material, energy, information, and environment) or the activities (people, methods, measurements, and machines/equipment) that transform those inputs into products/services. This variation can result in poor quality and/or inefficient operations. Variation and processes are intertwined and can be difficult to separate as variation in a process can create additional steps in the process (such as a re-work step) or alternative paths which create more opportunities for failure and longer processing times. A highly variable process is unpredictable and more costly to operate. Failure to incorporate variation into product and process design and management can negatively impact an organization's ability to deliver value. Note: The focus of statistical thinking is not on the data, but on using the statistics to tell the "story" of the product/process so the sources of variation can be identified and if not eliminated, minimized.

Statistical Thinking is one of the two exterior walls that support value creation

Essential 6: Relationships

Organizations interface with customers, suppliers, employees and the community on a daily basis in many ways. If the relationships are not "win-win," where customers, suppliers, employees, and community are respected and engaged in delivering value **together**, these relationships will be weak. Over time, customers will seek alternative products/services, suppliers will not respond in a timely manner to requests for materials/information, and/or employees will leave the organization to work elsewhere, reducing the organization's ability to deliver value. This in turn may cause the community to lose jobs, funding and protection of public health, safety, and the environment (shared value).

Bottom-line, when variation is managed in processes that are clearly defined and communicated by a cohesive leadership team in relationship with customers, suppliers and employees, productivity and quality problems often take care of themselves. Silos and conflicts disappear and relationships improve without any complex analysis tools; value is created for the entire community.

The last essential which forms the second exterior wall supporting value creation is relationships.

SOS Consulting believes any organization can improve execution to address their challenges to create value and be successful over time with the six "essentials" of cohesive leadership, strategic clarity, communication, process thinking, statistical thinking and relationships, but especially US small-to-medium manufacturers that have been hit hard during the last decade.

Why Vital Signs?

In medicine, the four vital signs of temperature, blood pressure, pulse, and respiratory rate are used to measure the body's basic functions to help assess the general health of a person.[7] Likewise, vital signs of the six essentials can be used to assess the general competitiveness of a manufacturing organization.

We measure so that we can monitor, control, and improve performance of the essentials over time in order to achieve and sustain high levels of productivity and profitability. Without measurement, leaders have no basis for:

- Communicating performance expectations to the workforce;

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- Identifying gaps in performance and prioritizing corrective action;
- Providing feedback to individuals and teams in the organization, including recognition; or
- Making decisions regarding resources, policies, schedules and infrastructure.[8]

To create an effective measurement system of the essentials for competitiveness that can be used to monitor and improve performance, it is necessary that: 1) it include sound measures to monitor the right things, and 2) there be a total measurement system, not a collection of unrelated measures, and 3) the data is converted into intelligent action.[9] Sound measures are indicators of the critical dimensions of the essential and answer the question "What indicator will tell us if this essential is in place and contributing to our competitiveness?" There are several indicators/metrics that could be used for each essential. We have selected one for each that captures the essence of the essential and can be easily segregated by groups within the organization, products/services/value streams or customers to identify root cause(s) of poor performance. Three vital signs are identified for Relationships. One for each critical relationship: customers, employees and community These 10 vital signs by essential are depicted in Table 1. Twelve additional vital signs may provide additional perspectives on the essential; these indicators are described in the companion paper, "Vital Signs of Manufacturing Competitiveness: 12 Supplemental Indicators of Performance Excellence" (available by request). We will explore each vital sign in the next sections.

Table 1: Vital Signs for Six Essentials of Competitiveness

Essential	Vital Sign(s)
1) Cohesive Leadership	Team Diagnostic
2) Strategic Clarity	Alignment Diagnostic
3) Communication	Employee Survey
4) Process Thinking	On-Time-Delivery
5) Statistical Thinking	First-Pass-First-Quality Yield (FPFQY)
6) Relationships a. Customer b. Employees c. Suppliers d. Community	 Net Promoter Score; Days Away/Restricted or Job Transfer Rate (DART); Net Partner Score; and Process Safety Incident Index
Process AND Statistical Thinking	Overall Equipment Effectiveness (OEE)

VITAL SIGN FOR COHESIVE LEADERSHIP: Team Assessment

A cohesive leadership team exhibits the following five behaviors:

1. Trust;
2. Constructively debate with one another;
3. Commit to important decisions;
4. Hold one another accountable; and
5. Pay attention to results

Peter Lencioni in his book, *Overcoming the Five Dysfunctions of a Team: A Field Guide,* provides a simple *team* diagnostic tool in Section 4 that asks each leader on the leadership team to rate fifteen statements on a 1-3

[8] Rummler, Geary and Alan Brache. Improving Performance: How to Manage the White Space on the Organization Chart. San Francisco, CA: Jossey-Bass Publishers, 1990.
[9] ibid

scale (1=rarely; 2 = sometimes; 3 = usually) that once scored can be used to calculate a score for each of the five behaviors. See Appendix A. A score of 8 or 9 indicates that the behavior is probably not a problem for the team; a score of 6 or 7 indicates that the behavior could be a problem; and a score of 3 to 5 indicates that the behavior needs to be worked on. In our experience this simple assessment is sufficient to determine the cohesiveness of the leadership team. Interviews with each leader and employee surveys may be used to understand the lack of cohesiveness, impact and identify actions to improve.

VITAL SIGN FOR STRATEGIC CLARITY: Alignment Diagnostic

In their book *The Power of Alignment,* George Labovitz and Victor Rosansky define alignment as" a state of being that ensures an organization is in balance." It is a balancing act that involves setting direction, linking processes and systems, and making constant adjustments (strategic clarity). It relies on two dimensions: vertical and horizontal; both dimensions must be in alignment. The vertical dimension is concerned with strategy and the people that transform strategy into meaningful work on a daily basis; it energizes people, provides direction and offers opportunity for involvement The horizontal dimension involves the processes that create what customers most value; it understands what customers really want and then delivers it when and how they want it. See Figure 2 for a representation of this model.

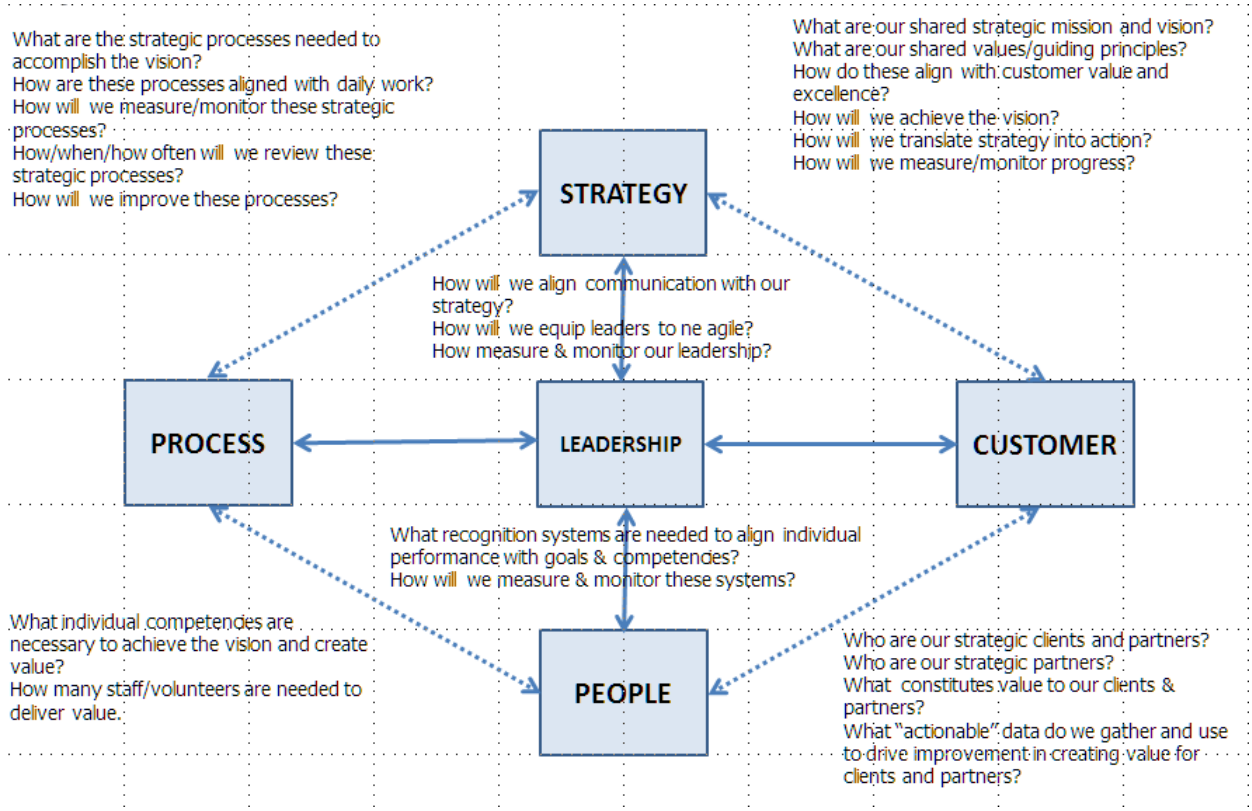

Figure 2: Vertical and Horizontal Dimensions of Strategic Alignment

Labovitz and Rosansky provide an Alignment Diagnostic[10] in the Appendix of the book which asks leaders to rate four statements on a scale of 1 to 10 (strongly disagree to strongly agree) for each of the four elements

[10] Labovitz, George and Victor Rosandky, *The Power of Alignment: How Great Companies Stay Centered and Accomplish Extraordinary Things*, John Wiley, 1997, p199

(Strategy, Customers, People, and Process). See Appendix B. The higher the score for each element, the better. More important is the balance in scores between the four elements. This is best represented in a radar chart in which the higher scores are closer to the center (See Figure 3 below). This short diagnostic is easy to understand and score making it an effective mechanism for revealing misalignment.

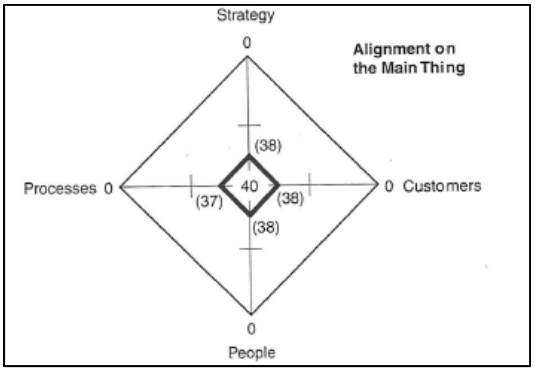

Figure 3: Sample Alignment Diagnostic Radar Graph

VITAL SIGN FOR COMMUNICATION: Employee Surveys

Internal communications play a key role in an organization's success. By influencing employee satisfaction, retention, engagement and performance, internal communications have a direct impact on the bottom line. However, proving this business value is difficult as qualitative key performance indicators (KPIs) are lacking.[11] Employee surveys can also be used to measure awareness, interest and engagement. Key factors often gathered include employee perceptions of:

- State of company
- State of quality/improvement efforts
- State of processes
- Reaction to policies and procedures
- Reaction to benefits
- Job satisfaction
- Company satisfaction[12]

Surveys can range from small regular, targeted polls to extensive annual surveys. An external Employee Surveying Consultant/Firm is not needed to conduct such surveys if the questions are well designed and results appropriately analyzed. We have found questions from the Malcolm Baldrige Performance Excellence Framework (MBPEF) "Are We Making Progress" survey[13] and the ISO 9004 Self-Assessment[14] to provide useful questions for periodic employee surveys. Appendix C includes questions we have frequently used to assess internal communications and the perceptions of employees of strategic elements and management systems. When analyzing the results from such surveys is it inappropriate to assign numerical values to each response and calculate an average; such a number is meaningless. Calculating the percentage of each response is appropriate and can provide the perception of the majority of the workforce (which one or more responses

[11] Mazour, Veronika. "How to Measure Your Internal Communications' Effectiveness?" *Exoplatform.com*, December 16, 2015.
[12] Snee, Ron D. "Listening to the Voice of the Employee." *Quality Progress*, January 1995.

account for more than 50% of the responses). The best analysis approach is to segregate the data by function, process, value stream and/or role and create stacked bar graphs (See Figure 4 for an example). Wide variation in the responses within and between functions, processes, value streams and roles can signal inconsistency of communication within the organization and help identify the source(s) of inconsistency. Note the spread in the responses in Figure 4, even for the Executive Staff. While 70% of the Executive Staff chose the last two options, 30% chose the second and third options; a second level analysis by functions (Marketing, Operations, Technology, Sales, Customer Service, and Shipping) may show how the communications by the Executive leader of the function influences the responses of the workforce within that function. Such analyses would provide direction for improvement.

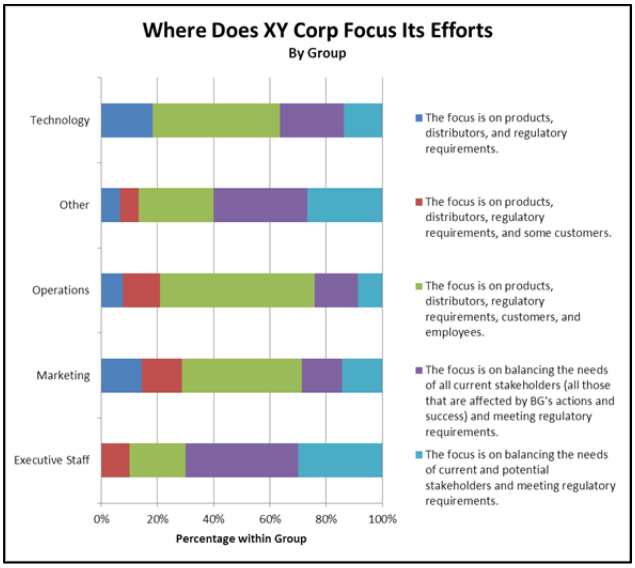

Figure 4: Example Analysis of Communication Survey Question

A "before and after" approach should be used when a new initiative/campaign communication is underway; survey immediately before launch and then after launch, perhaps at different points in time to determine how well the message has "stuck." *Industry Week* Best Plants average one employee survey per year.[15]

VITAL SIGN FOR PROCESS THINKING: On-Time Delivery

On-time-delivery (OTD) is calculated as the percent of orders that are accepted by the customer as "on-time," where "on-time" is defined as a range of dates (X days before and Y days after the due date) in which at least 99% of the requested items in the order are accepted by the customer. In order for product to be delivered to the customer on time in the right quantities of product, product must flow through the manufacturing process as planned with little variation. For example, if the OTD range is 5 days early and 0 days late and an item is due June 1st, it would be considered on time only if at least 99% of the items in the order arrive on any day between May 27th and June 1st. Manufacturing process requirements and cash flow are the two main factors that influence the OTD window. If an item is expensive, it may be planned for delivery very close to the production need date so as not to be late and since it is expensive, it should not be early, making a tight delivery window appropriate. On the other hand, if the item is inexpensive, it can arrive within a wide window and be considered

[15] *The Industry Week Best Plants 2014 Statistical Profile*, Industry Week, 2015.

on time. Commodity classes based on cost are commonly used to set the OTD window (A items -5, 0; B items -5, +1; C items -10, +5).

Both customer and supplier need to make sure that they define OTD the same way. One of the most common misunderstandings is what days are counted – working-days or calendar-days. Calendar-days is the easiest to understand and the most widely adopted. Another misunderstanding is the date used to measure OTD. Is it the date the item(s) are shipped (also known as ship date – the date the item leaves the supplier) or the date it is received by the customer (also known as dock date)? Dock date is the most widely used. It does require, however, that the supplier consider transit times to determine the ship date that allows the item(s) to arrive within the OTD range, which requires knowledge of the variation within the transit time and a good relationship between the supplier and transit organization (a topic for the next section). A supplier may promise a date other than the required date needed by the customer. It is not fair to judge a supplier to a date for which they have not agreed. Therefore, promise date is used to calculate OTD. The promise date may change after it is set for a variety of reasons by either supplier or customer. It is customary for customers to use the original promise date and not the revised promised date when calculating OTD. A manufacturer should measure and monitor OTD on their own products and on the raw or intermediate materials received from suppliers to assess process and statistical thinking and identify opportunities for improvement in their processes. Improvements may need to be made in the Sales & Operations Planning (S&OP) process, inventory levels, material supplier relationships, amount and types of equipment, equipment maintenance and repair, set-up reduction, and first-pass-first-quality yield (FPFQY). Customer and supplier should meet periodically (quarterly is recommended) to reconcile each other's measurements.[16] The 2014 Industry Week Best Plants averaged 75.6% OTD.[17]

VITAL SIGN FOR STATISTICAL THINKING: First-Pass-First Quality Yield (FPFQY)

First-pass-First Quality Yield (FPFQY), is the number of product units coming out of a process with no rework divided by the number of units going into that process over a specified period of time. Only good units with no rework or scrap are counted as coming out of the process. Variation in a process creates product outside specifications/requirements that require rework or must be scrapped. FPTY is a good measure of the elimination of variation from a process. If the process contains more than one process step, the FPFQYs at each step are multiplied together to obtain the FPFQY for the process otherwise known as Rolled *Throughput yield (RTY)*. As an example, consider the process represented in Figure 5 below:

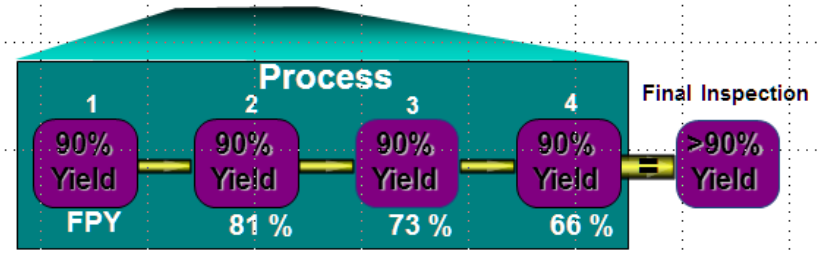

Figure 5: FPFQY Example

The process consists of four steps, each with FPFQY of 90%. The FPTY of the entire process, or RTY is: $\prod_{i=1}^{k} FPGQY(i)$, where k=4 or (0.9)x(0.9)x(0.9)x(0.9) = 0.66 or 66%. This is in contrast to the final yield or the yield at the final step of the process which is 90%. An organization that understands statistical thinking and

[16] Optimum Design Associates Blog, "on-Time Delivery Definitions and Measurement," http://blog.optimumdesign.com/on-time-delivery-defined.

[17] *The Industry Week Best Plants 2014 Statistical Profile*, Industry Week, 2015

seeks to reduce variation in its manufacturing processes will measure FPFQY on each step of the manufacturing process and calculate RTY for each value stream. Benchmark data indicates that FPTY performance can vary by industry as shown below. The 2014 Industry Week Best Plant statistics show the best plants average 98.3% FPTY.[18]

Average FPTY Performance by Industry:

- Aerospace and defense industry: 95.5%, ranging from min of 81% to max of 99%;
- Automotive industry: 97.4%, ranging from min of 90 % to max of 99 %;
- Electronics industry: 94.1%, ranging from min of 81% to max of 98%; and
- Material Equipment industry: 96.5%, ranging from min of 89% to max of 98%.[19]

VITAL SIGN FOR PROCESS AND STATISTICAL THINKING: Overall Equipment Effectiveness

As stated earlier, variation and processes are intertwined. Variation in a process can create additional steps in a process (such as a re-work step) or alternative paths which create more opportunities for failure and longer processing times. Individual vital signs for process thinking and statistical thinking may be in an acceptable range and miss disconnects between the two that lead to a lack of competitiveness. The disconnects may be identified using three vital signs: Overall Equipment Effectiveness (OEE). ORR may give a different perspective on the essentials of process thinking and statistical thinking and should be used to complement OTD and FPFQY.

In a manufacturing organization executing with process thinking, there will be flow from suppliers to customers with little wasted time or materials as value is created. In order for this to consistently occur, equipment availability and performance must be high, where: equipment availability (often known simply as Availability) is the percent of time the equipment is actually operating and creating value. Equipment performance (often known simply as Performance) is the percent of time the equipment is running at full speed. Equipment availability and performance calculations are shown below[20]:

[18] *The Industry Week Best Plants 2014 Statistical Profile*, Industry Week, 2015

[19] Littlefield, Matthew, "Manufacturing Metrics: First Pass Yield Benchmark Data," LNS Research, on-line January 23, 2013.

[20] Nakajima, Seiichi. *TPM: Introduction to Total Productive Maintenance*. Cambridge, MA: Productivity Press, 1988.

Equipment Availability = $\frac{(loading\ time - downtime)}{loading\ time}$ x 100

Equipment Performance Efficiency = $\frac{(theoretical\ cycle\ time - actual\ cycle\ time)}{operating\ time}$ x 100

Loading time = available time/day

Availability will identity and prioritize opportunities to improve flow and reduce waste caused by downtime (both unplanned and planned), set-up/adjustments, exchange of tooling, and administrative activities (morning planning meeting, paperwork). Performance will identify and prioritize opportunities to improve equipment maintenance and stability of the flow of the process; it is also useful information to identify improvements in product and process design.
Ideal conditions are:

- Availability greater than 90%
- Performance greater than 95%

The 2014 *Industry Week* best plants averaged 95.9% Availability as a percent of scheduled uptime.[21]

When equipment availability and equipment performance are combined with First-Pass-First Quality Yield (FPFQY), we obtain a measure known as **Overall Equipment Effectiveness (OEE**):

OEE = Equipment Availability x Equipment Performance x First Pass First-Quality Yield
= Availability * Performance* Quality * 100

OEE measures how much right-first-time product the process produced compared to what it should have produced in the allotted time and is therefore, a measure of productivity that takes into account both process and statistical thinking (see Figure 6 for a graphical depiction of OEE components).

Under ideal conditions, OEE is ≥85% (95% each for Availability, Performance and First Pass Yield).[22] Ideal OEE will vary based on complexity of the product and equipment. The lower the OEE, the more untapped potential exists. An increase in OEE produces an increase in productivity. The individual elements of OEE must be explored to determine how best to increase OEE. Methods to increase OEE include equipment maintenance and repair, start-up/set-up reduction, operational discipline (such as housekeeping), employee training, and material variation reduction. Trends in OEE and its three primary components should be monitored as well as the value of OEE over time to identify opportunities for improvement. A manufacturing organization that is measuring and monitoring OEE will be able to quickly assess the status of process and statistical thinking, their interdependence, as well as any manufacturing functional initiatives (Total productive maintenance, set-up reduction, statistical quality control, etc.) to improve productivity.

[21] *The Industry Week Best Plants 2014 Statistical Profile*, Industry Week, 2015
[22] Nakajima Seiichi, TPM: Introduction to Total Productive Maintenance. Productivity Press, 1988, pp 24 – 28.

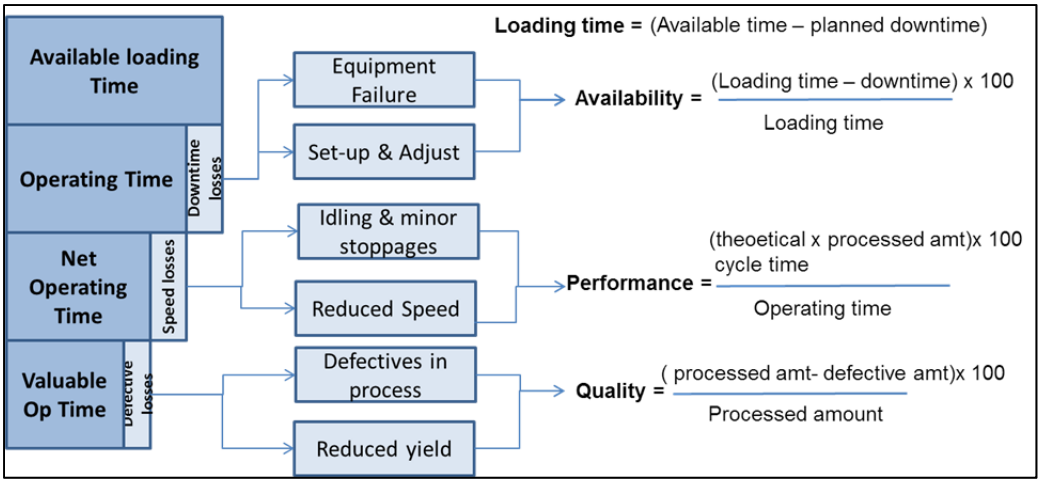

Figure 6: Graphical Depiction of OEE [23]

VITAL SIGNS FOR RELATIONSHIPS: Net Promoter Score, Days Away/Restricted, Net Partner Score, and Environmental Incident Rate

A healthy, competitive manufacturer has strong, loyal relationships with customers, employees, suppliers and their community. We will explore four vital signs of these relationships.

Manufacturers have traditionally used customer surveys to measure the satisfaction of their customers with the products and services they provide. Research over the last two decades, however, finds customer satisfaction surveys to be useless. They tend to be long and complicated, yielding low response rates and ambiguous results that are difficult to translate into operations improvements. Most senior leaders do not take the results seriously as the results do not correlate with profits or growth.[24] For a customer, loyalty means sticking with a supplier who treats him well and gives good value over the long-term, even if the supplier does not offer the lowest price. True loyalty is more than repeat purchases as there may be other reasons for which a customer continues to purchase from a supplier other than loyalty (inertia, exit barriers, indifference, etc.). The customer's choice to stay with a manufacturer's product/service reduces the manufacturer's customer acquisition costs, drives top-line growth, and increases profitability. The one question of twenty questions tested by Bain & Company that correlated with loyalty and growth has to do with the customer's willingness to recommend a product/service to a friend or colleague. Loyal customers bring in new customers, and in effect, become the manufacturer's marketing department, at no charge. The answer to this one question can be used to calculate the Net Promoter Score (NPS). NPS is simple and easy to implement and interpret; it can be calculated and reported in near real-time. The score can be calculated and compared for different regions, customer segments, supply chains and/or manufacturing facilities to help identify root causes of low scores. For this reason, the question is often followed-up with questions that segment the customers and/or regions that can help unearth the reason for the score (both high and low)

Net Promoter Score is calculated using the following steps:

1) Ask customers: how likely is it that you would recommend <company X> to a friend or colleague? With a response scale of zero to ten, where zero means "not at all likely" and ten means "extremely likely." Customers with a score of nine or ten are "promoters" while customers with a score of zero are "detractors."

23 Nakajima Seiichi, TPM: Introduction to Total Productive Maintenance. Productivity Press, 1988, p. 25

[24] Reichheld, Frederick F., "The One Number You Need to Grow," Harvard Business Review, July 2001.

2) Calculate the percentage of customers who respond with nine or ten (promoters) and the percentage who respond with zero (detractors).
3) Calculate Net Promoter Score by subtracting the percentage of detractors from the percent of promoters

Don't be surprised with a low score. The median score of more than 400 companies in 28 different industries, representing 130,000 customer responses as gathered by Satmetrix's customer feedback software was just 16%. In comparison, organizations with enthusiastic customer referrals such as Amazon, USAA, and Nordstrom consistently receive Net Promoter Scores of 75% or higher[25] Converting detractors into promoters will require quick reporting to front-line employees as well as functional leadership (process-thinking) and linking the score to employee rewards (salary, bonuses, promotions) to encourage workers to improve their daily work practices and interactions with customers.

A key to satisfied employees is a safe workplace. A safe workplace is a positive driver of behavior and culture. Nobody wants to get hurt or see anyone else get hurt. A safe workplace starts with communication of expectations from the organization's leaders (the essential of communication) and provision of the right tools in a safe arrangement and training to do the job. OSHA provides three measures to track safety performance:

1) Recordable Incident Rate = number of accidents in a specified time period multiplied by 200,000, divided by the total number of hours worked for the same time period. .
2) Days Away/Restricted or Job Transfer Rate (DART) = total number of incidents that had one or more lost days, one or more restricted days or resulted in an employee having to transfer to a different job within the company due to the injury multiplied by 200,000 and divided by the total number of employee hours at the site.
3) Cost per Recordable Incident = Worker's Compensation Costs divided by number of Recordable Incidents for the time period.[26]

SOS Consulting prefers DART as it captures the lost, restricted or transferred days of a trained employee. Every day an employee is off due to injury or working in a job other than their regular job opens up the opportunity for errors and decreased productivity that may show up in FPTY and/or Availability or Performance resulting in decreased competitiveness. Segmenting incident data by type, location, time of day, employee type and years of service may discover needed equipment, procedure, training and/or equipment improvements. *Industry Week Best Plants* average 0.5 DART. 97%. of the best plants monitor and investigate near-misses as part of their accident-prevention programs.[27]

Manufacturers are dependent on their suppliers for defect-free and timely delivery of materials and services from their suppliers. Suppliers in turn need to feel a part of the manufacturer's team through open, honest and frequent communication, fair business dealings (manufacturer's willingness to pay a fair market price for their material/services) and ease of doing business. A loyal supplier will go out of their way to meet the manufacturer's needs and prioritize the manufacturer's business over new customers. Supplier loyalty to a manufacturer is rarely measured; supplier performance in terms of quality, delivery, and cost are most often measured. 50% of 2014 industry Week best plants focus supplier relationships on quality while 3% focus on total cost.[28] A Net Promoter Score of sorts, we call Net Partner Score (NPS), could be calculated based on the response to one question: "If given the chance to recommend <company X> to a non-competing supplier, how

[25] ibid
[26] Fast, Larry, Safety And Quality: 'Must Have' Metrics for Continuous Improvement," *Industry Week*, October 25, 2016.
[27] *The Industry Week Best Plants 2014 Statistical Profile*, Industry Week, 2015
[28] *ibid*

likely is it you would recommend working with <company X>?" with a response scale of zero to ten, where zero means "not at all likely" and ten means "extremely likely." Suppliers with a score of nine or ten are "partners" while suppliers with a score of zero are simply "suppliers." Net Partner Score is then calculated using the following steps:

1) Ask customers: how likely is it that you would recommend working with <company X> to another non-competing supplier?"
2) Calculate the percentage of suppliers who respond with nine or ten (partners) and the percentage who respond with zero (suppliers).
3) Subtract the percentage of percent of suppliers from the percent of partners

The result of these three steps is the Net Partner Score. Low scores indicate lack of open, honest communications with suppliers, lack of trust with your suppliers, poorly designed processes for doing business with your suppliers and/or disrespectful interactions between your employees and your suppliers. Segregation of supplier response data by buyer, class of material purchased combined with supplier surveys and/or focus groups may discover the causes(s) of low scores that can be removed or improved.

A manufacturer that seeks a good relationship with its community will do everything it can with the community to prevent safety & environmental incidents. Process Safety Incident Index[29] may be a leading indicator of process safety issues. Incidents are classified by severity on a scale of 1 to 4, where level 1 is the most severe. It is calculated as:

Process Safety Incident Index =

$$\frac{[(\#\ level\ 4\ incidents*1)+(\#\ level\ 3\ incidents*3)+(\#level\ 2\ incidents*9)+(\ \#\ level\ 1\ incidents*27)]*200{,}000}{[OSHAS\ worker\ hours\ for\ the\ year}$$

Where, OSHA worker hours includes both employees and contractors.

A process safety incident is one that meets three tests:

1. Chemical/process involvement – a chemical or chemical process (reactors, tanks, piping, boilers, cooling towers, refrigeration systems) is directly involved in the damage caused. Note that incidents with no direct chemical or chemical process involvement such as office fire and employee injury in which the process plays a direct role are included.
2. Reporting threshold – one of the following thresholds is exceeded:
    a. Fire damage of $25,000 (replacement cost of property and equipment)
    b. Explosion (detonation) or over pressure damages of $25,000
    c. Chemical release – episodic loss of containment in quantity of material listed in 40 CFR 355.40; 5,000 lbs. of flammable material
    d. Injury/Fatality – one or more serious injuries (days away from work injury or illness) or fatalities.
3. Location - incident occurs in production, distribution, storage, utilities, pilot plant or laboratory areas, including tank farm and ancillary support areas. Transportation incidents are not included unless within boundary of a fixed facility.

Process incident severity level definitions may be found in Appendix D. The chemical assessment tables are based on type of chemical and quantity of material involved in the incident. Generally the higher the toxicity of a material, the lower the quantity of material involved to be classified a level 4 (lowest severity level).

[29] The American Chemistry Council. "Performance Measures Guidance Document For Responsible Care ® Partner Companies", 2010

Ensuring Good Measurement

Several of the vital signs of manufacturing competitiveness require data collection (most notably FPTY, Availability, Performance, OEE, Asset Productivity, DART, and Environmental Incident Rate); the remaining involve subjective analysis using survey tools. A Gage R&R study is not required for data collection and evaluation if good measurement system practices are followed. In all cases, good measurement system practices should be applied, such as operational definitions, unbiased sampling, and reproducibility of measurement between two or more data collectors. Good operational definitions are needed to ensure consistent measurement and evaluation over time. Survey tools should be piloted/tested prior to use.

How do you tell if you have good data? Three telltale signs are:

1) Inconsistency – you get different data depending on the source of data and/or the timing in which it is gathered.
2) Inaccessibility – you have to jump through hoops to get to the data; it Is outdated by the time you get it.
3) Incompleteness - the data you expect to be found in a data source is not there; you find large chucks of data missing[30]

Deriving insights from the vital signs can be disastrous without good data: leaders take action when they should not and do not take action or the right action when they should, so it is very important to get good, trustworthy data using good measurement practices.

The vital signs, like human health vital signs, are best when used to make decisions to take action. Good data, however, will not guarantee good decisions. A recent study by Insight IQ[31] found the best equipped employees to make good decisions are "informed skeptics" that effectively balance judgment and analysis. They also found that analytical skills are concentrated in too few employees, IT needs to focus more on the "I" than the "T", reliable data is hard to locate, and business leaders do not manage information well. Manufacturers wanting to make better use of the data they gather for the vital signs need to focus on two things: 1) increasing data literacy within the workforce and 2) more efficiently incorporate data into decision-making with the right tools.

Summary

This white paper has described the six essentials and associated vital signs that may be found in world-class manufacturing organizations. Vital signs of the six essentials of performance excellence can be used to assess the general competitiveness of a manufacturing organization and used to take action to improve productivity and profitability. Good measures/vital signs allow leaders to:

- communicate performance expectations to the workforce;
- identify gaps in performance and prioritize corrective action;
- provide feedback to individuals and teams in the organization, including recognition;
- make decisions regarding resources, policies, schedules and infrastructure, and
- identify the root cause(s) of poor performance.

10 primary vital signs are described in this white paper, "Vital Signs of Manufacturing Competitiveness: 10 Indicators of Performance Excellence." Good data may not be available for all of 10 vital signs, or too time consuming, too costly to obtain. Twelve alternative indicators may provide insights into the performance/

[30] Romeri, Mike. "Improving Data's Health is Nothing to Sneeze at!" *Industry Week online*, March 10, 2016.
[31] Shvetank, Shah, Sndrew Horne, and Jaime Capella. "Good Data Won't Guarantee Good Decisions," *Harvard Business Review*, April 2012.

fitness of the essentials; these 12 indicators are described in the companion paper, "*Vital Signs of Manufacturing Competitiveness: 12 Alternate Indicators of Performance Excellence*."

APPENDIX A
TEAM ASESSMENT[32]

Rate each statement below as a member of the leadership team using the scale of 3=Usually; 2 = Sometimes; and 1 = Rarely. Calculate total sum for each column:

TRUST		CONSTRUCTIVE DEBATE		COMMITMENT		ACCOUNTABILITY		RESULTS	
Team members openly admit their mistakes and weaknesses.		Team members are passionate and unguarded in their discussion of issues		Team members know what their peers are working on and how they contr9ibute to the collective good of the team.		Leadership team members call out one another's deficiencies or unproductive behaviors.		Leadership team members willingly make sacrifices (such as budget, turf, head count) in their departments or areas of expertise for the good of the team.	
Team members quickly and genuinely apologize to one another when they say or do something inappropriate or possibly damaging to the team.		During team meetings, the most important and most difficult issues are put on the table to be resolved.		Team members leave meetings confident that their peers are completely committed to the decisions agreed upon during the meeting, even if there was initial disagreement.		Leadership team members are deeply concerned about the prospect of letting down their peers.		Leadership morale is significantly affected by the failure to achieve team goals.	
Team members know about one another's personal lives and are comfortable discussing them.		Team meetings are compelling and not boring.		Team members end discussions with clear and specific resolutions and calls to action.		Leadership team members challenge one another about their plans and approaches.		Leadership team members are slow to seek credit for their own contributions but quick to point out those of others.	
SUM									

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APPENDIX B

ESSENTIAL 2: STRATEGIC CLARITY: ALIGNMENT DIAGNOSTIC[33]

Rate each statement for the following four categories on a scale of 0 to 10 where 0 = strongly disagree and 10= strongly agree Sum ratings for each of the four categories

STRATEGY		CUSTOMERS	
Organizational strategies are clearly communicated to me.		For each product our organization manufacturers, there is an agreed-upon, prioritized list of what customers care about.	
Organizational strategies guide the identification of skills and knowledge I need to have.		People in this organization are provided with useful information about customer complaints.	
People here are willing to change when new organizational strategies require it.		Strategies are periodically reviewed to ensure satisfaction of critical customer needs	
Our senior leaders agree on the organizational strategy.		Processes are reviewed regularly to ensure that they contribute to the attainment of customer satisfaction.	
SUM		SUM	
PEOPLE		PROCESSES	
Our organization collects information from employees about how well things work.		Our leaders care about how work gets done as well as about results	
My work unit or team is rewarded for our performance as a team.		We review our work processes regularly to see how well they are functioning.	
Groups within the organization cooperate to achieve customer satisfaction.		When something goes wrong, we correct the underlying reasons so that the problem will not happen again.	
When processes are changed, the impact on employee satisfaction is measured		Processes are reviewed to ensure they contribute to the achievement of strategic goals.	
SUM		SUM	

[33] Labovitz, George and Victor Rosandky, *The Power of Alignment: How Great Companies Stay Centered and Accomplish Extraordinary Things*, John Wiley, 1997, p199

APPENDIX C
POTENTIAL EMPLOYEE SURVEY QUESTIONS FOR ESSENTIAL 3: COMMUNICATIONS

Question and Answer Choices	Source and Insights Provided
Where does <Company Name> focus its efforts? * Please select the ONE option that best describes your perception. ( ) The focus is on products, distributors, and regulatory requirements. ( ) The focus is on products, distributors, regulatory requirements, and some customers. ( ) The focus is on products, distributors, regulatory requirements, customers, and employees. ( ) The focus is on balancing the needs of all current stakeholders and meeting regulatory requirements. ( ) The focus is on balancing the needs of current and potential stakeholders and meeting regulatory requirements.	From ISO 9004 Self-Assessment Insights into clarity and communication of strategic focus and linkage to the daily work of the people (vertical alignment)
How are business decisions and priorities communicated? Please select the ONE option that best describes your perception. ( ) Communication of business decisions and priorities takes place in a reactive way. ( ) A basic communication system is in place for sharing business decisions and priorities. ( ) The communication system for sharing business decisions and priorities is effective. ( ) The communication system for sharing business decisions and priorities is effective and efficient, appropriate for my work area. ( ) The communication system for sharing business decisions and priorities is effective and efficient, meeting the needs of each stakeholder.	From ISO 9004 Self-Assessment Insights into the employee perception of how and when communication of strategic decisions and priorities is communicated.
I know my organization's mission (what it is trying to accomplish). ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey Insights into clarity and communication of strategic focus and linkage to the daily work of the people (vertical alignment).

My organization's senior leaders share information about the organization. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey Insights into amount of information shared with direct reports by functional leaders.
I know the parts of my organization's plans that will affect me and my work. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey. Insights into clarity and communication of strategic focus and linkage to the daily work of the people (vertical alignment)
I know how the measures I use in my daily work fit into the organization's overall measures of performance. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey. Insights into clarity and communication of strategic focus and linkage to the daily work of the people (vertical alignment).
My organization's senior leaders ask for my feedback and ideas. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey Insights into two-way communication between senior leaders and employees and the relationship between senior leaders and employees.
I have all the important information I need to do my work. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey. Insights into clarity and communication of strategic focus and linkage to the daily work of the people (vertical alignment) as well as processes that add value (horizontal alignment).
I know how my organization as a whole is doing. ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey. Insights into clarity and communication of strategic focus and measures of performance.
I know who my most important customers are (those to whom I supply material, information or services, internally or externally). ( ) Strongly disagree ( ) Disagree ( ) Undecided ( ) Agree ( ) Strongly agree	*Are We Making Progress* survey. Insights into clarity and communication of strategic focus and the processes that add value (horizontal alignment).

APPENDIX D
PROCESS INCIDENT SEVERITY LEVEL DEFINITIONS[36]

Severity Level	Safety/Human Health	System Equipment	Chemical Impact	Community/Environment Impact
NEG	Does not meet or exceed Level 4 Threshold	Does not meet or exceed Level 4 Threshold	Does not meet or exceed Level 4 Threshold	Does not meet or exceed Level 4 Threshold
4	OSHA recordable injury associated with a process safety event	Equipment damage of $25,000 - $100,000	See chemical assessment tables	Short-term remediation to address acute environmental impact. Examples: Spill cleanup, soil and vegetation removal
3	Lost time injury associated with process safety incident	Equipment damage of $100,000 - $1,000,000	See chemical assessment tables	Minor off-site impact with precautionary shelter-in-place of environmental remediation required with cost less than $1,000,000 or local media coverage
2	On-site fatality of employee or contractor; multiple lost time injuries or one or more serious off-site injuries associated with process safety incident	Equipment damage of $1,000,000 - $10,000,000	See chemical assessment tables	Substantial shelter-in-place or environmental remediation require with cost $1,000,000 - $2,5000,000
1	Off-site fatality or multiple on-site fatalities associated with process safety incident	Equipment damage > $10,000,000	See chemical assessment tables	Significant community evacuation or national media coverage of environmental remediation required in excess of $2,500,000; federal government investigation an oversight or other significant community impact

[36] The American Chemistry Council. "Performance Measures Guidance Document For Responsible Care ® Partner Companies", 2010

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