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Pictorial Process Analysis (PPA)

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Abstract

In 2004, the author created Pictorial Process Analysis (PPA) as a tool to improve manufacturing and non-manufacturing business processes. PPA is a unique methodology which offers Ten layers of additional analysis to standard process mapping techniques. The goal of PPA is to identify and quantify all forms of waste and inefficiencies in a manufacturing process, starting with the assessment of the process management, work environment, work habits, performance metrics and general employee attitudes towards the process. This detailed process assessment and analysis is carried out during process improvement brainstorming efforts and Kaizen events to identify and improve the efficiency of a targeted manufacturing process. PPA creates a detailed visual efficiency assessment for each process step of a manufacturing process. A selection of 54 Inefficiency Icons are available to pictorially highlight major inefficiencies that are present in the manufacturing process under review. These inefficiency icons were identified based on over 25 years of the author's experience in improving manufacturing processes and by researching the causes for business, quality and manufacturing disasters that have been published over the past 100 years. This paper will highlight the steps required to conduct Pictorial Process Analysis on a select manufacturing process. The author has successfully used PPA to dramatically improve manufacturing processes in over 20 industries since 2004 but this technique has not been published until now in this paper. As with any continuous improvement tool, PPA requires training in order for it to be implemented correctly and effectively.

Keywords: process mapping; bpm; business process management; flow charting; workflow, process management; process flow; risk management; business process reengineering.

1 Introduction

In 1910, Frederick Winslow Taylor published "The Principles of Scientific Management", which described the need for management to develop and document the science and definition for each element of an employee's work to replace the old "rule-of-thumb" way of working. He firmly believed that it was up to management to determine the best way to do efficient work with the use of "time and motion" and other process analysis techniques.

PPA incorporates Taylor's Principles through an expanded version of standard process mapping, while assuring management involvement. Using PPA during business process analysis and mapping events is an enlightening and often enjoyable experience for the participants because it allows all of the constraints of a manufacturing process and the surrounding enterprise to be openly discussed and assessed. When facilitated properly, all inefficiencies and waste are identified using the additional 10 layers of analysis in a process mapping exercise, which are added to a detailed process map, one layer at a time.

When clusters of 54 available Inefficiency Icons are assigned to one process step, this offers a visual signal that this particular process step is in need of major re-engineering. The highly visual efficiency assessment of processes using PPA with its 10 layers of analysis allows the process analysis group to focus in on areas of the process that are not working well and are in need of immediate improvements.

The use of PPA will be demonstrated in this paper with the analysis of a simple generic manufacturing process shown in Figure 1. Each of the 10 layers of Pictorial Process Analysis will be added to assess this manufacturing process and bring it to life and determine its true efficiency levels, including all aspects of process management and process work habit assessments.

The manufacturing process shown in Figure 1 is very general and generic process map, which does not help us to assess the processes opportunities for improvement. Ten layers of process analysis will be added to this simple process map to identify its true efficiency levels, which is necessary to critique, analyze, then optimize this manufacturing process.

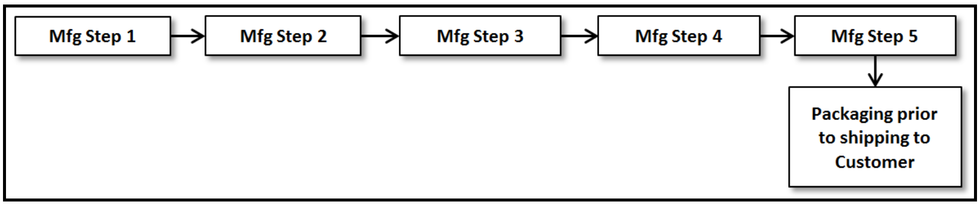

Figure 1: The simple manufacturing process shown here will be the basis for demonstrating how to conduct Pictorial Process Analysis of a manufacturing process to identify its forms of waste and inefficiency that should to be addressed.

2 The 10 Layers of Pictorial Process Analysis

A PPA event is best conducted with the use of a core team of less than 10 people. When more people are required, only bring them in on a temporary basis and politely dismiss them after their inputs are received. It is important that the core team never gets larger than 10 people who should almost always be fully engaged during the process analysis event. This will help to ensure that the process analysis efforts stay on track and maintain their momentum. Trained and competent PPA facilitators can achieve this goal.

The 10 layers of Analysis used during PPA are listed below with a short explanation for each layer of analysis.

1. Identify and add specific “Swim Lanes” to the process map to show each functional area or department that interacts with the manufacturing process.
2. Identify all correction, redo, rework and repair loops on the process map, even if they do not happen all the time. Show how many times these loops actually happen.
3. Identify how long (Low to high range) each process step takes. If there are extended waiting times, elevate the “Wait” step to an official process step so it can be targeted for improvement.
4. Identify and note what percent of VA (Value Added) activities are included in each process step. If the VA% is less than 50%, note it as red. If the VA% is greater than 50%, note it as green. Use innovation techniques to pursue 100% VA. Focus on possibilities and solutions, not excuses.
5. Note the estimated FTY (First Time Yield) of the process step and decision. In other words, what is the percent of the time that this process step is done right the first time?
6. Show Red dotted boxes to depict redo, fix, rework or repair loops in the process necessary to correct errors. Also note the number of times each redo loop happens.
7. Note if data is being collected for each process step that can be used for process efficiency and performance analysis purposes.
8. Show which of the 54 Inefficiency Icons apply to this process and place them next to the process steps when they are present. This will highlight areas that need to be improved.
9. Add a Total Process Efficiency Scorecard noting the ranges in efficiency from low end to high end, for the following criteria:
    1. Total Process Lead Time (How long does the process take?)
    2. Adjusted VA Time for the process (The true value present in the process)
    3. Total % VA Time for the whole process (The true process value in %)
    4. RTY (Rolled Throughput Yield) for the whole process (The probability that a product will make it through the process without any issues)
10. Add a concise executive summary of the process analysis findings that PPA identified.

2.1 Analysis Layer #1: Adding Swim Lanes to align tasks to Departments

Identify and add specific "Swim Lanes", shown in Figure 2, to each functional area or department that interacts with the manufacturing process depicted in Figure 1. This is important so that the amount of department hand-offs are fully understood and displayed. It might be discovered that certain department hand-offs create more delays and errors. This will help to determine if one department is too overloaded with work and if too many tasks are being done in series and not in parallel, which could slow down the process. 7 to 21 swim lanes will usually be required to represent smaller manufacturing processes to capture all of the actual department activities and interactions.

Joseph M. Juran was a strong proponent of cross-functional process excellence as defined in his "Juran Trilogy". Most processes cross different functional and department lines. Juran stressed the need for cross-functional excellence, which includes quality planning, quality control and quality improvement in manufacturing processes. Management should not just let processes randomly develop on their own but help to design and manage processes to ensure an efficient, productive and competitive outcome.

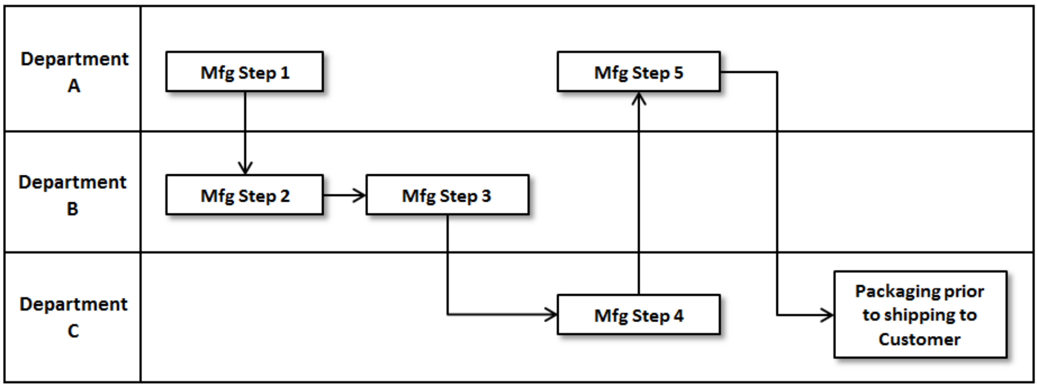

Figure 2: All activities should be assigned to the appropriate departments responsible for those activities.

2.2 Analysis Layer #2: Identify and add all Redo and Correction Loops

Add a description of all correction, redo, rework and repair loops to the process map, even if they do not happen all the time. Show what percent of the time they actually happen. Do the same for any decision point (diamond symbol). This will help you to assess the impact of all process decisions. Figure 3 shows what the manufacturing process looks like after the swim lanes, decision points and redo loops have been added to the process map. Figure 3 shows a simplified version of PPA since a real PPA event can typically include documentation of 50-100 process steps. Whenever decision points are listed, note the percent of the time for each of the optional outcomes of the decision, as shown in Figure 3.

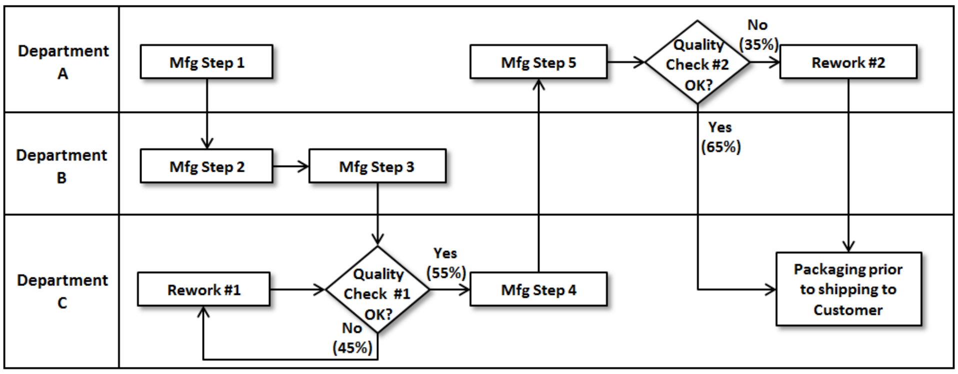

Figure 3: All correction, redo, rework and repair loops are added to the manufacturing process.

2.3 Analysis Layer #3: Identify how long it takes for each Process Step

Add a time note on the process map for the duration of each process step and decision point. If there is variation in the time estimates, note the range of those times on the process map, from the best time to the worst time. Figure 4 shows what the process map now looks like when the times are added to the process steps. Unacceptable waiting periods are often identified during this analysis. When excessive waiting periods are identified, add them as an official process step. Do not just add those waiting times to the process step before or after the waiting periods in an indiscriminate manner.

Carrying out time studies for manufacturing processes is an important analysis step, which was identified as early as 1910 by Frederick Taylor and others. It is also an important aspect of Value Stream Mapping as originally defined by Shingeo Shingo from Toyota and in later books from James Womack and others.

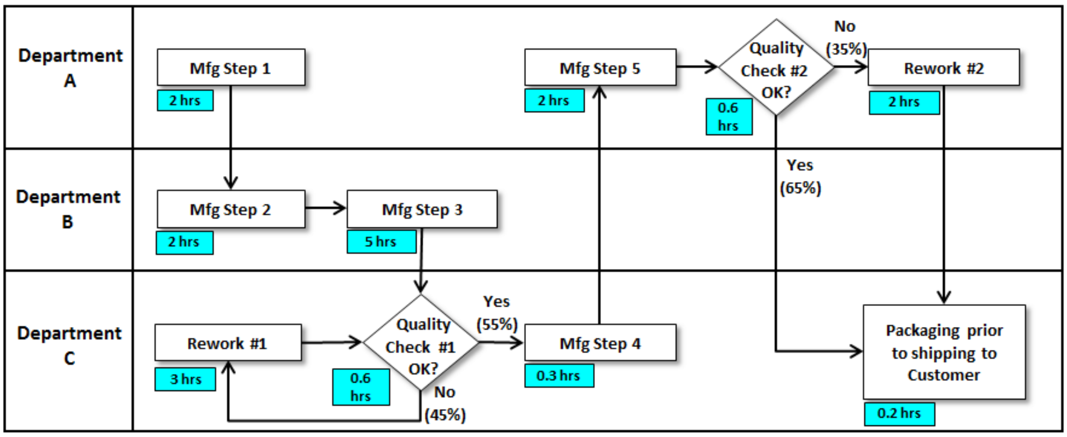

Figure 4: Seperate notes are added to show how long each step in the process takes to complete.

2.4 Analysis Layer #4: Identify the Percent of Value added for each Process Step

Adam Smith was a Scottish economist and moral philosopher. He published a book in 1776 titled "The Wealth of Nations", which argued that "productive labor" adds to the wealth of an entire nation and its economy, while "unproductive labor" does not. That drove the birth of the concepts for VA and NVA.

PPA will identify and note what percent of VA (Value Added) activities are included in each process step. If the VA% is less than 50%, note it as red. If the VA% is greater than 50%, note it as green. The team must ask themselves 2 questions:

- Does this process or decision point add any true value to the final customer (%VA external)?
- How efficient is each of the process steps (%VA internal)?

Efficiency estimates for each process step will have to be made. An example estimate follows.

- Example #1: A certain manufacturing process activity is only 50% internally efficient but it is 100% important to the customer. In that case, the %VA would be 0.5 x 1 = 50% VA.
- Example #2: A certain manufacturing process activity is 95% internally efficient but it is totally unimportant (0%) to the customer. In that case, the %VA would be 0.95 x 0 = 0% VA.

The percent of value that should be added for each process step will be calculated as follows: The true efficiency of the internal activities (% internal VA/100) multiplied by the perceived value of this process step in the eyes of the final customer (% external VA/100). The results can range from 0% to 100%.

It could be argued that quality checks are VA. In PPA, we argue, as Shingeo Shingo and others did from Toyota, that quality should be built into the product and manufacturing process and not inspected into the product. If manufacturing processes were rigorously error-proofed (poke-yoke), they would not need to be quality tested. Shingeo Shingo implemented this concept at Toyota and made it part of the Toyota Production System. Highly efficient manufacturing processes prevent mistakes from happening and do not rely on imperfect quality checks to sort out defective products. Figure 5 shows how %VA information can be added to a PPA process map.

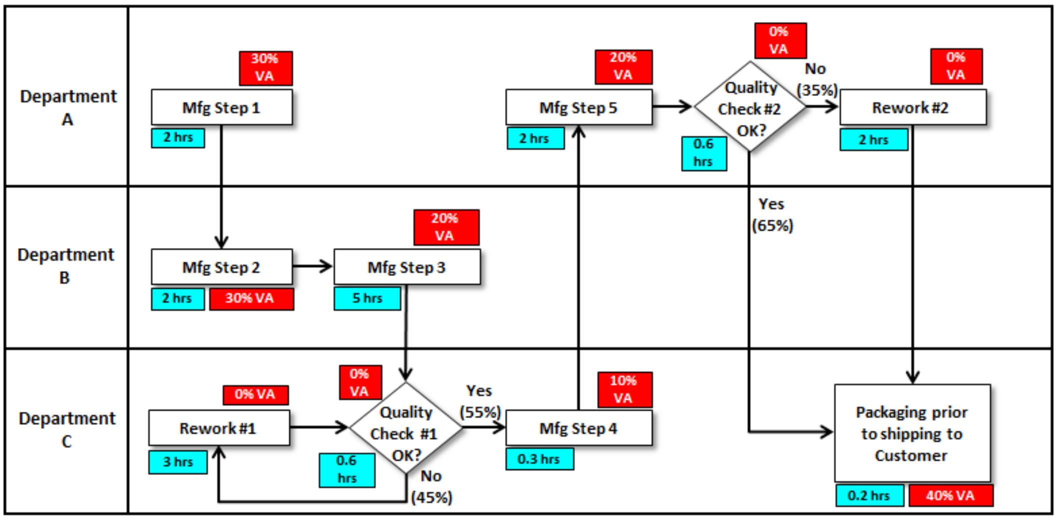

Figure 5: The percent VA for each process step is added to the process map.

2.5 Analysis Layer #5: Identify the FTY for each Process Step

The estimated FTY (First Time Yield) should now be added for each of the process steps and decisions. The team is now being asked here to estimate what is the percent of the time that this process step is done right the first time. If exact data is not available for this required performance metric, the team should make a good estimate, which the team can agree on. See Figure 6 for how this information is added to the PPA process map.

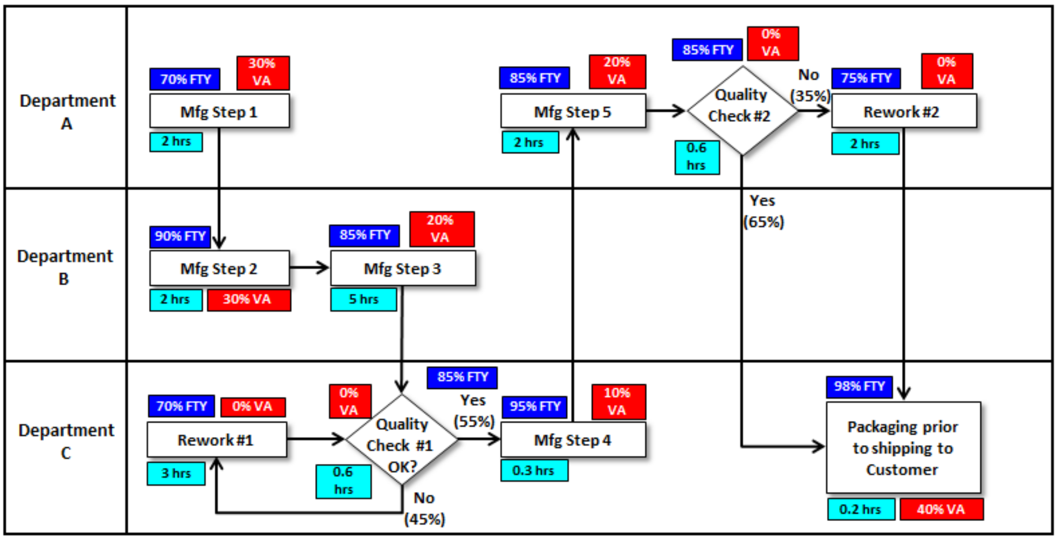

Figure 6: A note is added to each process step and decision to designate the FTY % for each process and decision.

2.6 Analysis Layer #6: Add Red Boxes around Redo Loops

Show red dotted boxes to depict redo, fix, rework or repair loops in the process necessary to correct errors. Also note the average number of times that each redo loop happens. The intent here is to identify how often these redo loops happen so they can be minimized or eliminated in the new and improved process. Figure 7 shows what this process map looks like when redo loops are highlighted with the red boxes.

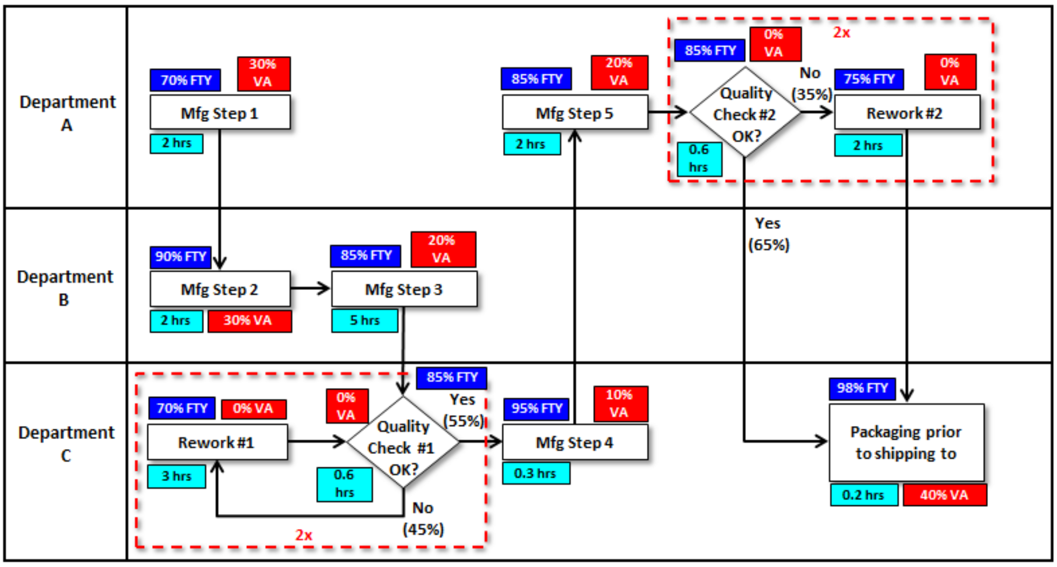

Figure 7: This shows what the process map looks like when 2 redo loops are highlighted.

2.7 Analysis Layer #7: Identify where Data is being collected in the Process

Note if data is being currently collected for any of the process steps that can be used for process efficiency and performance assessment purposes (See Figure 8). If process data is available, analyze it to learn more about the process efficiency and performance levels over time and use that data to calculate efficiency and performance levels for different customers and products. Check if the efficiency and performance levels vary for different shifts, days of the week, times of the day and for other analysis groupings.

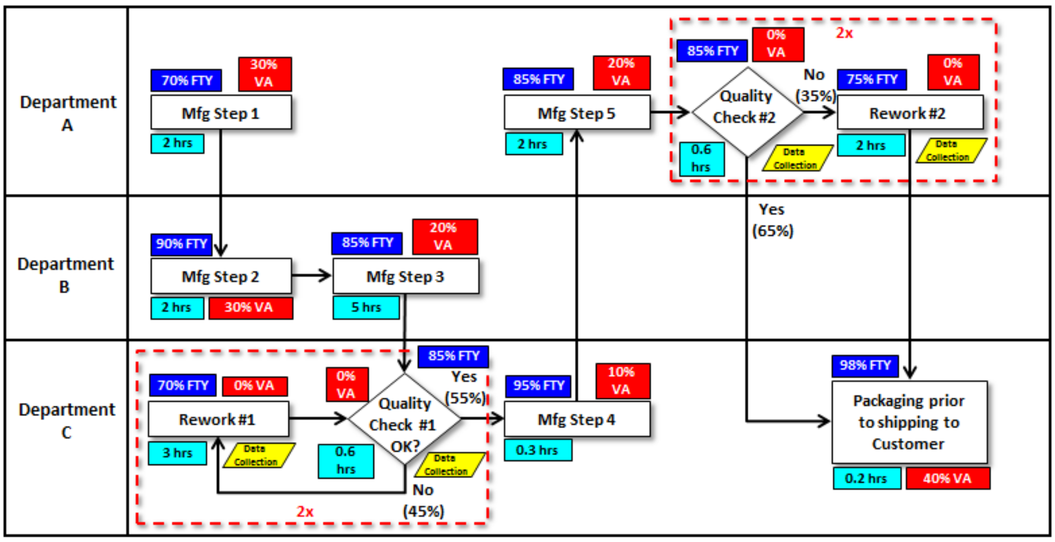

Figure 8: Data collection symbols are added to show if process data is being colected for the process steps.

2.8 Analysis Layer #8: Adding Inefficiency Icons to represent the forms of Waste and Inefficiency present in the Manufacturing Process

The following "seven wastes" were identified by Toyota's Chief Engineer, Taiichi Ohno and became part of the Toyota Production System. These 7 forms of waste are activities in manufacturing processes that do not add value to the customer. An easy way to remember the 7 forms of wastes is to remember the term TIMWOOD.

T: Transportation, I: Inventory, M: Motion, W: Wait, O: Over-processing, O: Over-production, D: Defect

The under-utilization of the human mind is often added to this list of 7 in recent years as another recognized form of waste. Lean manufacturing has helped very many companies reduce inefficiencies and waste in their processes but many companies still struggle with implementing lean because identifying waste in a manufacturing process is easier than driving the cultural change to eliminate the waste.

The reason why Lean has not made more breakthroughs into more companies and industries is not because organizations cannot comprehend a list of 7 or 8 forms of waste; it is because management in many organizations exhibits certain behaviors and attitudes that allow them to reject the logic and adoption of Lean Manufacturing concepts. The list of 7 or 8 forms of waste has accidentally created a huge and unrealistic perception that if this list is addressed, all manufacturing problems will go away and the company will be Lean. The list of 7 or 8 wastes are just the symptoms of an inefficient organization, not the root causes. In reality, the root causes of the Lean forms of waste lie in the management of the process and the work culture surrounding the process, not in the execution of the process.

There are actually 54 forms of waste and inefficiency that can influence a manufacturing porcess, not 7 or 8. The Inefficiency Icons used in PPA are shown in Figure 9 are ranked using playing card logic as to their negative impact on any organization. The top ranked cards (Aces) are management controlled Behaviors and Attitudes (MBAs). The lower ranked Inefficiency Icons (Kings, Queens, Jacks and Jokers) are the results of inefficient management decisions and an ineffective work environment, all of which is in the hands of management to ignore or address.

The 54 Inefficiency Icons are aligned to 5 groups of waste and inefficiency. These groups are listed below in rank order of their impact on an organization, from high impact to low impact. They are also pictorially shown in Figure 9.

- 13 reckless MBAs (Management Behaviors and Attitudes), which can hold any organization back from greatness (The 13 Aces in the card deck of Inefficiency Icons).
- 11 inefficient aspects of the work environment (The 11 Kings in the card deck of Inefficiency Icons).
- 21 inefficient work habits (The 21 Queens in the card deck of Inefficiency Icons).
- 7 key efficiency metrics (The 7 Jacks in the card deck of Inefficiency Icons).
- 2 resulting bad practices of not being able to prioritize work correctly and ineffective fire-fighting, which attempts to address the symptoms of a problem and not the true root causes of a problem (The 2 Jokers in the card deck of Inefficiency Icons).

Some of the best hands-on and iconic CEOs in the USA, like Jack Welch (GE) and Larry Bossidy (Allied Signal/ Honeywell) have written about their management philosophies and paths they followed that enabled their successes in business leadership. Jack Welch, at the end of his career, reflects in his book "Jack - Straight from the Gut" on what made GE a great company. He does not boast much about the great products they made but rather he states: "in the end, I believe we created the greatest people factory in the world, a learning enterprise, with a boundaryless culture". Jack Welch knows that if you create great people, great products will follow, so he and GE addressed the root cause (people development), which in turn will drive the creation of great products. Any effective process analysis technique must be able to assess such cultural issues; PPA does. Jack Welch also states: "I stuck to some pretty basic ideas that worked for me, integrity being the biggest one". PPA also has an inefficiency icon that helps identify any integrity issues that can have a negative effect on a manufacturing process.

Larry Bossidy's book "Execution – the discipline of getting things done" talks a lot about the right and wrong management behaviors and attitudes he observed later in his career. He saw manufacturing facilities where "plants were run by accountants instead of production people". He also notes that "many people regard execution as detail work that's beneath the dignity of a business leader. That's wrong. To the contrary, it's a leader's most important job". 13 of the 54 inefficiency icons in PPA focus on reckless MBAs (Management Behaviors and Attitudes) to avoid or correct. Leadership aspects of an organization have a paramount impact on the efficiency of their manufacturing processes. Other process assessment techniques avoid this sensitive issue of Operations Management assessment; PPA does not.

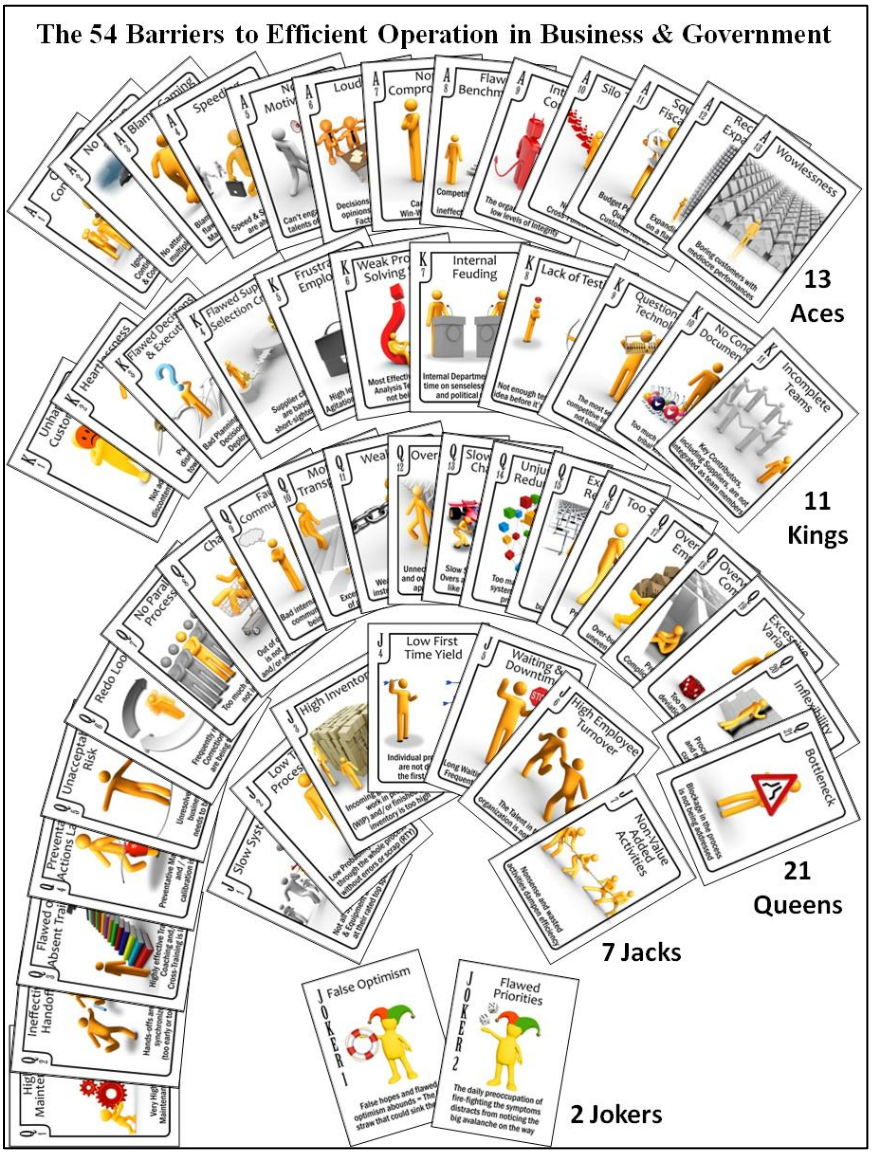

Figure 9: The 54 forms of waste and inefficiency that could be present in any organization.

The previously listed 54 forms of waste and inefficiency are fully capable of holding organizations back from attaining high levels of Lean Manufacturing and process efficiency. Figure 9 shows the inefficiency icons available for use in PPA. For organizations with mature business process management techniques in place, the Ace and King Inefficiency Icons might not be required for the assessment of their organizations. These 54 forms of waste also incorporate the philosophy of Deming's 14 Key Principles published in his book "Out of the Crisis", which are actions required by management first to signal that they are capable and seriously engaged in the right activities to drive efficiency, stay in business and protect investor interests and employee jobs. These culture-shift activities must be driven by top management.

Frederick Winslow Taylor also noted many strong opinions in his book "The Principles of Scientific Management" where he notes that management should take over all work for which they are better suited for than the workers, stating that in the past almost all of the work and responsibility was thrown upon the workers to struggle with. They usually did not have the proper level of expertise or management authority and support to deal with the challenges they were given.

Figure 10 shows what the next level of a PPA process map could look like if all top to bottom aspects of the enterprise were assessed and not only the direct activities in which the production workers are active. The top row of Inefficiency Icons above the process map shows inefficiencies in the operations management. The second row of Ineficiency Icons assesses the weaknesses in the work culture and the resulting organization's overall mode of operation.

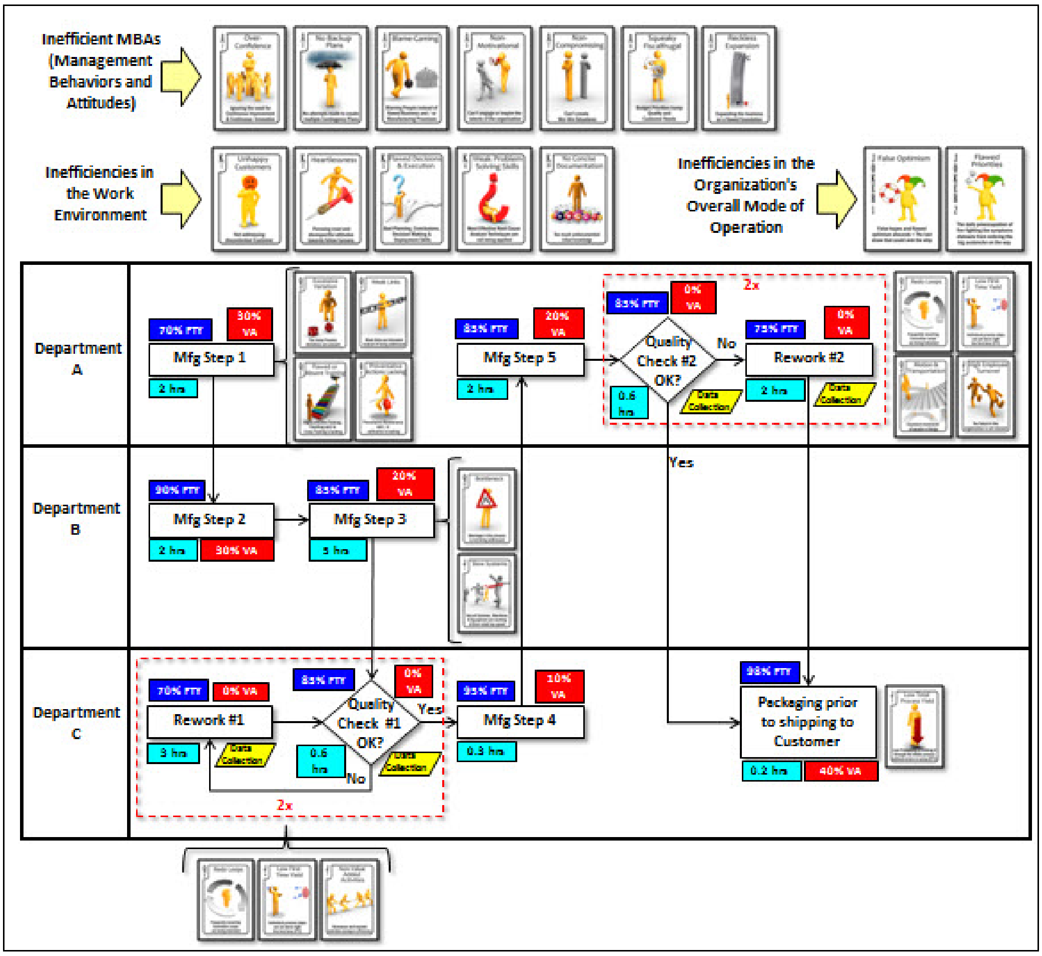

Figure 10: The PPA team now assigns the Inefficiency Icons that relate to this manufacturing process.

The Inefficiency Icons shown inside the process map identify the forms of waste and inefficiency inside this process. The icons above the process map highlight management and cultural issues to address.

2.9 Analysis Layer #9: The Total Process Efficiency Scorecard

A Total Process Efficiency Scorecard (Figure 11) should be added to the process mapping analysis, which includes key calculated efficiency performance metrics for the manufacturing process. This particular PPA assessment was supplemented with 3 Inefficiency Icons, which best described the manufacturing process under review. The RTY range shown here of 16 – 31% on the scorecard in Figure 11 is the Rolled Throughput Yield, which is the result of multiplying all FTY values against each other. RTY is best described as the probability that a product will make it through this manufacturing process without being scrapped, reworked or being defective in some way.

This process scorecard is somewhat similar in nature with the Balanced Scorecard (BSC), which was popularized in the 1990s by Bob Kaplan and others. The PPA process efficiency scorecard, as with the BSC, is not meant to be a replacement for traditional financial or operational reports but is intended as a summary of the process metrics most relevant to efficiency and value-added aspects of a process.

Total Process Efficiency Scorecard (Low end - High end)
Total Process Lead Time = **10.9 hrs - 17.4 hrs**
Total VA Time for the whole process = **12.7 - 17.7 hrs**
Adjusted VA Time for the whole process = **2.7 hrs**
Total % VA Time for the whole process = **21.3 - 15.3%**
RTY for the whole process = **16 - 31%**

Figure 11: The Process Efficiency Scorecard and Inefficiency Icons that best describe the whole process.

2.10 Analysis Layer #10: An Executive Summary of the process analysis findings

What follows is an example of an executive summary typically used to wrap up the PPA work.

> There are various management and work environment inefficiencies that handicap this process and hold it back from greatness. Actual process activity inefficiencies include unsynchronized cycle times, low VA percentage process steps, low First Time Yield (FTY) activities and low quality levels, which result in low internal and external customer satisfaction levels. The organizational fire-fighting efforts are ineffective and only address the symptoms and not the true root causes. This leads to elevated employee stress levels, frustration and high employee turnover.

Inefficient Operations Management is to blame here for the lack of performance stated above. It is not the fault of the employees who work in an ineffectively managed process. Jim Collin's book "Good to Great" also describes beneficial and reckless management styles that can greatly influence the success or failure of entire companies. The next step for the PPA team would be to create a new and improved process, which is not shown in this paper. That new process map, supplemented with a detailed action plan list, will have to demonstrate how the PPA team will eliminate the waste and efficiencies in the current process.

3 Conclusion

Figure 12 shows how PPA surpasses the performance of 7 other process analysis techniques. PPA uses all-encompassing and enterprise-wide assessment criteria. Each column in the matrix uses a 1-5 rating scale. The far right column shows the assessment scores for each of the mentioned techniques. PPA puts a strong spotlight on the health of the entire enterprise required for manufacturing process excellence. It is the only detailed process analysis technique that incorporates the 14 Deming Key Management Principles for business transformation. Deming wrote that most causes of low quality and low productivity belong to the system and thus lies beyond the power of the work force. PPA supports that philosophy by identifying the weaknesses in the whole "system" that hinders progress towards manufacturing excellence.

Process Assessment Techniques	Top to bottom enterprise-wide efficiency assessments	Integrated root cause analysis of low efficiency activities	Efficiency scoring of the whole process	Assessment of the 13 management inefficiencies	Assessment of the 11 work environment inefficiencies	Assessment of the 21 work habit inefficiencies	Assessment of the 7 process efficiency metrics	Assessment of the 2 efficient attitudes and organization priorities	Total score of Process Assessment Technique
Pictorial Process Analysis (PPA)	5	5	5	5	5	5	5	5	40
Value Stream Mapping (VSM)	3	2	4	1	1	2	3	0	16
Time and motion studies	0	2	3	0	0	2	3	0	10
Strengths, Weaknesses, Opportunities & Threats (SWOT) Analysis	1	1	1	1	1	1	1	1	8
Balance Scorecard	1	0	2	0	0	1	3	0	7
Spaghetti Charting	1	1	1	0	1	1	1	0	6
7 forms of Lean waste assessment	0	1	1	0	0	2	2	0	6
Basic Process Mapping	1	1	1	0	0	1	1	0	5

Figure 12: PPA scores 40 points compared with a score of 5-16 points for seven other process analysis techniques.

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