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AUTOMATIC BAR CODE DATA COLLECTION

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Automatic Bar Code Data Collection
Forest Products Industry
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by Geoffrey Malecha
G.S.D. Associates, Inc.

1. INTRODUCTION

American industry is rapidly putting automatic data collection to work tracking raw materials, work-in-process (WIP), finished goods, labor, and time & attendance. Automatic data collection using bar codes, radio frequency data communications (RFDC), radio frequency identification tags (RFID), electronic data interchange (EDI), and other technologies are responsible for improved inventory accuracy and cost controls, as well as significant new efficiencies in the flow of materials in the production process. Accurate and timely inventory, labor and work-in-process tracking are among the prime benefits of successful factory (i.e. mill, plant, etc.) floor data collection.

This monograph will focus on some of the key elements in a bar code data collection system for the forest products industry. The general focus of the monograph will be on the use of bar code data collection and labeling in the "primary production" arena. The specific focus will be in the rough/finished mill environment using bar code for labeling and inventory control. The areas of this application that will be addressed and described in detail are unit labeling and shipping. Although the focus will be on "primary production", there will also be a discussion of how the ideas and concepts presented with the "primary production" application apply to other forest industry facilities (i.e. secondary or value added).

There will be some discussion of the specifics of bar code technology (such as Code 39, UCC and UPC standards) as it applies to the above application. However, the monograph will assume some basic level of knowledge about bar codes and will not be a "primer" on the subject. Its main thrust will be on how the technology is applied in the field of wood products production.

2. PRIMARY PRODUCTION DATA COLLECTION

The main thrust of improving inventory control in the primary production mills begins with creating and applying a tag, or label, containing a unique serial number to each unit of lumber as it is wrapped at the banding station. This serial number then becomes that unit's license plate until it is consumed. This serial number appears on the tag (or label) in both human readable form and as a bar code that can be scanned each time the unit is transferred, moved, consumed, counted, etc. As a by-product of tagging this unit with a unique serial number, the crucial specific information about the unit, i.e. the grade, species, length, number of pieces, is collected for inventory control. This information is automatically associated with each unit's serial number as it is assigned and the tag (or label) is printed. When this tag (or label) is created, the specific information about the unit, which only needed to be entered one time (at the start of a run, shift, etc.), may also be printed on the tag in human readable form for easy reference.

This unit specific data is collected automatically at the time of the tag's creation by a data collection device (such as a fixed mount bar code "reader") for storing and sending to a PC or main computer (and the corresponding computer data bases) elsewhere in the mill or main office. This transfer of data can be done immediately (***on-line***) or later as the reader is polled (***batch***). Either method can done using radio frequency (RF) technology or a cabled bar code reader network.

In the primary production industry, the creation of a unit of lumber, whether at the rough or finish mill, produces an item of inventory that needs to be tracked and accounted for as the unit moves through the production facility and is eventually shipped and invoiced. The use of bar code labels and tags provides the ability to collect this movement of inventory (or physically counting the inventory) using bar code data collection hardware in lieu of labor intensive, manual record keeping. This not only saves time and effort in recording the data but also produces immediate access to the collected data. This provides better accuracy for the sales and financial staff for better customer service and increased sales.

2.1. UNIT LABEL SPECIFICS

A bar code industry accepted phrase states, "It all starts with a label." The wood products industry is no exception. The critical element for collecting production data automatically is creating an appropriate label or tag that is applied to the product being produced (see Exhibit 2-1). A label has an adhesive backing of some type (rubber, acrylic, etc.) to allow it to adhere to a surface. A tag on the other hand has no adhesion and would need to be stapled, or otherwise adhered, to the intended surface.

2.1.1. Tag/Label Data

The type of information that a company needs, or intends, to track can vary greatly from site to site. However, some of the basic types of information that are typical for this environment follow:

1. Grade
2. Species
3. Dimension
4. Dry or Green
5. Length
6. Surfacing
7. Board Footage
8. Number of Pieces
9. Weight of the Unit
10. Date and Time Stamp

In addition to the standard information displayed above, some companies also collect the equipment being used (for maintenance/service or QC information) or the person doing the work (for labor tracking or performance data). In addition to being collected, this information can also be displayed in human readable text on the label or tag. With the use of high quality thermal transfer printers, very large, well defined, characters can be used to allow viewing this information from a distance for easier recognition by the mill employees or the mill's customers.

2.1.2. Serial Number versus Smart Bar Codes

The number assigned to the unit must be a unique number. Typically it is a sequential number assigned by the main computer or the bar code data collection system. For example a fixed length unit might look like this:

Serial Number:	234567
Species:	DF
Grade:	#2 & Better
Dry/green:	Green
Length:	10'
Surfacing:	S4S
Board Footage:	1280
Piece Count:	128
Weight:	5690
Date/Time:	021396(08:25)

Some companies, however, prefer that the unit number also incorporate some of the above information in order to provide an intelligent (or smart) bar code serial number. This would allow someone looking at only the number to know what is contained in the unit. For example, the information above might look like might look like this:

Serial Number:	1282610123456
Product Code:	67890
Species:	DF
Grade:	#2 & Better
Dry/green:	Green
Dimension:	2x6
Length:	10'
Surfacing:	S4S
Board Footage:	1280
Piece Count:	128

The serial number, 1282610123456, tells the observer that the unit contains 128 pieces of 2 x 6, 10 feet long, number 123456. Note that the serial number still requires a sequential number (123456) at the end to make it unique. Notice also that the general information above lists a product code. This product code is typically a 5 digit number (to conform to UPC standards) that uniquely identifies each product produced by this manufacturer. It can also be part of the smart bar code. This product code becomes important at the final shipping stage. It is required to conform to the latest UPC (Universal Product Code) or UCC (Uniform Code Council) shipping container codes symbol formats set by the AIM technical Symbology Committee. As we will see later on in this document, it also is important for EDI (Electronic Data Interchange) conformity.

2.1.3. Unit Number Length

The length of the unique bar code unit serial number described in the previous section determines several major effects in the inventory application. Typically the sequential serial number is six (6) to nine (9) digits in length. The general rule is that the serial number should not repeat in one year.

However, the more digits contained in the serial number, the longer the bar code, and therefore, more space is required to print the bar code. As we will see in a later section, bar code densities and "X" dimension (width of the narrowest bar, typically 20 mil to 40 mil in size for unit labeling) can be altered to save space. If the bar code is printed with a smaller "X" dimension, higher density and less space used will result (i.e. smaller lines in the bar code). However, the smaller the "X" dimension of the bar code the closer one has to stand in order to scan the bar codes with a laser scanner (smaller is better for wands).

As will be discussed in later sections, the newer bar code scanning devices (long range laser scanners) can read a low density bar code (40 mil) up to 10 or 12 (or more) feet away. This is an important requirement for reading bar codes in the inventory application. If the serial number contains too many digits in order to provide some intelligence (i.e. smart bar codes), the distance from which it can be scanned will be severely hindered. Because of this restriction, together with the advent of more computer intelligence and the ability to print high quality human readable text information, smart bar codes are becoming less desirable.

2.1.4. Tag/Label Placement

Once the unit tag or label is created, the exact placement on the unit is important to the inventory control application. It is critical that the tag or label be placed in the same location every time. This makes the label easier to locate to speed up data collection. Typically, the tag is placed in one of the lower corners of the unit. One of the reasons for this lower placement is too put the label as close as possible to someone needing to scan the bar code from a distance, such as from a forklift. When the units are stacked in the storage facility or yard more than two units high, the lower corner placement minimizes the scan distance for the newer long range scanners.

In addition to the specific placement of the tag, it can be important to put more than one tag or label on the unit. Most mills will stack the lumber close together in order to minimize storage space used. This increases the likelihood that one label will be hidden during the putaway process of the unit. To get around this problem, some mills will place a tag on the side and one on the end of the load. Although this serves to minimize the impact of "close quarters" in the storage area, it does not solve the problem of hiding the labels without putting a tag on all four sides of the unit.

To avoid increasing the cost of tags by putting a tag on all four sides, a commonly used approach is to place a tag on each side of the unit with a portion of each tag wrapped around each end of the unit. The smaller portion that is wrapped around the end of the unit could contain a smaller (high density) duplicate of the serial numbered bar code (to be used in case the larger bar code cannot be scanned due to being hidden, damaged, etc.). This smaller portion of the tag could also contain human readable text about the unit to aid the mill employees in sighting specifics about the unit when needed. It also provides a fallback position of allowing the serial number to be viewed easily and keyed into a portable scanner should the bar code not be able to be read by the laser scanner (due to distance, sunlight, a damaged bar code, etc.).

Some mills wrap their finished units with a sheet of material (cardboard, paper or similar material). In this instance, a bar code label (with a sticky back adhesive) would be applied to the wrap in the same manner that a tag would be stapled directly on to the unit. This label could also be wrapped around the end in a similar manner described above. However, if the wrapping material is a top wrap only, putting a label on the wrap will increase the distance required for scanning the unit number when the units are stacked.

2.1.5. Weight

Often the unit label information will also contain the weight of the unit. The bar code data collection device, in addition to being connected to the bar code label/tag printer, can also be connected to a scale. This allows the automatic capture of the unit's weight for printing on the tag (both in human readable form and/or bar code format) and for uploading to the main computer data base. Having this information available electronically would allow easier prediction of over weight conditions saving time in the loading and shipping process. However, mills are producing more and more green lumber. A word of caution: the weight can vary widely on a unit of green lumber to the point of being useless.

In lieu of getting the weight information from the main computer data base, the person loading the truck could also scan the weight bar code on the unit tag (if the weight was contained in a bar code format on the tag) into a portable data collection device, used in the loading process. The portable reader could then total the weight as the truck is loaded so that the loader and trucker could determine when the truck would be close to the legal weight limits and avoid unnecessary time and effort associated with overload conditions.

However, more and more mills are using green lumber. Therefore even if the weight is captured at the bander or wrap station the weights can vary over time as the unit sits in a covered warehouse or in sunlight. This should be taken into consideration in the design of any new system.

2.1.6. Fixed Length vs. Random Length

The bar code label or tag specifics will change based on whether the unit of lumber is fixed or random length. The information contained in a fixed length unit is described above. However, a random length unit is a little more complicated. Typically, a random length unit contains all of the same dimension but will contain two or more different lengths of boards. Although the principal of assigning a unique serial number to the unit remains the same, how this information is captured, placed on the tag and sent to the main computer data base varies much more from sawmill to sawmill than for a fixed length unit created in the finish mill.

The basic information on the tag described above for a fixed length unit remains the same. However, the number of pieces associated with each length may need to be captured. More often, an entry for average length, or "short, medium and long" or a range (such as 10-14), is used.

In a very automated mill environment, the bar code reader/printer station would be located at the strapper. The sorter PLC (Process Logic Controller-i.e. the computer like controller that controls a specific manufacturing line) would pass the board count associated with each length in the unit directly to the reader. The reader would then pass the piece count to the printer for printing on the tag. If the PLC cannot pass the piece count to the reader, the bander operator can enter the piece count directly into the reader using a series of bar codes from a bar code menu. Although the operator can still miscount or enter the number incorrectly, it still automates the process much more than a manual environment.

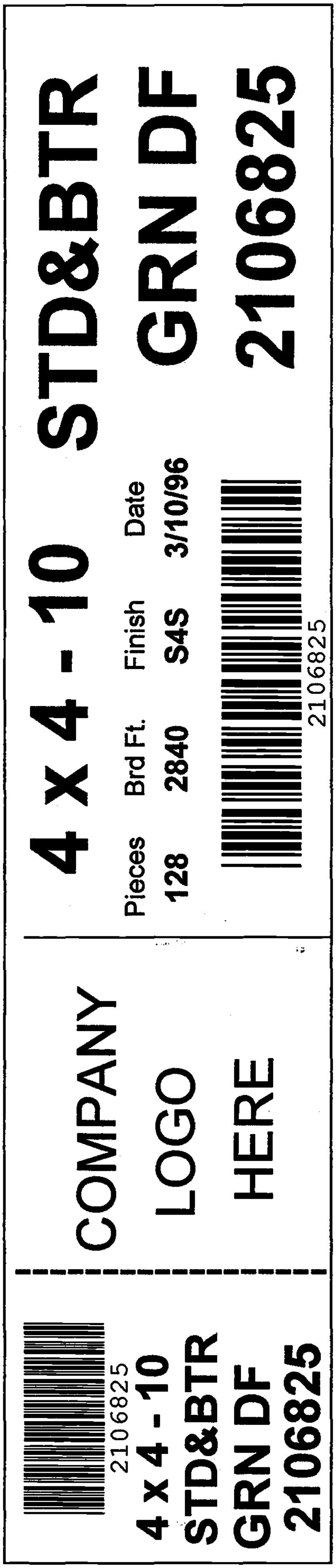
In a more manual environment, a two part preprinted tag with a perforated stub containing a unique serial number on both pieces can be located near the strapper. This preprinted tag could contain standard size and dimension descriptions with boxes for writing in total unit counts (See Exhibit 2-2). As a unit is created and strapped, the operator would write in the appropriate boxes the number of boards in each size. The stub would be removed from the main portion of the tag and stapled to the unit for unit tracking, and the main portion of the tag returned to the office. In the office the serial number would be scanned into the data entry device connected to the main computer using a "wedge reader" (a bar code reader that "wedges" between the keyboard and the screen of an input device such as a PC or computer terminal) and the individual statistics associated with the unit would be keyed in as before.

An intermediate stage would have the bander operator manually entering the board lengths and piece count data from a bar code menu (Exhibit 2-3) into the bar code reader. The reader then would produce the tag as if it got the information from the PLC.

Exhibit 2-1
Finished Goods Tag Sample

4" X 20" With 4" Tag Stub

(Scale for tag shown is 1" to 2")



< ——— MAIN TAG

< ——— Perfs For Removal

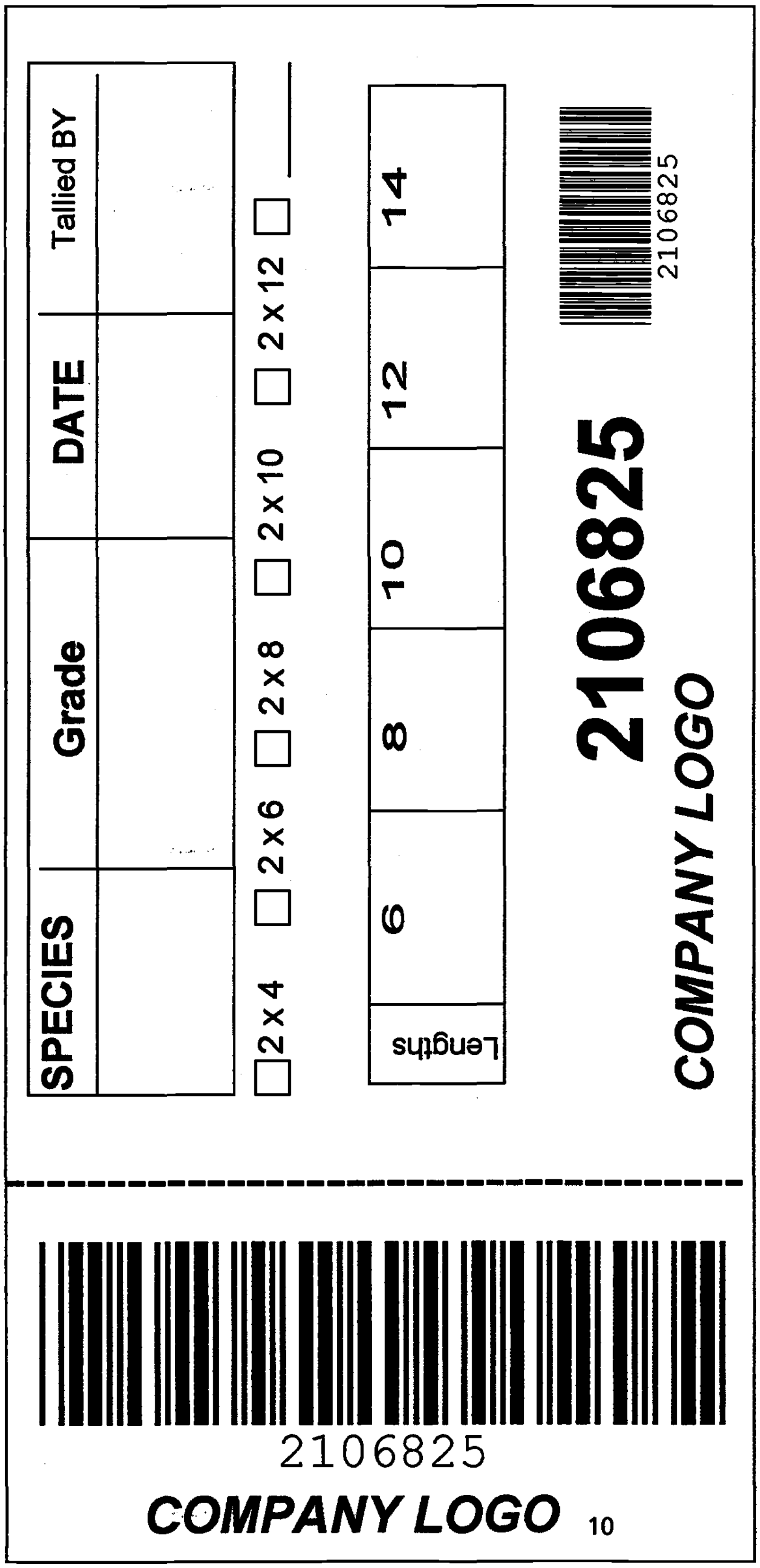
< ——— "STUB" or Trailer

Exhibit 2-2

Tag Sample Using Hand Written Data

4" X 8.5" With 2.5" Tag Stub

(Tag shown is done to scale)



COMPANY LOGO

EXHIBIT 2-3

06/26/96

SAMPLE BANDER MENU

SIZE:

2 X 4 | 2 X 6 | 2 X 8 | 2 X 10 | 2 X 12

GRADE:

#1+BTR | #2+BTR | #1 | STD+BTR

SPECIES:

DF | HF

GRN | DRY

LENGTH:

8' | 10' | 12' | 14'

FINISH:

RGH | S4S

NUMERIC KEYPAD:

1 | **2** | **3**

4 | **5** | **6**

7 | **8** | **9**

0 | DECIMAL | ENTER

FUNCTIONS:

PRINT

CHANGE #/Labels | **REPRINT**

Back Up One Step | **DONE** | **CANCEL**

BACKSPACE | CLEAR | LOCATION

Exhibit 2-4
Random Length Tag

4" X 8.5" With 2.5" Tag Stub

COMPANY NAME

Pieces: **100**

DIMENSION: **2 x 4** < — "STUB" or Trailer

2106825

- - - - - - - - - - - - - - - - - - < Perfs For Removal

COMPANY NAME

3/10/96 Weight: **2100**

Grade: Dim Outs **HFS4S** < MAIN TAG

SIZE:	PIECES:
2 x 4 x 10	**40**
2 x 4 x 12	**30**
2 x 4 x 14	**30**

2106825

2.2. THE APPLICATION: ROUGH MILL/FINISHED MILL

2.2.1. Basic Inventory Control

Applying the tag with a unique serial number to a unit of lumber allows the handling that unit of lumber throughout each step of the mill (rough or finish) easily. This is done by scanning that unit tag at each step involved in mill processing. This allows the mill personnel, as well as corporate financial and sales staff, to know precisely where inventory is located, how much has been produced, what is in process, what has been shipped, etc. without extensive manual labor to record and enter this information into the mill's computer systems. Also as units are moved to different locations within the mill, it provides an easier way to handle location tracking, reducing the time it takes to find product. Tracking units this closely also provides the ability to track yields. Knowing the "quantity in" versus the "quantity out" provides recovery information needed for yield tracking.

In the rough mill, after a log is cut, the various dimensions and lengths are stacked and then strapped into a unit. A bar code data collection station is located at this bander station. It can get information about the unit directly from the sorter's PLC or the worker manning the bander can enter it via a series of scans from a preprinted bar code menu (see Exhibit 2-3). The reader would then assign a serial number to the unit based on the rules discussed above and a tag would be created and applied to the unit.

The reader program can also be set up such that only the data that changes would need to be scanned at the tag creation point. For example, let's say the sawmill is running DF (Douglas Fir) and producing 8, 10, and 12 foot 2 x 4's and 2 x 6's. If the bander operator is strapping only 2 x 4's for the moment, the only scan required to create a new tag is to scan the lengths and quantities for each length. The final scan would be to "print a tag", which also tells the reader that we are done with entering lengths and quantities. The reader would already know that the unit is DF 2 x 4's (See Exhibit 2-4). If the strapper operator then begins strapping 2 x 6's, the bar code for 2 x 6's would have to be scanned before the lengths and quantities are scanned.

If the sorter PLC is able to communicate directly with the reader, the reader would already know that DF 2 x 4's (including the various lengths and quantities) are coming down to the banding station. The operator at this point would only have to scan the "print a tag" bar code to create a new tag and send the information up to the mill's host computer.

In a more manual environment the tag could be preprinted and the data written on the tag as described in the above section. The main portion of the tag would be entered into the computer system in the office by scanning the serial number bar code on the stub and scanning (or keyboarding) the remaining data from stub using the same kind of menus at the PC or terminal in the office.

In some rough mills the actual board lengths are replaced by the categories of "short", "medium" and "long". This reduces the amount of accuracy somewhat because board footage is approximated, however, it does eliminate the bander operator from needing to enter specific board lengths.

In the finished mill the process would be similar to the approaches described above except without the need to enter length and quantities (unless a random length unit is being created with finished lumber). As each unit comes off of the planner/sorter, the bander operator would create and apply the tag in a similar manner described above.

2.2.2. Work In Process-Consumption/Retagging

Creating a finished unit of lumber usually requires consumption of a rough unit in mill processing. In the more modern mills being built today, this process is becoming more and more automated, creating less of a need for this step. However, many mills today still have separate facilities for the rough and finish process, creating the need for tracking work in process inventory. Some mills also dry their lumber creating an additional work in process step and therefore a need for an additional consumption transaction. By tagging a unit in the early stages of the mill processing, the operators can consume this unit easily and collect the unit serial number as it is fed to the saw or planer or enters the dryer. This is the same concept that will prevail in other wood products environments, especially fiberboard and panel plants where tracking work in process is critical.

This "collection" of consumed unit serial numbers varies by site. Some sites will collect a "stub", such as described above, and scan the consumed unit in at a later time in the office using a "wedge" scanner (Exhibits 2-1, 2-2). Other sites will have a portable or a fixed mount scanner station located near the consumption station and will scan the tags as they are consumed.

As a new unit of lumber is created from the process, a new tag is created with the new information using a bar code data collection reader and printer located near the out feed and strapper station. With this retagging step, the process described in the previous sections begins again, with the new information being sent to the mill's host computer. This process will also allow collection of recovery and falldown statistics.

2.2.3. Shipping

Now that a unit has a unique serial number identity, shipping the unit and capturing what shipped is a matter of scanning the tag at some point in the shipping process. However, when this scan occurs determines how streamlined the scanning process can be.

In an ideal environment, the tag would be scanned using a portable reader and laser scanner as soon as the unit is picked by the forklift driver. In a more basic environment a "stub" or "trailer" would be pulled as the unit is loaded on the truck or railcar and scanned at a later time in the shipping office using a wedge or fixed mount reader.

Using this basic "wedge" scanner approach would replace the manual record keeping, in place today, saving time and improving accuracy associated with the completion of the shipping documents. However, with the ideal approach, the tag is scanned before the unit is handled. This provides a great deal more control of the shipping process eliminating many more mistakes and errors that normally occur today in a manual shipping process. For example, by checking a unit before it is placed on the truck, mistakes and errors can be caught before much time is spent handling and loading the unit, and before the truck is miles down the road.

This is accomplished by using the unit's tag serial number to look up the detailed information about that unit. In the ideal environment the forklift driver would be given feedback as soon as the tag is scanned indicating whether this tag meets the criteria for shipping against this particular order. This "lookup" can be accomplished in a couple of ways.

An order to be picked can be downloaded to the portable reader before the picking begins. That data contained in that download may include a quantity and a product code for each line item on the order. This is usually done by placing the reader in a communications docking station before the driver leaves the shipping office to begin picking. Radio frequency technology would let this download happen right on the forklift eliminating the need for the communications dock and allowing the operator to stay in the vehicle.

This download would provide the reader with some basic information that the program running in the reader could use for comparisons. For example, the portable could check for quantities of a particular product and let the forklift drivers know if they have picked too many or too few of an item before they finish the picking and loading process.

If the bar code on the scanned unit has the product number as part of the bar code serial number, such as in the UPC Shipping Container code, or the product code is part of the bar coded information on the tag, the unit could be checked before it is placed on the truck. Additionally, if the weight is contained on the unit in bar code form, the portable could keep a running total of weight that could be recalled periodically to see if the truck being loaded is getting near its weight limit.

By using radio frequency technology, the portable reader could send the tag serial number via a radio communication signal to the main computer. That computer would send a response containing information about that unit number, letting the driver know if the unit is correct for that order or not. The driver would then have the option of overriding the unit or not. Perhaps the mill is out of a particular grade and is substituting a higher grade until more can be produced. By using radio frequency in this way, the picking process would screen out most of the errors that occur before the unit is even handled.

Regardless of the method used, a good number of errors now associated with the shipping process can be reduced or eliminated. In either case, once the order is done being picked, the portable can then send this information to the computer or workstation located in the shipping office and a bill of lading can be prepared for the shipper to take with them and one or more for internal mill processing.

Most importantly, the shipped information can be immediately sent to the host financial accounting system within minutes of the order leaving the dock. This will allow immediate invoicing, as well as providing sales agents immediate access to shipped information for better customer service. Finally, if the customer is requiring EDI notification of shipments, this can be easily accomplished by taking the shipping data collected automatically at the mill and creating the corresponding EDI transactions without the need for any rehandling or keypunching of the raw data.

2.2.4. Physical Inventory

Once the units in the yard are properly tagged with a bar code number, the process of taking a physical inventory can be fairly straightforward. Using a portable reader with a bar code scanning input device (laser scanner, wand scanner or CCD, explained later in this report), the mill personnel can walk the yard and scan each unit number. This information is then uploaded from the reader to a PC or main computer via a cable, a communications docking station, or radio frequency. A comparison is made between the scanned data and the perpetual unit inventory information in the computer. The exceptions are printed on a report for the mill personnel to reconcile units not found or units found but not in inventory.

There are other situations, or problems, that exist in the yard that will complicate what seems like an easy process.

- A unit may be found but it is mislabeled, i.e. the perpetual inventory and tag says it contains 10 foot 2x4s, when it actually contains 8 footers.

- The bar code serial number may be damaged and be unscannable.
- The units are stacked so close together that the bar code label may not be readable or scannable.
- The units are stacked outdoors in a bright, sunny location

Each of these problems can be solved with proper planning and good system and tag design. Take the problem of product being mislabeled. By taking the inventory by product code (or product type) the units that are mislabeled can be found and relabeled. Or in the case of the perpetual inventory record being wrong, it can be edited on the computer and given the proper product code. Unit numbers that have damaged bar codes can be keyed into the portable reader via a ten key pad (although this introduces chance for a keying error, it is better than writing it down and keying it in later). Alternately, the bar code can be printed in two different places on the label (see earlier examples). If one is unreadable there is a high likelihood that the second, alternate, bar code can be scanned. If the units are stacked closely together, having a tag that "wraps" around the end of the unit, and applying two tags (one on each side/end) greatly increases the chances of it being read.

The portable reader can also be programmed to handle additional errors that commonly occur. If a tag is scanned twice, the reader can sound an audible beep pattern that the mill person would recognize as an error and be able to view on the reader's screen that they scanned the tag or label twice and ignore it. Common problems also arise that cause the tags to be difficult to scan. For example, the units are stacked too high and the bar code is physically too many feet away from the person taking inventory. Or the units are in an open yard on a sunny day which will cause the tags to be difficult to read. The effect of these environmental issues can be minimized or are solvable and are discussed in a subsequent section.

Cycle Counting is becoming a more popular means of taking a physical inventory. Cycle counting really means taking a smaller subset of the entire inventory and counting only those items. Taking a whole yard at once could be done with many simultaneous or concurrent cycle counts. In this manner, more errors could be caught. For example, if we are only cycle counting DF 2 x 4's, when we find a 2 x 6 unit in the area with 2 x 4's the fork lift driver can move it to the appropriate location. If we were just scanning everything in the yard, this error condition would be more difficult to detect. Alternately, if we scan a tag for a unit of Hemlock 2 x 4's and not Douglas Fir 2 x 4's, but the unit is DF, the unit can be retagged.

Cycle counting also allows a more manageable count, especially during cut over from a manual system to a computerized system. However, reconciliation issues can complicate getting the perpetual inventory in line with the actual inventory. Take the situation where the unit is not tagged correctly. The unit is DF but the tag says Hemlock and the perpetual inventory thinks it is Hemlock (this can occur at the bander through human error or a PLC error). In a batch mode of taking inventory, this error would not be discovered until the portable reader's data has been downloaded to the computer and the comparison report run. Much time can be consumed by the staff going back into the yard to find that unit, confirm the problem, and retag it.

Because of the difficulties presented for reconciling units of inventory in a batch mode by a sequentially generated serial number, radio frequency technology is being adopted to allow immediate access to information for a unit. If the portable reader has radio contact with the perpetual inventory data base, the person doing the cycle count can know if a unit is mislabeled or misplaced.

2.3. BENEFITS OF AUTOMATED DATA COLLECTION

As alluded to above, there are many tangible, cost saving benefits to using this technology and systems. Some of these are listed below:

1. The information about the unit is collected automatically as a by-product of putting a tag on the unit of lumber. This eliminates a labor intensive process of hand writing the information (typically after the fact) and entering it into the system.
2. Better data accuracy is also achieved because the data is collected automatically, in lieu of keyboard data entry.
3. It also eliminates the time delays of knowing what was produced today (and can now be sold or consumed).
4. By creating a unique tag for each unit, the unit can then be easily tracked (example, shipped) or counted (example, physical inventory) without the need for the mill employee to create handwritten documents. These also have to be interpreted and entered into some system at a later time via yet another labor intensive data entry process.
5. Because the unit now has a unique serial number, each time the unit is transferred and the bar code scanned, an immediate system check can take place to insure that the correct unit is being used (example, eliminating mistakes in shipping the wrong unit.)
6. Because the actual unit information is entered into the system at the production point, the person responsible for production is doing the collecting. Unlike a keypunch person in the office, the person on the mill floor takes more "ownership" in the data, and can handle situations or problems as they occur, rather than after the fact. This makes the data more reliable and more accurate.

3. THE BAR CODE LABEL/TAG

As mentioned in the earlier portion of this monograph, the critical element in tracking inventory is the bar code label or tag. However, many issues come into play in making sure that the bar code label or tag will be read when it needs to be read. This section will discuss some of those critical issues. An excellent source for more detailed information on the use of bar codes for the wood products industry is "Bar Coding Guidelines for the Wood Products Industry II", published by the American Forest & Paper Association. It is available for $20.00 by writing to the following address:

American Forest & Paper Association
American Wood Council
1111 19th Street, N.W. Suite 800
Washington, DC 20036
Telephone: (202) 463-2733
FAX: (202) 463-2791

3.1.1. Characteristics of Symbologies Used

The basic principle behind most types of bar codes is to represent a character with a pattern of parallel, black and white bars of various widths. Various types of bar codes were developed to meet different working environments and conditions. These different bar code types are called symbologies.

A bar code symbol is an arrangement of varying width bars and spaces. The way a bar code reader, or input device, "reads" and interprets a bar code is based on several characteristics of these bars and spaces. The reader's internal decoder looks at these bars and spaces, measures their widths, compares the ratios between thick and thin widths of both bars and spaces, interprets start and stop characters, and processes this measurement data. This "decode process" ends with a "good read", i.e. the bar code is turned into valid data that a program or human can use.

"Symbology" is the term used to describe the unambiguous rules specifying the way the data is encoded into the bars and spaces. Some symbologies can encode only numbers, some can encode alphanumeric information, while others can support the entire 128 unique codes of the ASCII character set.

In a bar code symbology, data is conveyed in the widths of the bars and spaces. Two kinds of linear symbologies exist, those that employ two elements of widths (wide and narrow) and those that employ multiple widths. In a two width symbology (like code 39) the ratio between the wide and narrow element widths is important. It is typically 3 to

1, although it can vary from 2 to 3. However, if a bar code is printed "in spec" the narrow bar, or space, is preferred to be one third the size of the wide bar or space.

Bar code symbologies differ in the amount of data that can be encoded in a given length. In order to allow meaningful comparisons, the value of X (width of the narrow bar or space) needs to be considered when examining relative densities. The overall length of a symbol needs to include any start and stop characters, quiet zones (the area immediately to the left and right of the entire bar code symbol), and any check digit characters that may be contained in the bar code symbology.

X dimension is the term applied to the width of the narrowest element in a symbology (both bars and spaces). It is usually expressed in mils (thousandths of an inch). This X dimension will determine the overall total width of the bar code, which printer is required to print the symbol, which input device to use for scanning, how far away the input device can be to scan the symbol, as well as many other critical factors. Even though the X dimension together with the number of characters in the bar code fixes the bar code length, the bar code height is variable based on space available for printing. The bar code height will affect scanability by the device and the target area for long range scanning.

A common situation to the primary manufacturing arena is tagging units of lumber to be readable from 15 feet, from a forklift, in an outdoor setting. Here the X dimension, the bar code height, the quality of the printing device, and the reading input device becomes essential to a successful shipping or cycle counting application.

The unit tag's bar codes are usually printed using a 20 to 40 mil X dimension with a height of 1 in. or more. Although this creates a much longer and larger bar code (as well as a bigger target to aim at), it is able to be read at longer distances. For example, a 40 mil bar code can be read at a distance of about 12 in. to 18 in. with a standard laser (current technology) scanner. Using a long range scanner this bar code can be read from 10 ft. to 12 ft. or more. Adding the height of an average mill worker (about 5 ft. 10 in. with a 30 in. reach) a bar code could be read as far away as 18 ft.. Some scanner distributors currently advertise 30 ft. scan distances. However, as of this writing, these are typically for use with high cost, retroreflective labels, in optimum lighting conditions using a 60 mil or more bar code.

Typically, a bar code menu (see exhibit 2-3) is printed with a 10 or 15 mil X dimension to conserve space and yet provide a clear, readable bar code. The bar code height is usually 0.5 in.. This layout is easy for a person to scan using a wand input device. Unfortunately, bar codes have to be read at both long and short distances. Long distance for the unit tag and short distances for the menus. Therefore the same device may not be employed for menus and long range scanning. However, some manufacturers are now beginning to produce longer range scanners that also can read at short ranges (some restrictions will apply to the bar codes printed, such as a minimum X dimension).

3.1.2. Common Symbologies Used

One of the most commonly used symbologies is Code 39. It is used by manufacturers and wholesalers for internal information tracking. This symbology is used for product marking, bar code menus, work order travelers, employee badges, and many other items. One of the reasons it was developed is that Code 39 allows for every character in the full ASCII standard character set to be represented without a maximum character length restriction. Although this makes code 39 a very flexible symbology, it does take up more space than a more restrictive symbology, like UPC.

UPC code is a fixed length, numeric only, continuous symbology employing four elements of widths (spaces and bars). Two common types of UPC are version A, which encodes twelve digits, and version E which encodes six digits. UPC is designed to uniquely identify a product and its manufacturer. It is used most at the retail level. One of the reasons it is defined here is that retailers are demanding that their suppliers label their product with a UPC code before shipping to the store.

This burden has added tremendous costs due to the effort required to place a UPC code on individual products. Placing an "in spec" UPC code on a piece of 3/4 in. trim becomes a very tricky proposition. As of this writing, it is not known if there is a better solution than the costly hand application of a UPC code to each piece of trim. Labeling individual sticks of lumber while they are banded can at least be done with a staple gun loaded with a roll of UPC coded tags.

The UPC codes contain 6 digits (formerly 5 digits) of numeric information in the left half of the bar code that indicates a unique manufacturer number assigned by the Uniform Code Council. It was developed as a standard symbology for labeling product consumed at the retail level. However, it is also becoming an integral part of standardizing shipping codes that are being readily adopted, such as UPC and UCC Shipping Container codes explained below. One of the reasons for their adoption is to assist in standardizing information for use in EDI (Electronic Data Interchange) transactions for shipping and invoicing data.

Another symbology that is gaining acceptance by the wood products industry is Code 128. This symbology was introduced in 1981 as a very high density alphanumeric symbology. It is a variable length symbology employing multiple element widths. Its best feature is its ability to represent numeric data in "double density" mode; meaning that it can represent two digits in one character. The result is a code that is more compact than some other symobologies, especially for numeric data. It is specified for the UCC and UPC shipping container codes which require many numeric digits. Further, a serial number tag can be printed with Code 128 using a lower density (larger X dimension), making the bar code larger and better for reading from a distance.

The Uniform Code Council has developed a specific format using Code 128. It is referred to as the UCC/EAN-128 Serial Shipping Container Code. This code format contains the manufacturer ID number (the portion of the UPC number described above) as well as the unique serial number assigned internally by the mill's bar code system to the shipping unit. This format must be used with Electronic Data Interchange in order to make the code meaningful. The result of using this code structure is that the receiver can scan this code and reference the Advanced Ship Notice (ASN) to identify the purchase order and the contents. Additional description of this code can be found in the "Bar Coding Guidelines ..." text referenced above.

The UCC Shipping Container Code has also been developed by a bar code industry governing body (AIM-Automatic Identification Manufacturers Technology Symbology Committee) to enable the format to contain the UPC format as part of the shipping. This essentially replaces the unique serial number described above with the UPC product code for easier identification and additional "intelligence" in the bar code for the receiver of the unit, or product. The other symbology discussed extensively in the "Bar Coding Guidelines..." text is the UPC Shipping Container Code Symbol Format. It utilizes the Interleaved 2 of 5 symbology, developed by the Uniform Code Council for shipping containers targeted at the retail industry. Its use will come into play for forest products shipped in containers.

One additional symbology that needs some attention here is the newer technology of 2D Symbologies (Matrix Code 1, PDF 417, etc.). These symbologies are growing in popularity. They are not linear codes such as UPC or Code 39, but are matrix codes containing a great deal more room for more data. They are being adopted for use when several fields of data are needed to be expressed in one readable code. For example, a 2D code could contain all of the information about a unit or the manufacturer number, the part number, the serial number of the unit, the purchase order number and the advanced ship notice in one code. These codes require different scan technology for reading. The availability of these types of scanners is increasing and will see an impact in this marketplace within the next five years.

Although additional new symbologies have been added, the following 1989 publications still provide useful, detailed information on common, standard symbologies.

"The Bar Code Book"
by Roger Palmer
Helmers Publishing, Inc.
174 Concord Street
Peterborough, New Hampshire 03458
1989

"Bar Code Symbology"
by David Allais
INTERMEC Corporation
6001 36th Avenue West
Everett, Washington 98203
1989

3.1.3. Media

There are many factors to consider when choosing the proper media (label or tag stock and printer ribbons, primarily) for a wood products application. The lack of a good quality, well printed, easily scannable bar code at the time of scanning has been the downfall of many early attempts at implementing bar code technology. It cannot be over emphasized that the proper media and printing technology needs to be in place for a successful bar code implementation.

In most mill operations the durability of the bar code label or tag determines how well a bar code will scan at some future date. Obviously, attaching a paper label printed on a matrix printer to product that will sit outdoors is not a good idea. Many media specialists and manufacturers can now provide different types of synthetic materials that withstand being exposed to the elements and are strong enough to withstand abuse and some chemicals. Tag and label materials have been developed that are not affected by water and dirt, can be exposed to direct sunlight (UV light) and will still be readable years later. There is a small premium to be paid for this type of quality material, but the price difference between this quality material and a less expensive, less durable material is becoming closer.

For tag stock, it is important that the material be strong enough to hold a staple, yet not tear when subjected to windy conditions, either weather related or the truck ride down the freeway. Some materials are strong enough to hold a staple well, yet when the small tear started by the staple is exposed to wind the tag will easily tear further and possibly blow off of the unit while on the truck. Reasonable cost material, have become available within the last two years that eliminate these problems.

For a label, in addition to the face stock (the material that the label is made of), the adhesive becomes a critical issue. The quality of the adhesive determines the strength of the adhesion, the application temperature, its ability to adhere to rough or green surfaces, permanence, and many other factors related to this environment.

3.1.4. Environmental Issues

In addition to the items noted above the environment of the primary production wood manufacturing facility provides new challenges to a successful bar code data collection system. As mentioned in an earlier section, taking physical inventory, doing a cycle count or shipping units, scanning in bright conditions, scanning units stacked 3 or 4 units high, or scanning from a forklift can present roadblocks to successfully implementing bar code technology.

Scanning a unit of lumber outside in bright sunlight has not yet been successfully addressed by manufacturers of laser scanners. One of the problems with scanning outdoors is physically aiming the laser beam at the bar code in order to get a good read. In bright sunlight, even at close range, this can be very difficult because the light beam emitted from the scanner is hard to see, let alone aim. With the newer long range scanners, aiming becomes almost impossible at a distance. One manufacturer has just announced their new long range scanner with a sight on the top of the laser gun to help the user "aim" at their bar code target.

One mill added sunglasses to the list of required equipment for their forklift drivers to help reduce the effect of bright conditions on bar code scanning. Some manufacturers have begun offering "high visibility" scanners to address the sunlight problem. These high visibility scanners produce a brighter beam for easier identification in outdoor conditions.

Another problem associated with scanning outdoors is the glare of the sun on the bar code media. Most scanning technologies use reflection of the laser beam off of the media to measure the bar code widths for its decode. The glare of the sunlight off of the media will intrude on this decode process, reduce the depth of field, and cause "no reads", which are frustrating to a rushed fork lift driver.

Scanning from a distance, especially in tight conditions, also presents problems for many mills. Most units of lumber are stacked two or three units high. As mentioned earlier, the newer laser scanners can read a 40 mil bar code up to 18 ft. away. However, if the units are tightly stacked it may be necessary to make a visual identification of the number and to key it into using the keyboard a on a portable reader. Other ideas that have been tried to get around some of these environmental condition issues follow:

1. Stack the lumber so that the tags are on the north side of the unit placing it in the shade as much as possible.
2. Take inventory at night or only at the beginning or end of the day when the sun is in a lower position.
3. If units are scanned on the truck during shipping, place a covering over the shipping area so that scanning is always done in the shade.
4. Place scannable tags on all four sides of the unit.
5. Place scannable tags in the lower corner of the unit and in the same place on the unit every time.

4. OTHER FOREST PRODUCTS PRODUCTION ENVIRONMENTS

Many applications, in addition to those mentioned here, exist for bar code and other Auto ID data collection technologies. The technology is also being implemented in logging operations as well as wood products re-manufacturing. These applications are similar to classic implementations in many other manufacturing industries. Applications for the technology include receiving, shipping, work in process inventory, parts inventory, finished goods inventory, cycle counting and physical inventory, time & attendance (for payroll), labor tracking (for costing), and other areas.

Other forest product environments employ the same techniques and concepts put forth in this monograph for the primary production arena. Bar codes are scanned from labels on the item being tracked, as well as other input sources such as bar code menus, shop floor travelers, labeled equipment, and employee badges. Bar code technology also works hand in hand with many current manufacturing state of the art concepts such as Just in Time (JIT), MRP, and ERP systems.

4.1. Logging

Bar code technology can be used at the source of the wood products industry -- the woods. Systems have been implemented for tagging and tracking both loads of logs as well as individual logs. If fact some of the first implementations of bar code scanning involved bar coded log tags. Region 6 of the U.S. Forest Service has also piloted the implementation of load tickets to replace the commonly used ticket books. The logs or loads of logs can be labeled at the point of harvest and tracked through U.S. Forest Service inspection review, scaling stations, and arrival at a mill. Log tags are often applied to logs purchased from a third party and then scanned upon their receipt at the purchaser's site. This same log tag can then be read as the log is consumed at the debarker, most often by pulling the tag and scanning through a reader at the debarker or accumulated and scanned in the office. Log tracking can be one of the easiest and cost effective pilot implementations of bar code technology.

4.2. Remanufacturing/Secondary Production

As discussed previously, units of lumber can be consumed and new units created through re-tallying and re-sorting processes in a remanufacturing plant, such as laminated beams. The inherent high value resulting in products of a laminated beam remanufacturing facility mean it is often imperative to track the individual product produced for costing, quality, yield and recovery in order to maximize factory usage and improve profit margins.

The importance of tracking this type of information also applies to high value secondary products such as melamine panels, wallboard, etc.. In these environments, it is also possible to produce a label to incorporate both the bar code tracking application as well as governmental safety labels, installation labels, UPC point of sale labels, and warning labels within the same process and labeling procedure. Further, by beginning to track information early in the production cycle, quality and lot traceability data can be easily maintained. By doing this, it will be easier to research and fix problems related to defective product, such as machinery needing service, poor quality raw materials or continuing employee errors.

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3	"A Decision Framework for Trading Lumber Futures," (October 1975).
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