# Increasing the Competitiveness of Missouri's Hardwood Producers: An Introduction To Lean Enterprise Principles for Loggers

Business and technical assistance to help you reduce costs and increase profits.

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# INTRODUCTION

The timber industry contributes significantly to Missouri's economy. Missouri has more than 13 million acres of timberland, covering some 30 percent of the state. The forest products industry is one of Missouri's 10 largest manufacturing sectors, employing some 30,000 people, or six percent of the manufacturing workforce, with an annual payroll of $681 million.

But, the contribution to the state's economic well being should be much higher. Many timber producers are not operating at the highest level of efficiency and some are producing only lower grade forest products, from high grade raw materials.

Recognizing this, and committed to helping Missouri businesses succeed, Missouri Enterprise Business Assistance Center partnered with the Missouri Department of Agriculture to submit an application for a U. S. Department of Agriculture Federal State Market Improvement Grant. The grant application proposed a study of the industry and development of ways for Missouri's timber producers to their enhance competitiveness in the global marketplace.

That grant was approved in February 2004. The study of the industry was undertaken, the results were evaluated and this Technical Report is the first of three reports addressing the application of modern industrial methods to the hardwood timber industry.

We are confident that this first report will introduce the timber products industry to proven principles and practical means to help all segments of the timber industry enhance productivity and increase profits. This first general introduction report will be followed by reports focusing on logging and milling.

# ACKNOWLEDGEMENTS

Missouri Enterprise Business Assistance Center wishes to acknowledge the following organizations, without whom, this project could not have been completed. We look forward to continued cooperative efforts with these organizations on behalf of our state's timber industry.

**United State Department of Agriculture**
**Missouri Department of Agriculture**
**Missouri Forest Products Association**
**Missouri Department of Conservation**
**Missouri Department of Natural Resources**

A special thanks to the companies who provided the photography locations:

**Perryville Stave Company**
**East Perry Lumber Company**

Special thanks to Orville Schaeffer of Perryville for helping with arrangements.

# ADVANCED MANUFACTURING TECHNOLOGY FOR VALUE-ADDED LOGGING


## *ABSTRACT*

Logging is probably the most crucial value-added step in primary processing of timber. The timber value chain starts with logging and it is here that the ultimate value of a tree is established. When you approach a standing 60 to 80 year old hardwood tree you can see it for the amount of lumber (board feet) that is in it or you can view it from the quality of the lumber that it contains. Once you put the chainsaw to the tree you begin a very critical process, which demands that the logger choose between getting as many board feet as possible from the tree or maximize the quality of the tree's saw logs. Once a tree has been cut, the value of the main log has been locked in place. Then, once the main log has been bucked into saw logs the value of each saw log has been fixed and there is nothing that any following process can to do to increase the value of the tree from which the logs came. The real tragedy here is the fact that a logger can be maximizing the volume of logs he is producing but he can be losing money because he is not capturing the true value of the tree. The concept of "Lean Value-Added Logging" requires development of a logging culture where everyone associated with the logging process has a responsibility for eliminating or minimizing waste and maximizing value-added processes. The utilization of advanced manufacturing technology and methods presented in this paper places the responsibility for valued-added logging on the shoulders of both the logger and the private landowner. Over 80% of Missouri's forest lands are owned by private individuals and, ultimately, they are the only ones who can control how their land is logged. The State of Missouri has many excellent programs to help landowners and the Missouri Forest Products Association provides excellent resources and training for the logger. This Technical Report is dedicated to providing both the land owner and the logger with an understanding of how using advanced manufacturing technology directly impacts their profits, future productivity of the timber stand, and minimization of damage to the environment. Therefore, a high-value sustainable hardwood forest system in Missouri is dependent on our logging activities being focused toward capturing timber value, protecting the environment and sustaining the quality of our hardwood forests.

## STRATEGIC PLANNING

### *Introduction*

Planning and communications are critical elements in re-engineering a company around Lean Value-Added principles. To start with, this is not just another "flavor-of-the-month" program that stirs everyone up and then slowly fades away. Re-engineering a company is changing the way a company does business and putting into place a process that seeks to continue to change in order to improve. Establishing a Lean Value-Added culture is not a one time project … it is a new way of doing business.

To better understand the philosophy behind this advanced manufacturing technology, it is recommended that the reader review the material in the first Technical Report in this series, entitled: **"Increasing the Competitiveness of Missouri's Hardwood Producers: An Introduction to Lean Enterprise Principles for the Timber Industry,"** (TI1011204).

The success of any Lean Value-Added implementation program is heavily dependent on the company's leaders being totally committed to both the planning and the implementation programs. Success of the program is also very dependent on the level of leadership participation in both planning and execution of all major changes. It is very important that company leadership presents all employees with a clear explanation of the program and that the employees can clearly see the commitment of the leadership. One of the most positive signs of company commitment is their providing employees with the training and tools necessary to make changes happen.

After all, change is both difficult and frightening. Planning and training for change will help ensure that change happens in the way you want it to and that costs are anticipated and controlled.

Once you are comfortable with the theory and philosophy behind Lean Value-Added principles, the next step is to develop a Lean Value-Added implementation plan. Prior to starting the plan it is essential that you undertake the following steps.

**1.** ***Initial Training*** - Begin to prepare yourself and your employees for the changes that are coming. It is important that you understand Lean and share this understanding with the workforce. The approaching changes should be topics for discussion and not rumors.

**2.** ***Target*** - Pick what processes that you and your workforce would like to see initially changed. Use common sense and attack areas where you will have a high probability of success. Once you are skilled in executing Lean changes you can take on more difficult issues.

**3.** ***Risk Management*** - Take the time to understand the impact your actions are going to have on the process and on the workforce. For each activity, it is important that you assess all risks to the success of the program and to the business as a whole.

**4.** ***Value Stream Mapping*** - One of the biggest mistakes a company can make is to start Lean implementation without having first completed a Value Stream Mapping (VSM) project. This mapping exercise is necessary to understand existing processes, workflows, lines of authority and communication mechanisms.

**5.** ***Vision*** - Carefully determine where your company is today and then develop a vision of where you want the company to be tomorrow. Be sure to define how the proposed changes will put the company in a better competitive position.

**6.** ***Metrics*** - Metrics is a fancy word that really means "this is the type of measuring stick we are going to use to determine how well our program is doing." Examples of logging metrics could be increased production, reduced fuel consumption or increased log values.

**7.** ***Scheduling*** - It is important to commit enough time, resources and people to implement changes.

**8.** ***Communications*** - Carefully plan how you are going to tell your workforce about the program and determine how you will keep lines of communication open. Put an end to unfounded rumors as soon as you hear about them. It is essential that everyone knows they can talk about anything to anyone. It is also important to keep suppliers, partners and customers informed of any changes that could affect them.

**9.** ***Teams*** - Lean implementation is not a "lone wolf" operation. Lean implementation requires team work. You must learn what a team really is and how a real team functions … then do it.

**10.** ***Landowner*** - The landowner is a key partner in your logging operation and should be involved in the planning. The landowner's attitude toward harvesting and sales of timber will have a major influence on the sustainability of Missouri's forests. Therefore, it is important for the landowner and the logger to work with Missouri organizations such as the Department of Conservation and Department of Agriculture during the application of advanced manufacturing technology.

**11.** ***Forest Management*** - This Technical Report is not intended to address forest management. An understanding of forest management, however, is essential to the application of advanced manufacturing technology. Therefore, landowners and loggers should seek assistance from the Missouri Department of Conservation to ensure that all harvesting activities focus on a common set of goals and objectives and that these are clearly defined in a written *forest management plan*. This plan will provide the proper foundation for subsequent development of a *Value-Added Logging Plan*, which is built around modern manufacturing methods and business models.

The Need for a Value-Added Logging Plan

The complexity and effort associated with the development of a logging plan will be directly proportional to the size and complexity of the area being logged. Regardless of the size and complexity, however, a logging plan should be developed, even if it is only laid out with a pencil and topographic map.

The complete harvest planning process, including evaluation of alternatives, verification of unit logging feasibility and development of a logging cost appraisal, is beyond the scope of this report. In all probability, such a plan will seldom have significant application in the harvesting of Missouri hardwoods, which is most frequently conducted in timber stands smaller than 500 acres. Still, even for a short-run or small area harvesting operation, it is essential that both the landowner and the logger develop a basic plan of operation. In general your harvesting plan should:

- locate all access points
- layout the general location of existing trails, roads, landings and boundaries
- establish a general plan for skidding and landings

- determine where you will start and how you will probably proceed with logging
- consider using a topography map or aerial photograph to layout your logging plan
- work with the landowner to determine forest management objectives (include timber type, grade production and yield estimates)
- document methods to protect soil and water resources
- determine what forest stewardship practices best meet the landowners objectives
- separate the timber tract into harvesting stands, if applicable
- plot tree types and grades, where applicable
- locate and map riparian management zones
- locate and map where wildlife trees are
- locate and map all archeological or protected sites (coordinate with landowner).

The landowners early and active participation in planning is of utmost importance in the preparation of your logging plans. Take the time to coordinate with and inform the landowner about all your planning activities. Pay close attention to the landowner's opinions on which timber areas should be harvested and adhere to their forest management plan. Take the time to explain to them your Best Management Practices and how these impact your operational costs. Getting the landowners input to your logging plan is an excellent opportunity to determine how easy or how hard it is going to be to work with the landowner. It is his land and his trees. Harvesting the trees will have to be done with the landowner's input and you must meet the landowner's expectations throughout.

The size and complexity of the harvesting operations will dictate the amount of planning required. For large undertakings, a comprehensive Value-Added Logging Plan can take time to develop, but it becomes the roadmap both you and the landowner can refer to in the future.

Remember, this plan focuses on the industrial technology and practices associated with cutting and removing timber. This is not a forest management plan. The harvesting plan is usually prepared by the logger or logging manager just prior to beginning the harvesting operation.

In order to build the *Value-Added Logging Plan* the logger should at least have the following information at his disposal:

**1.** Cutting type (clear-cut, thinning, stand harvesting, individual tree selection, etc.). This information is necessary to determine the VSM and it will impact your choice of equipment, skidding methods, log landing placement and size, hauling and workforce requirements.

**2.** Market analysis. It is very important to identify who is going to purchase your logs and expectations. In most cases, as an independent logger, you will want to sell your standard logs to various mills in the area. A careful selection of mills will enable you to maximize your profits from standard logs. For specialty logs, based on type, size and quality, it is important to sell to a log buyer. If you have a sufficient quantity of logs, it is often advantageous to have log buyers bid. Many log buyers prefer that you sell to them in tree length logs, which they will then mark for bucking. A careful marketing analysis will help you determine what is cut for what type of sale, how it is cut and how it is handled.

**3.** Timber sales contract. The logger not only generates a product (logs) but also provides a service to the landowner. It is important that all forest management activities to be conducted by the logger, are clearly spelled out so the logger can include this work in calculating services rendered and their subsequent costs. The principles of Lean require that the logger and the landowner enter into a true partnership. Remember, you are not just purchasing trees from the landowner …

you are also providing the landowner with a set of services. These services cost money and the landowner must know, up front, what harvesting is going to cost.

**4.** Boundaries, easements, and rights-of-way. This information is necessary to locate access points, log landings and skidding trails. Careful planning is required to minimize both skidding distances and environmental impact.

**5.** Missouri laws and regulations. Missouri does not have an abundance of laws and regulations affecting logging on private lands. The logger should, however, treat logging on private land with the same respect as operations on state lands.

**6.** Tract topography. In Missouri, topography will often limit the logger's options for cutting, skidding, roads and landing locations. Topography will also play a very significant role in determining forest management costs.

**7.** Tract soil conditions. Soils will affect skidding and landing operations, especially in areas where pasturing or hay production will be affected. Soils also impact equipment decisions and scheduling of activities.

**8.** Tract hydrology. A considerable amount of time and money can be wasted in building and repairing stream crossings. It is important to know how much water can be expected in a stream after a big rain and if this will impact the logging plan. It is also necessary to make special plans for harvesting near streams.

**9.** Timber to be removed. The type of timber, its size distribution, its volume, its general distribution within the tract being logged and its grade distribution will all have a major impact on how the tract is most efficiently logged. The basic principle is to treat log differences like product families and use this concept to most efficiently flow the product.

**10.** Logging process and equipment. The logging process should be planned to minimize the 8 major wastes associated with any operation and to flow the logs to maximize quality and minimize resource utilization, including time.

**11.** Close-down requirements. It is important that close-down requirements are clearly defined in the logging contract and that the cost of these services have been fully identified to the landowner. They can include such activities as re-grading ruts, installing water-bars on abandoned roads or designated skid trails, reseeding certain landings and roads, removing any temporary stream crossing structures, scattering brush, opening ditches or water turnouts, and any clean-up necessary to leave the tract in acceptable shape. Many of these operations can be scheduled during "slow" times as harvesting is completed on various parts of the tract, thereby avoiding a massive job at the end. It is important to make the landowner aware of his responsibility to maintain the tract in the environmentally sound condition in which it was left after logging was completed and BMP compliance recorded. It is also vital that you take the time to help the landowner understand the cost of these operations.

**12.** Best Management Practices (BMP). Although Missouri does not have Best Management Practices (BMP) as a compliance issue for logging, it is still recommended that the logger present this information to the landowner in the *Value-Added Logging Plan*. An excellent source for BMP compliance in formation can be found in the Environmental Protection Agency's Watershed Academy's module on forestry Best anagement Practices (BMPs) in watersheds.

A great deal of care must be taken in the planning phase to eliminate as much non-value adding activity as possible. Worker transportation into and out of the timber must be planned and kept to a minimum. Refueling of equipment and saws must be scheduled to minimize down time. Skid trails designed to minimize distance traveled. Bucking, loading and hauling schedules balanced with falling and skidding times. These activities, and others, must be planned in a dynamic living fashion, which changes as the logging operation progresses. As care is taken in developing the *Value-Added Logging Plan* it is important to inform and consult with the landowner to build good relations and meet their expectations.

## Planning Where to Start the Value-Added Logging Plan

A great deal is written about Lean principles, but very little has been written about how to implement Lean. Most companies hire a consulting firm, which provides training about Lean and perhaps shows the company how to set up and execute Kaizen events. Usually the company learns a few of the Lean implementation tools and makes a bit of headway, but never really captures the benefits associated with re-engineering the company around Lean principles. For one thing, re-engineering a company is a major undertaking that requires top level commitment and a willingness to empower change agents. Many companies learn something about Lean, but only a few immerse themselves in its philosophy.

The first Technical Report in this series, entitled: "Increasing the Competitiveness of Missouri's Hardwood Producers: An Introduction to Lean Enterprise Principles for the Timber Industry," is a brief introduction to Lean philosophy. This Technical Report is a continuation of our journey into the world of Lean, but it is not sufficient in and of itself. Developing a "Lean" way of doing business is an extremely complex, ongoing process. The best we can hope to do in these few pages is to introduce the world of Lean, give readers some ideas to try out from a logging perspective and, more importantly, instill in the reader a desire to learn more.

To begin with, the further an operation is from classical mass production manufacturing, the more difficult it is to find information and case studies dealing with the implementation of Lean principles. One reason is that the further you get from the classical manufacturing model the more difficult it becomes to determine which Lean tool or principle will best apply to your specific situation. In fact, there are situations where the implementation of Lean philosophy or the use of a lean tool will actually worsen the situation. And, logging is one of those operations where improper application of Lean philosophy will cause more harm than good! After all, logging is not like classical manufacturing because you do not manufacture a product. You are recovering a product from the tree. Yet the processes for recovery are like classical manufacturing in the sense that we can develop a pattern of material flow with separate and unique steps making the flow of our product happen. This can be a bit confusing, so what do we do? The most logical approach is to examine each Lean principle and each Lean tool based on what we need to do, and use common sense in its application. If it works we will use it. If not, we will try to modify it so that we can use it or we will discard it. Remember, the farther an operation is removed from classical manufacturing the greater the demand will be for the practitioner to use common sense.

When you start developing a logging plan, you need to use a great deal of common sense. Lean philosophy and tools are excellent and will contribute to betterment of a value-adding process, but not all principles or tools work for every situation. For example: Lean philosophy states that single piece flow is the optimum way to flow a product through the manufacturing process. If we are getting hardwood trees to the

ground, cutting one tree at a time makes sense. If we are hauling logs to the mill, doing it one log at a time is operationally impossible. You cannot use the principles of Lean as if they were a step-by-step method found in a shop manual. In applying Lean principles to the logging operation, in an attempt to better the value-added process, you should use what works and reject what does not.

## The Art of Planning Value-Added Logging Around Lean Principles

There are many Lean gurus, but very few of them can agree on the tenets of the philosophy they are teaching. If the experts can neither agree on an exact definition of Lean philosophy nor how best to implement this elusive philosophy, then there is little purpose in our spending a great deal of time discussing the various theories concerning implementation. Therefore, it seems logical for us to look at Lean from a very simplistic, but highly usable, point of view where our philosophies are best quality, lowest cost and shortest delivery times. This means as we go through the various activities making up the logging process, we will always be seeking to maximize quality, lower cost and flow material in the most efficient manner. From this perspective, we can define the elements of our plan to implement Lean based on the following:

**1.** ***Quality*** - Our desire is not to manufacture quality into the log so much as it is to capture the value that nature has already put into the log. Every tree already has the log in it. The logger must have the capability to recognize the maximum quality log or logs that the tree can provide and then flow the tree along a production process, which will capture that quality. Everything that the logger does improperly (make the wrong cuts or cause damage to the log) reduces the quality of the log. We will use our Lean implementation tools for the purpose of empowering the logger to recognize and capture the true value of standing timber.

**2.** ***Cost*** - There is an old saying that, "you can make the best product in the world, but if you cannot sell it for more than it cost you to make it, you really have made nothing." Our Lean philosophy calls for us to do nothing that does not add value to a log; and for those things that do add value, we want to reduce the cost as much as possible. Common sense tells us that we cannot eliminate all of our non value-added activities. To do so would require us to move the sawmill into the forest. We can, however, layout our harvesting plan in the most efficient form, select the right equipment and operate in the most efficient method. Our Lean tools can help us determine how best to proceed.

**3.** ***Delivery*** - A survey was made of manufacturing companies that purchase components for their products from other companies. When asked what their top three criteria were in selecting a supplier they responded, "on-time delivery, quality/service and price." On-time delivery must be a major driving force in our logging operation. This means getting the logs to the mill on time, and also harvesting the logs in accordance with the landowner's expectations. Remember that logging is as much about rendering service to the landowner as it is providing a mill with logs.

## Essential Elements of The Master Plan

Quite frequently a manufacturing company will become interested in Lean and Six Sigma and immediately hire a consulting firm to train them in the art of "Lean Manufacturing." The consulting company talks about how the company will soon be reaping the benefits of Lean and, to be truthful, they probably will have a great training program. During the short time that the consultants are in the factory, the company becomes a regular beehive of activity with team building, kaizen executions and such. There is generally a lot of speech making, hand waving, banner hanging, team meetings and shuffling equipment around the factory floor. But, all too soon the consultants leave and people get caught up in "just getting product out the door." Team leaders and managers are forced to delay Lean projects so that they can handle more pressing emergencies. They have every intention of getting back to the Lean project, but they have just got to put out the fire first and then go see where all the other smoke is coming from. Finally, when the dust settles and things are back to normal, management is left wondering, "where is the Lean beef?"

The best training in the world, executed by the most skillful trainer, is a waste of time and money if you do not have executive commitment and careful implementation planning. There is not one single company in the timber industry that can afford to let itself get caught up in the euphoria of "Lean". Lean is a truly excellent philosophy and it will work for almost any operation. But, you must take the time required to learn about Lean Value-Added principles and you must care fully plan for its implementation in your business. It would be very easy to show on paper that it is more logical to use a forwarder with roll-off bunks than it is to use a skidder and knuckle-boom loader / log truck. The truth is, however, that Missouri terrain would severely limit forwarder use. And, there certainly are no sawmills wanting to deal with roll-off bunk, even if there were such a thing. It would be a foolish company that listened to a Lean pitch and then went out and borrowed the money to buy and build such equipment because they thought it would be a good Lean Value-Adding tool for their operation. The implementation of Lean philosophy is not something you run out and do. The first thing you do in the implementation of Lean is careful planning.

Careful planning is absolutely necessary because there are almost as many processes for implementing Lean as there are Lean practitioners. If you boil down all of these methods, however, you will find that every single one of them contain two major phases: preparation for Lean implementation and Lean implementation itself. Most consulting companies excel in the preparation phase. After all, training people in the art of Lean principles is much easier than firmly rooting a company in the processes of continuous Lean improvement. There are numerous roads that lead a company to establishing a Lean culture, but success on any of the roads requires careful planning and implementation.

In some ways, planning and implementing Lean is just like planning and racing in the Daytona 500. You don't just hop into the family car and drive down to Daytona expecting to race in the 500. If you want to race then you have to be willing to commit to the time and resources required. In getting ready to race, you will have to plan for those activities required prior to entering the track and then you will have to plan for the activities required in circling the track many times (see Figure 1on next page). If you are going to run in the Daytona 500, you must prepare the driver, the pit crew and the car. In preparing to enter the Lean track you must prepare the leadership, the workforce and the Lean tools. At the 500, you will also have to plan for keeping the car on the track lap after lap. To do this, you plan for fueling, tire changes, driver needs and many other activities. Once you are on the Lean track, you will also have to plan for those activities

required to keep you on the track. You will have to monitor our value stream, communicate planning activities, manage change, measure your progress and plan for the next lap. You cannot win the Daytona 500 without a careful race plan, you cannot win on the Lean track without careful planning and skilled implementation.

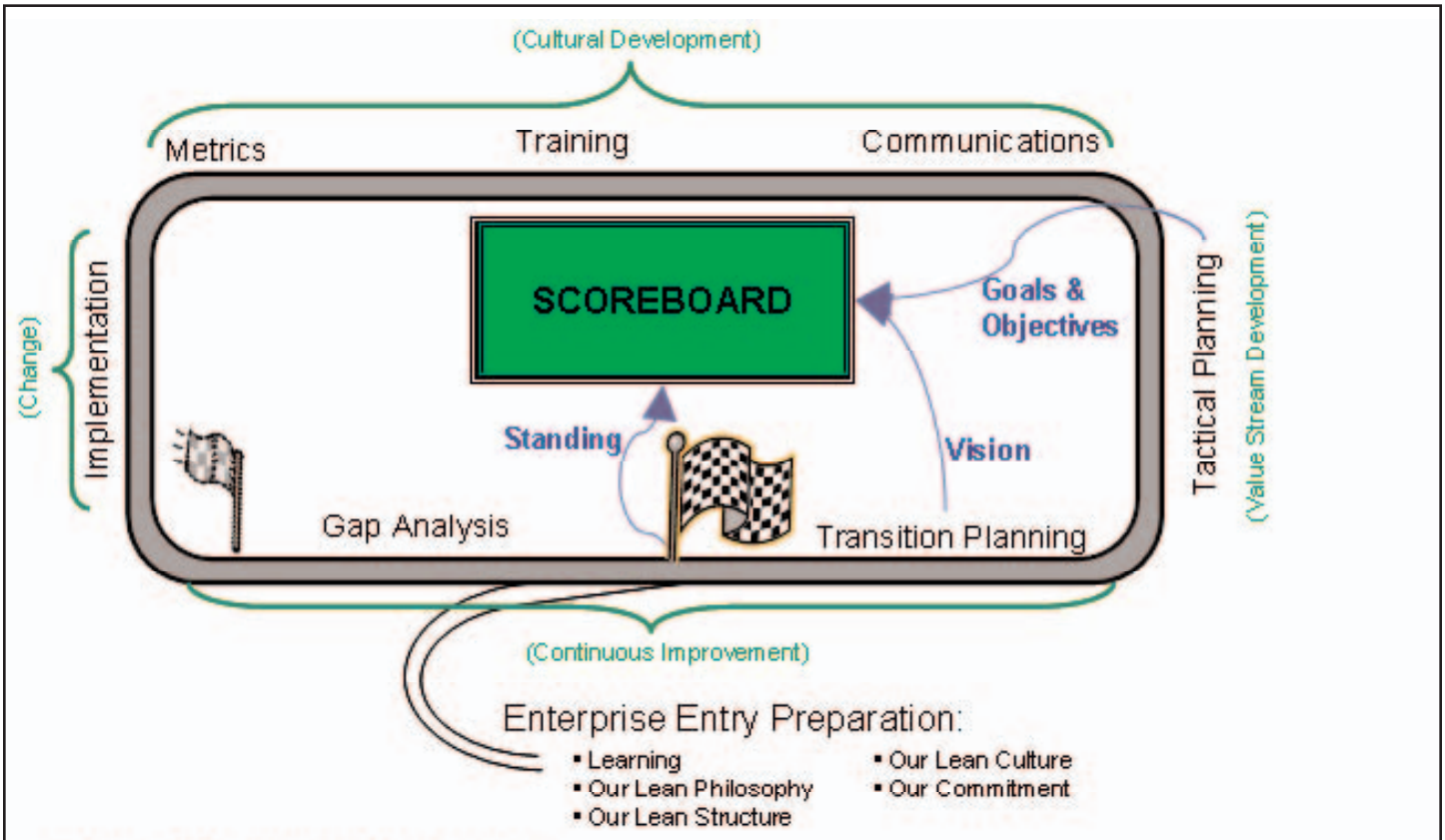

Figure 1: The Lean transformation track

In general, the 2 basic steps in Lean transformation can be summed up as follows.

### 1. Prepare The Company To Enter The Lean Continuous Improvement Track.

A company cannot just call in a consultant to give them training and instantly turn into a Lean company. To capture the true benefits of Lean, a company must be willing to take the time to prepare to enter a continuous cycle of Lean transformation and improvement.

***a. Training*** - You must learn what Lean is and about the tools used in implementing Lean.

***b. Know Yourself*** - Take the time to figure out who you are and understand your company structure and its culture.

***c. Vision*** - You have to develop a vision with obtainable goals and objectives. Each lap must have a finish line and support preparing for the next lap.

***d. Change*** - You are not now Lean. To become Lean you will have to change. Change is not easy so be prepared to face problems.

### 2. To Stay on the Track a Company Must Commit to Lean Philosophy

Implementing the Lean paradigm requires revisiting every assumption, practice and process associated with customer interactions, product design, production, quality assurance, human resources, work supervision, organizational structure, business systems and supplier relations. We must learn to do business, behave and see value in fundamentally different ways.

Once a company has entered the Lean track, there are four activities that will be repeated as long as the company has a continuous improvement focus. These are process flow, cultural change, implementation and continuous improvement.

***a. Focus On The Value Stream Flow*** - A primary concept of Lean thinking is that all the actions and resources of a company should be focused on *creating value*. Any action or resource expenditure that does not contribute directly to the goal of creating value is waste and should be eliminated to the greatest extent possible. Value stream definitions and analysis will identify those areas where you will get the most "bang for the buck." During each lap, concentrate on these areas and don't let the company's attention wander into areas you are not prepared to tackle.

***b. Develop Lean Structure And Culture*** - Both

the *organizational makeup* and the *way a company* thinks and acts will have to change if the company is to truly recognize the benefits of Lean. A Lean Track creates the mental model and conditions necessary for the implementation of Lean principles and practices. Incentives, structures, systems and policies of the company must be aligned with the desired behavior. Every one of these principles are applied, evaluated, re-engineered and re-applied over and over again in a quest to continuously improve. Probably the most difficult change that a logging company will have to make is re-evaluating the role of quantity verses quality. In other words, the value of a load of logs is more important than the volume of that load.

***c. Implement Lean Initiatives*** - It is here that the changes in practices and procedures are actually implemented. We can say that value is more important than volume, but what are we doing to make this a reality. We can say that it is necessary to minimize the amount of time taken to service a chain saw, but what have we done to provide the logger with tools and equipment to make the job easier. For example, would providing the logger with an ATV increase the logger's efficiency?

***d. Focus On Continuous Improvement*** - At the close of each lap, the results of the changes we have just made are measured and assessed. Our plan called for providing the logger with an ATV to minimize the amount of time spent walking to get fuel and service the chainsaw. Did it work?

Has the logger's output in both volume and quality improved enough to justify the ATV? Did we choose the right style ATV? What can we do to further improve operations? Our answers become input for the next transformation plan which will be executed in the next transformation lap.

## THE TWO BASIC PROCESSES OF IMPLEMENTATION

### *Introduction*

We have spent a great deal of time talking about the art of planning before starting the process of re-engineering a logging company with Lean Value-Added principles. Now that the planning is over, the actual implementation can begin. The first key activity will be to map, on paper, the all the processes associated with a logging operation. The full collection of these process and information about what is happening at each step in the process is the "Logging Value Stream" and the map we produce is called the "Value Stream Map" or VSM. There is a basic VSM for logging, which will be true for logging operations in general and will help us identify areas in our general operation that need attention or perhaps even change. Each new logging project, however, can add features and requirements to the logging

process, which may require generating a new VSM for the specific logging operation. As stated earlier, re-engineering a company is a never ending process of continuous improvement and a company should expect to do and redo their logging VSM.

The second key activity, associated with re-engineering a company under the Lean Value-Added philosophy, is to identify waste and use Lean tools to eliminate or at least minimize it. The eight basic wastes associated with any process and the 13 tools used to combat waste are covered in detail in the first Technical Report entitled: "Increasing the Competitiveness of Missouri's Hardwood Producers: An Introduction to Lean Enterprise Principles for the Timber Industry," (TI1011204). In this Technical Report, we will evaluate individual logging activities from the perspective of Lean and discusses methods for improving each activity.

## Value Stream Mapping

Value Stream Mapping (VSM) is the process of visualizing, on paper, all the "things" that have to be done to make "something," and recording information about how each "thing" is done. For the logging industry, the "something" being made (product) is a log and some of the "things" being done (processes or activities) are falling, trimming, bucking, etc. In creating a VSM for logging, we will be mapping out the processes required to transform a tree into a saw log, which has been delivered to the customer, probably a sawmill. We do this not because we do not understand the process flow for turning a tree into a log. Rather, we are conducting this exercise so that we can view the process in a different way, with a different set of reasons and by thinking about the general concept of what each "thing" does to increase the value of the log.

In most factories, application of the VSM will serve as a starting point to help management, engineers, production associates, schedulers, suppliers and customers recognize waste and identify its causes. The process includes physically mapping how the factory is presently set up (current state) and then mapping the factory the way the company wants it to be in the future (future state). This "future state" map will become the master blueprint for the continuous process of eliminating or at least reducing the number and degree of wasteful processes and activities. The collection of activities associated with making changes in how things are done is often referred to as, "implementing Lean improvements." The VSM helps us determine where to start Lean implementation and it also gives us a picture of where we want our Lean journey to take us.

In this exercise, taking a value stream perspective means working on the big picture of logging, before we start working on the individual processes. It is important to realize that at this stage, we are not saying that anything needs to be changed. Our goal is simply to understand what is happening in the logging process from a "what adds value to the log" and "what does not add value to the log" point of view. Mapping the log's value stream is one way for us to start "thinking outside of the box." It is a tool to help get us away from the concept that "logging is different" or "we have never done it that way" or, even worse, "it won't work!" We will map the value stream for logging so that we can see the big picture from a different vantage point.

For logging applications, Value Stream Mapping is not something that each company has to do. It is done here as an exercise for the purpose of generating data and to support our understanding of how Lean principles relate to logging and to the entire timber industry. After all, the logging VSM is only one piece of the timber industry, which is itself made up of numerous individual value streams. As we begin to build the logging VSM, we need to remember that the logging VSM comes after the forest management VSM and it comes before the milling VSM. We could say that the logging VSM is also part of the local, national and global timber marketing value streams. Our main goal in building the logging

VSM is to lay the foundation for implementation of Lean principle, but we will also use our map to predict how the overall timber industry may be changing in the future. Therefore, the logging VSM format we will use here is generic and can be applied to all logging operations.

The basic principles of the Lean philosophy are to maximize the value adding capability of every resource and activity, eliminate or minimize all non-value adding resources and activities, empower the workers and control operations based on customer expectations. To be quite honest, we will probably find that VSM reveals logging to almost be a naturally occurring Lean manufacturing process. In most cases, there are a minimum number of resources utilized in logging. In most good logging companies, employees are crossed trained and take the initiative to do what ever needs to be done. Logging maximizes the use of visual controls and requires empowerment of the operator. No one has to tell the skidder operator what tree to skid or when to skid it. A trimmed log is the visual command to move it. Much of the Lean philosophy is a natural way of working for logger, but we can still look for ways to add value and eliminate waste.

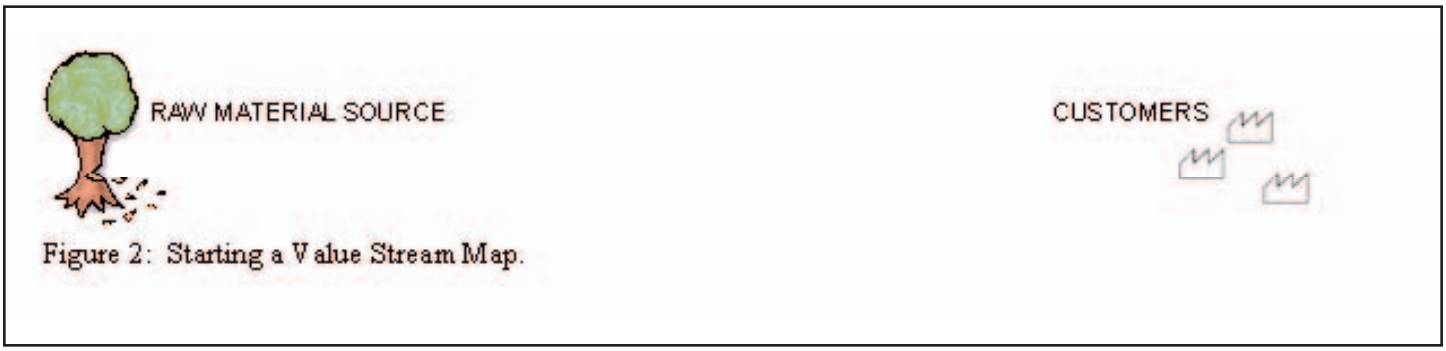

Figure 2: Starting a Value Stream Map.

The first step in constructing a value stream map is to start at both ends. The raw material source on the left and the customer plotted on the right (see figure 2). In industrial VSM exercises, the source of raw materials has to be transported to the factory and it often comes from another factory. Our logging operation is different. The source of raw material is the forest and logging takes place in the forest. Also, in manufacturing, we tell the company providing us with raw material what to bring, how much to deliver and when to bring it. In the timber industry, we select our own raw material and haul it ourselves. The only communication taking place, relative to the raw material source, will be with the landowner. The landowner will control what raw materials (type, size, location, etc.) are to be harvested. The customer will be some form of milling operation. Actually, a good independent logging company will probably service multiple mills and perhaps even log buyers. This will enable matching product types with specific customer requirements thus maximizing the value of the product.

The next step in generating the VSM is to list every process that a tree must go through to become a saw log, which is our finished product for the logging operation. For example, the most common sequence of operations would be as follows.

- cutting or falling the tree,
- trimming the limbs from the tree,
- topping the tree,
  - skidding the log to a central location,
    - cutting the log into marketable saw logs,
    - loading the saw logs onto a truck and
      - hauling the saw logs to a mill.

In order to build our value stream map, we will need to record information about each one of the processes in our list of activities. The exact nature of the information that we will need is not explicitly defined because it will be dependent on the type of operation being mapped. In general, however, you will almost always need to know:

- the name of the process,
- how long the process takes (its cycle time),
- how many people are working on the process,
- how many pieces are worked on during one cycle (batch size)
- how much of the time is needed equipment available at a specific process.

Figure 3 is an example of how information about a specific process is recorded on a value stream map. The top information box is the name of the process, in our example is skidding. The second box from the top indicates that process only requires one operator. The third box (cycle time) tells us that, for the specific operation, it takes 10 minutes for the skidder to make one round trip. The fourth box (change over) is left blank because there is no equipment change over to be factored into this process. If we were plotting data for felling trees we might consider the time it takes to move from one tree to the next and prepare for cutting to be change over time. In the skidding process, the number of logs hauled in each trip (batch size) averages out to be 5. Our last box tells us that 90% of the time that the logger is in the woods he is felling trees (up time). This is a very elusive number and one that probably will be very hard for us to find a use for. You will also notice a small triangle located to the upper left of the information boxes in Figure 3. The triangle signifies that the skidding operation is feeding an inventory location where the average amount of inventory is 10 saw logs, the number below the triangle. When it comes to putting

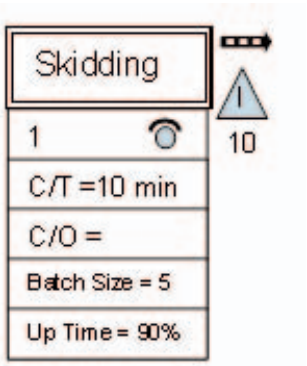

Figure 3: Process Info

the final touches on your logging design, these inventory levels, called Work In Progress (WIP) can be critical to the process. Too much and you are wasting money. Too small and you are starving the operation. The number of information boxes you will use in documenting data about each process in your logging operation is up to you. IF you feel that it is important to have more information than shown in this example, just add more boxes. The numbers used in this example are not intended to reflect those that you might find in a real logging operation. They only illustrate the concept of documenting process information.

Once each process is identified and pertinent information determined for each process they are laid out in the proper sequence of operations (see Figure 4). In our example, cutting or felling is staying 10 trees ahead of the trimmer, the trimmer is staying 5 logs ahead of the skidder, the skidder is staying 10 logs ahead of bucking and bucking

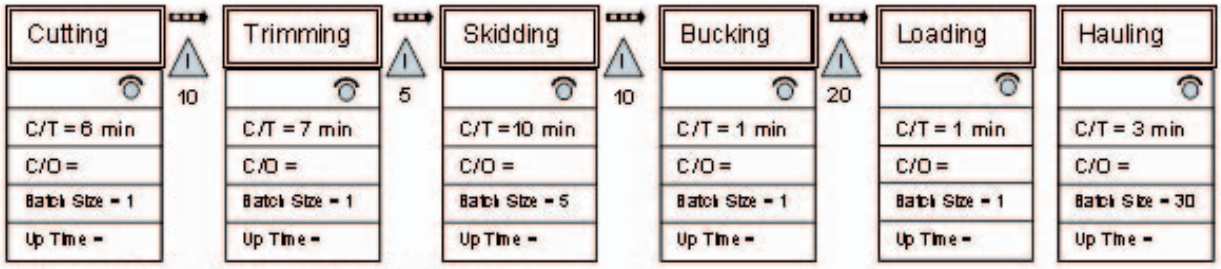

Figure 4: The sequence of logging processes

is staying 20 saw logs ahead of loading. There is no triangle between loading and hauling because there is no WIP between these two operations. The solid arrows with holes in them are located between processes to indicate that the process to the left is pushing the process to the right. In the theoretical Lean world, we would want the process on the right to be pulling product from the process on the left. In other words, you don't cut a tree until the inventory level between you and the trimmer drops to a predetermined level. In the same way, a skidder operator would not skid logs unless there was a visual indication that the person bucking needed more logs. This is a perfect example of where theoretical Lean principles will not work in the real world and we must use common sense in our Lean implementation.

The next step in mapping the value stream is to generate a plot of value-added time verses non value-added time during the logging process. A careful consideration of the processes in logging will reveal that there are only 3 logging processes that add value to our product: felling the tree, trimming/topping the tree and bucking. The rest of the time the product is either being moved or it is waiting to be moved. We can plot these times underneath our processes as shown in Figure 5. From a purist perspective, we have simplified our 3 value added process by including the time it takes to move from tree to tree or log to log into our cycle time. One could argue that only the time taken to actually cut the tree should be considered in determining cycle time. On the other hand, too much detail can render VSM meaningless. Remember to use common sense in all phases of Lean implementation. IF the situation warrants breaking out moving between trees and calling it change over time, then do it. In any event, the main purpose here is to document the current ratio between non value-added time and value-added time. In our example 8.2 hours are non value-added and 14 minutes are value-added. This may seem to be a poor ratio but from a classical manufacturing perspective it is not too bad at all. Some manufacturing ratios can be days verses seconds. However, we are spending over 30 times more in non-valued-added activity than we are in adding value to our product. This means that cut-

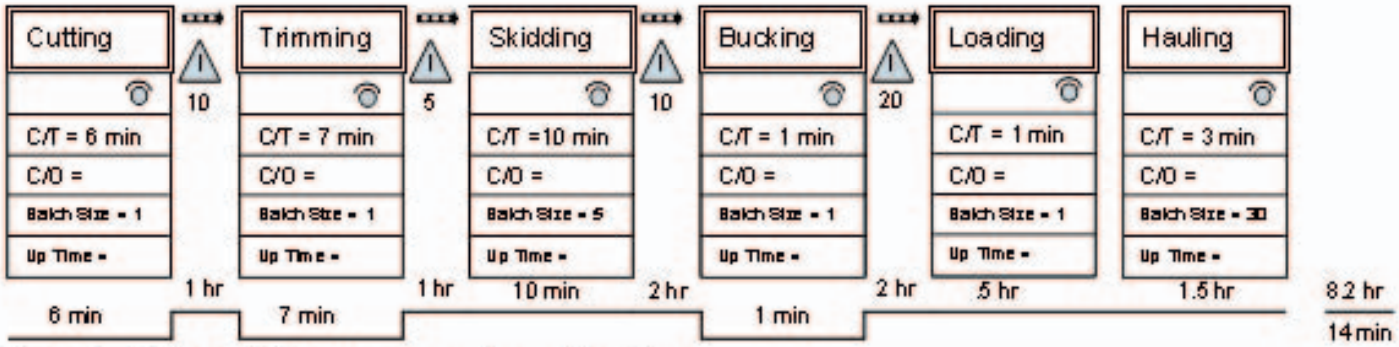

Figure 5: Value-added verses non value-added time.

ting, trimming and bucking are the processes most critical to capturing the true value of our raw material, a standing tree. This is not to say that the other operations are not important, because they are. It is just that the other operations cannot add value. All they can do is cost money to perform and diminish value if the process damages the log, which often happens in the skidding and loading processes.

Now that we have documented our processes and arranged them in their sequence of operations it is time to fit them into the overall logging operations. In constructing our value stream map, we start with the raw material plotted at the left and then added processes in sequence until the finished product is produced (see Figure 6). Each activity or process in the value stream is mapped with a process box under which is placed all the things about that activity or process to include processing time. The complete value stream has now been graphically represented and its process information documented. Appendix A contains a listing of the graphic symbols we have used in generating the value stream map.

At this stage of value stream mapping, we identified where our logging process starts, what

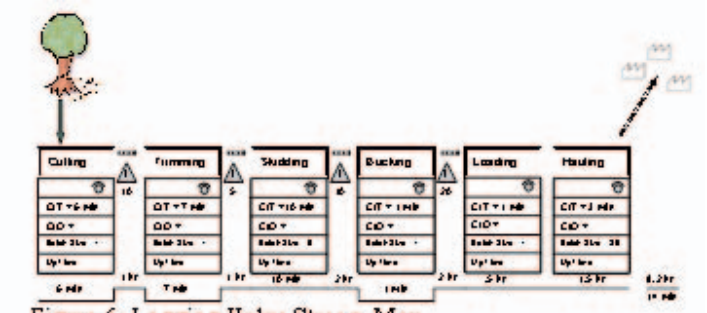

Figure 6: Logging Value Stream Map

happens throughout the logging process and where the logging process ends. What we do not know is how all of this activity is controlled. In logging, there are two direct controlling factors (landowner & mill) and one indirect controlling factor, the weather. Operational directives and requests come from these three sources to the production controller, which is probably the logging foreman or superintendent. Production control evaluates what the landowner wants, in light of what the customer requires, and schedules the logging operation based on this information and weather projections (see Figure 7). In most cases, production control signals are passed to the felling crew telling them where and what to cut. Production control signals are also passed to the truckers telling them what to haul and where to haul it. In a theoretical Lean "pull" process you would only have production controls coming to the truckers as they removed saw logs from the landing, which would signal the bucker to cut more saw logs. The bucker consuming logs would signal the skidder to go get more logs and the skidder removing logs from the forest would signal the need for the feller and trimmer to produce more logs. Theories can be good. Right now, however, we have documented the processes for a logging value stream that is "pushing" the product.

In most classical manufacturing applications the first Value Stream Map generated is a realistic look at the current state of the factory using real data and information, which has been gathered from the current process. The next map that a factory produces is one that shows how the process should look in the future. In this "future state" value stream map the objective will be to reduce the non value-added time verses value-added time ratio as much as possible. A predominate objective in lowering this ratio is to flow material from the beginning to the end of the process without having any WIP in the process. In developing this new process, it is also common to try to develop a means to control it through the concept of pulling the product through the process rather than pushing it. These are excellent objectives, even for

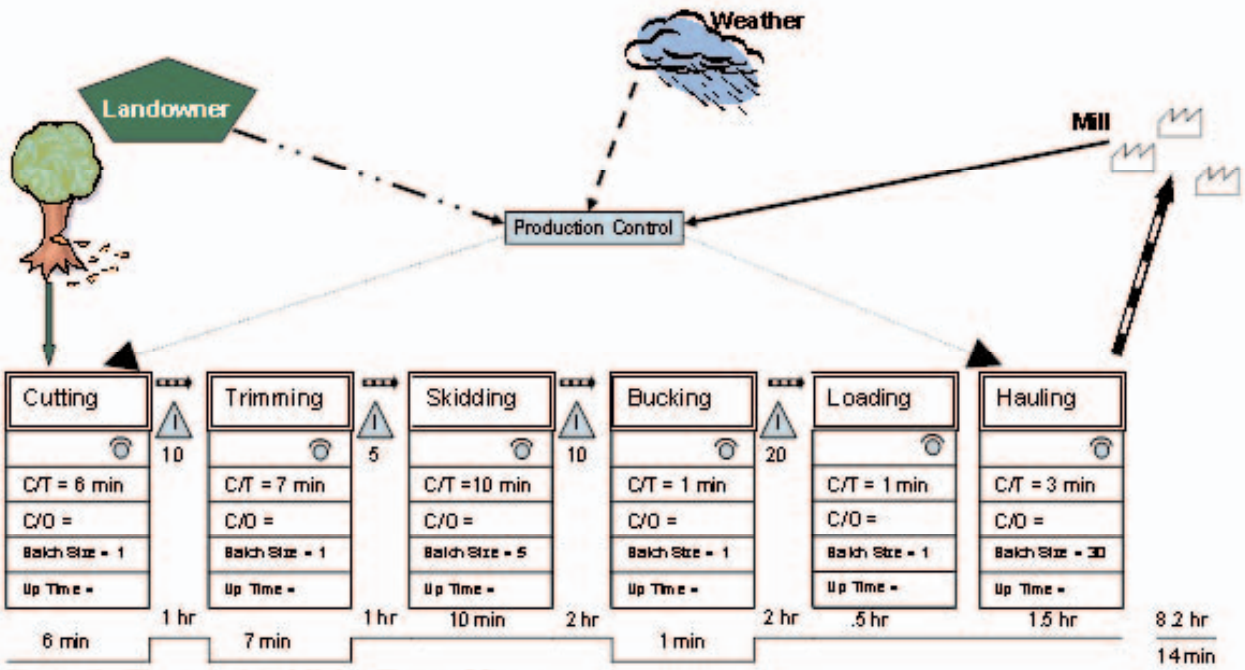

Figure 7 The completed Value Stream Map

logging, but they must be executed with common sense. Remember, theoretical goals only contain the objectives that we try to reach … the uniqueness of the process and common sense control how close we get to these objectives.

## Value Stream Analysis

The Value Stream Map has given us our first analytical look at where we are and where we want to be. Now we will use the map to plot the changes (kaizen events) we plan to make in our system to get where we want to be tomorrow. In our logging example, we have identified 6 basic processes associated with harvesting trees. The VSM is an excellent process for understanding how these 6 events relate to one another and how their operations are interdependent and impact the cost of logging. The VSM is truly the starting point for our analysis of logging, at least from a Lean implementation point of view.

For our VSM, we can consider our product to be logs. In reality, this product can be further divided into product families based on the type of tree and grade of the log. For our study, the first thing we will do is to determine our production volume and investigate how it flows through the process. In this analysis we will investigate 5 key areas:

**1.** Calculate Takt Time. Takt time is the average time it takes to manufacture each production unit relative to the number of units the customer demands per day. To calculate our operational takt time, we divide the available time in a day by the required number of units we must produce to meet the customers demand. For example, let us assume that the mill to which we are selling requires 9,000 board feet of oak per day. For the timber stand that we are going to be harvesting, we know that each truck load will average about 30 logs or about 2,250 board feet. This means that the logging company will have to produce 4 truck loads per day. This calculates to be 120 logs or 9,000 board feet. If the crew starts at 7:00 am and works until 3:00 pm, they have 480 minutes to produce 120 logs or 4 minutes to produce a log. Before you say that it cannot be done … remember we have not yet determined the size of the logging crew or the equipment they will use.

All we are doing is translating the customer's requirements into the takt time for our production system.

**2.** Determine Material Flow. The flow path for producing a log starts with the tree. The tree is cut (value has been added) and left on the ground waiting to be trimmed. At this point, the tree is Work In Process (WIP) and no value will be added until it is trimmed. Once the tree has been trimmed (value added), it becomes WIP waiting for the skidder (no value added). Once the log has been skidded to the log landing (no value added), it once again becomes WIP (no value added). Eventually the log will be cut into prescribed lengths (bucked) (value added) and again it becomes WIP. Finally the logs will be loaded onto a truck and hauled to the mill (no value is added). It is very important for us to view our material flow from a value added verses no value added relationship and compare it to the times we calculated in our value stream map.

**3.** Analyze Value in the Flow. The value stream map reveals the amount of time spent adding value to the log and the amount of time the log has spent waiting or being moved. In our example, a log will spend 14 minutes having value added, but 8.2 hours in non-value added time activities. Our first inclination is to get rid of the WIP. But, before trying to do the obvious, let us first spend a bit more time looking at log value and the processes in our VSM. The table below is one way of doing just that. For every waste, both process and operational, you must identify a solution. For example, if pulling fiber from the butt cut has proven to be a problem for a specific feller, then a reasonable solution would be to retrain the individual in using a bore or plunge cut for felling a tree (see Figure 8). Although a slower and somewhat more complicated method for felling a tree, the bore cut probably offers the best option in elimination of fiber pulling. The cut is also one of the safest cuts you can perform. The Logging Value Matrix is one of the best ways to evaluate the processes in your value stream and identify problem areas. As shown here, it only contains a few examples of the types of activities

**LOGGING VALUE MATRIX**

| PROCESS | SOURCE OF PROCESS VALUE WASTE | OPERATIONAL WASTE |
|---|---|---|
| Cutting | pulling fibers from butt log | time when tree hangs up |
| | splitting butt log | moving from tree to tree |
| | improper butt cut | sharpening chain |
| | breakage of upper log | refueling |
| | cutting the wrong tree | fighting brush |
| Trimming | leaving limbs to long | wrong trimming sequence |
| | topping to short | moving from tree to tree |
| | topping to long | sharpening chain |
| | cutting to deep into the log | refueling |
| | | fighting brush |
| | | waiting for trees |
| Skidding | chunking log with grapple | taking too long a route |
| | damaging log end by dragging into objects | waiting for logs |
| | damage from dragging log against objects | using wrong pickup sequence |
| | | operating vehicle too rough |
| Bucking | improper cut placements | moving from log to log |
| | damage logs in handling | moving logs |
| | | sharpening chain |
| | | refueling |
| | | waiting for logs |
| Hauling | damage logs in handling | waiting for logs |
| | | using long route to mill |
| | | operating vehicle too rough |
| | | |

that can be identified and is not intended to be a complete listing.

**4.** Find the Bottlenecks. A takt time of 4 minutes per log means that each process must have a per log cycle time of 4 minutes or less. The most logical place to start looking for bottle necks is from the right side of our logging VSM. Hauling is almost always the longest cycle time and is dependent on the distance to the mill. In our example the hauling cycle time is 90 minutes, well over our allotted takt time of 4 minutes. But, we are hauling 30 logs! If we divide 30 logs into 90 minutes we find that our, per log, cycle time is 3 minutes and is well under our 4 minute takt time. Bucking and loading both have a cycle time well under 4 minutes. The skidder has a cycle time of 10 minutes, but hauls 5 logs at a time so the, per log, cycle time is 2 min or half our takt time. The feller and trimmer have cycle times within our takt time constraint but when we include the "change over" (time to move from tree to tree) their cycle times are in excess of our takt time. Here is where we can expect to find our bottleneck. If our calculations are correct, and if we are going to meet the takt time required to get out 9,000 board feet per day, we will have to make some changes, perhaps adding additional resources or equipment. Another logging bottleneck can be in skidding. If landowner or environmental constraints limit the number and location of log landings, skidding trails can become excessively long. You could add more skidders, probably not a wise choice from an environmental perspective, or you could consider using a forwarder. The point here is not to state solutions, but to show how the VSM can be used to document and put real operational values on the logging process. The VSM is an aid in finding bottlenecks and shows them relative to the big picture.

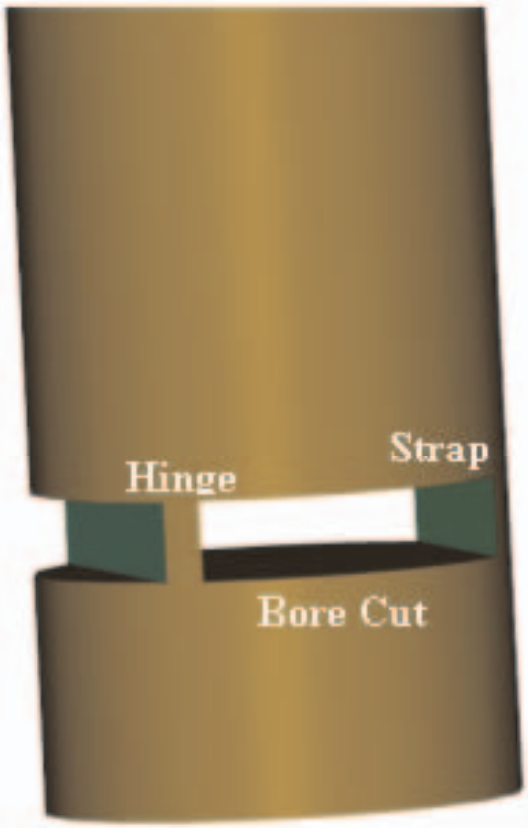

Figure 8. Plunge or bore cut.

**5.** Solution Sets (Kaizen). The real value of the VSM is in using it to help us to initially focus our Lean implementation project on key tasks and to keep us from getting overwhelmed by too much detail. The value stream map has enabled us to visualize the flow of our product from the standpoint of what will add value, what does not add value, where quality can be lost and where operational costs need to be controlled. It is now time to use this information in determining what we are going to do to become a more efficient and customer focused operation. To do this we select projects, call Kaizen Events, to find solutions. In our example, there are three processes where we spend considerable amounts of money, but we do not add any value to our product: skidding, loading and hauling. Thus, we may want to do a Kaizen event that involves recording our harvesting stands on a topographic map or aerial photograph. We can use this information to lay out the best plan for log landings and skidding trails. Even routes to the mill need to be selected based on time and equipment. As another example, our VSM shows that we have a bottleneck at the front of the process. We may want to do a Kaizen Event to address this issue. Then again, perhaps we know that our logging crew has had difficulty in producing the quality of logs desired by the mill. We could do a Kaizen Event to set new work standards and conduct training. The idea is to find areas of waste and fix them.

## Lean Implementation Principles for Logging Operations

### *1. General Operations*

***a. Customer Relations.*** Larger companies often have staff, or contract with a timber buyer, to search out and initiate the purchase of standing timber. For the smaller operator, they will have to assume the responsibility for marketing their services, cruising timber and negotiating purchasing contracts. Here, as in all other aspects of a business, there are reasons for applying Lean principles and implementation tools. The logger is responsible for being the middle man between the landowner and the sawmill. He must understand both of their expectations and bring the two sets of expectations together.

Probably the most important Lean philosophy in your marketing and sales effort is building customer relationships and putting in place mecha-

nisms to support channels of communications. Most logging companies will repeatedly sell to the same set of mills and log buyers and they will have probably developed good relationships with them. The odds that a logger will work multiple times with the same landowner are far less than using the same mill more than once. For this reason, it is very important that the logger make a concerned effort to develop strong lines of communication with the landowner. One excellent relationship building tool is for the logger to bring industrial information to the landowner regarding standard activities and processes associated with timber sales (see Appendix B for example data). If a logger will provide landowners with information, such as that found in appendix B, and if the logger will assist the landowner in following this marketing and sales advice, the logger will have established excellent lines of communication and begun a good relationship building program. Appendix C is an example of how a logger can document log sales and revenue sharing with the land owner. The best way to bring relationships to a close, at the end of the roject, is to have the landowner fill out a customer satisfaction survey (see Appendix D). This survey is your report card and for those loggers meeting landowner expectations this survey becomes an excellent marketing tool in getting future logging contracts.

***b. Logging System.*** It is very important to give careful consideration to selecting a logging method (system) that is compatible with both the timber and the terrain. The design of your logging system will control how efficient your logging operation will be. Again, the principle theme in developing a logging system is to keep the specialized logging process working in its particular niche as defined by the timber and terrain. If the logging system is applied in conditions for which it is not suited, harvesting costs and adverse environmental impacts will likely be high. For example, in mechanical felling, both tree size and slope are major factors. It is well known that mechanical felling is safer, more productive and less expensive than manual felling; however, in certain areas of Missouri our abundance of steep slopes limits the range of applications for mechanical felling equipment. A logger should first plot all of the harvesting stands for a particular logging track on a topographic map and determine the average slope for each stand. Now the proper logging system can be chosen for each stand and overall harvesting can be scheduled to optimize a mix of felling methods. Developing a Lean logging system requires careful evaluation of the terrain, timber, environment and available equipment.

***c. Logging System Layout*** - One of the best ways to visualize the logging operation is to work

with averages and consider the entire operation as a single manufacturing cell. Each harvesting stand can be treated as a modification to the cell to allow for economic production of a new product family. In this way, the average distance from the logging stand to the landing, methods of cutting, number of personnel and equipment can be adjusted for each stand and the overall process can be balance in accordance with the required takt time. To do this we will have to make a few assumptions such as:

- each log contains 2 saw logs,
- each saw log contains 50 board feet,
- each load of saw logs contains 2,300 board feet or 46 saw logs,
- the skidder hauls 4 logs at a time and
- our logging crew cuts 3 loads or 6,900 board feet per day.

We have also assumed certain cycle times for each operation and, if we further assume that these are valid for a specific harvesting stand, we can use the numbers in balancing our new manufacturing cell (see Figure 9). Based on this data, the truck driver sets the pace for our daily operations with a 2 hour cycle time for the process of: loading-hauling-unloading-returning. This means that the remainder of the logging crew must produce an average of 32 logs every 2 hours, which is equivalent to 32 trees per 120 minutes. In balancing our logging workload for this timber stand, there is a possibility that we can combine the skidding and bucking operations. If these processes fall behind we can have the trucker assist with the bucking process. The two processes that are going to give us problems are felling the trees and trimming them. Tree felling will be running 72 minutes behind schedule (192-120) and trimming will be running 104 minutes (224-120) behind. This is a combined time of 176 minutes and it will require almost 1.5 additional persons working in the felling and trimming processes.

The point being made is not that you need 5.5 persons to produce 6,900 board feet of saw logs per day. In a good timber stand it is not unusual for a 3 man crew to produce at this level. This illustrates a method for balancing the workforce for a linked sequence of operations, which in manufacturing is often called a manufacturing cell. For a logging company, this same technique can be used to determine the most probable workforce needed to harvest a new stand of timber. Based on the terrain and harvesting method an experienced logging superintendent will be capable of predicting the times and numbers (see Figure 9) and thus balance the workforce with the situation.

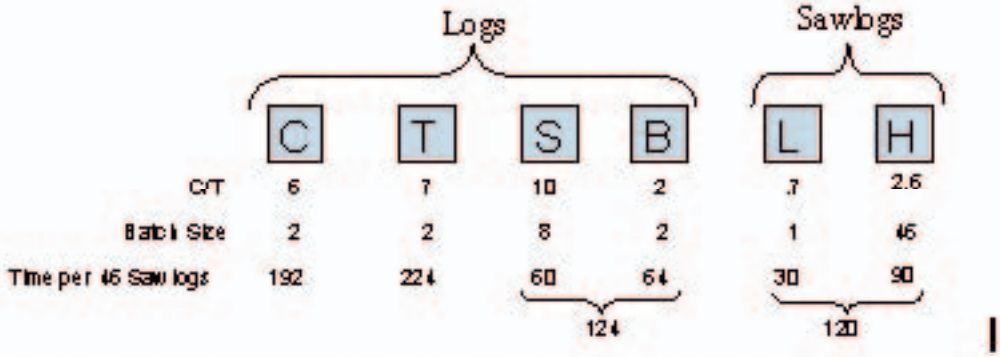


Figure 9: Manufacturing cell or harvesting stand resource balancing.

## 2. Specific Logging Processes

***a. Felling and Trimming*** - In much of the timber industry, the process for cutting hardwood timber has not changed significantly in over 200 years. Originally 2 men approached a tree carrying a crosscut saw and an ax. The tree was notched and then sawn down. Today, one man approaches the tree and it is notched and sawn down. The number of people performing this process has changed, the technology of tools used in the process has changed, but the basic procedure remains the same. It is only in a small portion of the industry that you will find large mechanical systems replacing the man. Where these systems can be employed, however, the process of felling trees is significantly more efficient and safe than the manual process. It is certainly recommended that a logging company evaluate their average harvest volume to determine if it will support purchasing a mechanical system for felling trees.

An important point to take into consideration is the fact that in most classical operations you cannot separate felling from trimming because the same individual does both processes. When you

employ a mechanical system you will have to make modifications in your felling/trimming operations. The mechanical system will require a skilled operator and it will produce felled trees at a cycle time that is much faster than trimming. In the right terrain and timber, it could take 5 to 10 trimmers to keep up with one mechanical felling machine. Adding a mechanical felling system to our logging operation will have quite an impact on our work cell model in Figure 9.

The addition of a mechanical felling system or remaining with the classical manual method for cutting trees will impact operations but it will not change the need to evaluate all 13 Lean tools. The table below is a compilation of the 13 tools and the potential level of impact they could have on the felling process. The application of Standardized Work principles will have an impact on felling trees just as it will impact almost every process. Appendix E contains a brief explanation of what Standard Work is and how to generate standardized work techniques for any process.

A second Lean tool that will find some level of application in almost every logging process is *Workplace Organization*. Workplace organization simply means that every tool and every part has a place and that they are in their place. In the felling and trimming procedures, there is not much to the workplace that can be organized other than placement of chainsaw fuel, lubrication, and tools. Still, having these materials where you need them and when you need them will increase efficiency.

A very close companion to workplace organization is *Point-Of Use Storage*. In classical manu facturing applications this most often refers to the parts and pieces required for assembling a product. In logging, point-of-use storage can also apply to the items required to support operations. If you provide a means for the loggers to keep fuel, lubrications and other equipment close to the working site, you will reduce time wasted in traveling to and from remote storage locations. An old used ATV, which has been modified to carry everything that a logger will need during felling and trimming operations, will pay for itself many times over in reducing wasted travel time and it will also dramatically reduce the impact of fatigue on the workers.

The two Lean implementation tools that will have the greatest impact on the felling and trimming, as well as all other aspects of logging, are *Quality at the Source* and *Total Productive*

*Maintenance* (TPM). Quality at the source is a work ethic that requires every operator, at every process, to be responsible for the quality of every product coming to his process and to also be responsible for the quality of every product leaving his process. In essence, you never accept a bad part from the person supplying you with parts and you never pass a bad part on to the next process. Total productive maintenance supports quality at the source by requiring the operator, at every workstation, to be responsible for the operational quality of their equipment. Implementing these Lean tools means that a feller will not consistently leave trees hung up for the trimmer to deal with. It also means that the feller and trimmer will know how to work on their own chainsaws and thus they are responsible to keep them in peak operating condition.

***b. Skidding -*** In the table for skidding, Lean implementation tools for *Standardized Work, Workplace Organization, Point-of-use-Storage, Quality at the Source* and *TPM* have the same application as they did in Felling and Trimming. From a Lean implementation perspective, it is also very important that all skidder operators are trained to skid in the same way. Riding around in a skidder is wasted time and motion, unless directly linked to the process of moving logs to the landing. A very important part of this is the layout of skidding trails. The land should have been walked and plans made for each and every skidding trail. Building skidding trails on-the-fly or when you get there will never produce the same level of efficiency as taking the time to plan the *Layout* and then follow the plan.

| FELLING & TRIMMING LEAN IMPLEMENTATION TOOLS | |
|---|---|
| **Lean Tool** | **Impact Level** |
| *Standardized Work* | Impact |
| *Workplace Organization* | Minor Impact |
| *Visual Controls* | No Significant Impact |
| *Cellular Manufacturing* | No Significant Impact |
| *Layout* | No Significant Impact |
| *Workforce Development* | No Significant Impact |
| *Batch Size Reduction* | No Significant Impact |
| *Quick Changeover* | No Significant Impact |
| *Point-of-Use Storage* | Impact |
| *Quality at the Source* | Significant Impact |
| *Pull/Kanban Systems* | No Significant Impact |
| *Takt Time* | No Significant Impact |
| *TPM* | Significant Impact |

Probably the most critical Lean implementation tool for the skidding process is *Quality at the Source*. Although skidding is a non-value adding process, it can be a significant value reducing

operation. The skidder operator can pick up a quality log, perhaps even veneer quality, and by the time he gets it to the log landing he has reduced the log to a tie log or worse. All the operator has to do is drag the butt of a veneer log into a large rock and split a 5 foot section to reduce a 10 foot

veneer log to one that will yield a few grade boards, but mostly pallet lumber. Dragging the same log too sharply around standing trees will peal the bark from the log and perhaps even damage the wood, thus lowering the value of the log. Even worse, the skidder operator will be leaving damaged trees in the harvested timber stand. Remember, building a Lean operation focuses on such activities as quality and customer relationships. The skidder operator is responsible for preserving the quality of both the log he is transporting and the land he is transporting it on.

The last and extremely important area that we need to cover is *Total Productive Maintenance*. Keeping a skidder operational is a demanding job and almost all of the responsibility falls on the shoulders of the skidder operator. To begin with, the people who designed and built the skidder knew what they were doing. It is highly unlikely that a skidder operator is qualified to change the operational design of a skidder. For example, a skidder will run without a water separator but it was not designed to run without one. The water separator plays a very important role in protecting the engine and it is required if the engine is to last as designed. In the same way, every fluid type and level have been carefully determined by the company building the skidder. It is the sole responsibility of the operator to see to it that the proper fluid is maintained at the proper level and changed on schedule. Every piece of equipment should have both an operator's log and a Preventive Maintenance Check (PMC) list that are kept current. It is also a myth that all heavy equipment leaks hydraulic fluid because they were designed to. Hydraulic leaks cost money in wasted fluid, contaminate the environment and they are a fire hazard to the skidder. Yes, leaks are a problem and they are a pain to stay on top of but they will only get worse unless fixed. We cannot escape the fact that every time a skidder is down for repairs when it is needed in the woods, money robbing waste is taking place in the overall operation.

***c. Bucking -*** Cutting a log or tree trunk into saw logs is the most critical value added process in the logging operation. No other process, except perhaps felling, has as direct an influence on log-

| SKIDDING LEAN IMPLEMENTATION TOOLS | |
|---|---|
| **Lean Tool** | **Impact Level** |
| *Standardized Work* | Impact |
| *Workplace Organization* | Minor Impact |
| *Visual Controls* | No Significant Impact |
| *Cellular Manufacturing* | No Significant Impact |
| *Layout* | Impact |
| *Workforce Development* | No Significant Impact |
| *Batch Size Reduction* | No Significant Impact |
| *Quick Changeover* | No Significant Impact |
| *Point-of-Use Storage* | Minor Impact |
| *Quality at the Source* | Significant Impact |
| *Pull/Kanban Systems* | No Significant Impact |
| *Takt Time* | No Significant Impact |
| *TPM* | Significant Impact |

ging profitability as bucking. Therefore the Lean implementation tool *Quality at the Source* is a mandatory part of re-engineering the value added aspect of bucking. In fact, the *Virginia Polytechnic Institute and State University, Blacksburg, VA* conducted a study entitled: An Applied Hardwood Value Recovery Study in the Appalachian Region of Virginia and West

Virginia. The abstract from the report on this study, written by Hylton J.G. Haynes and Rien J.M. Visser, is listed in its entirety: *"An analysis of log-making (bucking) performance for five logging crews in southern Appalachian mixed-hardwood stands of Virginia and West Virginia was conducted. Cutting accuracy and value recovery were analyzed and compared to an optimal solution that was determined through the use of the HW-BUCK computer software. In total 148 trees were bucked into 510 logs and only 11 percent were cut accurately. Fifteen percent were under cut and 74 percent were over length. The crew with the best performance in length cutting accuracy also recorded the lowest value recovery loss. An average value loss of 20.7 percent was calculated for all five crews."*

In the table for Bucking, Lean implementation tools for *Standardized Work, Workplace Organization, Point-of-use-Storage, Quality at the Source* and *TPM* have the same application as they did in previous operation. In classical manufacturing applications, the Layout tool is viewed as redesigning the workplace or even the facility to reduce cost, increase capacity, and dramatically improve cycle times. In the logging procedure for bucking, *Layout* is closely linked with workplace organization. The concept here is to arrange the logs so that their positioning reduces excessive travel by the bucker and enhances his capability to efficiently layout and execute cuts. The use of a bucking station, which provides for log turning, linear movement and power cutting, can dramatically improve bucking efficiency. Hydraulics for powering the bucking station can be provided by the log truck and log manipulation can be accomplished using the truck's knuckle boom loader.

Training is a given in any Lean exercise and the effectiveness of the value added process for bucking is more dependent on training than it is on equipment. It is impossible to do value added bucking if you do not know how to grade a log

**BUCKING LEAN IMPLEMENTATION TOOLS**

| Lean Tool | Impact Level |
|---|---|
| *Standardized Work* | Impact |
| *Workplace Organization* | Minor Impact |
| *Visual Controls* | No Significant Impact |
| *Cellular Manufacturing* | No Significant Impact |
| *Layout* | Impact |
| *Workforce Development* | No Significant Impact |
| *Batch Size Reduction* | No Significant Impact |
| *Quick Changeover* | No Significant Impact |
| *Point-of-Use Storage* | Impact |
| *Quality at the Source* | Significant Impact |
| *Pull/Kanban Systems* | No Significant Impact |
| *Takt Time* | No Significant Impact |
| *TPM* | Impact |

and if you have not covered all aspects of the customer's expectations.

***d. Loading -*** In the table for skidding, Lean implementation tools for *Standardized Work, Quality at the Source* and *TPM* have the same application as they did in the other logging operations. Most logging companies are using trucks mounted with knuckle boom loaders and thus loading is done by the truck driver. Like skidding, this is a non-value added process where the operator can reduce log value. The knuckle boom loader is a great time saver, but when improperly used it can cause serious damage to a grade log. This is especially true when it comes to rearranging logs in the load or trying to remove logs that have become lodged together during the trip to the mill. It is the job of the person loading and

unloading to maintain log quality.

***e. Hauling -*** Hauling the logs to the mill is another process in logging that is necessary, but adds no value to the log itself. For the most part,

| LEAN IMPLEMENTATION TOOLS IMPACT AREA | |
|---|---|
| **Lean Tool** | **Loading Impact** |
| *Standardized Work* | Impact |
| *Workplace Organization* | No Significant Impact |
| *Visual Controls* | No Significant Impact |
| *Cellular Manufacturing* | No Significant Impact |
| *Layout* | No Significant Impact |
| *Workforce Development* | No Significant Impact |
| *Batch Size Reduction* | No Significant Impact |
| *Quick Changeover* | No Significant Impact |
| *Point-of-Use Storage* | No Significant Impact |
| *Quality at the Source* | Significant Impact |
| *Pull/Kanban Systems* | No Significant Impact |
| *Takt Time* | No Significant Impact |
| *TPM* | Significant Impact |

hauling is by the very nature of its operation a lean process. All truckers need to be trained in doing things the same way (*Standardized Work*) and they all need to minimize travel time. The one area that will impact operations the most however, is *Total Productive Maintenance* (TPM). Keeping the truck and loader operational is the sole responsibility of the trucker. Every piece of equipment should have both an operator's log and a Preventive Maintenance Check (PMC) list, which the trucker keeps current. We cannot escape the fact that every time a truck is down for repairs, when it is needed in the woods, the company is experiencing a loss in profits.

| LEAN IMPLEMENTATION TOOLS IMPACT AREA | |
|---|---|
| **Lean Tool** | **Area of Cutting Impact** |
| *Standardized Work* | Minor Impact |
| *Workplace Organization* | No Significant Impact |
| *Visual Controls* | No Significant Impact |
| *Cellular Manufacturing* | No Significant Impact |
| *Layout* | No Significant Impact |
| *Workforce Development* | No Significant Impact |
| *Batch Size Reduction* | No Significant Impact |
| *Quick Changeover* | No Significant Impact |
| *Point-of-Use Storage* | No Significant Impact |
| *Quality at the Source* | No Significant Impact |
| *Pull/Kanban Systems* | No Significant Impact |
| *Takt Time* | No Significant Impact |
| *TPM* | Significant Impact |

## CONCLUSION

The need for American manufacturers to reevaluate the benefits of implementing elements of Lean philosophy can no longer be questioned. Logical implementation of some aspect of Lean has been proven to work in every single situation … at least where common sense has prevailed. This is just as true for the timber industry. As more and more wood products manufacturers adopt Lean manufacturing principles the industry will come to recognize the potential of the concept to increase their competitiveness, and to improve their bottom line. It is very important to point out that success will only come to those committed to Lean re-engineering and who use common sense in its application. There are a great many consultants and industrial engineers, skilled in the technical aspects of Lean, who are offering Lean training but are not capable of transforming Lean to non-classical manufacturing applications. The timber industry is not classical manufacturing and a strictly technical application of Lean to logging will only create conflicts in the recovery/inventory/cost equation of this business.

Unless the Lean practitioner can adjust their Lean thinking to incorporate and use such deviation in philosophy as multipart flow virtually being single part flow; a push system that works as a pull system; product recovery instead of product generation; and value retained being value added they will only generate confusion. Lean is good. The application of Lean philosophy will work in logging. But, it will not be easy to implement and it absolutely cannot be adopted through a "one time" training session conducted by a Lean technician offering a "cookbook" solution to all your logging problems.

## APPENDIX B:
## Marketing and Sales of Timber

### *Landowner Responsibility*

As a landowner you should take time to insure that the timber you sell has been marketed in a manner which will obtain its true fair-market value. To do this will require that you know the type, quantity and quality of your timber resources. Once you have a rough estimate of your natural resource worth, the next key step is proper marketing. The company you hire to log your timber should provide the landowner with information concerning how, where and why the various types and grades of logs will be sold. For example: stave quality white oak logs should not be sold to a mill that only produces pallet lumber and blocking. Stave quality white oak logs should probably be sold to a stave mill. As a landowner, it is your responsibility to ensure that the value of trees standing in your woods ("stumpage" values) is fully captured by the logging company's harvesting skill and their marketing methods.

### *Value Stream Impact on Landowner Profits*

It is unpleasant to think that any landowner would sell our land's greatest natural resource strictly based on financial gain. When properly done, harvesting timber will capture the monetary and environmental value of a biological resource, which would otherwise be lost due to its death and decay. Proper harvesting can also improve the quality and value of the next stand of timber. The key here is proper harvesting and the willingness to commit to the little additional time and cost required for proper harvesting. If you measure this additional cost against returns such as: improved future timber crops, wild life habitat maintenance, stream protection, soil maintenance and general aesthetic quality, the minor cost in time and money is returned to the landowner many times over.

Putting together a cash flow balance sheet can be an excellent method for understanding the elements, which impact the value of a timber crop. In general, the stumpage value of your crop will be reduced by all the processes required to deliver the resultant logs to a buyer. The first cost in this value chain starts with the process of preparing the land for harvesting operations. As a landowner you should be involved in planning the location, design, maintenance and closing of all: log landings, major skidding roads, stream crossing and access points. It is the landowner who must make the final decision on the amount of time and money that will go into proper preparation of the land for harvesting. Once the harvesting process begins, the standard logging cost chain is cutting (felling), moving the tree trunks out of the woods (skidding), cutting the trunk of the tree into logs (bucking), loading the logs onto a truck. Collectively, these costs are referred to as "logging costs." Hauling the logs to a mill is generally the last link in the harvesting chain. The value of your stumpage is the amount the mill is willing to pay for logs minus the cost of getting the logs to the mill.

LANDOWNER PROFIT = PRODUCT VALUE - {(site preparation-maintenance-repair costs), logging costs & transportation costs}

### *Value-Cost Factors the Landowner Has no Control Over*

Careful planning of the harvesting process and marketing is one excellent way for the landowner to realize both financial and conservation profits. There are other factors, however, over which the landowner has very little or no control. Some examples of these areas are:

1. ***Site accessibility***. All other things being equal, timber in tracts that are easily accessed by log trucks is more valuable.
2. ***Logging difficulty***. Steepness of terrain and soil moisture conditions determines the logging equipment that can be used and the efficiency of this equipment.

***3. Tree Types (Species)***. Differences in value among species can be very significant. Grade black oak may bring $.35 per foot but a grade black cherry could bring $.85 per foot or more.

***4. Tree Size.*** Larger trees generally have a higher probability of producing grade lumber. In general saw timber-sized trees are worth more per unit of volume than hardwood flooring trees, and veneer quality trees are worth more per unit volume than saw logs.

***5. Quality***. Larger diameter trees with no defects on the first 12 to 36 feet of the trunk can produce veneer quality logs. Trees which have limbs and defects in the trunk will probably only make pallet or blocking grade logs. The quality of the tree will also dictate the logging cost verses return ratio. For example it will cost a logger just as much to harvest a low grade tree as it does to harvest a high grade tree. The landowner should not expect to receive the same percentage of profit from a low grade tree as they do from a high grade tree.

***6. Volume of sale.*** In general, fixed logging costs will decrease, per unit of volume produced, as the total volume logged at one location increases. Fixed costs include roads, construction of a place to load logs (landing), drainage structures, and moving equipment between jobs. The larger the volume of sales the easier it will be for the landowner to afford having the logging company give special attention to environmental and aesthetic quality issues.

***7. Distance to market*** and market availability. The closer the mill is located to the logs purchased, the lower the hauling costs.

***8. Market conditions***. The market strength for a given species and quality of stumpage varies by season, market cycle, and many other factors.

***9. Buyer's log inventory.*** When a mill's log inventory is low, buyers may offer more for logs to keep their mill in operation.

***10. Quality of the Logging Company***. A landowner may not be capable of controlling the quality of a logging company but they have total control over who logs their land. Take the time to question a logging company on who they are, what they have done and what they know. A quality logging company should be capable of answering your questions and providing you with a list of landowner references.

## *The Harvesting Method*

It is always best to select the trees to be harvested with the advice of a professional forester who will assist you in establishing or maintaining management objectives to keep the woodland in a vigorous and productive condition. Therefore, the type and intensity of harvesting required will depend on your objectives and on the type and condition of the timber stand. There are four basic harvesting methods for consideration.

***1. Area limit clear cut.*** Terrain boundaries are defined and marked. All the trees within these boundaries are available for cutting or must be cut, depending on your management requirement. This method may be appropriate if you want to make a clear cut to regenerate species needing direct sunlight or to clear land for conversion to non-forest uses. If clear cutting is a requirement your profits may be eroded by the cost of removing low-value and no-value trees.

***2. Area limit select cut***. Terrain boundaries are defined and marked. Only select trees within these boundaries are available for cutting, depending on your management requirement. Trees may be selected based on species, grade, size, age, health, etc. This is an excellent forest management tool but not always as profitable as uncontrolled harvesting.

***3. Diameter limit.*** All trees larger than a certain diameter breast height (dbh) are to be harvested within a defined area. In larger tracks of timber this can be the preferred method for maximizing your timber sales profits but it can also be one of the poorest harvesting methods from a forest sustainability perspective. This method usually results in "high grading," that is, cutting only the best trees and removing smaller diameter trees that may provide the highest financial return dur ing the next growing cycle. What really happens,

however, is removal of quality trees and leaving of cull trees resulting in the accumulation of poor-quality trees and a decrease in the value of the residual stand.

***4. Single-tree selection***. This method requires that each individual tree to be cut is marked with paint spots, one at eye level and one at ground level. The lower paint mark remains visible on the stump after cutting. When the logging is completed this allows you to verify that only marked trees were cut. This is the method usually recommended by foresters. The landowner must be willing to pay for the cost of selection and marking. This is very similar to area limit select cutting, except that in area limit select cutting the selection process is left up to the logger.

Once you have determined what method you will use for selecting trees to be harvested it is important to determine what method of harvesting will be used. It is the landowner's responsibility to get with the logger, and together determine how the harvesting process will take place. As the land owner you need to be involved in planning for activities such as:

- Selecting access points
- Selecting log landing locations and design
- Selecting main skidding trail
- Selecting stream crossing sites
- Determining methods of erosion control
- Setting terrain maintenance levels
- And determining levels of remediation

The land is yours but the responsibility for execution of activities such as these falls on the shoulders of the logger. As the land owner, however, you must be willing to accept your share of the cost for this work. The more forest stewardship activities the landowner demands the more it is going to cost. Missouri has no forest stewardship regulations nor does it enforce Best Management Practices for logging. Under these conditions the next best thing is for the landowner and the logger to work together in maintaining our greatest natural resource. Of course the state of Missouri has excellent programs to assist both the logger and the landowner.

## *Types of Sales*

Sales of standing timber fall into one of two basic types: gross sales or unit sales. In gross sales, all the timber being offered for sale is sold for a fixed price. For this reason they are often called lump-sum sales. Such sales are relatively easy to administer and they minimize risk to the seller, but only if the seller has an accurate estimate of the volume of timber in the sale, the products it is suited for, and their relative value. A major draw back to this type of sale is the fact that the landowner can dramatically limit the number of companies competing for the timber. Often large but less than stellar logging companies are the only ones that can afford to purchase the timber and thus the competition is less.

Unit sales are those in which payment is based on the amount of timber cut, as measured by cords, tons, thousand board feet, or other suitable units. Unit sales sometimes increase the seller's risk in such areas as volume measurement, payment arrangements, and conduct of harvesting operations. The advantages of such sales are that capital gains tax treatment is more easily available to landowners with uncertain tax status, and that they are often better suited to timber, which is difficult to sell because of size or access problems. This type of sale also opens up the timber sale to both small and large logging companies.

## *Selling Methods*

Timber is sometimes sold by the "sealed bid" method. Sealed bid selling involves sending invitations to bid to prospective buyers and taking bids from them. It is imperative that the landowner get as many bids as possible and that the landowner carefully spell out all the harvesting requirements of your forest management system. The buyer's integrity, experience, and reputation are factors to consider in selecting the winning bid.

Negotiation is another commonly used selling method in which face-to-face bargaining takes place between seller and buyer. This is probably the most common form of selling in the hardwood industry. Here it is also wise for the landowner to enter into negotiations with more than one company. To be successful, it is necessary for the seller to be as well informed on current market conditions and timber values as the buyer.

## *Selling Considerations*

There are two basic types of timber sale contracts: "lump sum" and "pay-as you cut," as well as variations of these basic types.

- ***Lump sum***. The buyer agrees to pay a fixed amount. The advantage to you is that the amount is not dependent on any future event, such as damage to the standing timber, timber theft, or overestimation of the value of the timber. Generally, you should be paid the full amount due prior to the start of the harvest however, you may contract to receive installment payments on designated future dates.

- ***Pay-as-cut.*** You retain title to the timber until it is cut. This is also referred to as an "economic interest retained" contract. The buyer agrees to purchase timber at a given price per unit volume of the cut product, usually logs. The contract price per unit may be an average or per species and log grade. The determination of the volume and grade of the logs cut is an administrative burden. Frequent inspection by you or your agent may be required during logging to assure an accurate accounting.

- ***On-the-shares.*** You agree with a logger to share the money received from selling the logs produced from your timber. The split is usually a fixed percentage for you and for the logger. For administrative and tax purposes, it is important to specify in a written contract the relationship between you and the logger.

- ***Logging service.*** You pay the logger a set fee per unit volume to cut and haul the timber to a log buyer you designate. The logs belong to you until you sell them. To prevent discrepancies between your estimate of timber volume cut and the volume delivered to a mill, it may be necessary for you or your agent to measure the logs at the loading point in the woods (the landing) before the logs are loaded and hauled to the buyer.

## *The Contract*

The landowner should never consider their timber to be sold until a formal, legally binding, written agreement, specifying the responsibilities and the expectations of both parties exists. Few of us excel in our communication skills and as a result misunderstandings crop up that can result in hard feelings and even litigation. A well-written sales contract is one of the best methods to keep this from happening between the landowner and the logger. The contract will ultimately serve as the mechanism by which any disputes are resolved. The contract does not need to be lengthy or complex but it must reflect the expectations and responsibilities of the seller and buyer. An effective timber sale contract will contain the following provisions:

1. ***Identification of parties.*** It is important that all persons associated with the sale and harvesting of the timber have been identified and their position spelled out. This should include: landowners, investors, logger, forester, contractors etc. All vital information for contacting these parties needs to be recorded in the contract.
2. ***Description of timber sold.*** The contract should give an estimated harvest volume by species and grade. It may also be advantageous to identify timber by individual stands or areas as identified in the logging plan.
3. ***Marketing.*** The contract should indicate how the logs will be marketed (based on type, grade, etc) and where the logs will be sold.
4. ***Harvest method.*** Document the harvesting method agreed upon by all parties and attach a copy of the logging plan detailing this method. Address the layout of log landings, skid trails, and areas to be cut. State any restrictions on equipment use and logging during wet periods or other times. The contract should state that the landowner and the logger both have the right halt all operations if they object to the way the harvesting operation is being carried out.
5. ***Care of property.*** Great care must be taken in describing each part of the property that could be subject to damage (i.e., fences, roads, bridges, buildings, nest boxes, residual trees, etc.). Include allowable limits of damage and provisions for repair or payment for damages.
6. ***Method of payment.*** This should specify the amount the purchaser agrees to pay the seller as a lump sum or pay-as-cut, as well as how the buyer will provide verification of the amount of timber cut and paid for.
7. ***Right of ingress and egress***. Provide buyer the right to come and go to remove timber. Specify entrances and roads to use.
8. ***Length of agreement.*** State the beginning and end dates of the agreement and provisions for or against renewing the contract if it expires before harvesting is complete.
9. ***Liability Protection***. Very few logging companies in Missouri carry specialty insurance. The contract needs to contain a clause that protects the landowner from any responsibility for injury to logging personnel or damage to equipment.

As the landowner, it is important that the contract is short and to the point, and free from long legalistic clauses that are irrelevant to your real requirements. Long, complicated, restrictive con tracts may scare buyers away and make supervision of the operation difficult. Many times buyers will have pre-written contract forms, which may satisfactorily reflect your objectives, but take the time to read them and be sure they cover all your needs. If the existing contract is not agreeable with your needs then ask to have your specific needs included.

## *Supervise Logging - Maintain Lines of Communication*

Take the time to review the logging plan and the contract with the logger one last time before logging begins. Do not let any "gray areas" go undefined. Do not let any questions remain unanswered. If the landowner and the logger cannot communicate at this point of the harvesting process, they never will be capable of resolving conflicts in the middle of the operation.

Before operations begin the landowner should have developed a plan for monitoring how the harvesting operation is progressing. If the contract is set up on shares have a payment plan (weekly is best) for recording type, grade and volume of the harvest and what the mill has paid. Visit the logging operation to monitor how well the harvesting method is sticking to the logging plan. If you have concerns communicate them to the logger right now. Work on a resolution right now or at least as soon as emotions will allow a calm and collected thinking process.

It is your land and the trees are yours. You have hired the logger to harvest your timber according to a predetermined plan. If you do not monitor the operation and something goes wrong it is ultimately your fault … the buck stops with the landowner. Most issues that crop up are due to unforeseen circumstances and a breakdown in the channels of communication. Taking the time for you and the logger to visit the harvesting area frequently is one sure way to minimize issues.

## APPENDIX E: WORK STANDARDS

Standardized work is the establishment and documentation of tasks which have been efficiently organized and are repeatedly followed and required for completion of a specific job. Simply put, standardized work is a "by-the-numbers" method for doing each and every process, and each of these steps has been carefully written down in a manual, which is available to all operators. The aim of standardized work is to reduce the variation introduced by the operator, thus eliminating waste and achieving high productivity. In other words, we know that the reason two parts, that are suppose to be identical, come off the assembly line different is because somewhere down the line someone did not do their job correctly. If we write down how each job is suppose to be done, we teach the operators what has been written down and we see to it that they can always refer back to, then the odds of work being done incorrectly will be dramatically reduced. Basically speaking then, standardized work is a detailed and documented system in which each production worker both develops and follows a repeatable sequence of tasks within a work assignment. The standardized work sequence represents the best practices for the operator to follow in the completion of his/her job. These best practices are documented and displayed at each workstation, using standardized work charts. The team members are taught these practices, and adherence to the work sequence is encouraged.

### PRINCIPLES OF STANDARDIZED WORK

The three principles that standardized work is built upon are the following:

- Standard inventory
- Work sequence
- TAKT time/operator cycle time

1. ***Standard Inventory.*** Standard inventory is a combination of always stocking the same type or brand of item and then stocking the minimum amount that meets Lean requirements. Like the work sequence itself, inventory is also well-documented and displayed where it is visible to the operator.
2. ***Work Sequence.*** Work sequence is defined as the order of the work elements that the team members follow as they complete their job. The work sequence is documented and relayed to the operator. It is not only developed with their input, but is used as a means of visual control by displaying the operator's work sequence at the workstation.
3. ***Takt Time.*** Takt time is defined as the time available to produce one unit of output. The Takt time is determined by an equation which relates the operation time available per shift to the required total production per shift. In theory, the Takt time is related to the demand generated by the customers, and will change if a drastic change in demand is experienced.

### HOW STANDARDIZED WORK IS DEVELOPED

The determination of the job elements and a suggested sequence of operation are first developed. The work sequence is then tested and modified by a team consisting of the team leaders and group leaders, who will be responsible for that process during production. The cycle time for each of the work elements will be determined during this phase by the development team. All general assembly operations are broken down into work elements. The work elements for each operation are then scaled according to the time required to perform the work. The work elements are then arranged according to the operations, and balanced to a goal of 95% efficiency. This balancing is accomplished by stacking the work elements in an operation from a line on the wall, representing time zero, until the work elements stack up to a line designating the Takt time.

To convey the standardized work to the team member on the production floor, two worksheets are utilized. Both of these worksheets are displayed at each workstation.

## USES OF STANDARDIZED WORK

Standardized work is utilized in various capacities to support the production system at planning and leveling purposes, for visual control, and for the reduction of variation. Other areas in which standardized work plays an integral role is in training of new team members, and support for the continuous improvement philosophy.

In training new team members, standardized work plays a key role. The new team member observes the worker currently on the job, and at the same time, refers to the standardized worksheets. After a period of time observing the job, the new team member is gradually allowed to work alongside the experienced team member and share part of the standardized work sequence. The team leader is responsible for ensuring that the new team member is taught the correct work sequence and understands the principles of standardized work. The team leader will eventually verify the proficiency of the new team member based on standardized work. This rigorous approach to the training of new team members is made possible through standardized work. The standardized work check sheets provide a documented baseline from which to train.

Continuous improvement is another area in which standardized work plays a key role. The continuous improvement philosophy is a critical factor in the production system. Involvement in the philosophy is encouraged by everyone and standardized work provides the means of involving the production worker. With each team member conforming to an established work sequence, all team members understand what the current process is. This understanding allows the team members to suggest beneficial changes to the system. Standardized work establishes the baseline for continuous improvement.