

The Soft Side of the Toyota Production System is the Hard Side

By

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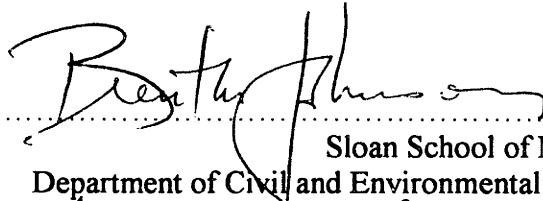
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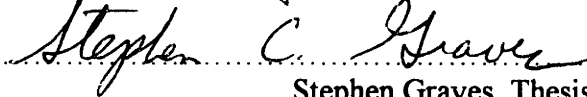
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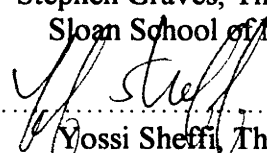
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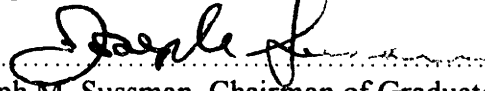
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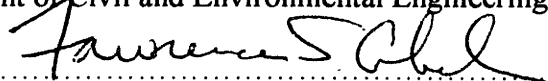
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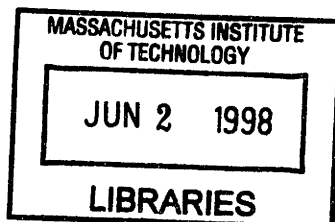


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**Master of Science In Management,
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Abstract

This thesis analyzes the challenges associate with the rollout of the Toyota Production System (TPS) in a US vinyl extrusion plant. There is a cursory explanation of some of the Technical aspects of TPS, and implementation problems are examined and analyzed in the context of cultural barriers. The thesis contends that the softer, more subtle, leadership principles demonstrated by Toyota management are just as important to Toyota as is the elegance of its production system.

Findings include the identification of three key leadership traits that are evident within Toyota, and that are necessary to facilitate the cultural shift to a TPS environment. Those leadership traits are: 1) Set Consistent Direction with Fluid Constraints. 2) Create a Culture of Removing Barriers. 3) Develop the Capabilities of People to Improve.

Thesis Supervisors: Stephen Graves
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Family

Most important, this is a document to and for myself, my wife Leslie, and children Linsey, Jacob, Katie, and Max. It has been an opportunity to solidify in our minds what we have been about over the past two years and the thesis includes principles that we believe in. My family has listened, given advice, and loved me through my successes, failures, frustration, and exultation. They truly have been a great support, and I hope this will be worthy of our time and sacrifice.

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Prologue

Toward the latter part of the 80's, the business climate for American manufacturing companies, particularly the auto companies, was that of desperation. Japanese competitors had consistently been invading traditional US strongholds such as automobiles and electronics, with both higher quality and lower cost products. At that time, the Massachusetts Institute of Technology (MIT) created a joint task force consisting of the MIT School of Engineering, the MIT Sloan School of Management, and several manufacturing company leaders called the Leaders for Manufacturing Program (LFM).

The LFM mission is: **To discover and translate into teaching and practice the principles that produce world-class manufacturing and manufacturing leaders.** Participating corporate partners in the LFM program are Allied Signal, Alcoa, Bay Networks, Boeing, Chrysler, Digital Equipment Corporation (DEC), Eastman Kodak, Ford, General Motors, Hewlett-Packard, Intel, Motorola, Polaroid, Tenneco, and United Technologies Corporation (UTC).

One of the elements of the LFM program is its Fellows program. LFM fellows receive two masters' degrees, one from the management school, and one from engineering. Part of this two-year fellows program is a supervised 6-month internship at one of the partner companies, on which the student works for the company, and writes a thesis on some element of the internship.

As a participating fellow in the LFM program, I had the pleasure of working for The Aluminum Company of America (Alcoa) at a plant in Denison Texas. This plant was in the process of rolling out the Alcoa Production System, a new manufacturing system similar to the much lauded Toyota Production System.

This thesis is my attempt to pass along the most important things that I learned at Alcoa, on their continued journey toward world class excellence in manufacturing.

Part I. Toyota: Not Easy To Duplicate

The Toyota Motor Company became recognized in the late 80's as the world leader in manufacturing excellence. As industrial leaders in the U.S. were concentrating on diversification, the leaders in Toyota were focusing on manufacturing and supply chain excellence. The results were staggering gains in productivity and quality.

Toyota's methods for excellence were named the Toyota Production System (TPS). TPS has become the competitive standard for companies worldwide (Maccoby, 1997), and many US manufacturing companies have attempted to emulate it, or portions of it under names such as lean production, JIT inventory management systems, Total Quality Management (TQM), and others¹.

These duplication efforts however, have shown mixed results (Milkman, 1997; Rinehart et. al., 1997). The cloning of the Toyota Model has proven to be much more difficult than originally expected. There is more to the Toyota Production System than a collection of mechanical tools of problem solving.

The first part of this thesis will describe the introduction of a "Toyota-like" manufacturing system to a large company, and then try to identify some of the problems that are involved in the implementation of TPS in an individual plant within that company.

The second part (Chapters 4 – 6) will be a description of leadership principles inherent in TPS, and which are necessary to overcome the problems, and assist in its implementation.

¹ Explanations of these terms will come later in the Thesis.

1.0 Introduction

“These guys just don’t like change!” said Robb McKay, the production supervisor. He and I had been discussing some of the challenges we were having with implementing some of the ideas we had developed for faster changeovers.

I was frustrated, and couldn’t see why this implementation was so hard to do. To me, it was obvious. If we could reduce the changeover time on these continuous process extruders, we would save money lost to scrap during the changeover, and could economically lower our lot sizes. With smaller lot sizes, we could run more products in a given day, thus making it possible to service our customers with lower inventory.

Was I the only person in the plant with an IQ high enough to see it? Or was Robb right? Maybe these guys could see the connection between quick changeovers, and lower inventory, but they were just stubborn because they didn’t think of it. It must be these small town Texans!

1.1 Manufacturing and Supply Chain Excellence as a Strategic Advantage

With the sudden strengthening of the Japanese yen in the mid 1980’s, Toyota’s export power should have been hurt dramatically by much higher priced Japanese products in the US. The company however, was better prepared to handle the crisis than was thought possible. From as early as 1902, the fathers of Toyota, Sakichi Toyoda, his son Kiichiro Toyoda, and Taiichi Ohno had been working on the ideas that would come to be known as the Toyota Production System (TPS). The evolution of this production system became so effective that the Toyota Motor Company emerged as the premier automobile manufacturer in the world. The formula for Toyota’s success was simple. Produce the best cars at the lowest cost.

Over the next several years, it became obvious to many corporations that manufacturing and supply chain excellence were an essential strategic part of remaining competitive. Old stodgy companies with high inventories, obsolescence, and poor supply chains would not be able to compete with lean and efficient competitors. The strategic direction for the 1990’s for manufacturing companies was set and the standard was in Japan.

1.2 *Toyota as a Model*

As Toyota opened up its manufacturing plants to the outside world, US companies were impressed. The most startling part of the Toyota plants was the lack of inventory. With elegant tools such as the Kanban (Japanese word for signboard or signal) to signal production and replenish parts, the Toyota plant operated in almost perfect harmony. The Kanban became a symbol of the Toyota tools, and the terms “Just in Time” (JIT) became synonymous with the Toyota plant methods of delivering product to the assembly line “**just in time**” for use, without inventory back-up.

Another aspect of the Toyota system that later started to be understood was the high level of involvement by the people on the factory floor in continuous improvement processes called “Kaizen”. The Toyota juggernaut not only had superior processes. but also was continuously improving them.

Then, most recently, TPS has come not to be understood as a set of tools, but as a complete system that functions together like a symphony (Wheelwright and Bowen, 1996). The realization of the power of a coherent manufacturing system has spawned the development of many clone, and near-clone production systems, all patterned after the **Toyota Production System (TPS)** (Toyota Motor Corporation, 1992), or **lean manufacturing system** (Womack, Jones, and Roos, 1990). Some of the most widely known clones are the COS (Chrysler Operating System), and the FPS (Ford Production System).

1.3 *Thesis Statement*

There are two sides to the Toyota Production System. The first is the **hard side** of TPS. It includes the mechanics and framework of the Toyota Production system. The hard side of TPS has been meticulously studied by people outside of Toyota, and taught by those within Toyota. It consists of the famous “pull system”, “kanban card”, “andon chord²”, “heijunka box³”, etc. The

² “Andon” is Japanese for a paper covered lantern i.e. a light. An andon chord is pull chord that is used in a Toyota plant to light a light, and ultimately stop the line to alert the necessary party there is a problem, etc.

³ “Heijunka” is Japanese for leveling. A typical heijunka box is a mailbox slot looking device that is used to visually schedule events in the plant, such as loading a truck, so that it is level.

purpose of the hard side of the Toyota system is simple: **To produce what the customer wants, in the quantity the customer wants, and deliver it when the customer wants it, every time, for the lowest cost, and with the highest quality**⁴.

The duplication of this system, however, is not as easy as the implementation of the mechanics of the system. The reason is because the implementation of a new manufacturing system has implications that go to the core of the company's culture. Therefore, I will call the important non-mechanical elements of the TPS duplication the **soft side of TPS, or the Toyota Leadership Model**. The soft side of TPS is less understood, and difficult to duplicate. However, it is what has enabled Toyota in its creation and implementation of the hard side. There are three interrelated keys to the Toyota Soft Side:

- Set Clear Direction with Fluid Constraints⁵
- Develop a Culture of Removing Barriers
- Develop the Capability of People to Improve

1.4 Objective and Structure of the Thesis

This thesis summarizes the observations I made over the 6-month internship of work on the implementation of the Alcoa Production System (APS) in the Alcoa Building Products plant in Denison Texas. During my involvement in the Denison journey to present, we experienced both successes and failures. Through the process of working with Alcoa in implementing this system, I learned the importance of leadership in directing the change, and that knowing what to do, was different from knowing how to do it.

The purpose of this thesis is to present some of the fundamental leadership characteristics that are necessary to implement TPS. By writing about these issues, I hope to solidify in my own mind

⁴ This is a quote from Steven Spear (Harvard Business School - HBS doctoral candidate studying the Toyota Production System), and Dr. Kent Bowen (HBS Professor). Mr. Spear was involved with a plant tour of the Ypsilanti Service Center (a Toyota distribution center) in Michigan, and I took a class from Dr. Bowen at HBS.

⁵ Fluid constraints are defined as flexible, evolutionary, and adaptive constraints. The concept of fluid constraints will be discussed in detail later in Chapter 4.0.

some principles for leadership, which will help me be more effective the next time I undertake a project similar to this.

The thesis has two parts. **Part I** will describe the background of the Toyota, and Alcoa Production Systems, as well as the APS implications in Denison, TX.

Part II focuses on the Toyota Leadership Model, which is the most important part of TPS. It will include the leadership principles that are inherent in TPS, as well as several examples from the Denison implementation experience.

The appendix provides a more detailed description of some of the experiences from the internship.

2.0 Background

Alcoa, the worlds leading producer of aluminum and alumina serves customers in the packaging, automotive, aerospace, construction, and other markets with a variety of fabricated and finished products. The company is organized into 21 business units, with 178 operating locations in 28 countries (Alcoa 1996 annual report).

As the business leaders in Alcoa learned of the Toyota Production System (TPS), they envisioned its power if implemented throughout their company. In order to do so, they developed two strategies. The first was to hire an outside consulting agency (TOYO-Consulting), which had experience with the implementation of TPS in other US factories. Second, they formed a central consulting group to work with TOYO-Consulting in an effort to build the internal capability to implement TPS throughout the company. With these two groups, the implementation was started throughout the various Business Units (BU's). The new production system named the Alcoa Production System (APS), and was designed as closely as possible to duplicate TPS.

Alcoa Building Products (ABP), a business unit within Alcoa, with 5 manufacturing plants, and 3 distribution centers was one of the first business units to be involved in the initial implementation. Gary Williams, the Vice president of Operation was in charge of the project, and together with the consultants, made the rollout strategy to start in Sidney Ohio, the BU headquarters, then gradually expand out as they built the expertise, and as resources became available.

The core group of change agents consisted of TOYO-Consulting and two Alcoa corporate people. They went to the first plant in Ohio and started the APS journey in the trim-sheet area. After a few months, the group moved forward with changes that enabled the trim sheet area to cut substantial inventories, as well as continue to service their customers.

As the work progressed, the enthusiasm for the project by the BU leadership grew, and the plant in Denison Texas was to be the plant next in line to implement. Approximately six months after the project start-up in Sidney, Jeff Jackson (one of the Alcoa internal resources), and TOYO-Consulting came to Denison, with experience, ideas, and a satchel full of training materials.

2.1 The Denison Plant (Denison, TX)

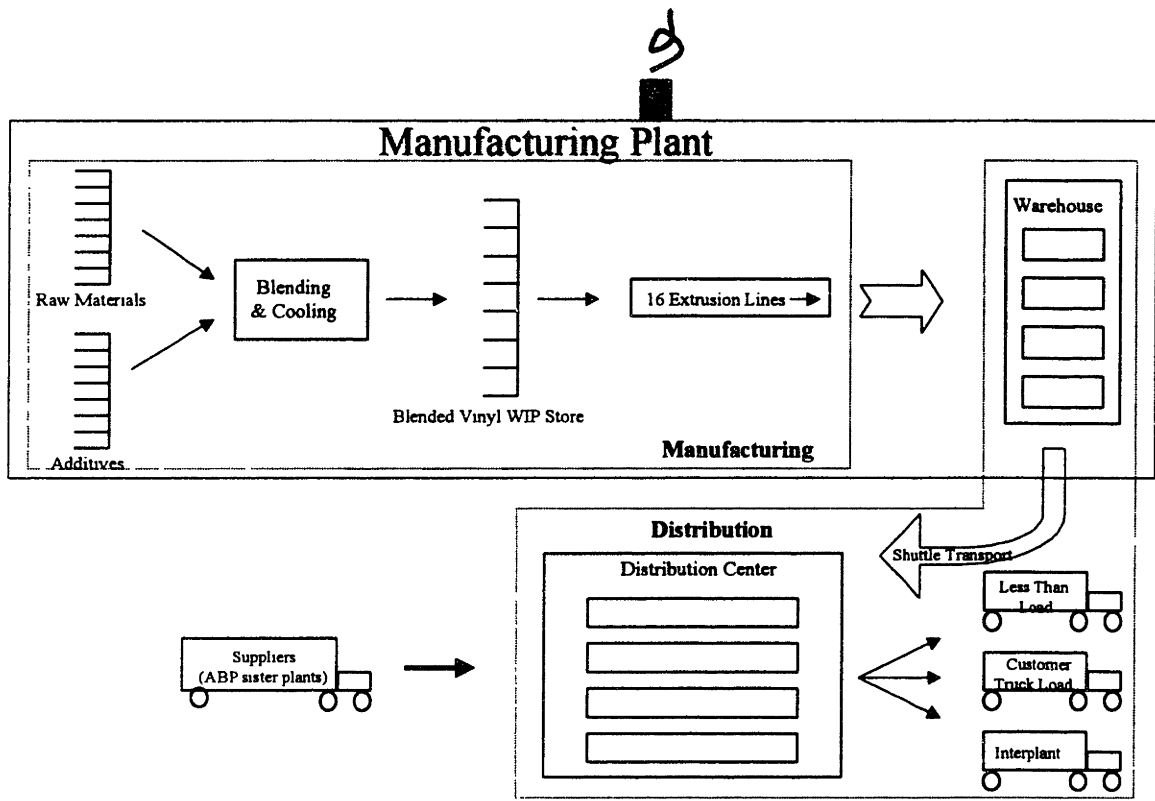


Figure 1. The Denison Manufacturing and Distribution Operations.

The Denison plant made co-extruded vinyl siding on 16 lines. It was a cost center, and thus focused its improvement activities on cost reduction to improve profitability. There were four engineers on staff in the quality and project improvement capacities, as well as a couple of staff engineers for the whole business unit. The plant ran 7 days a week, 24 hours per day, with 4 distinct shifts, and no overlap. The previous year had been a good year for the Business Unit who shared its profits with a bonus program for the employees.

Within the plant, engineering and plant management level personnel led most of the cost-cutting efforts. For example, in 1995, an engineer discovered that an adjustment in material used for the siding could save a lot of money. This project was evaluated, approved and the changes were made. There had been a few suggestions from the hourly people in a suggestion box program, but enthusiasm came and went, and many of the suggestions were never implemented.

The plant had a fairly flat management structure with all the key management people reporting directly to the plant manager and production supervisors and engineers only a step away. The

plant employed about 350 people, in two main divisions (Figure 1). The largest of the two divisions was manufacturing, which manufactured over 600 SKU's (stock keeping units). The second was distribution, which received product from both manufacturing and external suppliers, and shipped over 2000 SKU's directly to customers.

2.1.1 Manufacturing

The manufacturing division had 4 main functions, Receiving, Blending, Extrusion, and Maintenance (Figure 1). Although not a union shop, there was a fairly rigid job classifications for operators, material handlers, packers, etc.

The hourly employees at the plant were highly educated and high quality because Alcoa was one of the higher paying employers in the community. However, historically workers didn't spend much time improving their jobs significantly; they were expected to "just do it".

2.1.2 Distribution Center (DC)

The distribution center was located in a building about a half-mile away from the plant, and employed about 80 people. There was a distribution manager, four supervisors and two dispatchers for the four shifts. The remaining 75 workers were pickers, loaders, and restockers.

The distribution center had three functions. First, it received product from the manufacturing plant, and other sister ABP plants in Ohio, Virginia, and South Carolina, which were placed in inventory. Second, it picked and shipped directly to customers on order. (A typical customer load was a one or two stopper⁶, which contained from 50 to 100 line items of varied quantities, and needed to ship within 48 hours of when the order became firm.) Third, it sent focused⁷ product to sister distribution centers in Ohio and Virginia. (Inter-plant loads were nearly always full truckloads of full skid quantities, which were required to ship within 24 hours of the time the order was received.)

⁶ A two stopper is a truckload which has either two customers orders on it, thus having two stops, or one customers order, but two "ship to" locations. Although there were many single stop orders, there were also frequently 3 stoppers.

2.2 The Alcoa Production System

The Alcoa Production System (APS) was a detailed model of the Toyota Production system. It was built on three overarching principles, with 20 interdependent subsystems linked together to produce a cohesive, functioning unit (Figure 2).

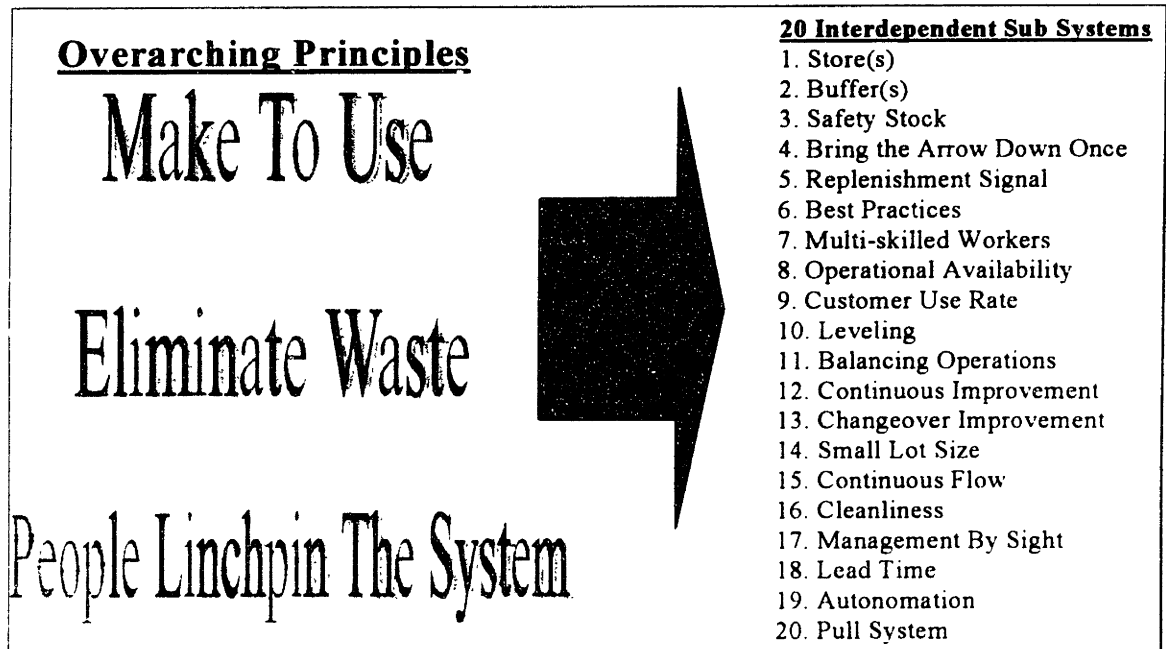


Figure 2. The Alcoa Production System.

The three overarching principles of the APS system were⁸.

- Make to Use – Make what the customer wants, when the customer wants it, and in the quantity the customer wants it. This is in contrast to the current state of make to inventory, then service the customer from that inventory.
- Eliminate Waste – Make perfect product, waste free, every time. Sources of waste are: overproduction, waiting, conveyance, processing, inventory, motion, and correction (rework).

⁷ Focused product is product that is made only in one of the plants. For example, all the shutters were focused in South Carolina. Conversely, several of the vinyl siding SKU's were made only in Denison.

⁸ The definitions and work for the Alcoa Production System are the property of Alcoa, which I got off of their Intranet explanation of the system.

- **People Linchpin the System – People are the key to aligning the system to customer use rate, operating flawlessly within the system, and continually improving it.**

The three overarching principles of APS were designed as the ultimate goals, or “**ideal condition**”. In order to accomplish these goals, APS focused on 20 interdependent subsystems. Each of these sub-systems worked together, to reach the ideal condition (Figure 2).

2.3 Denison Ideal Condition (Make to Order)

The ideal condition for the Denison plant was to become a make to order system, with product coming off the lines, into a staging area, directly to the customer trucks (Figure 3). The ideal condition was the specific application of the overarching APS principles as they applied to the plant. Under the ideal condition, an order would come in from a customer, thus producing a “production kanban⁹”, which would signal production in the exact quantity the customer ordered. After it was produced and came off the line, a “move kanban” would be placed on it, so it could be taken to the proper staging area, where it would be unitized and loaded on a truck.

⁹ A production kanban is a signal to produce product. It is in contrast to a move kanban, which would be a signal to move product.

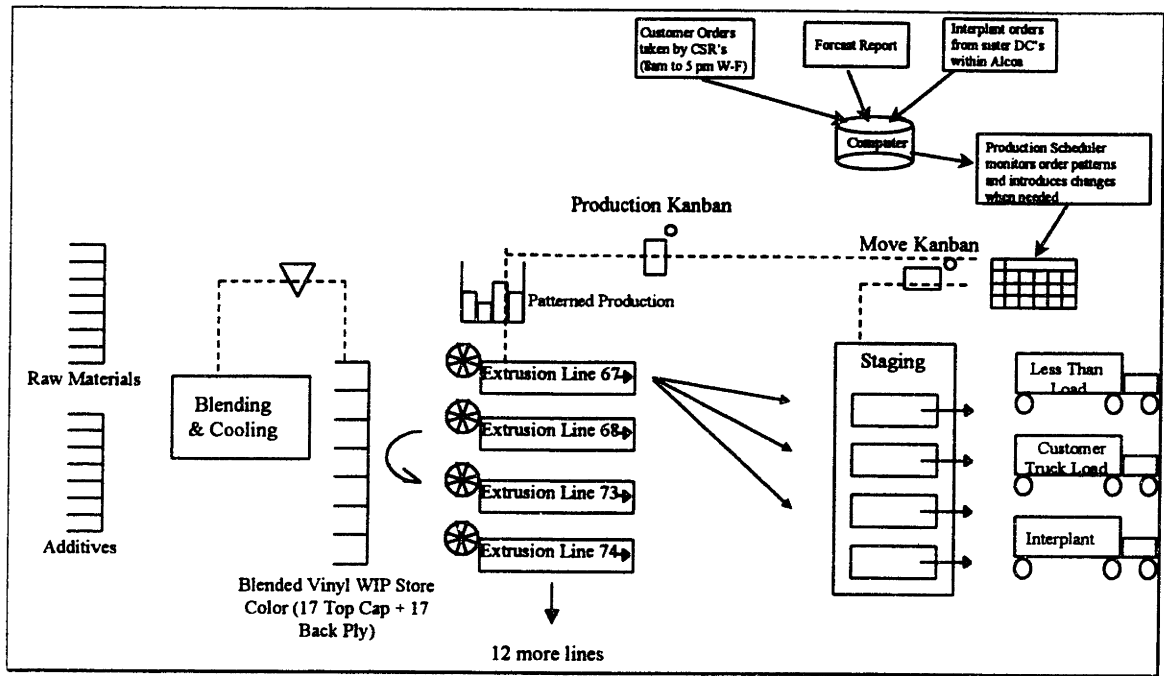


Figure 3. Denison Ideal Condition¹⁰.

One of the implications of the ideal conditions was the ultimate elimination of the warehouse. The reason for this was that in the ideal condition, the only product that would be made would go directly from the production lines to a staging area, where it would then be loaded directly onto the truck. Therefore, the only inventory would be in the staging areas.

¹⁰ Jeff Jackson, an Alcoa internal consultant originally did this drawing, with an inventory buffer between production and staging. The purpose of this inventory was to buffer against daily, weekly and seasonal customer demand variation. I eliminated the inventory store for this thesis in an attempt to simplify the idea of an ideal condition. However, in the case of demand variation that is out of the plant's control to effect, an inventory will become a necessary countermeasure (Chapter 4.0).

3.0 Culture Analysis and Barriers to Change

If I'm having problems implementing my ideas, and don't look at myself, my leadership, and the culture I'm in, then I am looking in the wrong place. People ultimately do pretty much what is asked of them.

The efforts to work toward the ideal condition (section 2.3) were met with various challenges and barriers. This chapter will talk about two specific projects that were started, and worked on, then analyze the cultural implications of this work.

There were two main projects that took priority. The first and most important was to reduce the changeover times. This was to be the primary APS focus for the plant. The second project was to eliminate excessive shipping variances¹¹. BU leadership had received complaints from various customers in a recent sales meeting, and set this second objective as a critical priority.

Changeover Reduction

A noticeable problem with transitioning toward a make to use system was the long runs for each product due to time consuming, and inconsistent changeovers. Changeovers included color changes, profile changes, die changes, and emboss changes. Changeover problems caused off-spec product, and took away from production time. As a result, batch sizes were high, and operators went to great lengths to avoid changeovers.

Specific changeover times ranged from 10 - 45 minutes for a color change, and to 2-5 hours for a die change. The goal of the changeover project was to get the color change down to 4 minutes and the die change to a consistent 30 minutes.

The Toyota consultants, the Denison APS team¹² and several participants from the production area worked on several kaizen events out on the shop floor. With the consultants leading the

¹¹ A shipping variance is defined as a variance between what the customer reports to have received, and what the loaders report to have sent. In other words, if ABP says there were 20 boxes of white vinyl panel, and the customer says they only received 19, then this would be reported as a shipping variance of 1 box.

¹² The Denison APS team consisted of APS manager within the plant, the plant manager, two corporate APS resources, two process engineers, and myself.

charge, we timed various events, and came up with a multitude of ideas on how to improve changeovers.

We worked very hard on the changeover project, with a lot of resources. However, we struggled from the beginning to make it go, and the only real significant progress we made was due to some on going work which had been started by one of the process engineers well before APS.

Variance Elimination

The variance¹³ elimination team consisted of the DC manager and supervisors, as well as myself. We were given a 3-month time-line, and a zero variance target to work toward.

I analyzed the variance data that was available, and found one of the specific problems was in the coil and shutter department. I noticed that over 50% of the shipping variances came from either coil or shutter (two of the SKU families that were segmented in a particular part of the DC). After watching the coil and shutter picking operations and questioning why there were so many mistakes, the workers showed me that the lack of organization in the coil room and poor stacking patterns of the shutters made it difficult to pick and count correctly.

I got some ideas from the workers, and within 4 hours, had the problem solved, with dramatic improvement in both productivity and accuracy of counting. I was pretty proud of myself, and felt like a real hero for solving problems. However, amidst my jubilation, a couple of questions came to mind:

- What is it about the way problems are solved in this organization that would cause a problem so simple to solve, persist?
- Why was this problem so easy for me to solve? Was I a manufacturing super hero?

The Answer is in the Culture!

Edgar Schein, one of the leaders of organization development research at MIT, defined culture as the accepted way of doing things (Schein, 1992). In other words, it is the way people have learned to solve problems in the past, translated to solving problems in the present.

¹³ Refer to footnote 11.

The culture of a company is one of the most fundamental means of understanding why people do what they do (when it doesn't make any sense). Culture can be analyzed on many levels, each one having important implications. In this thesis, I will analyze the culture in the context of how things are done, or how problems are solved.

3.1 Basic Assumptions: The Foundation of Culture

The central element of a company's culture is called the **basic assumptions** (Schein, 1992). These are the unconscious taken-for-granted beliefs, perception, thoughts, and feelings, which is the source of values and action. Basic assumptions are tacitly understood, and thus neither debated nor confronted, consequently, they are the most difficult to change.

An example of a basis assumption is demonstrated by a situation where we observe someone sitting in a seemingly idle posture at his or her desk. In a case such as this, we automatically interpret the behavior of that person depending on our basic assumptions. If our basic assumption were that people are lazy, we would tend to interpret their behavior as loafing. However, if our basic assumption is that people are highly motivated, we may interpret the behavior as thinking about an important problem (Schein, 1992).

An understanding of the basic assumptions is extremely important to understanding behavior. And understanding the basic assumptions of a culture can provide insight into some of the barriers that make the implementation of things like the Alcoa Production System very difficult.

3.2 Denison: A Culture of Reliance on the "Problem Solver"

From the examples mentioned in section 3.0 of the changeover project, and the variance elimination project, I would describe the culture of "reliance on the problem solver". This means there is a tacit distinction between problem solvers and workers. I will call this the culture of "Problem Solvers". A pictorial example of a problem solver is shown in Figure 4. The status, rank, charisma, determination, and other problem solving characteristics, give problem solvers the ability to solve problems. Moving out to the end of the lever represents the amount of these problem-solving characteristics a person has. Therefore, to the extent someone within this culture has leverage, they can overcome the barriers and solve various degrees of problems.

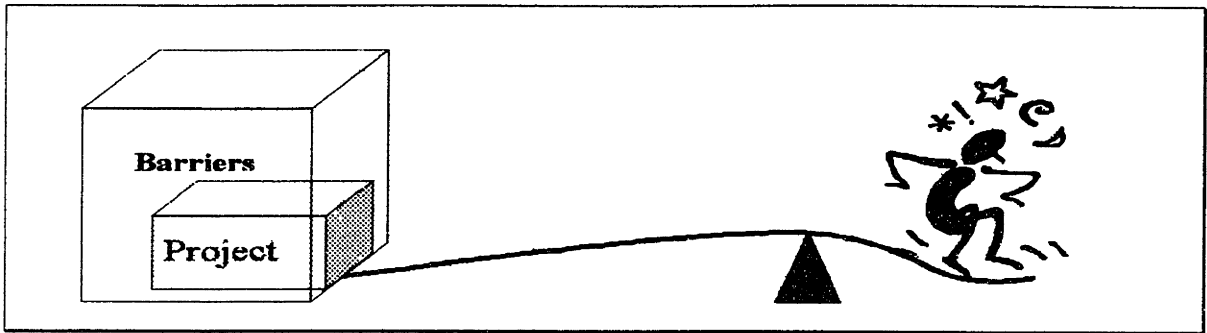


Figure 4. The cultural Problem Solver Model.

An important aspect of a problem solver culture is the barriers. Barriers are a necessary part of the business as the implications to solving certain types of problems may lie outside the realm of people working on them. For example, on the production floor, there was an occasional color problem when product being extruded comes off color. Usually this problem is easy for the blenders to fix so they do. However, on occasion, this problem is caused by a variation in the color pigment, in which case the blenders who mix the product can not hit the color spec without a re-formulation of the formula.

This is a problem that could only be solved by the process engineer. If he is not at the plant, the supervisor will evaluate the expediency of the problem, and decide whether to call him at home or wait until he will be back. Once the process engineer is back, he reformulates the mix and the process is started all over again. Due to quality concerns it may be thought of as disastrous to give everyone in the plant the ability to re-formulate the mix. Therefore, in order to prevent a well-meaning person from inadvertently creating a problem, procedures and policies are placed as barriers to change.

By setting up the system, the person who experiences the problem finds someone with enough weight to overcome the barriers to solve the problem. This system works well, and minimizes the potential problems mentioned above. However, by having these types of rules, a basic assumption is nurtured that engineers solve the problems. Though in this instance there may be very compelling reasons to continue this practice, enough of this type of problem-solving on a level above where the problem is, reinforces the basic assumption that problem solving, is done by problem solvers.

Going back to my problem solving expedition at the beginning of this chapter, I talked about solving the variance problem, with all the weight I could muster. My efforts at solving the coil

room variance by listening to suggestions of the worker, then going and getting the job done, fit very well into this model. For a person on shift to solve this problem, it would have required setting up both picking and restocking rules across shifts. It also would have required the ability to make sure those rules were followed, and the ability to follow-up. Each of these things served as barriers, which in effect exceeded his weight. Therefore, by getting someone with more weight (myself with the endorsement of the plant manager), or with the “problem solver” label, the problem was solved, and the basic assumption that the problem solvers solve problems, was reinforced.

3.3 Two More Examples of “Problem Solvers”

Corporate: Alcoa Corporate made the determination that they would develop and move forward with the rollout of the Alcoa Production System to accomplish the goal of manufacturing and supply chain excellence. This was a massive undertaking, which required the support of corporate officials from the very top on down. In order to get this job done, they decided to hire a consulting company to assist with the role-out in the various plants. These consultants, who had all either worked for Toyota, or had done TPS implementations in their own companies, would serve as resources for the plants, and provide the necessary leadership for the rollouts.

In the case of the Denison plant, the consultants were responsible for developing the ideal condition for the plant, then setting the priorities. After this general groundwork, they would periodically come back and evaluate the progress, ensuring things were moving along in the appropriate direction and at the appropriate speed.

Going to an outside consultant, who could bring in additional weight of experience, knowledge, force of personality, and political support from above may have been the only way to place enough weight on the end of the lever. However, going to the outside and bringing in a consultant reinforced the basic assumption of problem solvers solving problems.

Shutter Label Change: As was mentioned previously, the Denison Distribution Center (DC) had a variance problem. The business unit vice president gave Denison three months to solve this problem. As I analyzed the root causes, set the game plan, and tried to get buy-in from the guys I was working with, one of the problems I heard about was the confusing nature of a recent shutter label change which had been made to cut costs.

The label had been recently modified in such a way as to make it very difficult for the eyes to differentiate between a raised panel and a louvered shutter of the same size. The result was several variances coming from the shutters. The pickers had complained, but it was thought that nothing could be done, as the problem stemmed from a decision made by marketing. However, with pressure from the business unit president on us to reduce variances and the other distribution centers having the same problems, several DC managers and myself independently called the marketing manager, and talked through the problem. Marketing put us in touch with the plant that manufactured the shutters, which re-designed the label to fulfill the needs of both marketing and the distribution centers. Once again, solving a problem, but reinforcing the assumption: **problem solvers, not workers, solve problems.**

3.4 Conclusion: Toyota Didn't Do it this Way

Though problems were being solved, it was plain that some cultural issues of how things get done in Denison were being brought to bear. The cultural assumptions that problem solvers solve problems created an environment where after 5 months of working on a variety of projects, I still felt that there were basically 5 people in the plant who were working on the APS implementation. The floor workers who were so helpful within Toyota, at Denison were reliant on the “problem solvers” to discover, implement, and do the follow through on their ideas.

However, it was also clear to me, that the culture in Toyota was different. At a Toyota Distribution Center I toured in Ypsilanti Michigan (the Ypsilanti Service Center – YSC; see Appendix A), workers at every level were developing and implementing solutions to the problems at their level of expertise and information. It was clear to me that Toyota employees had a different basic assumption, that **everyone was a “problem solver”**.

The real learning then, is not what needs to be done, but what is a good way to go about doing it. Though it is impossible to speak definitively on such a fuzzy subject, our APS implementation at Denison provided a nice breadth of experiences that I learned some very important principles of leadership from. These principles of leadership are exemplified within Toyota, and have over the years, nurtured a culture where the Toyota Production System was developed, and continues to be perfected. These leadership principles will be the topic of the second section of my thesis.

Part II. Toyota as a Leadership Model

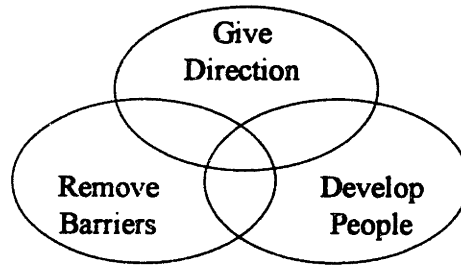


Figure 5. The Toyota Leadership Model

While at Alcoa, I came to believe that coming to understand and teach the mechanics or the tools of TPS was only a portion of the challenge. The other portion was determining how to motivate, give direction, and change the culture of Alcoa, so that TPS principles were not only understood, but internalized, and utilized by the production workers to solve daily problems within the manufacturing plant.

This section is the heart of my learnings while at Alcoa. It is an attempt to explain how the mechanics of the Toyota Production System were implemented and developed within Toyota, and then to draw conclusions as to how to implement them in another company such as Alcoa.

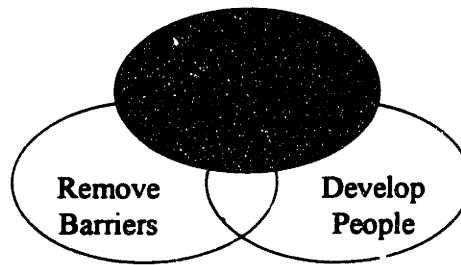
Part II will suggest that there are three central leadership principles (Figure 5) that were crucial to the development of TPS. These principles are:

- Set Consistent Direction with Fluid Constraints
- Create a Culture of Removing Barriers
- Develop the Capabilities of People to Improve

I believe these three principles are the basic building blocks of leadership necessary to implement a TPS-like system. By thinking about the implementation part of TPS in the terms of the leadership principles, its duplication becomes less of a mystery, and more accomplishable as it give specific direction to a change agent, or manager as to what their key role needs to be.

The format of this section will be to look at some of the history of Toyota available in the literature, and compare that to my experience at Denison. By doing so, I will try to support and illustrate the points I make.

4.0 Set Consistent Direction With Fluid Constraints



The first leadership trait of Toyota Management is to set *consistent direction with fluid¹⁴ constraints*. This means that Toyota Leadership has helped everyone within Toyota understand where they are going, and the framework or constraints on how they can get there.

4.1 Consistent Direction

The essence of the Toyota direction is: *To perfect the manufacturing and supply chain by developing a system which delivers exactly what the customer wants, in the quantity the customer wants, at the time the customer wants, with the lowest possible cost, and perfect quality¹⁵.*

From my observance, Toyota sets and maintains this direction by three methods:

- Create A Shared Vision With Noble Goals
- Develop And Deploy A Yearly Hoshin (Ho-Sheen)
- Give Specific Direction Through Master Teachers

¹⁴ A fluid constraint is a constraint that is not rigid, but adaptable to the specifics of each situation.

¹⁵ Refer to footnote 4.

4.1.1 Shared Vision or Noble Goals

The highest level of consistent direction is the shared vision, or noble goals of the company. Noble goals are generally too abstract to guide people within a company on strategy for obtaining specific objectives (Shiba et. al., 1993). At Toyota, the elements of the Toyota vision are:

- **Make to Use¹⁶**: Deliver what the customer wants, where the customer wants, when the customer wants, and in the quantity the customer wants. Taken to an extreme, this principle equates to single piece, continuous flow, delivered directly to the customer, at exactly the use rate. This is true for every product that is used from a lug nut to the power train.
- **Minimize Cost**: Accomplish the above at a minimal cost. This is always important, and is the great motivator of the measures and countermeasures for each problem
- **Perfect Quality**: Accomplish the above, with perfect quality.

This vision, like a corporate mission statement is very general. Therefore it does not focus the company on specific actions, but helps set general direction, and gives framework around what kinds of projects are important. Another element of the mission statement is the fact that it is “results” oriented, and directs improvement activities at every level of the company toward the strategic objective of manufacturing and supply chain excellence.

I believe one of the reasons this noble goal is not codified, and quoted at the beginning of every meeting is because it is more tacit in nature, and has evolved over time, through the experience and culture promulgated by the founder and early leadership of the Toyota Motor Company.

In 1902, Sakichi Toyoda, one of the fathers of the Toyota production System, invented the automatic loom that would stop automatically when a thread snapped. This invention made it possible for one operator to simultaneously run dozens of looms, with fewer defects and waste than ever before (Toyota Motor Corporation, 1995). This invention revolutionized the productivity of the workers in the textile mill, and instilled in the mind of Toyoda the belief that **excellence in productivity, and quality was a fundamental strategic pillar of success**. This experience is symbolic of the **direction** of the Toyota Motor Company.

¹⁶ See “make to use” with APS explanation in section 2.2.

The second important event leading to the development of the Toyota production system vision happened in the 1930's, at the time the Toyota Group set up an automobile manufacturing operation. Sakichi Toyoda's son Kiichiro (the head of the new venture – The Toyota Motor Corporation), traveled to the United States to study Henry Ford's production system in operation. He returned with a strong grasp of Ford's conveyor system. However, he also realized that the volumes needed to justify a conveyor system exactly like the Ford model were not possible in Japan, and space constraints would limit the warehouse availability for inventory. He therefore adapted the system to accommodate the small production volumes of the Japanese market, and the space constraints of the Japanese factory (Toyota Motor Corporation, 1995).

Then in the late 1940's, Taiich Ohno, the man who did the most to structure the Toyota Production System, was in charge of a machining shop. He experimented and developed various ways of setting up the production equipment to produce needed items in a timely manner. Later, after a trip to the US, and seeing a large supermarket, he developed the concept of the pull system¹⁷ to signal production from the supplier to the customer at every level.

Through these experiences, and the monumental work of continually improving every element of the company, the vision and noble goals became tacit knowledge, and the consistent vision of TPS was ingrained into Toyota workers at every level of the company.

4.1.2 The Hoshin

The second method which Toyota disseminates direction to the plant is through what is called a hoshin (ho-sheen). A hoshin is a tool to align all the people throughout the company or all the members of a team toward the key goals by specifying the goal, and the sense of urgency.

The hoshin aims to align all jobs and tasks, whether daily work, or improvement work, toward key mid term goals which focus the company or team toward specific targets. However, a hoshin is not a synonym for goal setting.

¹⁷ A pull system is a phrase that has come to refer to the concept of pulling product through production, as opposed to pushing. When a customer pulls product off a supermarket shelf, a signal is sent to the vendor for the production of more products. An example of a push system would be to make product, then push it into the market or onto your.

What in the Heck is a Hoshin: A hoshin is a statement of desired outcome for the next year, plus the means of accomplishing the desired outcomes, plus the metrics to measure the progress of the goal, plus the target value for the metric, plus a deadline.

Hoshin = Desired outcome + Focused means + Metrics of Progress + Target Value + Deadline

Deploying a Hoshin: The company leadership first sets its yearly hoshin, which is given to those who need it. As a company goes through the years, the environment in which it operates changes. Therefore, its focus must change and the CEO, president, or team leader must determine the vital issues for success in accomplishing the noble goals. These vital issues are then translated into a desired outcome, with strategy and means to accomplish them. This strategy then becomes the desired outcome for the subordinates. As each successive manager or team member translates his superior's hoshin into a hoshin for his own stewardship, there is an eventual alignment of the companies' projects and efforts (see Figure 6). The reasons for needing a hoshin beyond the noble goals talked about in the previous section are:

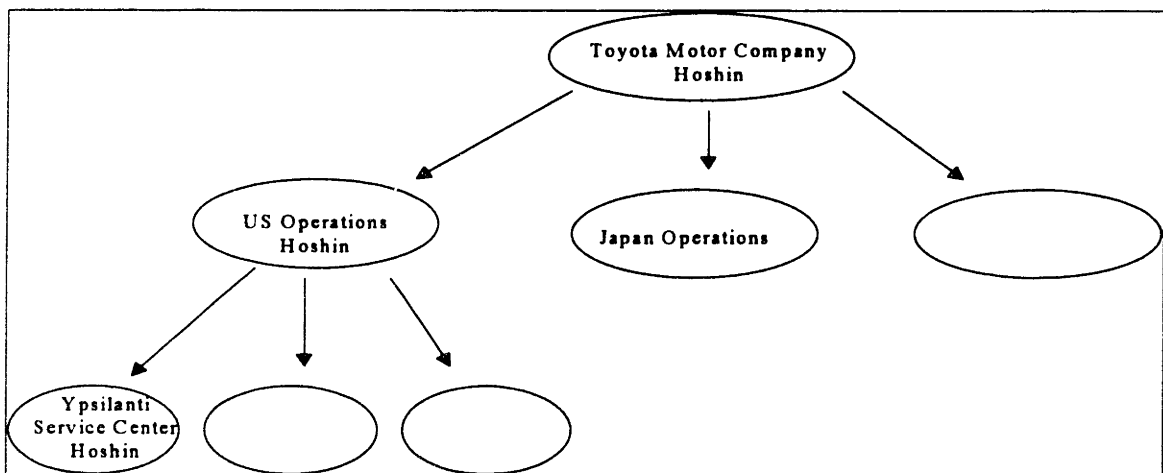


Figure 6. Schematic of a "Hoshin" deployment.

- Alignment And Communication Of Goals
- Visible And Participatory Process
- Focus On The Vital Few¹⁸
- Management By Fact And Analysis

¹⁸ The "vital few" is a reference to the most critical elements to focus on (Shiba et. al., 1993).

The Ypsilanti Service Center

The way a hoshin works is illustrated by the **Ypsilanti Service Center (YSC)**¹⁹ story. The Toyota distribution system in the US was set up just like in Japan in a classic “milk run” (Figure 8 in Appendix A) type of system from each of the suppliers to the Toyota Motors Manufacturing Plant in Toronto Canada (TMMC). However, the cost of these frequent deliveries direct from the suppliers was greater than in Japan due to the greater physical distances from the suppliers to the assembly plant. Thus, additional cost from logistics was balanced with larger lot sizes, to optimize the system. This created tension between the desire to make to use, and minimize cost.

The leaders of the North American operations for Toyota therefore developed the concept of a modified milk run (Figure 9 in Appendix A) which would deliver parts more cost effectively, in smaller volumes (approaching make to use, low cost, and quality). This system was set up, and deployed, and is now working very well. However, how do the leaders of Toyota Motors communicate specific needs to this Service Center?

For example, approximately two years hence, from the time I visited the YSC, Toyota had plans to expand the YSC concept to the creation and integration of a second distribution center. The second center will work with the first to service assembly plants in Indiana and Tennessee. Toyota communicated this and other of its future plans to YSC by a hoshin. The specific Hoshin for the YSC was four fold:

- To contribute to the production of cars which the customer wants in the shortest possible lead-time.
- To design a flexible transportation and logistics system to cope with future demand fluctuation.
- Prepare external routes for future complexity in American car production. (Make the YSC concept expandable it to deliver to Indiana in one year and Tennessee in two years.)
- Establish a proper joint transportation system with all Toyota affiliates (continue to look at other suppliers who should participate in order to take out cost).

¹⁹ A complete explanation of the Ypsilanti Service Center is found in Appendix A. Visit to the Ypsilanti Service Center (YSC).

These hoshins were deployed down to the supervisor of YSC, who then set up his hoshin for his stewardship that was in alignment with his supervisor. As the hoshin cascades down to the shop floor, they become more and more specific to the individuals within the company (Figure 6 on page 31).

4.1.3 Direction Toward Greater Process Knowledge Through Master Teachers, and Emergent Leaders²⁰

Another important part of giving direction is to ensure that the people, who are in charge of the implementation, have an adequate level of process knowledge of the process that they are changing. Therefore, the ability to give direction which helps the improvement teams generate the process knowledge to enable changes is a part of the Toyota Leadership model.

Zone Pick Implementation Problem

An example of the importance of process knowledge is a problem that we encountered during our zone pick implementation project. While working in the Distribution Center (DC), one of my natural tendencies as a consultant/leader, was to have great ideas on better ways of doing things. One such idea was a better way to pick product.

The current state of picking and loading product on a truck was to get a skid of product at the location slot, and then take it to a unitization area, where product was offloaded onto the shipping pallet, staged, and loaded on the truck. After the needed product was pulled off the skid, the remainder of product still on the skid would be returned to its location, for the next loading crew if they needed it (see Figure 7). This system created a lot of forklift traffic to and from the unitization area, and thus was a key target to eliminate waste.

²⁰ Emergent leadership is discussed more fully in section 6.3)

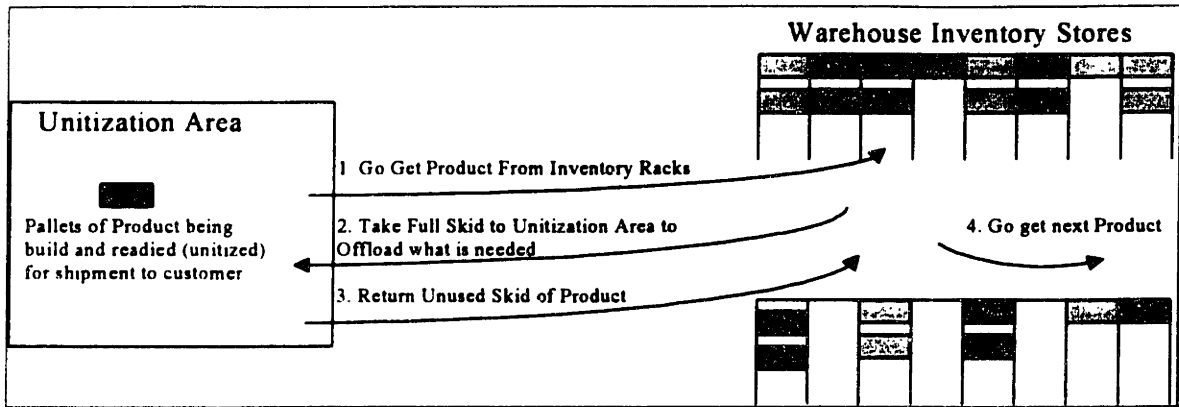


Figure 7. Old Picking Process at Distribution Center.

With the help of the Toyota Consultants, we decided the best way to solve the problem was to go to a zone pick strategy. This would be a system where a team of pickers would efficiently pick all the product in their zone for all the trucks in a given day, which would one by one come together at the right time, unitized, then loaded on the trucks in a synchronous fashion. In our minds, we saw this system working much like an automobile assembly line that Toyota had perfected.

As I attempted to explain this system to the DC supervisors, and loaders, it was obvious that they were not as excited about the masterpiece as I. Quickly, many seemingly insurmountable barriers came up. For example, everything would need to be double handled because each load was different, and there was no way of determining ahead of time, load order. Another problem was the 3000+ SKU's in over 100 box sizes and stacking preferences created 1000's of tacit rules for loading. This made for a very complex sequencing problem. For example, A was always on bottom, with either B or E on top of that, unless there was no B or E, in which case C was used, but needed to be combined with every other D.

The lack of ability to streamline the loading process and lack of clear loading rules indicated that there was a low level of process knowledge about it²¹. Therefore, we needed to force the process knowledge. Once the loaders developed sufficient process knowledge of how the loads came together (see Appendix B for an excerpt from the Denison load order for siding) was

²¹ We did not know at the time that our process knowledge was lacking. However, as we started learning more about the loading process, it became clear, that the lack of knowledge would have become a substantial barrier to implementation.

developed, these problems were not so indomitable. Oddly enough, the same people which were the most skeptical, were the first to see how to make it work and the potential advantages from the new system.

Mr. Ohba, the North American sensei for the Toyota Production System was a master at understanding production principles. His focus was on ensuring the people making decisions on the plant floor had the process knowledge to effectively solve the problem. One of the techniques which is a famous Japanese way of forcing the process knowledge in order to facilitate problem solving by the plant personnel is by asking the 5 why's. Using the example above:

Why don't we pick at location? – Because we don't have the space in the aisles to turn around.

Why do we have to turn around? – Because we need to access the aisles from both directions, with multiple crews.

Why do we do that? – Because the information that we get on loading a load has multiple aisle picks on it, and we need to get the products in the proper order.

Why does the information appear jumbled? – Because we don't know how our loads come together, and how to organize the warehouse.

From this series of questioning, it became clear that the team did not have process knowledge necessary to set up a zone pick scenario. By forcing process knowledge, it is possible to give direction toward a better solution that is consistent with the hoshin, and consistent with the noble goals.

This forcing of process knowledge is a skill, which is very important to the Toyota Leadership model, and is not transferred, but developed by the people. In the above example, we struggled to get to this point for a couple of months, trying different things, which didn't work due to our lack of process knowledge. However, when talking to Mr. Ohba, most questions were answered with questions, to drive process knowledge, and to force understanding down the ladder of abstraction.

4.2 Fluid Constraints

On the surface of the Toyota Production System, it appears there are many very hard and rigid constraints such as always using a kanban card to signal production, rather than an electronic media. However, these once thought of as hard constraints are in fact very fluid, and grounded in

principles. The Toyota Production System tools are not the desired result but a necessary piece of the puzzle, when a signal needs to be sent, and a card is appropriate.

4.2.1 Toyota Production System Framework as a Fluid Constraint

There are many ways to skin a cat.

Once the direction is given by the shared vision, noble goals, and hoshin, and the direction toward how to do it is given by master teachers and emergent leaders, the specifics of how to solve the problems are of necessity left to the individual improvement teams. This kind of bottom up improvement is the key to the involvement of people at all levels of Toyota.

However, there are some risks to bottom up improvement teams. Peter Senge, in his book, *“The Fifth Discipline”*, suggested some of the problems with giving people the ability to solve their own problems. He said, *“To empower people in an unaligned organization can be counterproductive. If people do not share a common vision and do not share common “mental models” about the business reality within which they operate, empowering people will only increase organizational stress and the burden of management to maintain coherence and direction.”* (Senge, 1990)

This is particularly true when a process such as building cars has a lot of dynamic complexity²² to it. A vision statement, or even clear hoshins are good for aligning direction, but lose their ability to help answer specific question and specific problem on the shop floor, such as “How should I set up my information system to signal production?”

One of the brilliant pieces of the Toyota Leadership Model is this system of fluid constraints, which gives direction on which of the many available solutions to a problem is the best to use. This system of constraints is in effect the mechanics of the Toyota Production System, or the systems and subsystems of the Toyota Production System. Therefore, TPS can be looked at as

²² Dynamic Complexity is a term used by Senge (Senge, 1990) to describe a process where solving one problem has ripple effects, or dynamic effects to other parts of the organization. An example would be holding inventory. In order to buffer against variability of demand for vinyl siding, it is necessary to hold inventory of the various components. However, by doing so, quality problems take longer to find, and obsolescence costs are increased. Therefore, the optimum solution for the warehouse to solve one problem ripples to other parts of the business.

the system constraints and framework, which provide direction and tools for the teams to solve problems.

The development of fluid constraints is the framework necessary to empower the workforce. With these constraints, an empowered workforce can individually work on improvement projects, and in the end creates a consistent, coherent manufacturing system. In this way, the dynamic complexities of a complex manufacturing environment can be taken into account with the constraints, and the ultimate solution is a synergistic solution.

Two examples of how this principle works in practice:

Zone Picking Problems at Sidney:

Throughout ABP, there are three distribution centers. On one occasion, I went to Sidney, OH, the location of a sister DC to Denison. In the Sidney DC, the process for picking orders was much different than at Denison. At Sidney, product was stored in three separate warehouses, linked together with large doorways. Product was picked according to zones, then transported to staging areas where it was gathered, assembled, and loaded onto the trucks. There were two problems with the information flow for this process. The first, if one of the zones were not ready, and the loaders were loading that zone, they had to wait on the product which hadn't been picked before they could finish loading the truck. The second problem was when the loaders waited for a zone to be completed only to find out there was no product from that zone on the load. Both caused delays and both had many possible ways that could be used to solve the problem.

The team which was organized knew what needed to be done, but had many options as to what way to solve it. However, the TPS constraints helped the team choose which of all the methods to use in solving that problem was the most appropriate. Ultimately, a Heijunka board was designed to visually solve the information problems, and alert the supervisors, loaders and anyone else what was going on. This may not have been the best local solution to the problem but was consistent with what was done in other parts of the plants, and thus contributed to the system as a whole, and helped to create a global optimum (see Appendix D for a complete description of this story).

Denison Stock-Out

The second example of the helpfulness of TPS constraints is from a project in Denison dealing with the variance elimination project²³ (section 3.0). After asking “why” there were variances, one of the consistent answers was due to a problem the workers called a “stock-out”²⁴. Stock-outs created both loading and paperwork problems such as the same product in multiple location on the truck, and miscounting and addition errors.

As we went to solve this problem, there were many ideas as to what would work. One particularly good idea was to take the information 24 hours before the truck would load for all the loads that day, aggregate them, then do a walk through of the warehouse, to ensure all the product was there for the following day. If product was found to be short, we could signal production ahead of the need.

A second good idea was to maintain tighter control of the inventory numbers in the computer, so that the production scheduler would know ahead of time where the needs would be, and subvert the problem before it happened.

Yet a third idea was to set up a signal or kanban system from the DC to the warehouse, and on through to production, which would signal the production of product as the DC pulled it. This would eliminate the need for the computer-controlled inventory, and also give the DC pickers the ability to signal production.

Any of these ideas were good ones, and all of them could help to solve the problem. However, the constraints of TPS gave us direction to choose the third option, which created a Kanban system, with the visual queues to customize it to the needs of those involved. The idea of having constraints was very helpful to the problem solving teams, as it helped determine which was the best way to solve the problem, and in the end, have a coherent solution.

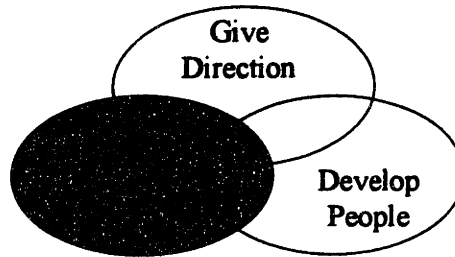
Equally as important as having the TPS framework as a constraint however, is the notion that **these constraints must be fluid and balance with the cost, and dynamics of the business.** For

²³ Variance is defined as when the customer count in unloading a truck does not match the shipping list that they receive with the truck.

²⁴ A stock-out is when a picker goes to pick some product for a customer load, and finds the location either empty, or possessing only a portion of the required amount.

example, on a continuous extrusion process, a frequent problem is changing the color. The ideal condition is to make the required number of panels, to fill the customers needs, then change to the next color. However, due to mixing in the extrusion die, there is cross contamination of colors that causes scrap costs to every changeover. Therefore, it doesn't make sense to produce and signal production of one panel at a time, until the technology makes it technically and economically feasible. In this instance, a temporary countermeasure of a minimum batch size must be a factor in the journey toward single piece flow.

5.0 Develop a Culture of Removing Barriers



A second important element to the Toyota Leadership Model, which facilitates the implementation of TPS, is to develop a culture of removing barriers.

Typical types of barriers that inhibit change efforts are informational gaps, authoritative imbalances, knowledge and skills deficiency, scarce resources, and improper incentives.

Barriers can slow down and stop the progress of implementing the Toyota Production System or any other changes that are attempted. Understanding these barriers, and realizing where they exist is an important part of understanding some of the challenges with changing a culture. This understanding also helps realize why good and productive people sometimes struggle making improvements.

The Toyota Leadership Model focuses leaders at all levels of the organization on removing barriers. Though the following list is not inclusive, I believe the following 5 examples are symbolic of the type of leadership commitment to removing barriers within Toyota.

- Link Problem Cost and Consequences to Root Cause
- Provide Visual Cues
- Modularize Problem Solving
- Train and Transfer Training and Knowledge
- Create a Safe Environment

5.1 Link Problem Cost and Consequence to the Root Cause

In order to get the necessary information to the people solving the problems, the costs and consequences for a problem must be linked to the root cause. A classic example of this principle is the reliability problem. One of the features of the Ypsilanti Service Center in Ypsilanti, Michigan, was there was no inventory on hand to protect the Service Center from an unforeseen accident. One of the first questions that came up was: “what if a truck were to break down en-route to the Toyota assembly plant? Did Toyota carry inventory in the assembly plant so the line wouldn’t stop?”

The answer from Mr. Ohba was “No! – Carrying inventory at the plant to buffer against a shipping problem would separate the consequences from the root cause, and thus take necessary information away from the maintenance department of the shipping company.”

“How then do you protect against accidents?” I asked.

“The trucking company puts another one or two trucks on the road at all times, so that if one breaks down, then the spare is there to deliver. The shipping company then owns the problem and they have all the information they need to solve the problem,” said Mr. Ohba.

By directly linking the consequences of the problem with the root cause, the incentives for all the operations in the entire supply chain are aligned, and linked to the end result. Any attempt to take inventory and hold it at the customer takes the information on cost and quality away from the supplier which they need to set the appropriate countermeasure for these problems.

5.2 Provide Visual Cues

Another important aspect of the Toyota production system culture of removing barriers is the focus on visual communication throughout the plant.

Restocking Example at the Distribution Center

In the Denison distribution center, there was a job called a re-stocker. The responsibility of the re-stocker was to replenish product in each of the product locations before it ran out. Because of space constraints for various products in the distribution center, the necessary inventory to service demand couldn’t all be stored at the DC pick location. As a result, some of the product was stored at an alternate warehouse location adjacent to the manufacturing plant. In order to

determine what product would need to be re-stocked for the day, each morning the re-stocker would do a walk around of the DC to see which of the products were low. When they saw a product location which wasn't full, they would write down on their log sheet how many skids could fit in the slot, so that they wouldn't send more product than there was room for. Then, throughout the day, they would start sending product that they thought was dangerously low, and attempt to keep ahead of the demand.

One of the problems that arose from this procedure was that the restockers didn't know the demand so could not assess which products were most likely to stock out. The reason was not because the information didn't exist, not because they were locked out from using it, but that the difficulty in accessing the computer system caused an effective barrier for them to use it. Therefore, re-stockers couldn't make an informed decision about what needed to be re-stocked, and in what sequence to do it.

The method that Toyota would use to solve this type of a problem illustrates what I will call the "**visuality principle**". Toyota eliminates information barriers such as in the above example, by utilizing visual countermeasures such as kanban cards. This commitment to visuality is one of the reasons that Toyota has gotten a reputation of not liking computers. Mr. Ohba, talking about computers said, "the problem with using computers to signal production, (or to signal re-stocking) is it takes information away from the guys on the floor, and gives it to only those with access to the computer terminal. This information is necessary for every person down on the plant floor." He then explained a computer, while a great tool for supporting operations associated with taking orders, etc., was mis-used as a re-order signal because information is not visible and accessible. Thus, the attention on visual signals, and the visual plant.

Another application of the visuality principle is the application of the **heijunka box**. A heijunka box is a mail-slot-looking thing, which is used to place kanbans for the purpose of leveling and sequencing production or movement. The heijunka box insures that every person in the plant can know the schedule and find out if they are meeting it. Only when every one knows what should happen, can they know something is wrong and take the necessary countermeasures to correct it.

At the Ypsilanti Service Center, visual queues were abundant. Toyota sub-systems at YSC which were easily seen were: heijunka boxes, kanban cards, standardized work charts, clearly marked shipping lanes with arrival and departure times clearly labeled, and correctly sized stores.

5.3 Modularize²⁵ Problem Solving

Another aspect of the development of the culture of removing barriers is Toyota's work to modularize the problem solving capabilities. A modular problem-solving scheme is the idea that there is some framework around how certain problems are solved, so that when the system is assembled, it fits together. In section 4.2, I talked about fluid constraints, which helped to give this framework. In this section, I will try to explain additional benefits that come from the framework of TPS in the context of modularity.

A typical barrier that is common in traditional manufacturing plants is to have a change agent trying to make change in areas that have impact on areas outside his/her responsibility (dynamic complexity). The result is one or a combination of three things. First, the dominant of the competing factions will have the final say, and that dominant player's area will be optimized, at the expense of the other. Second, the two competing factions will each optimize what they can internally, and changes which involve dynamic issues between the two's interest will not be made due to the inability to come to a decision. And third, the problem will be presented to a central authority figure that can make tradeoffs based upon input from both sides.

The way Toyota has worked to solve these types of problems is by setting up a **supplier-customer** relationship throughout the entire organization at every level. Every operation is both a supplier, and has customers, from the janitor, to the maintenance shop. By modularizing the relationship in such a manner, they have started giving autonomy to people and functions at every level. This culture creates a relationship where dynamic complexities are thought about in terms of suppliers. Even the worker at the assembly station supplies his customer who is the downstream worker.

End Cap Change-Over

In the Denison plant, I worked with a changeover team that was trying to improve the ability to make more frequent changeovers. One of the problems with the quick-change overs was the time it took the boxers to prepare the wrappers (boxes), and end caps (ends to the boxes) which needed to be pre-glued with contact cement before they were used.

²⁵ The idea of the modular aspect of TPS came from Professor Kent Bowen in a class discussion while at Harvard Business School.

One of the packers (the people who do the boxing) had an idea to put the brand name information more clearly on the labels, then remove the printing off the endcaps, so as to cut back on the change-over preparation when changing to same sized cartons. This would not only make changeovers easier, but would help to eliminate the scrapped endcaps that occurred when a changeover was made. Two other advantages from the idea were: 1 - lower inventory of endcaps, and 2 - lower cost to buy them due to savings of printing setup for specialized printing on the endcap. Although the endcaps had brand names on them, the label was sufficiently large, that it covered up most of the printing. Therefore, it was obvious that a change would be virtually unrecognizable to the customer.

Due to the dynamic complexity of a change in the appearance to the packaging, to make such a change required us to go through the marketing department at business unit headquarters, the local quality engineer, local purchasing, and the purchasing and production managers in other BU plants. About a month after this work was done and the change was made, we learned that we had missed the corporate logistics coordinator, who wanted us to send him the label before we used it.

Although there were good reasons for each of the checks, the result is a system with sufficient barriers that the practical ability of a shop floor team of workers to break all the authoritative barriers, and make the change is non-existent. Therefore, the change potential stays with the people in the top positions, who may not have access to all the information, and thus the decisions become the best average.

The breakdown of these authority barriers is a difficult task, especially when there is a lot of dynamic complexity. However, the shared vision, and modularization of relationships into supplier-customer models help create an environment where the things that are important to the customer are the same things which are important to the supplier, and direction for these types of complex dynamics are given.

A second result is the liberation of a supplier to make improvements in his product, which will help his direct customer and ultimately the end customer (the only one in the entire chain who doesn't have his/her own customer).

5.4 Train and Transfer Training and Knowledge

The training and transferring of knowledge and skills is another artifact of a culture of removing barriers. The lack of knowledge and skills necessary to solve certain types of problems will not only frustrate change efforts, but also give a sense of hopelessness to those involved. The lack of this knowledge transfer creates an environment of dependence.

This does not mean that every company with a training program has a culture of removing barriers. The training must be carefully thought out, and meet the needs of the customer (the person receiving the training). The following two stories are symbolic of this message.

First Example: Leadership Development

After some muffed attempts to push the Alcoa Production System down to the shop floor, some teams were set up to help with the process in the distribution center. After the teams were set up, the plant APS manager and I attended a team meeting. One of the things that the team decided as important was to solve some of the problems with banding and unitizing a pallet of product in preparation to putting it in the truck. In particular, they felt the banding material, and clips currently used to do the job were inadequate. A couple of the guys in the team were given the assignment of leading the efforts to solve the problem by finding the best clips and banding material, then standardizing it. There had already been some work done on the problem by Smith, the supervisor and team leader for the entire productivity team. During the meeting, he started to explain to the APS manager and to myself what he had done, and where the project currently was.

When he started doing that, I quickly told him that he did not need to be talking to us, but to the two fellows to whom he had just made the assignment. They were the one who he needed to make sure had the information and were ready to move forward with it. This changed the culture of the meeting from simply an information transfer session, to a working meeting, with assignments, and follow-up plans being made.

These types of leadership skills, and development happen on an individual basis, through time and effort by all involved. These “teaching, training, and knowledge transfer moments” are crucial to the success of developing the culture. The Toyota Leadership Model includes extensive individual training, in everything that is done, in an effort to remove these barriers. It is a mistake to assume a general training meeting can accomplish the needs of each individual.

Second Example: Store Size Calculation

Another change which we implemented at the DC was to develop a “pull system” to replenish the distribution center by pulling product through as it was used by loaders. As we tried to set up this system, it became evident that the necessary store size for each of the products was a function of the demand rate, demand variability, cycle time on the production lines, minimum batch quantities, replenishment delays, and possibly other things.

Due to our lack of pull system knowledge, we didn’t have a good way to determine appropriate store sizes to maintain adequate customer service rates. We relied on training from TOYO-CONSULTING, and corporate APS training people to both ask us the pertinent questions of desired service rates, and to teach us how to calculate cycle time etc. We also got direction and help in building a simulation to come up with store size values, which we could test on, historical demand data before we made the change. This transfer of knowledge was extremely helpful, and removed barriers of knowledge and skill deficiency which we had.

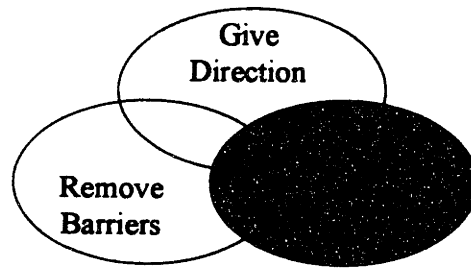
5.5 *Creation of a Safe Environment*

Finally, the last example of a culture of removing barriers is the creation of a safe and secure environment for all the workers. Creating a safe environment is multi-faceted, and includes both physical and emotional safety.

It is important to protect the continued success of an improvement process by ensuring that making efficiency gains will not jeopardize the jobs of the people. It becomes a huge barrier to progress if workers think that they will improve productivity just in time to lose their job. At Denison, the commitment was made that no one would lose his or her job due to productivity gains. Toyota is also very loyal to its employees, and this loyalty to its employees is a key element of the Toyota Leadership Model.

These examples which I have given are examples of Toyota’s commitment to understand the barriers that stand in the way of improvement projects, and remove them. This culture of removing barriers is a lifestyle, not an event, and must be looked at continuously.

6.0 Develop the Capability of People to Improve



Peter Senge in his book *"The Fifth Discipline"* said, "when placed in the same system, people, however different, tend to produce similar results." (Senge, 1990) In other words, the current actions of employees seem to be approximately what management has asked them to do. Therefore, even though "stubborn and hard headed - tradition loving employees" may be the easiest and most popular reasons given for stalled change efforts (see dialog in section 1.0), it is not the root cause.

The last element of the Toyota Leadership Model is possibly the most. It stems from the values held by Toyota that everyone in the company is capable of contributing and improving the company. Therefore, the development of the capability of the people to improve themselves and their surroundings is taken very seriously. This capability to improve is non-transferable knowledge, and must be developed, and nurtured over time, one person at a time, on an **individual basis**. All the direction, knowledge and information coupled with the clearing the way of barriers. is ineffectual if a person doesn't have the capability to do something with it.

There are many elements to the capability to improve both an organization and an individual, and they may be developed on both an individual and a company wide level. Some of the most common characteristics about an individual with the capability to improve are; knowledge, confidence, enthusiasm, charisma, authority, initiative, persistence, humility, courage, vision, skill, etc. I can best introduce this subject with the following anecdotal stories from my work in Alcoa.

My Initial Try at Being an Agent of Change

While at Alcoa, as part of my efforts to help with the TPS implementation, I made a large and concerted effort to transfer the knowledge and ideas I had with regards to TPS, inventory management, and more efficient pick strategies to the plant and distribution centers. However, in

every case, though I felt good for trying, I in essence failed, as nothing changed in the way things were done as the result of my masterful orations.

After about 4 months of this type of efforts, I was frustrated and could tell that I was having little if any impact on the plant. Therefore, I quit trying so hard to teach and train what I thought was important, and started to work on developing the people I worked with, and the organizational structure so that they would have the capability to improve the things which they felt were important. The change in the distribution center was immediate.

In an important pivotal meeting, one of the supervisors informed me that the problem with all of my ideas was that the warehouse wasn't organized properly to facilitate the proper assembly of pallets to be unitized and loaded on the trucks. Therefore, he wanted to head a team that would look at the warehouse layout, and organize it more efficiently. From there, another team discovered that many of the products could be grouped in families according to how they stacked on a pallet. Then by bringing the families together, some changes would need to be made to the information system, and so on.

As the organizational and individual capability to improve started to develop in the individual people who did the work, they started to implement their own ideas. Only after that point did additional knowledge and skills, which the APS implementation team and myself could share with them, become important.

Similarly, in the manufacturing plant, we spent a great deal of time talking and gaining "intellectual buy-in" regarding the necessity of quick changeovers on the extrusion lines in order to approach a make to use system, and to lower inventory costs. However, once again the progress was slow and painful to implement, and relatively ineffective in demonstrating the wonders of TPS due to our inability to develop the capability to improve in the workforce.

I will separate this chapter into four sections. These sections will contain explanations of the tacit level leadership traits I will call the **Toyota Leadership Model**. The sections will be:

- Develop the Capability to Improve by Improving - Need vs. System Driven Changes
- Stewardship Delegation of Modular Tasks
- Emergent Leadership is the Key to the Future
- Organizational Structure of Teams

6.1 Develop the Capability to Improve by Improving - Need vs. System Driven Changes

One of the real strengths of the Toyota Leadership Model is the understanding of some basic truths. The first is that people learn by doing. The second is that learning is done on an individual basis, one person at a time, according to their needs, over time, through consistent effort, and experience.

However, just understanding these two fundamental truths of people is not enough. It needs to be done, and there are none better than Toyota for getting out on the shop floor and doing it. This experience became one of the key learnings for me while at Alcoa as I participated in many team meetings and on improvement projects. When it comes to improvements, Toyota has become famous for kaizen²⁶ events, or kaizen improvement projects. These are geared toward building the capability to improve in those who participate. From my experience, I came to think about improvement projects as in one of two categories.

- System Driven Improvements (Push)
- Needs Driven Improvements (Pull)

In the following two sections, I will explain what is meant by system vs. needs driven change with examples and explanations. I will then argue that it is much easier and more effective to develop the capability to improve with needs driven improvements, which is an important distinction with the Toyota Leadership Model.

6.1.1 System Driven Improvements (Push)

System driven improvements are defined as improvement projects that are driven by the implementation of a system. A good example of a system driven improvement project is the aforementioned quick-change changeover project (section 3.0). Engineers are very good at initiating system driven changes by looking at a system and driving changes based on their kind of analysis. Most change efforts are initiated by the desire for a new, more efficient system.

²⁶ Kaizen is the Japanese word for perfection. Therefore, a kaizen activity is an activity that progresses toward perfection. Kaizen events is an event where a group of people goes out to the shop floor and evaluates a process, and come up with improvement ideas, then implement them.

At Alcoa, there was a shared vision from the plant management that we wanted to create a “make to use” system in an effort to reduce inventories, reduce obsolescence, and save costs. In order for this “make to use” system to be implemented, it was necessary that product changeover times be reduced. The reason for this was that in the plant, there were 16 extrusion lines, and over 600 SKU’s which need to be run on them. On an average day, there were on 1200 line items of product ordered and shipped to both external and internal customers. Under these circumstances, in order to progress to a “make to use” system, the obvious key would be to reduce changeovers so they could do a lot more of them.

The reasons for focusing on changeovers were good ones. First, if the changeovers took a long time, then more frequent changeovers without significant improvements would cause machine utilization to go down, and significantly cut the capacity of the plant. The second reason was the expense of scrap on a changeover. In a continuous process such as extrusion, any changeover has some waste produced, and any decrease to changeover times, would save cost by reducing waste.

Our plan and emphasis to reduce changeovers made perfect sense, and we all knew changeover reduction would be responsible for the most important gains. However, for some reason, the plan was difficult to implement, and we continually struggled trying to get involvement. Reasons such as “changeovers create more work and more scrap” were talked about by the workers, and no matter how much talk about making it easier, there was an element of resistance.

Other obstacles for the changeover reduction project were some of the physical constraints of available equipment such as extra extrusion die adapters, and vacuum pumps for material transfer were too slow. These problems couldn’t be overcome without significant capital investment, which was also a barrier to making these improvements quickly.

Another challenge was the perceived lack of need for quick changeovers from a demand perspective and a perception that there were much more important things to work on such as reliability. All the systems were in place for longer runs, therefore, the quick changeover efforts were perceived by employees as unnecessary and wasted time.

On one occasion, a team of operators on the quick die changeover team cut the time for changing a die from over 3 hours, to under ½ an hour by working as a team, and having all the parts ready when they needed to make the change. However, once that was done, and vinyl was coming back out of the die, the color was off spec, and it took over an hour to get good product running on the machine again. To the operations, time spent on quick changeovers, while possibly relevant in

the future, was irrelevant now. Even if the changeover was instantaneous, the un-reliability of the extrusion lines made the quick change irrelevant.

Bob, one of the maintenance people on the quick changeover team had an experience he shared. One night, he had come in the middle of the night to assist with a quick changeover due to heavy demand. However, after he got his part of it finished, he went home and back to bed. The next day, when he came to work, the line was still down, as there was nothing to run on it for the time being.

Working on system driven changes went very slow, and the energy and enthusiasm to make improvements came primarily from the “problem solvers”, or the management team involved in the process.

6.1.2 Needs Driven Improvements (Pull)

The second type of improvement projects is called needs driven improvements. These are improvements that solve existing problems for the workers. Typically solutions to needs driven improvements won't have the same obvious economic advantage as a system driven change because a workable system typically already exists.

However, needs driven improvement projects are typically easier to get support from the workers, as they deal with their current problems about which they have a natural tendency to want to solve, and about which they can recognize an immediate gain. Therefore, even though the gains from needs driven changes are typically not perceived to be as high as envisioned with a system driven change, it is easier to develop the **capability of people to make improvements** by working on needs driven improvement projects.

Also, as will be illustrated by the following story, the gains from a need driven change will frequently have much bigger impact than may be obvious at the beginning. The following is an example of needs driven change efforts.

The Pull Of the Pull System

In the previous example of the stock-out problem explained in section 5.2, stock-outs created a variety of problems for the loaders. For example, stock-outs created delays for getting a load done on time, and were a nuisance for customers who received a load with the same SKU on

multiple locations on the truck, or had loose product thrown on the back of the truck where it could be damaged in transit.

This problem of stock-out occurred frequently throughout the day (2 – 3 out of stock items per load), and was exacerbated during the busy time of the year, when customer demand exceeded plant capacity. On one truck I saw, there were over 10 out of stock items which accounted for almost 20% of the product which needed to be loaded on the truck.

This problem with stock-outs created a pull for the pull system. In other words, there was a need for some method for pickers to signal both the production, and the transfer of product to the warehouse.

As the pull system was developed, and implemented, the added ability of the pickers and loaders to signal production, and to control the re-stocking of product was an immediate gain, which was a great boost to the enthusiasm of the DC workers. As problems were solved, involvement increased, and additional four DC teams were formed: two teams to eliminate the waste in the picking process (productivity teams), another to change the floor plant of the warehouse (floor plant team), and a third to expand the pull system to all the products in the DC (replenishment team).

Once the capability to improve has been developed and nurtured, the people with that capability could be deployed to work on system driven change projects for the big gains. It became easier for two reasons. First, they have developed the skills and capability to do it, and second, they are less likely to resist if they have the confidence that they can continue to go back and fix the problems with the system change once it is made.

In summary, to acquire the capability to improve, it is easier to start with needs-driven improvements as it yields quick, tangible returns to the workers. Then over time, the process will evolve into the system-driven improvements. In many cases, the end result will turn out to be what was wanted in the first place, only it will be pulled through, rather than pushed through.

6.2 Stewardship Delegation of Modular Tasks

Important in building capabilities within people is to give them responsibility. Steven Covey, in his book titled *“The 7 Habits of Highly Successful People”*, talked about two types of delegation, gopher delegation, and stewardship delegation. In the former, the leader tells the worker exactly

what to do, and he does it. The other, stewardship delegation focuses on results, not methods. It gives people a choice of methods, and makes them responsible for results (Covey, 1990).

Because of the modularization of relationships into a supplier-customer scenario (section 5.3), the Toyota Leadership Model is set up to use stewardship delegation principles, with stewardship interviews and follow through. Each person, regardless of the scope of his or her job, is given a stewardship for that job. As they update and improve that job, they make changes in their standardized work²⁷, and continue to work on their stewardship.

In order to maintain consistent direction, shared vision and the annual hoshin (section 4.1.2) are deployed throughout the organization. However, as mentioned before, these hoshins are combined with an elegant system of constraints and framework understood as the TPS. This gives both the advantage of developing people by increasing their capabilities, as well as helps to solve the challenges and inefficiencies inherent in the dynamic complexity of a highly integrated and complex business.

6.3 *Emergent Leadership is the Key to the Future*

Once the teams and individuals start to understand the nature of stewardships, and the responsibilities that come from servicing their customers, they become part of the improvement teams. In the process of participating on improvement teams, there is a natural tendency for certain people to emerge as leaders. As their capability grows, and they emerge as leaders, then the ability to transfer the implementation grows. Therefore, the secret of a phased or pilot scale implementation process is not only to have a visual example of the “way things ought to be”, but to facilitate capability development on an individual basis. As leadership emerges, it is transferred across the organization (see Appendix C for an explanation of the roles of individuals in teams). This may seem like the slow approach at first, but the exponential effect of individual development is profound.

²⁷ Standardized work is a specific document written to explain what the job of the workers is. It is often misinterpreted to mean standard operation procedure (SOP). However, standardized work is different from a SOP. Standardized work is one of the key communication tools used by workers and supervisors within Toyota to manage and update their stewardships, and is easily changeable by the worker in conjunction with the supervisor.

In 1986, when Toyota built and staffed their first US car assembly plant in Georgetown Kentucky, they brought hundreds of trainers-on-loan from a sister plant in Japan, who stayed for years. These coordinators were charged with working one-on-one with their American counterparts only with persuasion – not to do things themselves. This intensely personal approach brought an “eye-opening” moment to most of the Americans (Mishina, 1992).

The following is an example of how this was working in ABP.

Sidney Flow Team²⁸

On one occasion, I was asked to transfer some information system modifications that we had made in Denison to a sister distribution center in Sidney Ohio. While in Sidney, I sat in on an improvement team activity for what they called the “flow team”²⁹. The purpose of the team was to look at, and improve the flow through the distribution center in an effort to eliminate waste. As I sat in the team meeting, it was clear that Sidney was much more advanced in their capability to improve, as there were several of the floor workers who gave stewardship reports of improvements they had made, and were receiving and giving feedback on what they had done.

One particular team had designed and built a scheduling board to help solve some of the information challenges that they had in loading their trucks. The solution to was elegant, and I was impressed. However, what was even more impressive was the obvious capability and leadership that the team leader who did the presentation had developed.

As I sat in the meeting, I remembered my experience in the Toyota distribution center, where every person we talked to from the supervisors, to the forklift drivers knew what the goals of the organization were, and had the capability to improve the processes within their areas to achieve those goals (Appendix A).

The development of people, one individual at a time is the secret key to the success of the Toyota Production System. And though the up front cost of time and effort is high, and the specific results difficult to quantify, the long-term effect is limitless.

²⁸ A complete story of this flow team is found in Appendix D. Schedule Board – for Load Assembly at Sidney

²⁹ Flow team was the name given to the team that was looking at product and information flow through the Sidney OH distribution center at ABP.

7.0 Conclusion & Recommendations

Conclusion

In conclusion, fundamental to the development of the Toyota Production System within Toyota is the soft side of the Toyota Production System. However, these softer, more ambiguous elements of TPS are the most difficult to duplicate. Where it is convenient to change the work of the workers to implement the TPS tools for higher productivity, it is not as convenient to change the way a manager manages.

One way to look at the soft side of Toyota is as the interaction of leadership principles, which underlie the development, and implementation of the Hard Side of TPS. Those principles are:

- Set Consistent Direction with Fluid Constraints
- Create a Culture of Removing Barriers
- Develop the Capabilities of People to Improve

Recommendations

The work to implement APS and the direction that Alcoa is pursuing is very important to their long-term success. However, I think it is vitally important to continue to think about, and make sure the soft side of the implementation is not forgotten.

Helpful questions for a manager to ask are: *“Am I giving consistent and clear direction with reasonable constraints to enable my people to accomplish our goals?” “What are the barriers that are impeding progress, and what can I do to assist in removing them appropriately?” and “What am I doing to develop the capabilities of the individuals who are working in this plant?”*

I hope this framework can give some direction, and examples that make it easier for a change agent to understand some of the challenges involved in a TPS implementation journey. Also, I hope it will give some ideas as to what kinds of things work to accelerate the improvement efforts in a plant to the point that every person is contributing on an individual level.

Appendix A. Visit to the Ypsilanti Service Center (YSC)

June 24, 1997

The Ypsilanti Service Center is a small cross-docking warehouse facility near Detroit MI, which serves as a distribution center for the Toyota Motors Manufacturing of Canada (TMMC) plant. The purpose of the service center is to go out and pick up parts from 38 suppliers, then by cross docking, holding and queuing, and manually picking and re-packaging, deliver them to TMMC in 10 equal shipments per day in the right order, and at the right time.

I. The Purpose of the Service Center, a “Temporary Countermeasure”

As Toyota has come to the U.S. and built automobile manufacturing plants, they have used the Toyota Production System (TPS) and its operations principles as the framework of success. The TPS system is an operational excellence strategy with the goal of “ideally” making a car under an “ideal condition”. This ideal condition is to have **single piece flow, delivered to the customer at the time the customer needs it.**

However, sometimes the costs of getting to the ideal condition, or in other words, delivering one lug nut at a time make it temporarily infeasible. Therefore, a “temporary countermeasure³⁰” is warranted. Within the U.S., long distances and shipping costs for certain suppliers has made a temporary countermeasure necessary. The YSC is the result of that countermeasure. It is a pick-up and supply network to better serve Toyota suppliers and internal customers.

³⁰ Mr. Ohba, the TPS “master” who lead our tour called YSC a temporary countermeasure. The philosophy of Toyota is when something arrives at the plant in a non-single piece flow, a temporary countermeasure is necessary. These temporary countermeasures are thought of as temporary distractions. The cause of these temporary countermeasures are: demand fluctuation, transportation and logistics costs, etc.. These countermeasures must always be looked at as change possibilities.

Initial Condition (Toyotas Original U.S. System):

In order to approximate the ideal condition, Toyota set up its supply lines to resemble an old fashioned milk run. In the “*milk run*” system, milk is delivered to the customer and empty bottles are picked up on a set schedule according to the needs of that customer (see Figure 8).

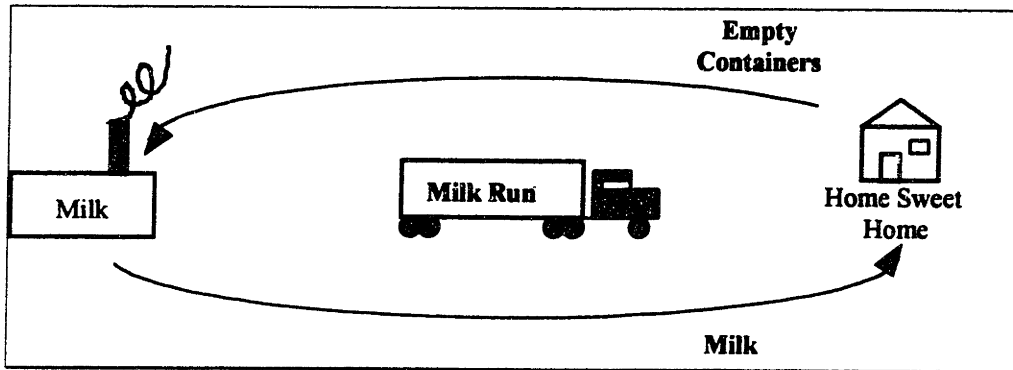


Figure 8. “Milk Run” System

This milk run system worked well for Toyota for most items as product was delivered to TMMC (the customer) in the desired quantities, and at the right time. However, due to large geographic distances in the U.S. and Canada, logistics and shipping realities for some of the smaller products made shipping the desired quantities at regular intervals somewhat costly. Therefore, a “temporary countermeasure” emerged where Toyota had to hold more than desired inventory, and in some cases, spend extra money on shipping.

This temporary countermeasure continued to raise a flag at the TMMC, until a “kaizen team” was established to find a better solution. Out of this kaizen effort came a service center concept, which envisioned a service center with sub routes picking up parts from several suppliers on their route, then bringing them together where they could be fed to TMMC on main routes at the desirable rate. This system would make smaller shipments from suppliers more economical due to the aggregation of suppliers on a single truck.

This new concept is an extension of the milk run called “*Complete Line of Dairy Products run*” (CLoDP) run (see Figure 9). It consists of a supplier pick-up route called a sub-route, and a customer delivery route called a main route. In this system, the “sub-milk man” will collect cheese from one supplier, ice cream from another, yogurt from another, and cottage cheese from the last, then bring them into his service center. This is called the sub route. Then, the “main-milk man”, on a main route will stop at the service center to get any products from the sub-routes, then pick up from en-route suppliers and deliver to the customer. In this way, the customer can receive the entire smorgasbord of dairy delight, when they want, in the quantity they want.

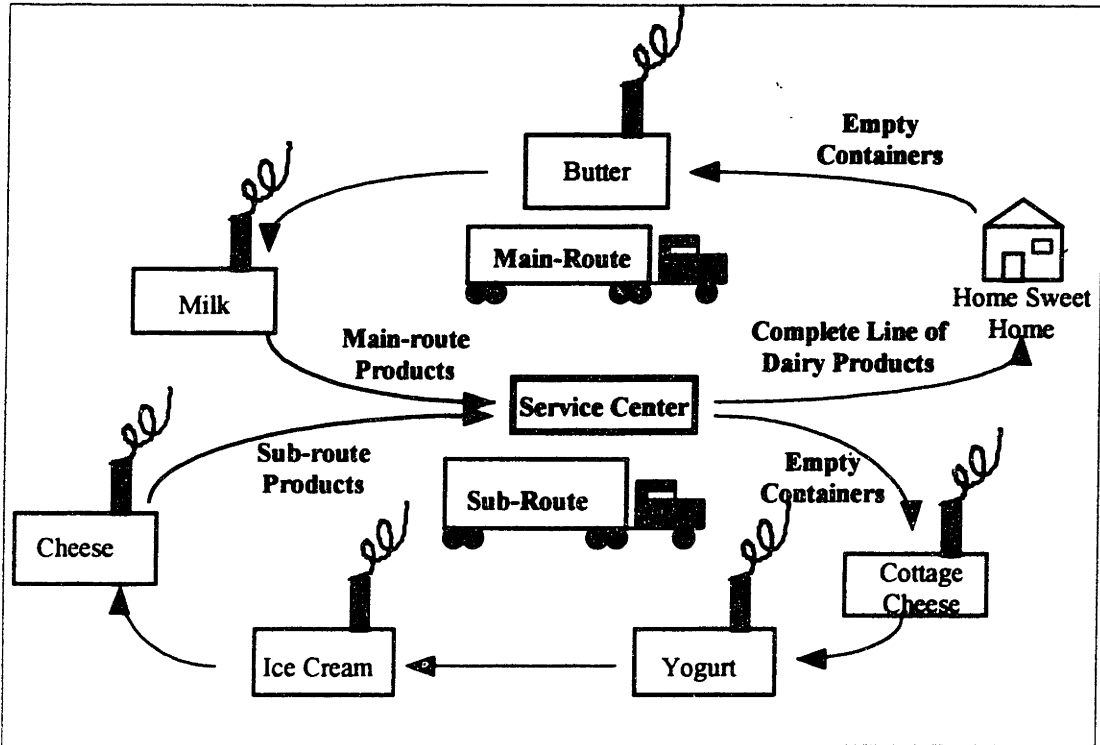


Figure 9. "Complete Line of Dairy Products Run" System

From this idea of a distribution like "complete line of dairy products" network, an improvement on the milk run, for certain suppliers was developed. The Ypsilanti Service Center was the germination of this idea, and was given the following goals from TMMC:

- To contribute to the production of cars the customer wants in the shortest possible lead-time.
- To design a flexible transportation and logistics system to cope with future demand fluctuation.
- To prepare external routes for future complexity in American car production.
- To establish a proper joint transportation system for all Toyota affiliates.

II. The Mechanics of the Ypsilanti Service Center

Order entry and Control Ticket Generation

1. TMMC electronically sends its daily order to both YSC and the supplier³¹. This order is the kanban³² (signal) to the supplier that his order is firm, and to the Service Center on what the aggregate daily order will be.
2. For internal control purposes, YSC prints “match route control tickets”³³. These tickets are color coated according to the route they will be on. The match route control tickets are in the lot sizes that will ultimately be shipped to the customer.

Supplier pick-up routes (Sub-routes)

3. The match route control tickets are taken and placed in the appropriate slots in the Sub-route control board³⁴.
4. When a sub-route driver is supposed to be there, he comes and gathers the cards for his route from the control board and puts them in his drivers carton. He then counts and loads on his truck the return containers corresponding to the pick-up cards, and then goes on his route.
5. As the sub-route driver goes to a supplier on his route, he drops the return containers, counts, picks up, and verifies that he received exactly what is on his cards³⁵. After which he places the cards on the product.

³¹ This daily order can be easily forecast out about 2 weeks, as the daily demand variation for these daily order quantities is within 5%. This daily demand rate is in lock-step with the production rate of TMMC. It was not clear what the lead time for a major demand fluctuation would have to be as truck quantities and route changes may need some alterations; however, it is clear that over the long term, they have the capability to make any changes they need to make.

³² Kanban is the Japanese word for signal, and is used to signal action. In practice, a kanban is usually a card, or a container, which when given to a supplier, signals them to produce and deliver the set amount of product.

³³ The match route control tickets are generated by the computer based on the daily order. This supporting role is the main purpose of the computer in this facility

³⁴ A control board is a “Heijunka” which is utilized any time there is a time, place, production decision which needs to be made. For example, in this case, the control tickets are printed, then put in the proper slots which sets when and where the corresponding parts will be picked up. In the case of YSP, some pick-ups are done twice per day, others are done weekly. This control board becomes the “kanban” mechanism to tell the pick up driver what and where to pick up. However it is also visual communication to every one else in YSC.

³⁵ This verification of the parts order pick up is the only counting that is ever done with these parts. No inventory or pick-up records external of these cards is used from this point on through the process to the final car at TMMC.

6. The driver continues around his route, until his cards are gone, and the full truck returns to the YSC³⁶ at the predetermined time.
7. The truck is unloaded at the YSC, and a kanban is placed on each container. The kanbans are white, yellow or green according to where the container is placed in the warehouse:
 - * *White (Staging Area)*- These containers are daily shipments and are immediately placed in the proper staging lanes³⁷. This entire product will be shipped within 24 hours of when it is received.
 - * *Yellow (Wait Area)*- These containers are received less frequently than one day intervals. Therefore, they can not be placed directly in the staging lanes and must be queued. From the wait line, they are staged according to a wait line control board³⁸. Since no product in the warehouse is in inventory, but in queue, all products in the wait line is staged according the First-In-First-Out (FIFO) principle.
 - * *Green (Re-pack Area)*- These containers are product that is either sufficiently small, that it doesn't yet make sense to cross dock it, or isn't yet purchased and packaged in single main route shipment size containers. This product is placed in the repack area, and re-packaged and staged according to the re-pack control board also FIFO.
8. The sub route truck driver then picks up his new sub-route control tickets and puts them in his drivers carton, picks up the proper empty cartons, and starts the whole process over again.

³⁶ There are mirrored routes, and always multiple trucks on the road at the same time. Since the logistics have been predetermined with the control board, the timing is all set, and the truck will always return full. The timing of the system is predetermined with reasonable pick-up targets, and the full truck returns to the YSC at a set time.

³⁷ In the warehouse, there were 10 staging lanes for the 10 shipments which would go out in the next 24 hours. The arrival and departure time for the trucks were hanging from the ceiling above the respective lanes.

³⁸ The wait line control board is a visual representation of where and when all the product in the wait line is going. This board is used to tell the warehouseman what in the wait area needs to be shipped on any given truck.

Customer Delivery Routes (Main Routes³⁹)

9. Ten full truckloads per day are shipped to TMMC. On their return route, they also pick up supplier product, similar to a sub-route. The truck backs into the dock, at the set time and the return cartons, along with any of the supplier products he was assigned to pick up is unloaded and a kanban is placed on them.
10. The product is placed in one of the three areas according to the same rules as the sub-route supplier products.
11. At the given time, product is loaded onto the truck from the staging lane, wait area, and repack area. What is loaded is communicated to the warehouseman by the main route control board⁴⁰.
12. The driver then goes to the main route control board and picks up his main route match tickets, which will indicate what he needs to pick up on the back haul⁴¹.
13. While we were at the warehouse, the main route driver pulled away from the dock within 3 minutes of the set time on the staging lane. He then delivers product to TMMC⁴².
14. Empty return containers are then picked up, and the driver commences his pick-up route to the suppliers on his return trip in the same way the sub-route drivers did.
15. The main route truck returns to YSC, at the arrival time in the staging lane, and the symphony continues as planned (See Figure 10).
16. If there are problems, YSC has in place the capacity to expedite products, to maintain it's customer.

³⁹ Main routes are 21 hour round trips. Therefore, it takes two drivers to do it. The two drivers aren't a partnership with both in the truck at the same time, but work like a tag team in pro-wrestling, with a set trade off point.

⁴⁰ The main line control board is very similar to the sub-route control board. Its purpose is to communicate to both the driver and the warehouseman both visually, and substantively what should be loaded on the truck for delivery to the customer, then what should be picked up and brought back from main route suppliers on the return trip. These trucks are loaded the same every time according to standardized work, and when they are received, don't need to be counted, or verified, as the internal controls make them accurate every time.

⁴¹ I don't believe it is necessary that product only be picked up on the back haul for this system to work. Product could be picked up both going to and coming from the customer, however, the main route trucks I saw were clear full as they left YSC, and had no room for a pick-up on the way to TMMC.

⁴² At TMMC, there is always one truck unloading, one truck waiting, and one truck coming in the gate for safety purposes. Since these trucks run mirrored routes, if one has trouble, then the one behind it can pick up the slack. YSC would have to have 3 truck break down at the same time to create any problems for TMMC.

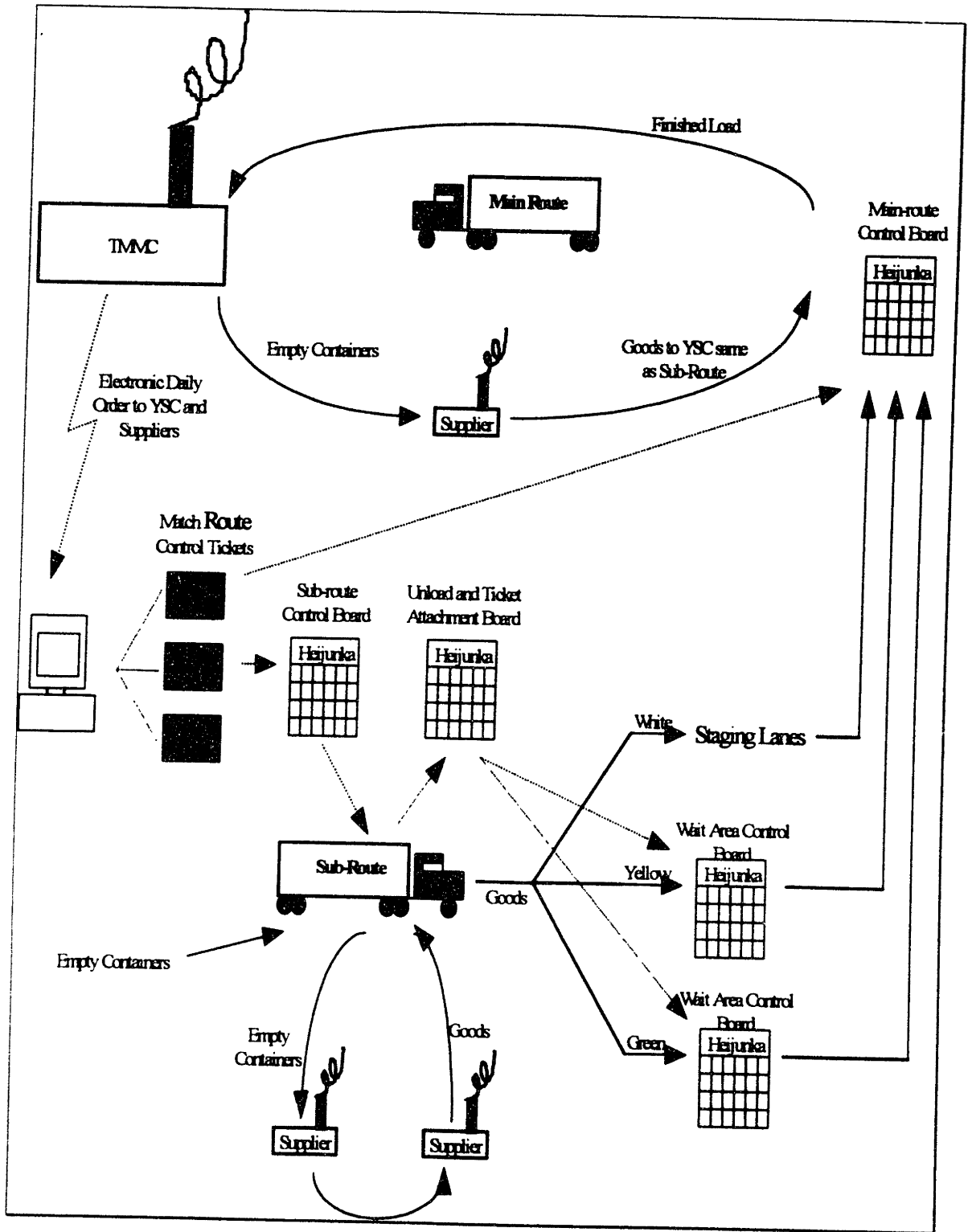


Figure 10. Ypsilanti Service Center Schematic

III. Other General Observations, and Estimations

- The YSC warehouse has less than 24 hours of queued product in it at any one time. They don't call it inventory because it all has a home before it is ever picked up from a supplier.
- I would estimate YSC accomplishes this whole process with about 3 warehousemen per shift, in a very small⁴³ warehouse (see Figure 11 for warehouse layout).
- The YSC is so organized, and efficient, that it never looks like anyone has to do anything.
- There is a place for everything that comes on or off the trucks, and double movement of products is very minimal.
- Although there are currently 5 control boards for this process, the YSC teams are working on system improvements which will take that down to 4 by consolidating duplicate information on the sub-route, and main-route control boards.
- Visual queues throughout YSC make it possible for supervisors to see which team members need support.
- Mr. Ohba and the YSC consider the service center an acceptable temporary countermeasure, but have plans to eliminate re-pack as is possible, and continually improve.
- Now the TMMC is being supplied consistently, phase two of the project is to bring on line TMMI (Toyota Motors Manufacturing of Indiana). Although YSC anticipates more complicated logistics for this change, they do not anticipate any additional space requirements to handle the additional volume. The higher frequency of pickups at the suppliers will make the amount of material in queue in the warehouse go down.

⁴³ You may wonder what I mean by very small. Well, I can only quote the great philosopher Anonymous when asked to describe a person who is beautiful within, he said, "There is no way I can describe an inwardly beautiful person, but I know one when I see one."

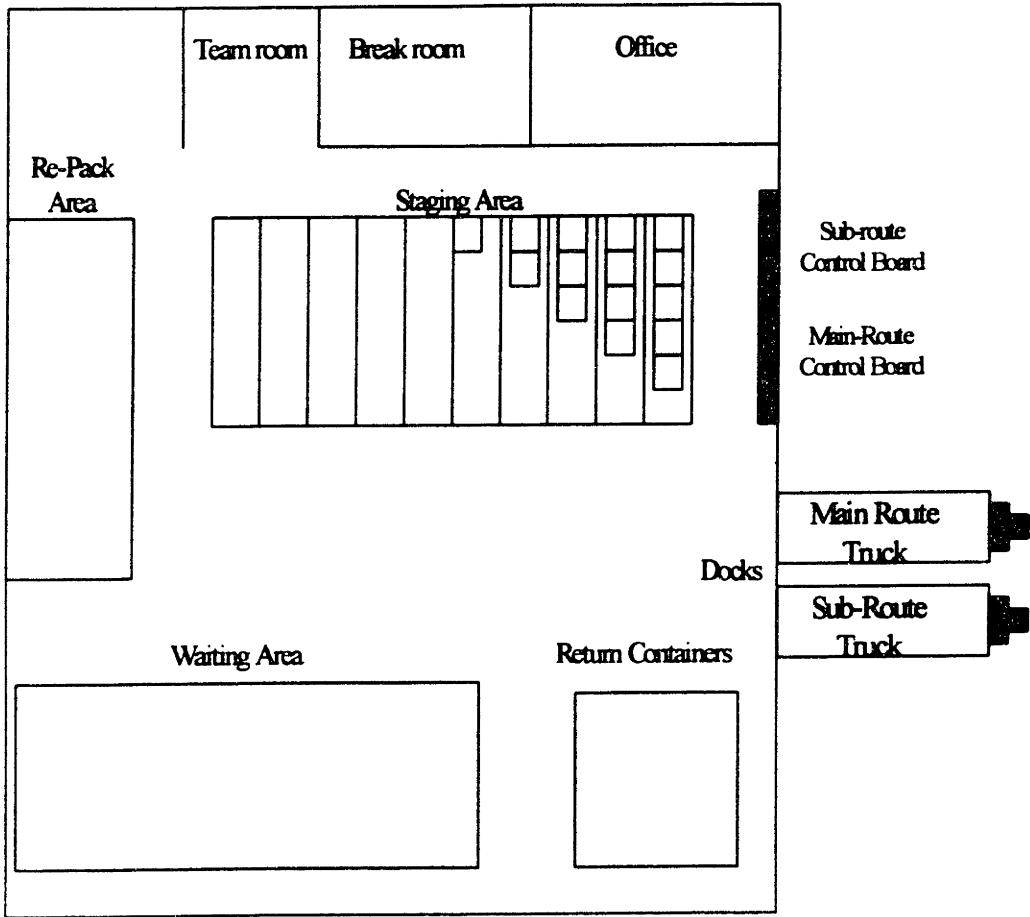


Figure 11. Ypsilanti Service Center Floor Layout

Appendix B. Vinyl Siding Prioritization Excerpt.

Product ID	Priority	Priority #1 Vinyl (Product Names)	Profile Style
SMB50	100	Sears Meadowbrook	Double 5"
WGV40	101	T-lok Barkwook	Double 4"
CW40	102	Carvedwood	Double 4"
L44T	103	Liberty Elite	Double 4"
WGV80	104	T-lok Barkwook	8"
STV44	105	Silhouette	Double 4"
STV80	106	Silhouette	8"
PBS80N	107	Pro-Bead Non-Vent.	8" Soffit
PBS80V	108	Pro-Bead Ventilated	8" Soffit
TRMS10V	109	Trade-Mark	Ventilated Soffit
TRMS10N	110	Trade-Mark	Non-Ventilated Soffit
WGV3266	150	T-lok Barkwook	
TRM40	151	Glenwood	Double 4"
BW40	152	Brentwood	Double 4"
MB40	153	Meadow Brook	Double 4"
MC40	154	Mill Creek	Double 4"
BR40	155	Brushedwood	Double 4"
LFP40	156	Lake Forest Prem.	Double 4"
MCD40	157	Mill Creek	Dutch Lap - Double 4"
CWD40	158	Carvedwood	Dutch Lap - Double 4"
STV3	159	Silhouette	Triple 3"
BR30	160	Brushedwood	Triple 3"
		Priority #2 Vinyl	
DWGV50	200	T-lok Barkwook	
LD55T	201	Liberty Elite	Dutch Lap - Double 5"
STVD55	202	Silhouette	Double 5"
LFP10N	203	Lake Forest Premier	Non Vent Dbl. 5" Soffit
LFP10V	204	Lake Forest Premier	Ventilated Dbl 5" Soffit
PSS10N	205	Pro-Select	Non Vent Dbl. 5" Soffit
PSS10V	206	Pro-Select	Ventilated Dbl 5" Soffit
		Priority #3 Vinyl	
WGV50	300	T-lok Barkwook	Double 5"
L55T	301	Liberty Elite	Double 5"
CW50	302	Carvedwood	Double 5"

These priority numbers are the primary sort for organizing data on a pick ticket. This has made it possible to group product in families, and ultimately zones. The sort is based on how products stack together on a truck.

Appendix C. Organizational Structure of Teams

Manager / Coach's Role

- **Make sure the people making the decisions are knowledgeable enough about the process they are dealing with to make good decisions.**
- **Reduce/Remove barriers that people can't remove by themselves, and see to it that the team leaders and support people are doing the same.**
- **Hold stewardship interviews with team leaders and subordinates to see to it that they understand the shared vision and hoshin, then to give them opportunity to report on their stewardship.**
- **Gain in depth knowledge of the processes at the plant so they can support their people when higher level managers question the decisions of the team leaders and team members.**
- **Participate on the teams so that they become familiar with the TPS constraints and framework, and can teach others.**
- **Find the natural or emergent leaders and give them responsibility to improve areas they feel the most passionate about.**
- **Be a good student.**

Team Leader's Role

- **Build the capacity to improve among all the team members by getting ideas, building upon them, and nurturing the collective energy and knowledge of the team to produce improvements.**
- **Understand completely the specifics and details of the process.**
- **Challenge and push the process knowledge of the team.**
- **Learn and understand the entire TPS system so as to use those principles to direct the team to solve its problems.**
- **Help prioritize the improvement activities.**
- **Train and nurture emergent leadership among the team members by giving stewardships, and following up on those stewardships.**
- **Make sure all the team members understand the shared vision, and hoshin.**

Team Members Role

- **Understand what the team is trying to accomplish.**
- **Contribute understanding, experience, and skepticism to the discussions in a way that is helpful, and accomplishes the hoshin.**
- **Take charge and lead where possible.**
- **Develop personal skills, and capability to improve.**
- **Follow through on assignments given.**
- **Help to communicate to co-workers what is happening on the team and gather additional input when it is appropriate.**

Appendix D. Schedule Board – for Load Assembly at Sidney

On a trip to Sidney, OH midway through my internship, I learned a great deal about the leadership that was necessary to implement the APS. I was sent to help develop a pick ticket program capable of breaking apart the consolidated pick ticket⁴⁴ into a series of zone pick tickets⁴⁵.

However, I learned that there were other problems beyond the pick tickets with the zone picking process. For example, there were communication problems between the zone pickers and the loaders that also needed to be solved. Frequently, loaders who were mid-way through loading would find out that one or more of the zones weren't completed picking thereby causing them to wait on product. Or alternately, the loader would be waiting on a zone to finish picking before he started loading the truck, only to find out there was no product from that zone on the load.

Why am I talking about this stuff?

Although the specifics of solving these problems is not particularly interesting, the methodology used to solve them is symbolic of both the evolving culture of APS, and the role of the TPS model in directing that evolution with sound manufacturing system principles.

The dominant culture at ABP has been for problem solving capabilities to reside primarily at a management and engineering level. However, the new culture of improvement that ABP is trying to foster is of developing the capability of the people on the shop floor to become the problem solvers.

Back to the Story

In solving this problem, the team leader (Steve) stood up and presented a recap of the problem and what they had done to solve it. They had developed a schedule board which they had nearly finished building, and were going to present to the group.

The board sat in front of the loading office, and had listed each of the current day's, and next day's loads on it. After each load, there was a place for each zone, in which was placed either an X if there was no product in that zone, or the picker's initials when they finished picking the zone for that load (Figure 12).

As the team presented the board, there were many questions such as who would update the board each morning and who would put the X on the boards. These questions hadn't yet been answered, but it was obvious that they would find a good solution, and if there were other problems, they would be worked out as well.

⁴⁴ A consolidated pick ticket is a document that contains all the products that goes on a load. Every loader irregardless of how many items are his/her responsibility would get the entire list of products, then pick off that list the things which were in his/her zone.

⁴⁵ A zone pick ticket is a document that contains only the products in a predefined zone.

Date: Friday - 11/14/97									Date: Monday - 12/14/97								
Zones:									Zones:								
Truck	Alum. Siding	Alum. Long	Vinyl Siding	Vinyl Long	Smalls	Gutter	Gutter Coil	Shutters	Truck	Alum. Siding	Alum. Long	Vinyl Siding	Vinyl Long	Smalls	Gutter	Gutter Coil	Shutters
Truck A	X	AB	ST	DR	FG	X	X	ER	Truck A								
Truck B	X	AB		DR	FG	DD	X	ER	Truck B								
Truck C	PD	AB				X	X	ER									
Truck D	PD					X	X										

Figure 12. Schedule Board at Sidney

The Sidney team I saw illustrates many of the leadership principles at Toyota:

- There was a problem on the floor for the loaders in completing their trucks in a timely manner. Therefore, there was a need that called for a solution (need driven solution – section 6.1.2).
- The stewardship to solve the problem was passed off to a team with a team leader (section 6.2).
- The team developed a solution, in harmony with their understanding of the Alcoa Production System (see section on fluid constraints – section 4.2.1)
- The manager supported the team, by giving them the time to solve the problem, then most importantly, the direction, help and resources necessary to implement the solution (see chapter on barrier removal – chapter 5.0). (This is a cultural shift of empowering people, and supporting them to improve both themselves and their environment)

The problem could have been solved in any number of ways. The warehouse supervisor had 17 years of warehouse experience, and probably had good ideas. However, by giving the workers the stewardship, he is building the capability of the team and team leader, to make improvements in the future (see chapter on capability development – Chapter 6.0). Also, by teaching and helping the workers solve the problem in the spirit of the Alcoa Production System, a harmonious system is gradually being built which will lead to target ends.

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