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Executive Summary:

Based out of California, the Bright Guitar Manufacturing Company manufactures and sells acoustic guitars from a brick and mortar storefront. The manufacturing facility is attached and is located directly behind the storefront. This is a relatively new business manufacturing and selling four basic models of acoustic guitars. Although we offer only for basic model in one "classical" shape, each guitar has its own tone and feel, which are the main attributes that make the customer choose one guitar over another. Our main suppliers are in Canada and New Jersey,

as we have found these suppliers fit our business model the best at the present time. Depending on the wood options chosen, our guitars cost from $280 - $413 for materials only to build. Skilled craftsman are used for most of the work, which we pay on average $12.00/hour. We also recruit local high school help for the lower skilled work, which we pay on average $6.00/hour. Regardless of which wood option, each guitar requires 14 hours of skilled labor and 15 hours of unskilled labor, which culminates into labor costs per guitar are $264. Therefore, the total cost for our handmade guitars range from $544 - $677. Our policy is to list price our guitars with 75% margins, which is standard for these types of instruments, and typically sell the guitars at 60% margin (markup). This puts our guitars selling at $870 – $1,084.

We manage the small storefront with min/max inventory levels of each guitar based on historical sales over the past year. These inventory levels are further managed with a ceiling of $10,000 (approximately one month historical income from selling an average of 22 guitars per month) based on total costs per guitar in the store. With the average guitar costing $610, there are about 16 guitars in the store at any given time. To maintain sales of 22 guitars per month, we have two full-time skilled workers and two full-time unskilled workers. This target output is attainable with our small staff working at 92% efficiency, which is usually not a problem (baring any excessive absenteeism or loosing a worker without sufficient notice) as the process dictates more hours of “setting” time (time for the glue to dry) than actual labor. The manufacturing area is divided into seven work centers: Sides, Back, Top, Install, Attach, Bridge, and Hardware. A detailed description of each of these work centers is provided in a separate documents on the flowing pages with a list of capital equipment, materials required, labor hours, and overall process flow(s).

Mission/Vision

Bright Guitar manufacturing mission is to provide world-class quality acoustic guitars and a fair price. We do this with respect to our customers, employees and vendors.

Goal and Objectives

Bright Guitar manufacturing is currently manufacturing and selling approximately 22 guitars per month in four basic model types. As these four models have proven successful, we plan to grow the business in the short and mid term with only these four model types. However, we are looking to grow our business approximately 20% over the next year. We believe this can be obtained with increased market exposure through our own WEB site. Below are the one year non-financial and financial goals.

Non-financial

1. Develop Bright Guitar Manufacturing WEB site
2. Set up repair and renovation shop
3. Provide Guitar lessons

Financial

1. Increase gross revenues by 20% over the next year.
2. Improve gross margins by 10%.
3. Improve manufacturing productivity by 15%.

Capacity requirements and availability to meet marketplace needs:

Through analysis it has been determined that Guitar Manufacturing needs two full-time skilled employees and two full-time non-skilled employees working at an average efficiency rate of 92% to meet the targeted goals of 22 guitars per month. This efficiency rate may appear to be high, but confidence is also high that this is a reasonable rate, as the process of building guitars

has a lot of wait time build into it and being such a young company have not started on batches and other efficiency techniques. The current business model dictates "high quality" as the number one objective, rather than short lead times, etc.

Utilization of capital equipment:

Capital equipment, as well as direct and indirect materials has been identified for each of the work centers. Capital equipment items are defined as items with more than $250. Materials, wood, glues, lacquers that actually ship with the guitars are considered "direct materials". Materials such as sandpaper, rags, water, etc. do not ship with the guitar and are considered indirect materials. All tools and other supplies required that cost under $250 would also be classified as indirect materials.

Work Center Characteristics:

Sides:

The "Sides" work center is where both sides of the guitar are bent into shape – offered in East Indian Rosewood and European Sycamore for both our guitar sides and backs. This process begins by first cutting the wood to size and then soaking the wood in a tub of water overnight. This operation takes about two hours per guitar and is usually performed by unskilled labor. The next step involves uses a bending iron to bend the guitar sides into place. This step requires skilled labor to perform and takes about 1.5 hours skilled labor per guitar. The sides are then left to set overnight in an assembly form (a wooden brace in the shape of the guitar). This half of the process takes about three days to complete with a total of six hours of labor.

The second half of this process takes about two days and involves installing linings, which are needed for added support in holding the guitar together (without linings it would be difficult to hold the top, bottom, and sides together). We use basswood for our linings, which are manufactured and installed in a six-step process as shown below. The two-day lining process

includes letting the glue set overnight, and requires 1.5 hours of skilled labor per guitar to complete. As Josh Brown, 2003 states:

- Cut the long pieces of material 1/4" x 3/8" x 28" on the table saw.
- Cut the kerfing 5/32" deep on the 1/4" section using the radial arm saw.
- Soak the long strips of wood in water for 15 minutes.
- Position the kerfing on the inside of the guitar sides at the top and bottom.
- Put clothespins around the outside to hold the material and cut it to a length that covers the inside of the guitar one time around.
- Glue the kerfing into its final position so that the edge is flush with the top of the guitar.

Process Flow	Labor Hours/Cost			Process Time (days)
	Skilled	Unskilled	Total Cost	
Cut and Soak	0	2	$12.00	2 Days
Bending	1.5	0	$18.00	2 Days
Cut & Glue Linings	1.5	0	$18.00	2 Days
Total	**3**	**2**	**$48.00**	**6 Days**

Capital Equipment	Tools and Supplies	Materials
Table Saw	Various Clamps	(2) 4" x 3/16" x 30" Wood for Sides
Radial Arm Saw	Various close-pins	¼" x 3/8" x 28" basswood
Plywood Bold	Various rags and sponges	Adhesive (glue)
Bending Iron	Various Buckets	
Tub for water		

Note: Capital equipment items are defined as items with more than $250. Materials under "Tools and supplies" are indirect materials, and the "Materials" column contains direct material.

Back:

The back is actually manufactured with three pieces of wood, two sides and one center strip down the middle that are all glued together – we offer East Indian Rosewood and European Sycamore for our guitar sides and backs. The first step is to ensure that all three pieces of wood are planed to the same thickness. This takes a skilled worker about 1.5 hours per guitar, including sanding. Next, the pattern is traced and cut by the skilled worker and takes about one half an hour per guitar. After all the rough edges have been sanded down the center strip is glued

together with the two back pieces and let to set overnight. This also takes approximately one hour of skilled labor.

After the back pieces set overnight chiseling and sanding down the rough edges before the Logo is branded are the next steps. This takes about one hour of unskilled labor. Back groves then need to be cut in the inside of the centerpiece for the back braces, which takes about one hour of unskilled labor. The back braces are then glued, clamped, and let to set overnight.

Process Flow	**Labor Hours/Cost**			**Process Time (days)**
	Skilled	**Unskilled**	**Total Cost**	
Plane & Sand	1.5	0	$18.00	See subtotal
Trace and Cut	0.5	0	$6.00	See subtotal
Glue center strip & clamp	1	0	$12.00	See subtotal
Subtotal	*3*	*0*	*$36.00*	*2 Days*
Chisel & Sand edges	0	1	$6.00	See subtotal
Cut back brace groves	0	1	$6.00	See subtotal
Glue back braces & Set	0	1	$6.00	See subtotal
Subtotal	*0*	*3*	*$18.00*	*2 Days*
Total	**3**	**3**	**$54.00**	**4 Days**

Capital Equipment	**Tools and Supplies**	**Materials**
Power Planer	Various Clamps	(2) 7” x 3/16” x 21” Wood for Back
Aluminum jig	Various rags and sponges	¼” x 3/16” x 21” Center strip wood
Logo branding iron	Plexiglas template	Adhesive (glue)
	Seam Clamp	Spruce strips for braces
	Skew Chisel	
	Various sandpaper	

Top (Soundboard):

The top, or soundboard is basically the same shape of the back, but is manufactured as one piece, with a hole in the middle – offered in Engleman spruce and Sitka spruce. The sound hole is fitted with either mosaic for the Engleman spruce soundboards or zebrawood for the Sitka Spruce soundboards. The first step is to ensure that the soundboard is planed to the same thickness as the back. This takes a skilled worker about 1.5 hours per guitar, including sanding.

Next the outline as well as the actual sound hole is traced and cut by the skilled worker and takes about one half an hour per guitar. After all the rough edges have been sanded down the center rosette is glued on the sound hole and let to set overnight. This also takes approximately one hour of unskilled labor. After the rosette inlay pieces set overnight the braces need to be installed. As Josh Brown, 2003 states:

- Cut the pieces of spruce to 3/8 inch wide, by 5/8 inch thick strips.
- Sketch the design to be followed on the inside of the soundboard, making sure to draw the lines 3/8 inch wide to allow for the thickness of the material.
- Cut the pieces of spruce to the lengths needed.
- Apply glue to the pieces needed to be installed, and apply even, constant pressure on braces until they are dried.

This is about a two-hour process for a skilled worker.

Process Flow	**Labor Hours/Cost**			**Process Time (days)**
	Skilled	**Unskilled**	**Total Cost**	
Plane & Sand	1.5	0	$18.00	See subtotal
Trace and Cut	0.5	0	$6.00	See subtotal
Glue Inlay & set overnight	0	1	$6.00	See subtotal
Subtotal	*2*	*1*	*$30.00*	*2 Days*
Cut braces	1	0	$12.00	See subtotal
Glue braces & Set	1	0	$12.00	See subtotal
Subtotal	*2*	*0*	*$24.00*	*2 Days*
Total	**4**	**1**	**$54.00**	**4 Days**

Capital Equipment	**Tools and Supplies**	**Materials**
Power Planer	Compass	(2) 7” x 3/16” x 21” Wood for Back
Aluminum Jig	Circle Cutter	Adhesive (glue)
	Various clamps	Rosette
	Various sandpaper	

Installing Tops and Sides:

This work cell basically glues the sides of the guitar that have been sitting in the assembly form with the top or soundboard. The process simply involves removing the sides from the assembly form, placing the soundboard facedown in the bottom of the form, and replacing the sides back into the form. With the presence of a skilled worker nearby, the more experienced

unskilled workers are assigned with make minor adjustments and sanding to ensure a snug fit before gluing – since the forms are shared with the "Sides" work center, there is always a skilled worker nearby, as both of these work centers are adjacent to each other. Once the fit has been verified by one of the skilled workers, the unskilled worker applies the adhesive between the kerfing and soundboard. This takes about two to three hours, depending on how much adjustment is needed, and is then let to set overnight.

Process Flow	**Labor Hours/Cost**			**Process Time (days)**
	Skilled	**Unskilled**	**Total Cost**	
Form Setup	0	.5	$3.00	See Total
Alignment and sanding	0	1	$6.00	See Total
Glue and set overnight	0	.5	$3.00	See Total
Final Sanding	0	1	$6.00	See Total
Total		**3**	**$18.00**	**1 Day**

Capital Equipment	**Tools and Supplies**	**Materials**
Assembly Form	Various sandpaper	Completed sides
		Completed top (soundboard)
		Adhesive (glue)

Attaching Body and Neck:

The current business model involves the Bight Guitar Manufacturing Company outsourcing completed guitar necks, as to build a guitar neck in house requires a unique set off skills we currently cannot support, but may perform in the future. All of the necks are made from Mahogany, with an Ebony or rosewood, all of which are purchased from our Canadian supplier. This is an extremely critical part of the process and requires at least two hours of skilled labor to perform it correctly. As Josh Brown, 2003 states:

- The soundboard and connected sides must be cut out to fit the end of the neck to be attached.
- The neck of the guitar is slid inside the cut out spot for the guitar to ensure a proper fit.

- The neck is pulled out of the whole, after the proper fit is verified, and adhesive is applied to the areas of the base of the neck to be in contact with the body of the guitar.
- Insert the neck into the cavity and apply pressure until the glue is properly dried.

After the completed assembly is allowed to set overnight, an unskilled worked sands and applies the appropriate lacquer and stain finishes. This usually takes about two hours per day over two days. The guitar is then allowed to cure for one week hanging in a clean room.

Process Flow	**Labor Hours/Cost**			**Process Time (days)**
	Skilled	**Unskilled**	**Total Cost**	
Cut slots in neck and back	1	0	$30.00	See Subtotal
Ensure proper fit	0.5	0	$15.00	See Subtotal
Glue, clamp, set overnight	0.5	0	$15.00	See Subtotal
Subtotal		*0*	*$60.00*	*1 Day*
Final Sanding & Finishing	0	4	$24.00	2 Days
Curing on Clean room	0	1	$6.00	7 Days
Subtotal	*0*	*7*	*$30.00*	*9 Days*
Total	**3**	**4**	**$90.00**	**10 Days**

Capital Equipment	**Tools and Supplies**	**Materials**
Clean Room	Various sandpaper	Completed Guitar neck (Outsourced)
Saws	Various clamps	Completed Sides and Top
	Various polishing rags	Completed Back
		Adhesive (glue)
		Finish lacquer and stains

Bridge Attachment:

After the completed guitar has been allowed to cure for one week, a skilled worker now must carefully measure and install the bridge. Bright Guitar Manufacturing purchases all of the bridges from their New Jersey supplier, but mounts it to their guitars in house. The first step is to carefully locate the bridge position on the top of the soundboard. The skilled worker then strips the lacquer finish in the bridge pattern drawn. The six holes for the guitar strings are then drilled

before the final gluing and clamping is performed. The process takes about two hours, then the bridge is allowed to cure for 48 hours before the final hardware step.

Process Flow	Labor Hours/Cost			Process Time (days)
	Skilled	Unskilled	Total Cost	
Locate and Trace pattern	.25	0	$3.00	See Total
Remove lacquer finish	0.5	0	$6.00	See Total
Drill string holes (6)	.25	0	$3.00	See Total
Glue, clamp, set overnight	1	0	$12.00	2 Days
Total	**2**	**0**	**$27.00**	**3 Days**

Capital Equipment	Tools and Supplies	Materials
Drill	Lacquer remover	Completed Guitar
	Centering ruler	Bridge
	Chisel	Adhesive (glue)
	Various sandpaper	

Hardware Installation and Final Tuning:

The final work center is the finishing area. This process consists of installing the bridge saddle, nut, tuning keys, and then the strings. Once the guitar is all tuned up and checked our, a final polishing is performed before the strap buttons are installed (a marker of a completed guitar) and sent to the show room. This process takes lees than two hours by one of our experienced unskilled workers.

Process Flow	Labor Hours/Cost			Process Time (days)
	Skilled	Unskilled	Total Cost	
Mount bridge saddle	0	See total	$	See total
Install Tuning Keys	0	See total	$	See total
Install Nut	0	See total	$	See total
Install Strings	0	See total		See total
Tuning and Polishing	0	See total		See total
Install Strap buttons	0	See total		See total
Total		**2**	**$12.00**	**1**

Capital Equipment	Tools and Supplies	Materials
N/A	Various polishing rags	Bridge Saddle
	Polish	Tuning Keys (Right & Left set)
	Screw Drives	(2) Strap Buttons

	Need nose pliers	One set of steel six strings
		Neck Nut (Bone Ivory)
		(1) Set of six pegs (Ebony or Ivory)

Communication with Customers

Communications per customer is mainly through our storefront sales and word of mouth. Bright Guitars has business cards and is listed in the local yellow pages. We are currently developing a WEB site, which is schedule for publication early next year. We also attend trade shows where awe exchange business cards and occasionally pass out flyers at concerts and other musical events. We are planning to set up a booth at the local arts and wine festival this coming year.

Communication with Suppliers

As mentioned in the business profile, our main suppliers are a single source in Canada and a single source in New Jersey, as we have found these suppliers fit our business model the best at the present time. We have established weekly conference calls with each supplier to discuss delivery schedules and orders. Bright Guitars is basically a “Class C” company using MRP primarily as an inventory ordering technique, but is slowly implementing scheduling into the system design. As we grow the business, we will begin to look into local suppliers as a second source, but feel that quality needs to meet or exceed our current suppliers before agreeing on any terms.

Physical Implications of the Manufacturing Activities

Each work center required a 10x20 foot area or 200 sq ft. However, by using a cellular manufacturing approach and capital equipment allocations, the seven work cells will fit quite nicely in a 600 sq ft space (approximately three single car garages). This factory will be located behind the 400 sq ft storefront holding our finished goods inventory of approximately 20

acoustic guitars. The table below is a break down by work center of the skilled and unskilled labor requirements, as well as costs associated with both labor and materials (on a per guitar basis).

Table 1

Bright Guitars Operations Work Center Labor and Material Cost									
Work Center		Sides	Back	Top	Install	Attach	Bridge	Hardware	Total
Time line (days)		6	4	4	1	10	3	1	29
Skilled labor hours		3	3	4	0	2	2	0	14
Unskilled labor hours		2	3	1	3	4	0	2	15
Total Labor hours		5	6	5	3	6	2	2	29
Skilled labor cost		$36	$36	$48	$0	$24	$24	$0	$168.00
Unskilled labor cost		$12	$18	$6	$18	$24	$0	$12	$90.00
Total Labor cost		$48	$54	$54	$18	$48	$24	$12	$258.00
Total Material cost	Avg.	$74	$111	$76	$5	$38	$5	$55	$346.86
Avg. cost/work center	Avg.	$122	$165	$130	$23	$86	$29	$67	$604.86
Avg. cost %	Dollars	20.1%	27.4%	21.5%	3.8%	14.3%	4.8%	11.1%	
Skilled labor %	Dollars	21.4%	21.4%	28.6%	0.0%	14.3%	14.3%	0.0%	
Unskilled labor %	Dollars	13.3%	20.0%	6.7%	20.0%	26.7%	0.0%	13.3%	
Total labor %	Dollars	18.6%	20.9%	20.9%	7.0%	18.6%	9.3%	4.7%	
Skilled labor %	Hours	21.4%	21.4%	28.6%	0.0%	14.3%	14.3%	0.0%	
Unskilled labor %	Hours	13.3%	20.0%	6.7%	20.0%	26.7%	0.0%	13.3%	
Total labor %	Hours	17.2%	20.7%	17.2%	10.3%	20.7%	6.9%	6.9%	

Financial Implications of the Manufacturing Activities

The financial spreadsheet below, defines the labor costs, materials, profit margin target, and labor efficiency. Assuming two skilled employees and two non-skilled employees work a standard 40-hour workweek with no over time and four weeks per month, the target monthly output is 22 guitars. Based on this work force and output targets an overall labor efficiency of 92% must be maintained. We have also targeted an average 60% markup (gross margin). All guitars will normally list at 75% margin, which is average for these types of hand made guitars, but will often negotiate down and have occasional sales – Christmas sales for example.

Table 2

Bright Guitar Manufacturing Profit/Loss Worksheet	
	Margin Trends

Model	Labor	Materials	Cost	50%	60%	70%	80%	90%	100%
A	$264	$280	$544	$816	$871	$925	$980	$1,034	$1,089
B	$264	$359	$623	$934	$997	$1,059	$1,121	$1,183	$1,246
C	$264	$335	$599	$898	$958	$1,018	$1,078	$1,138	$1,198
D	$264	$413	$677	$1,016	$1,084	$1,152	$1,219	$1,287	$1,355
Average	$264	$347	$611	$916	$977	$1,038	$1,100	$1,161	$1,222
				Labor required based on guitars manufactured per month					
Guitar builds per month				20	22	30	34	40	44
Skilled labor hrs per Guitar			14	280	308	420	476	560	616
Unskilled labor hrs per Guitar			15	300	330	450	510	600	660
Total labor monthly per guitar			29	580	638	870	986	1160	1276
Skilled labor required (avg./mo)			173.3	2	2	3	3	4	4
Unskilled labor required (avg./mo)			173.3	2	2	3	3	4	4
Total labor monthly hours/employ			346.6	4	4	6	6	8	8
Skilled labor monthly cost			$12	$4,159	$4,159	$6,239	$6,239	$8,318	$8,318
Unskilled labor monthly cost			$6	$2,080	$2,080	$3,119	$3,119	$4,159	$4,159
Total labor monthly cost			$18	$6,239	$6,239	$9,358	$9,358	$12,478	$12,478
			22 guitars per month is the most efficient use of current labor						
Guitars per month			20	22	30	34	40	44	20
Average monthly cost			$12,217	$13,439	$18,326	$20,769	$24,434	$26,878	$12,217
Gross margin			50%	60%	70%	80%	90%	100%	50%
ASP Trend - 22 Guitars			$20,158	$21,502	$22,846	$24,190	$25,534	$26,878	$20,158
Average monthly cost - 25 guitars			$7,631	$7,631	$7,631	$7,631	$7,631	$7,631	$7,631
Total labor monthly cost			$6,239	$6,239	$6,239	$6,239	$6,239	$6,239	$6,239
Total monthly cost			$13,870	$13,870	$13,870	$13,870	$13,870	$13,870	$13,870
Average monthly net profit			$6,289	$7,632	$8,976	$10,320	$11,664	$13,008	$6,289
			60% Margin Target is our business plan - guitars listed at 75% margins						
Labor Efficiency - Skilled worker			80.8%	88.9%	80.8%	91.6%	80.8%	88.9%	80.8%
Labor Efficiency - Unskilled worker			86.6%	95.2%	86.6%	98.1%	86.6%	95.2%	86.6%
Labor Efficiency - Total			83.7%	92.0%	83.7%	94.8%	83.7%	92.0%	83.7%

Material Planning Requirements

Beginning with the Master Production Schedule (MPS), Bright Guitar Manufacturing utilizes a 13-week quarter planning system with the last week of each quarter allocated for sprint capacity and general manufacturing cleanup and organization issues. The gross requirements

show an estimated sales figure based on historical data that totals approximately 22 guitars built and sold per month with a maximum inventory equal to one month's sales. There are four guitar models A, B, C, and D accounting for 32% (7 guitars), 32% (7 guitars), 23% (5 guitars), and 13% (3 guitars) of sales, respectively.

The MPS then explodes down to five major subassembly processes; Sides, Back, Top, Neck, and Bridge and Saddle, that align with the overall Gantt chart shown in table 3. These five subassemblies then explode into 10 individual MRP items. The majority of the items have a one-week lead-time. The Sitka Spruce, used for the linings of all the guitars as well as being one of the sound board options, and the Brazilian Rosewood bridge come from our Canadian supplier, which we allow a two-week lead time for. The East Indian Rosewood is a fairly rare wood, so we ten to stock a little more of this and order one-month in advance of forecast.

Finally, all of the hardware; tuning keys, strap buttons, guitar strings, neck nuts, sets of pegs, are purchased the second week of every month for that month's usage. An inventory of approximately one-half month's inventory is maintained for all items, except for strings, which is maintained at a minimum of one month. NOTE: Misc. items will be added to the final GRPP.

Planning Schedule Requirements

Bright Guitar manufacturing maintains a crew of two full-time skilled workers and two full-time unskilled workers. All of these workers are trained in all of the seven work centers. Turn over is low and skilled workers always train and assist the non-skilled workers. Should we have the need to replace a worker, we can get skilled labor from a variety of sources and the unskilled labor can be trained quickly. Furthermore, we are currently running under a no overtime policy, five days a week (M-F). Most of our processes require over night curing and we reserve the weekends for recovery time should we fall behind schedule.

The following discussion references Table 3 below. The overall manufacturing process begins in the S*ides* work center. This process takes about six days to complete for each guitar, but only requires five total (skilled and unskilled) labor hours. Based on 192 available labor hours over the six day period, this cell has an over capacity of 38.4 guitars versus a plan of 22 guitars. This is managed by some of the labor moving on to the next work center. The *Back* work center takes about four days to complete with three total labor hours per guitar. With 128 available labor hours, this cell is slightly constrained at 21.3 versus a demand of 22, hence the need for the labor moving from the *Sides* work center to the *Back* work center after four days into the process. As the remaining guitars complete the *Sides* process, the remaining labor moves on to the *Top* work center. This work center also requires four days to process and five total labor hours per guitar. With 128 available labor hours, this cell has an approximately capacity of 25.6 versus a demand of 22 guitars.

After the first three work cells have completed their respective subassemblies, the worker move to the *Installing* work center. The installing work center, as it implies, attaches the sides and the tops of the guitars together. This is a relatively short process that takes about one day, including overnight curing. Three labor hours per guitar are required for this process. Therefore, the 22 guitars (66 labor hours) are installed over a three-day period. The next work center, *Attaching*, which is where the neck is attached to the body of the guitar, is broken down into two separate functions. The first requires approximately six hours of labor over a three-day period. This process overlaps with the *Attaching* work center on the front end and the second half of this process, which is a 7-day cure on the back end.

The *Bridge* (attachment) work center is the next step. This requires approximately two hours of skilled labor over a three-day period per guitar. With 96 labor hours available, the

capacity is 48 guitars versus a demand of 22. Therefore, the frontend of this process overlaps with the curing side of the *Attaching* cell, and the backend overlaps with the *Hardware* work center. The Hardware work center is the final process where the guitar gets fitted with tuning keys, strap buttons, nuts, pegs, and finally strings. Final tune up and intonation is also performed during this process before sending the finished product to the storefront. The work cell requires two hours of unskilled labor per guitar, and had a capacity of 32 guitars over two days, allowing enough time not to cause a bottleneck. As the workers rotate through the work cells any free time within the 40-hour workweek is used to clean up the work center to prepare it for the next month's cycle.

On a final note: The table below shows a total process of 22 days per month. This does not include weekend or the extra week at the end of each quarter. As the text states on page 545, "good labor scheduling practice enable us to vary labor capacity at work centers to better match day-to-day fluctuations in work loads." Since our process is in fact a labor-limited system, it is important to maintain a flexible work force of well-trained workers.

Table 3

Bright Guitar Manufacturing Gantt Chart																					
Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Sides	Cap: 38.4																					
Back					Cap: 21.3																	
Top						Cap: 25.6																
Install									Cap: 21.4													
Attach 1											Cap: 32											
Attach 2													Cap: Curing not a factor									
Bridge																		Cap: 48				
Hardware																					Cap: 32	

Resource Tracking

Bright Guitar manufacturing employs one full-time planning manager that mangers the resources tracking of material, people, customer orders and equipment. Being a relatively new business, the four direct labor workers are needed for the manufacturing of the guitars in the workshop, while the planning manager performs all the material purchases, and customer sales through the storefront. The manager/owner handles the payroll, and other logistical issues as well as running the storefront.

- Material: Material tracking is based on the seven work centers' needs generated by the MPS. For example, the 'Sides' work center requires monthly purchase orders of two types of wood; East Indian Rosewood from the New Jersey supplier and European Sycamore from the Canadian supplier. Based on this quarter's forecast, 55% of the 'Sides' material will be ordered from the New Jersey supplier and the remaining 45% will be ordered from the Canadian supplier. However, the 'Top' work center also requires material from both suppliers, while the 'Bridge' work center requires ordering only from New Jersey with the balance of the material coming from the Canadian supplier. Many of the orders, with few exceptions, are ordered on a monthly basis and the planning manager is responsible for consolidating all required materials for each work center into two orders; one for New Jersey, the other for Canada. These orders are then tracked using spreadsheet reports and discussed with the manager/owner with each supplier once a week.
- People: All initial interviews and hiring of the planning manager, any assistants, and the skilled labor are performed by the manager/owner. The unskilled labor is usually interviewed and hired by the skilled labor workers, as these workers are basically their

assistance. All payroll functions are performed by the manager/owner, as well as attendance tracking via sign in/out sheets and all other HR type activities.

- Customer Orders: The Store Front managed by the manager/owner and is open from 10AM to 8PM Tuesday through Friday, 10AM to 6PM on Saturday, and is closed on Sunday and Monday (the manufacturing crew works Monday through Friday, 8AM to 5PM). Customers orders are initially tracked in a computerized log book, as there are only a few when the type of body is not available at the time a customer requests it and is basically "allocated" for that customer during the next month's manufacturing schedule. All sales are tracked through an electronic register system, which creates various reports that are generated by the systems' database. The planning manager prepares the reports, which are formally reviewed at least twice a week with the manager/owner.
- Equipment: All manufacturing equipment is maintained by skilled labor during process gaps. It is basically a big workshop with saws and clamps – not too heavy of a capital investment and very reliable equipment. However, about 50% of the equipment is under warranty, while the other half are on service contracts for major repairs.

Resolution of System Problems and Contingencies

Bright Guitar manufacturing runs its business basically on network desktop computers. Using password protection for entry to various levels everything is connected from the cash register in the storefront, to the manager and planner's offices to the shop floor where each work center gets their schedules. We have a service contract setup with a local computer store that installed the system. Complete system failure is rare, and there is an extensive backup procedure performed automatically everyday. We do have a file of manual log sheet and various forms as a backup in a worse case scenario. In regards to the manufacturing equipment, there are nearly two

of every thing as many of the work centers share the same saws, router, and various other tools. So the redundancy is the contingency plan. However, should we lose any of out major saws for an extended period of time, there are a few local shops where we can rent a piece of equipment.

References

A & M (2003) Wood supplier. Retrieved November 12, 2003 http://www.amwoodinc.com/

Brown, Josh (2003) Acoustic Guitar Manufacturing. Retrieved November 10, 2003 from http://www.harmony-central.com/Guitar/Articles/Guitars_Wood_And_Tone/

Exotic Woods (2003) Wood supplier. Retrieved November 12, 2003 http://www.exoticwoods.com/

Hoffman Guitars (2003) Wood supplier. Retrieved November 15, 2003 http://www.hoffmanguitars.com/MAKING%20THE%20BACK.htm

Vollman, Thomas E., Berry, William L., and Whybark, D. Clay (1997). *Manufacturing Planning and Control Systems* (4th ed.). Boston, MA: Irwin McGraw-Hill.