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## **Production Preparation Process (3P): Lean Concepts for Project Planning**

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### **Introduction**

The 3P – Production Preparation Process – is a project management, design, and process-development approach that creates a dramatically more reliable and efficient production process. It focuses on eliminating waste through product and process design. 3P causes the development team to reject the idea of incremental improvement and provides a structure for trying alternative solutions. Toyota has used 3P to achieve competitive advantage. Progressive companies in the aerospace, automotive, and other industries are using 3P. However, its use within companies in the metals, petro-chemical, and similar industries is rare. This paper will describe its origin, define 3P, summarize what companies that use 3P say about it, explain its benefits, introduce Lean Thinking, describe the 3P method, and explain how 3P can apply in the metals industry.

### **3P's Origin**

3P's origin begins at Toyota Motor Company in Japan. Adopting Ford's concepts of eliminating waste and continuous flow assembly, Kiichiro Toyoda introduced Toyota's first vehicle in 1935. During that time, he documented so called management innovations that included precepts (guiding principles) and the foundations of continuous and breakthrough improvements. Over time, these management innovations were refined and extended to include production systems by others. Toyota also refined the concepts of *kaizen*, meaning continuous improvement, and *kaikaku*, meaning a radical overhaul of an activity or process to achieve a breakthrough in performance.

After World War II, as Toyota was struggling to survive as a company, its leaders studied American manufacturing. They admired Boeing's and Ford's war-based system of producing a bomber an hour, but they knew that the relatively low volume (at that time) for their products required a different approach. Toyota's leaders realized that a system that integrated product design, launch, and manufacturing together more tightly would create competitive strength and enable a more flexible production system. By this time, Toyota's culture included teamwork and quality control. As a result, even before Toyota gained recognition for its high-quality and efficient production, the principles of 3P were apparent in the ways that multiple functions worked together to integrate product and manufacturing design.

During the 1950s, Taiichi Ohno developed the Toyota Production System (TPS), often called Lean or Operational Excellence outside of Toyota. TPS included principles and tools. Some of these principles are to identify and eliminate waste in order to collapse the order-to-cash time, develop standardized work and pace of work based on customer demand, provide simple and direct connection from one process to another, make problems visible, and others.

Building on the principles and experiences of Lean and integrated product and manufacturing design, Sensei Chihiro Nakao developed the Production Preparation Process in the mid-1980's. He based 3P on *kaikaku* thinking so that the results of the development process would achieve a breakthrough in performance rather than incremental improvements. 3P structured a process to bring *kaikaku* to the development process. It included integrated development teams from multiple functions, applied Lean principles, investigated alternative solutions, and applied "try-storming" to refine the solutions.

### 3P Defined

The Production Preparation Process (3P), as defined by Sensei Nakao, means developing, by a target date, a production system—the assets, software, standards for work, and their interaction with process flow and people—that satisfies the requirements of the following:<sup>2</sup>

- Design quality set during the product planning and design stages
- Needed production volumes
- Cost

The Production Preparation Process represents a dramatic shift from continuous, incremental improvement. Instead 3P offers the potential to make quantum-leap design and manufacturing improvements far beyond those possible through continuous improvement. 3P methods examine multiple Lean solutions to eliminate costly waste.

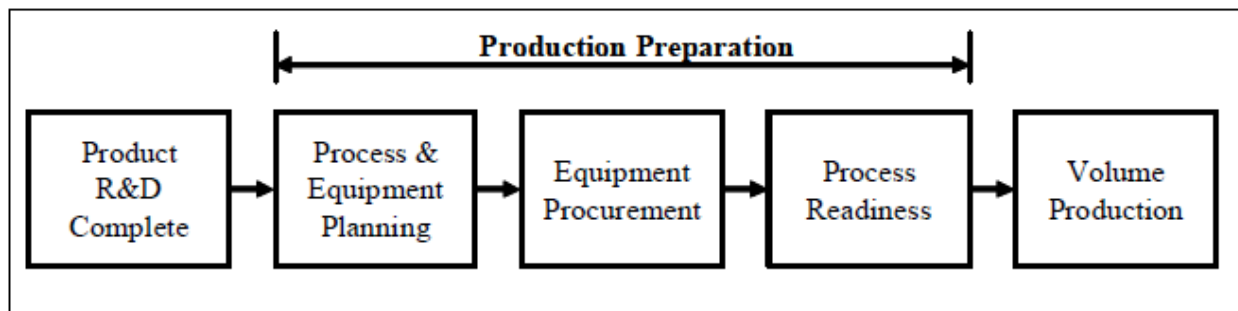
3P provides a structured process ensuring that people, process, and technology are optimized by bringing Lean Thinking to factors such as the production process, people operating and maintaining the production process, tooling, facilities, and the ability to meet customer quality and output requirements. It results in a streamlined development process, a more complete capital project plan, and improved operating and maintenance performance. The Production Preparation Process consists of simultaneously developing a new product and manufacturing system while also minimizing the development time. A key feature of 3P is that it simulates the actual components, product, and production line during the early stages of the design process to learn about manufacturing or delivery requirements before making commitments to a floor plan or process flow.

Production Preparation applies to the following situations:

- Release of new products
- Design changes to existing products
- Changes in demand for the product
- Changes to production capacity, equipment, or facility

As shown in Figure 1, Production Preparation begins at the point where the product concept is well enough designed to enable the development of the manufacturing process. It ends once production ramps up, but includes capturing lessons learned from volume production ramp up.

Figure 1, Where Production Preparation Fits.



The Principles of the Production Preparation Process include the following, which require close attention and adherence:

- Voice of the Customer. This provides linkage from the customer-required product features and performance to the product design, and ultimately to the manufacturing system.
- Integrated Product and Manufacturing Development. This brings together product and process engineering, vendors of equipment, front-line workers, and others to ensure simultaneous development with minimal rework.

- Quality Built into the System. This focuses on ensuring that the equipment and other processes hold required tolerances, temperatures, pressures and other operating parameters.
- Flexible Processes and Equipment. This ensures that the system is designed to meet current and future customer requirements, and can adapt to changing economic conditions.
- Lean Principles. This ensures that the manufacturing processes will launch with best practices from Lean Thinking.
- Timing. In the 1990s, Motorola compared a 30% development cost overrun to a six-month delay in launch and learned that the profit reduction due to a launch delay was 10 times larger than from the cost overrun. While this doesn't say to overrun budgets, it does say that completing developments on time is essential.
- Target Cost. Since the market sets the price, design of the process to enable lowest cost is essential. The greatest reduction in manufacturing cost is possible during design of the new process.

### What Companies Say about 3P

While 3P has yet to gain as wide a following as Lean Manufacturing, leading companies have embraced 3P. For example, Volkswagen is developing the manufacturing processes for its new U.S. facility and other facilities using 3P. Genie Industries uses 3P as an integral part of their product launch process. This section highlights what Freudenberg-NOK, the Haskel division of United Technologies, and Danaher publically say about 3P.

Freudenberg-NOK's website summarizes 3P, a key element of their business system as follows:

"3P is a technique used to invent or completely redesign a manufacturing process and build quality into the system. It is the ultimate weapon to integrate:

- Flexibility
- Speed
- Cost Reductions
- Minimal Capital

"It is at the core of Freudenberg-NOK's Lean manufacturing practices, used throughout the entire organization.

"Rather than tweaking an existing shop floor process, we start with a clean sheet of paper. Traditionally, when developing processes, manufacturers tend to concentrate on maximizing the efficiency of existing capital, labor, and materials to achieve the lowest cost. With 3P, we turn it around and focus on minimizing the total resources – capital, labor, and floor space.

"3P provides significant benefits and Freudenberg-NOK is proud to have a production process where quality is world-class and waste is significantly reduced with both achieved at the lowest capital cost."

Haskel, a specialist in the design and manufacture of high pressure air-driven liquid systems, gas booster and air amplifiers, along with their associated packaged systems, and part of United Technologies describes how it uses 3P:

"The 3P tool simulates the actual components, product and production line of a new product throughout its design and development cycle. Early in the design, during concept generation and selection, a cross-functional team of Haskel designers, manufacturing, quality and process engineers, suppliers, and operations experts apply lean principles and non-negotiable productivity rules to product, process and tooling mockups made from cardboard, styrofoam and/or wood. In the later stages of design and development, the 3P simulation events incorporate development hardware and software and, finally, production versions. The practice of 3P simulation can also be applied to non-product applications, for example, to the development of a new or upgraded service or information infrastructure. In these cases the simulation media may be different (e.g., concept of operation scripts, live storyboards, role playing, process models, and pilots), but the intent -- to learn as much as possible about the implementation environment before committing to it -- is the same.

“Used for:

- Delivering customer-required quality
- Delivering production capacity for expected demand
- Delivering target date of market availability
- Delivering target cost in business case”

Brad Trago, director of engineering for Danaher Motion, says that 3P has become associated with cost savings, as well as faster product development. He adds that 3P is a disciplined, methodical procedure that facilitates the rapid evaluation of ideas for product design and manufacturing processes. Danaher adopted the 3P process in the early 2000s to design and manufacture its new line of AKM high-performance servo motors. A feature of 3P is try-storming, a hands-on extension of traditional brainstorming. Try-storming takes brainstorming one step further in that an idea is mocked-up quickly so that it can be evaluated physically.

In the HON 3P Doer’s Manual, part of the HON Production System, Tom Hammer says that 3P provides a formidable weapon in “The Race for Office Furniture Space.” He describes 3P as revolutionary similar to *kaikaku* which means big changes or a period of major change.

### 3P’s Benefits

The benefits of 3P come in two broad categories: those that are more tangible and measureable and those that build long-term competitive advantage.

The Michigan Manufacturing Technology Center provides a good list of the tangible benefits:

- Improve performance of new and existing products and processes
- Design products and processes right the first time
- Develop alternatives to design products and processes to meet core customer needs
- Minimize cost of product launch and life cycle by incorporating lean thinking at the beginning of launch
- Reduce cost due to poor planning
- Report a 20% reduction in manufacturing costs
- Report a 30% - 40% reduction in capital spending
- Experience growth on an existing footprint (without expanding manufacturing floor space)

While these benefit competitive advantage, the true long-term benefit comes from creating capabilities that enable your company to get ahead and stay ahead of competition. This requires building what is often referred to as a learning organization, and 3P contributes to that environment.

The engineers working for equipment manufacturers understand how to design equipment to meet operating parameters for speed, product quality, automation, and design life. Working with specialist in controls, they design control room man-equipment interfaces that enable control room operators to easily set operating parameters and monitor equipment performance. They may also design features that enable quick changeover from product to product and that simplify maintenance. Over time, equipment manufacturers have made important improvements in the features of their equipment.

From the point of view of a particular company, these equipment features offer no sustainable competitive advantage. The features available to one manufacturer are available to all. A company might gain a temporary advantage immediately after the installation of the new assets; however, staying ahead requires continual capital expenditure. Capital expenditures at the required level to stay ahead almost certainly will lower key financial metrics such as Return on Capital Employed (ROCE) or Return on Net Assets (RONA).

Consider the following statements from Steven Spear. Spear explains that most of today's products and operations are complex and difficult to design and operate well. Spear identifies organizations that manage this complexity and outdistance their competition as high-velocity organizations. He says they are adept at designing, developing, and operating exceptionally complex systems to achieve exemplary and constantly improving performance in the design, production, or delivery of complex goods or services.<sup>3</sup> He describes companies that exemplify high velocity learning including the U.S. Navy's Nuclear Power Propulsion Program (referred to as NR for Naval Reactors). The NR program has had extraordinary success. Since the launch of the *Nautilus* in 1954, NR hasn't suffered a single reactor-related causality or escape of radiation while the Russian navy has had many calamities and NASA has lost three crews while undertaking comparably difficult and dangerous missions.<sup>4</sup> NR created a culture that ensured that people started with the best possible knowledge. The characteristics of NR's culture include: rigor and discipline, treating any incident as an opportunity to learn, experimenting to gain fundamental understand of their processes, and building comprehensive set of standards and procedures built upon all of the prior learning. Together these characteristics ensure that their processes and their propulsion systems are the best they can be.

3P has similar characteristics: it is a structured process, it includes experimenting with alternative solutions to learn which is best and learn more about the system, and when done properly, it takes advantage of and builds standards and procedures that exploit and capture the organization's knowledge. This last point is important. While some people see the obvious features of 3P like investigating alternatives, the way the organization's knowledge is developed and used provides an important source of competitive advantage. Companies that use 3P well will take the equipment available to all of their competitors and create a superior manufacturing system.

### Lean Thinking

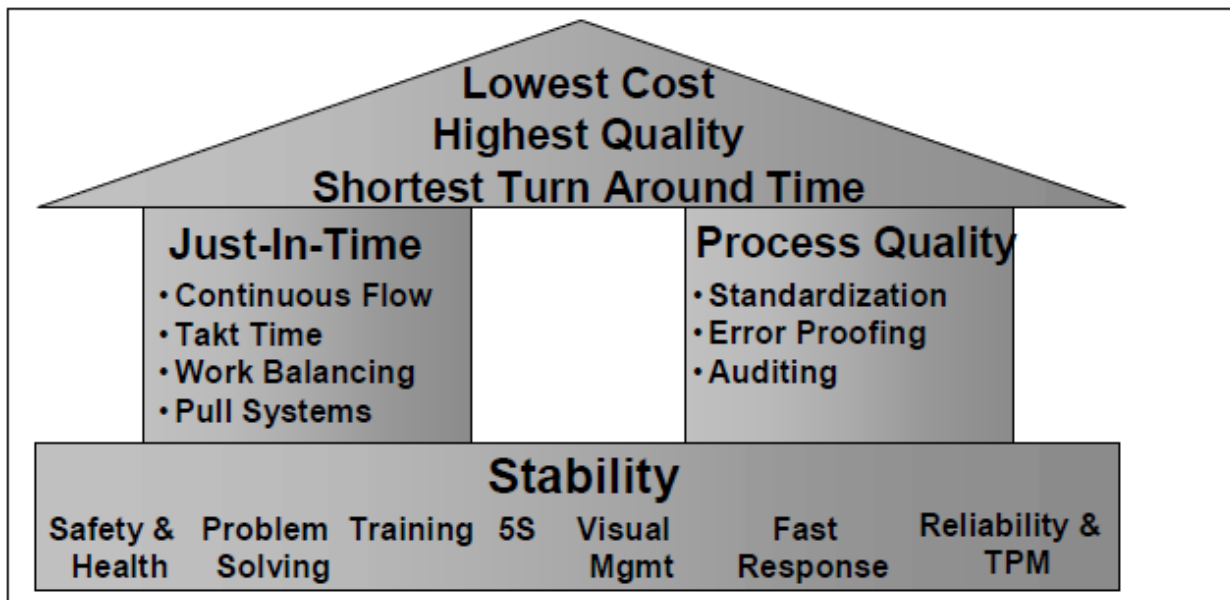
3P derives its approach from Lean Thinking and develops Lean production capabilities.

Taiichi Ohno, the founder of the Toyota Production System said, "All we are doing is looking at the time line, from the moment the customer gives us an order to the point when we collect cash. And we are reducing that time line by removing the non-value added wastes"<sup>5</sup>. Ohno echoed Henry Ford who said, "Time waste differs from material waste in that there can be no salvage. The easiest of all wastes, and the hardest to correct, is the waste of time because wasted time does not litter the floor like waste material."<sup>6</sup>

Within 3P, collapsing time by removing waste applies to both the development process itself as well as the production process that is being designed. This section will introduce some Lean principles and methods that 3P builds into the production process.

Figure 2, The Toyota Production System house, illustrates the major elements of the production system. A thorough introduction is beyond the scope of this paper; however, many good resources exist.<sup>7,8,9</sup> The TPS House is founded on process stability. Methods to create stability include 5S for workplace organization, visual management to communicate status, and reliability and TPM to ensure that equipment runs when needed and produces quality output. One pillar of the house is Just-In-Time meaning the right part at the right time, just when needed and of the desired quality and quantity. Just-In-Time is enabled through designing the production process for continuous flow, production rate to meet the customer's actual demand (takt time), balancing work, and allowing the downstream operations to signal when upstream production is needed. The other pillar is Process Quality meaning that only good output is passed to the next operation or customer. Process Quality is enabled through standard work for production and maintenance, equipment designed to prevent errors, and checks on how people perform standard work and in-process quality checks. This production system is designed to provide the lowest cost, high quality, and flexibility.

Figure 2. The Toyota Production System House.



However, there is more to Lean Thinking than the methods of production. Just as important are management principles and Lean culture.<sup>10, 11</sup> These principles give meaning to tools such as 5S that are illustrated in the TPS House.<sup>12</sup> Bresko summarized four of the principles that have direct impact on the design of operations as follows:

1. Use Visual Control so no Problems are Hidden. Simple, visual indicators help people determine immediately whether the process is in a standard condition or deviating from it. With this principle in mind, 5S is no longer a tidiness program, but a critical tool for providing visual control and quick recognition and correction of non-standard conditions.
2. Create Process Flow to Surface Problems. Continuous flow that moves material and information with minimal waste (e.g., inventory or waiting) and a clear pathway helps to surface problems with materials, people, or processes. For example, batch-style processing it is hard to determine if excess inventory is accumulating, but in continuous flow, excess work in process or unexpected equipment delays are soon obvious. With this principle in mind, processes are designed so that problems surface quickly. Of course, the organization needs the capability to quickly solve the problem—an ingredient for continuous improvement.
3. Standardize for Continuous Improvement. This might seem paradoxical at first, but a standard is the best known way to perform the tasks and provides the baseline for further improvement. This principle means that the production process needs to enable people to both follow existing standards and look for ways to improve them.
4. Go See for Yourself – Genchi Genbutsu. *Genchi genbutsu* means going to the source of the problem or opportunity to thoroughly understand the situation. This principle means that managers and supervisors must be engaged in, and not distant from, operations. Therefore, the layout of operations must make “going to see” easy.

When applying 3P, the design team must understand the details behind the three broad concepts just summarized:

- The reduction concept-to-launch and order-to-delivery times via elimination of non-value-adding activities.
- The tools and methods of Lean as illustrated in the TPS House.
- The management principles and how the design of operations help put the principles into practice.

## The 3P Method

Figure I-1 illustrates the high level Production Preparation Process. While there are two paths, one for product and one for production, the process is highly integrated and includes feedback between product and process design. Figure I-2 provides a more detailed look.

**Moonshine** - When several Japanese consultants from Shingijitsu were working with Boeing on kaizen they observed a team member bringing some homemade fixtures in to solve a problem. Described as "doing a little moonlighting" this term was misunderstood or mistranslated as moonshining, now the common term used to describe a key stage of 3P - Production Preparation Process. Moonshine is a focused, team-based workshop for creating and testing alternatives.

At first glance, you might think that the process is similar to typical development processes. However it differs in the following important ways:

- 3P starts with the customer – what it really means to provide the right quality, at the right time and quantity, and at the right price.
- 3P requires consideration of multiple alternatives – seven during the moonshine events – to cause revolutionary thinking to occur.
- 3P includes early experimentation with alternative solutions
- 3P looks for low-cost, low capital solutions.
- 3P provides rules and guidelines for eliminating waste, applying Lean tools and methods, and enabling the Lean principles.
- 3P captures learning in the form of best practices for design.

Moonshine events occur during the Production Preparation Process. These illustrate some of the ways that 3P differs from traditional design. Here are some of the key steps in the Production Preparation Process moonshine events:

- **Define Product or Process Design Objectives and Needs.** This means to understand the true customer needs. While we might be tempted to design a production system for efficiency in producing large quantities of the same product efficiently, if the customer really prefers to receive smaller quantities more frequently, then design the manufacturing process for that need. This also means to understand the components or elements of the product, including the raw material.
- **Diagramming.** This means to create a flow diagram, fishbone diagram, or similar illustration to understand, in detail, the flow from raw material to finished product. In this step, the design team analyzes where work in process will occur and how information and material will come together. The team looks for non-value-added activities.
- **Find and Analyze Examples in Nature.** This means to consider how each process step or product feature has a parallel in the natural world (e.g., the movement of an animal). This step helps the design team break out of existing paradigms and to look at the product and process in an entirely new way.
- **Sketch and Evaluate the Process.** This means to create hand-drawn sketches of the product or process. It forces the design team to carefully observe small details, and provides an effective and quick way to communicate and to encourage rapid discovery of alternatives. During this step, the design team divides into small sub-teams and develops competing sketches (solutions) before evaluating the best solution.
- **Build, Present, and Select Process Solutions.** This means to bring selected sketches to life as prototypes and to test and refine the concept.
- **Hold Design Review.** During this step, the moonshine design team reports to a larger team, gains feedback, and determines the steps to implement the solution.

This section introduced the 3P method and some of the steps to perform 3P. You might react by saying that 3P must apply better to assembly operations or other less-capital-intensive processes. This is not so. Whether in the metals industry, petro-chemical industry, or similar industries, products flow from raw material to finished product along a value stream, and that flow and the product can both be improved. The next section describes ways to apply the 3P process to these industries.

### 3P Application

When adding a new asset, building a new facility, or upgrading existing assets, management and design teams in the process industry need to consider and create solutions for the following requirements:

- Process Technology
- Process Control
- Quality Control
- Equipment Maintenance
- Maintenance Training
- Flow of product and production is supported
- Equipment Technology
- Operating Practices
- Safety and Environment Practices
- Operator Training

While these are generally known, a surprising number of capital projects or equipment upgrades focus primarily on the technology and the creation of an engineering solution. The design team jumps to an attractive capital solution, or relies almost exclusively on equipment OEM for technology, or pays too little attention to the need to set standards for operating and maintaining the equipment or the training that operators and maintenance staff will need.

As one example of this, Alcoa in the early 1990s was an engineering-driven company. A large corporate department of engineers, supported by researchers at Alcoa's Technical Center developed technology-intensive solutions to manufacturing needs. These solutions were typically capital intensive. When Paul O'Neill became CEO, changes began. For one, he set an ambitious target for RONA (Return on Net Assets). Another change came as Alcoa adopted Total Quality thinking and began to learn about Lean. As a result, Alcoa established a new process for equipment upgrades and capital projects. In a nutshell, this process required that each project be treated as a root cause analysis. The root of the need for the capital was studied, and multiple solutions were required. One of the solutions had to be a low-capital or no-capital alternative. Within a little more than a year after this new process was implemented, Alcoa's capital expenditures declined by over 50%. Despite initial protests that lower capital expenditures would hurt productivity, productivity actually increased, as did RONA. Having been at Alcoa during that time, I witnessed the change and can say that it was dramatic.

As another example, General Physics Corporation, a provider of process documentation and training development for capital equipment projects (among many other services), is frequently called into bid on standard development and operator and maintenance training with surprisingly little time before the capital is installed. When this happens, it appears that the way personnel will operate the equipment was an afterthought.

While disappointing, these examples are not surprising. Most of these projects are highly complex. However, when we see the success of high-velocity organizations like the nuclear navy and the benefits of 3P, we know better outcomes are possible.

In the next paragraphs, I provide specific ways to apply Lean Thinking and 3P to the metals industry.

Develop an Overall Manufacturing Strategy and Guiding Vision. This step answers the degree to which you will adopt Lean Thinking. For example, the manufacturing strategy might include the following statements:

- The upgrades will enable a financial break even at low production volumes.
- The manufacturing process will enable fast dock-to-dock time, minimal work-in-process inventory, and the ability to keep finished good volume low while responding to flexible customer demand for specific product types.
- The equipment and the organization of the area around the equipment will enable rapid changeover.
- Operators will perform routine equipment care such as routine inspections and lubrication, and the equipment will simplify these tasks.

This activity occurs at the management level and often requires education on best practices and potentially

benchmarking visits to world-class manufacturers. The manufacturing strategy sets the tone for all decisions to follow. These types of strategy statements can apply to upgrades of existing processes as well as major capital projects.

Perform a Manufacturing Analysis. This analysis looks at each product type required and the flow path that the product must follow. This defines the value stream for each product. While many steel plants have only one line, understanding these value streams and potential grouping of product types by similar value stream can change the sequence of production and potentially the layout of a plant.

Identify a Cross-Functional Design Team and Charter the Project. In this step, include individuals from operations, maintenance, engineering, purchasing, and other functions on the team. Train the team in the 3P and Lean Thinking.

Follow the 3P Steps. The 3P provides a roadmap. Begin to follow it, and while doing so, develop your organization's standards for process design for future projects. Be sure to work cross-functionally, develop and evaluate alternatives, use try-storming, and apply Lean Thinking.

The next two paragraphs provide two ways to encourage and facilitate the evaluation of alternatives.

Create a Matrix of Alternatives. Post a 7x8 matrix using brown paper on the wall. In the first row, leave the first cell blank, and label each additional column with the numbers 1 through 7 to indicate the seven alternative solutions. Then, in the first column, label the remaining rows "Material," "Method," "Control," "Fixtures," "Operating Practices," and "Maintenance Practices." (You will probably decide to use different labels eventually, but these are good ones for a start.)

Refine Decision Making. For further refinement of the alternatives and making decisions, evaluate each alternative on additional process criteria.

- Low capital investment
- Known process technology
- Error-proofs operation
- Easy to maintain
- Ergonomically correct
- Fast changeover
- Minimizes work in process inventory
- Simplifies training requirements
- Minimal space required
- Minimal development time
- Error-proofs maintenance
- High reliability
- Enables visual control and management
- Enables operator maintenance
- Reduces dock-to-dock flow time
- And other relevant criteria

Of course, while learning and applying 3P, remember to continue following your existing best practices and remember to develop solutions for each of the requirements listed at the beginning of this section (e.g., safety, process technology, equipment maintenance, training, etc.).

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## References

1. R. Spiegel, “3P Process Helps Engineers Design Better Parts,” *Design News*, March 15, 2004.
2. C. Nakao, “Production Preparation Process,” Shingi Jutsu Co., Ltd. internal documentation.
3. S. Spear, “Getting to the Front of the Pack,” *Chasing the Rabbit: How Market Leaders Outdistance the Competition and How Great Companies Can Catch Up and Win*, McGraw Hill Co., New York, NY 2009.
4. S. Spear, “High Velocity Under the Sea, In the Air, and On the Web,” *Chasing the Rabbit: How Market Leaders Outdistance the Competition and How Great Companies Can Catch Up and Win*, McGraw Hill Co., New York, NY 2009.
5. S. Hino, “The Toyota Paradigm,” *Inside the Mind of Toyota: Management Principles for Enduring Growth*, Productivity Press, New York, NY, 2006.
6. H. Ford, “The Meaning of Time,” *Today and Tomorrow*, page 114, originally published 1926, reprint edition by Productivity Press, New York, NY, 1988.
7. J. Womack, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Free Press division of Simon & Schuster, London, England, 1996.
8. K. Suzaki, *The New Manufacturing Challenge*, Free Press division of Simon & Schuster, 1987.
9. K. Sekine and K. Arai, *TPM for the Lean Factory: Innovative Methods and Worksheets for Equipment Management*, Productivity Press, Portland, OR, 1992.
10. J. Liker, *The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer*, McGraw Hill, New York, NY, 2004.
11. D. Mann, *Creating a Lean Culture: Tools to Sustain Lean Conversions*, Productivity Press, New York, NY, 2005.
12. M. Bresko, “Institutionalizing Lean Six Sigma and Reliability Excellence Organization-Wide: Concepts and Methods You Can Use, Noria—Lean, Reliable, and Lubed, Louisville, KY, May 15-16, 2007.

Appendix I

Figure I-1, The 3P Process High-Level Flow.

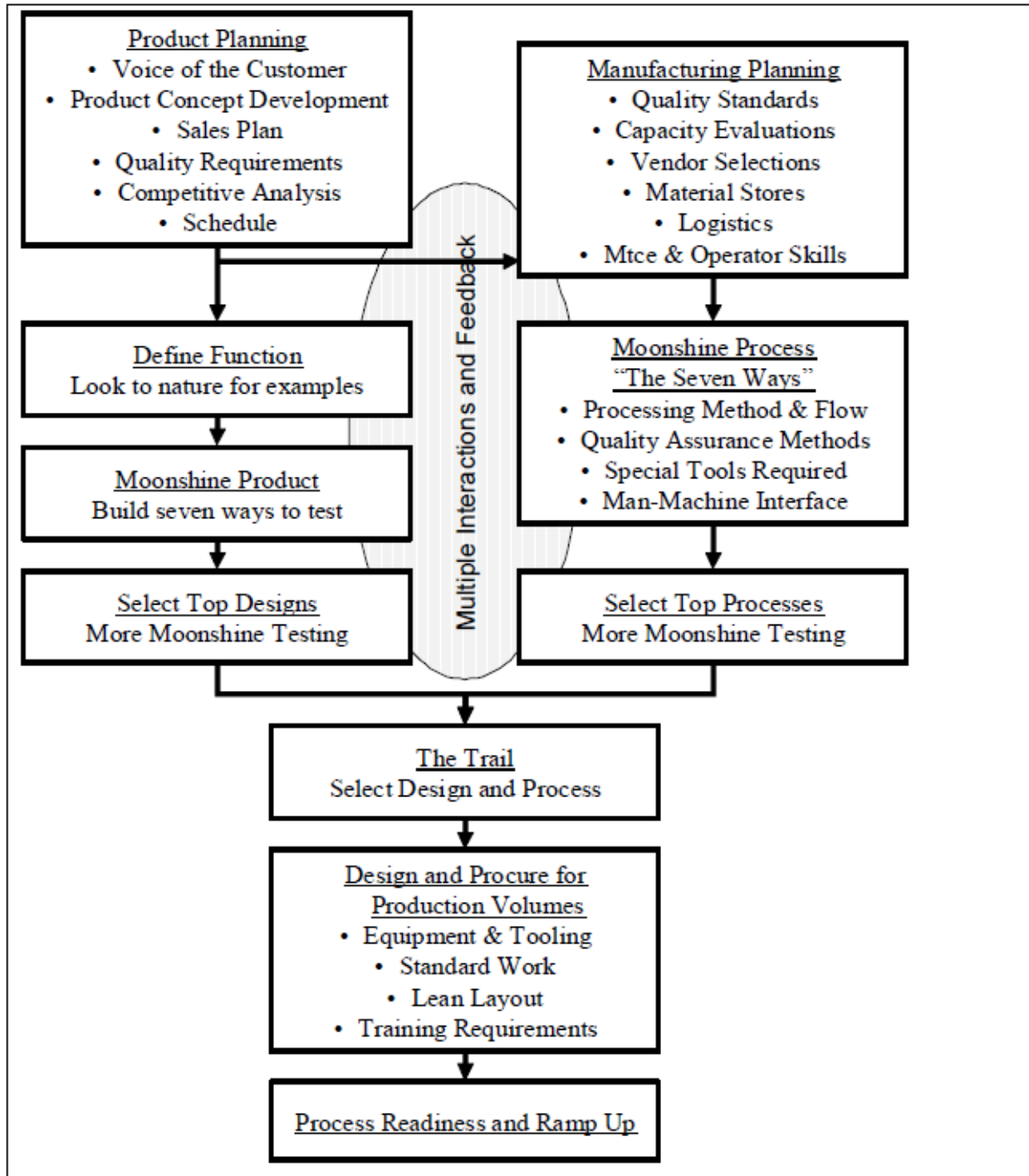


Figure I-2, The 3P Process, More Detailed Level

