Tri-Star Manufacturing:

A Case Study in Lean Implementation

The discussion taking place around the large walnut conference table at Tri-Star's headquarters was heating up to boiling point. In fact, Mark Redmond, Senior Operations Manager at the Lansing, Michigan facility no longer considered what was going on to be a discussion. What started out as a meeting to discuss manufacturing issues at the Tri-Star facility and the prospect of additional business with a key customer had escalated into a full-scale gripe session and Mark was very uncomfortable about the tone of some of the things being said.

Mark's operation produces component parts in support of Cranston, Inc.'s assembly factory which is located directly across the street from Tri-Star. The Cranston assembly plant is a major supplier to the automotive industry. Tad Morton, the general manager at the Cranston assembly plant, had called the meeting and had brought his production manager, Stacy Bleadsoe, and his marketing manager, Jonathan Williams. Going into the meeting, Mark new that his plant had issues, and that Tad Morton and his crew was not pleased with the delivery performance of component parts to the assembly operation, but he had no idea about the extent of the dissatisfaction until today. When Tad Morton opened the meeting by saying that Cranston "…has reached the point where we are going to look for a new supplier if things don't change and change soon," there was little room for misunderstanding about how things sat.

Jonathan quickly followed by complaining about the beating he was taking from customers like GM and Ford because of Cranston's inability to meet delivery schedules. In fact, he stated emphatically that there was a distinct possibility that Cranston would lose their preferred supplier status if things didn't change soon. Stacy Bleadsoe piped in with a litany of examples about how late deliveries from Tri-Star had caused Cranston to miss their own delivery dates to GM and Ford. Her comment that it might be better to go back to the "old days" where they had multiple suppliers for these components and stockpiled inventory to make up for '….the suppliers inability to meet due dates" hit Mark hard because he had spent so much effort trying to implement changes to his manufacturing processes based on Stacy's past suggestions. Hadn't he adopted her suggestion for in-line inspection and re-work to assure high quality? Hadn't he rearranged the machine centers to reduce wasteful movement time? Hadn't they made the transition to a just-in-time delivery program like Stacy wanted?

However, Mark could not dispute the bottom line complaint from Tad and the others; Tri-Star was constantly late with deliveries to Cranston! As difficult as it was to listen to these complaints and criticisms, Mark new that Cranston was a major customer and that things were going to have to change or he would lose them. In fact, Tad Morton indicated early on in the meeting that Cranston was getting a new contract with GM that would require higher production volumes and less time between deliveries from

Tri-Star if they were going to be considered for the new business. Mark new that if Cranston, Inc. "walked", Tri-Star would be in serious trouble.

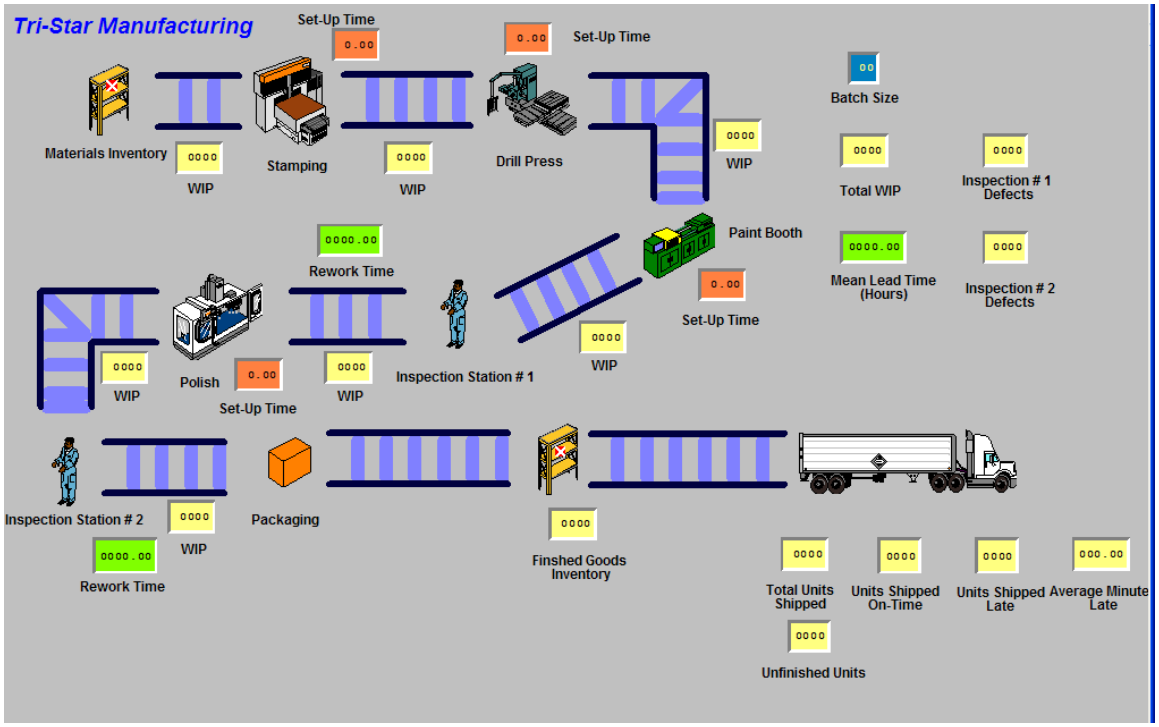
Fortunately, Mark's administrative assistant, Denise Smith's timing was perfect once again. When she opened the conference room door and brought in a large tray of pastries, fruit and beverages, the sight of the food broke the tension in the room and as the group dug into the treats, cooler heads took over. Tad Morton said, "Look, Mark, we prefer to do business with you and Tri-Star. Your quality is near 6-sigma levels and the people here are first rate. There must be something that you can do to improve your on-time deliveries. If you could just do that, there would be no problem from our end. You are right across the street which makes it possible for us to get multiple deliveries every day so we don't have to store parts inventory." Jonathan jumped in to say that a deal they have worked out with GM calls for a very defined production schedule and that Cranston would be able to provide Tri-Star with a parts requirements schedule on weekly basis that would be solid for the next few months.

Mark felt a little better after hearing Tad's remarks, but new that achieving the improvements that Tad alluded to would be no easy thing. When the Cranston trio left an hour or so later, Tad went back to his office to check e-mail and phone messages. Among the more than twenty e-mails was one from Hal Brookings, one of Mark's colleagues at a previous company. In the message, Hal mentioned that his company had embarked on a Lean Manufacturing initiative and that he was very excited about what was happening so far. Hal's company was seeing reduction in lead times, lower work-in-process inventories, and generally smoother operations. Mark's reply simply stated "Let's get together, SOON"

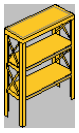
The Tri-Star Baseline:

The Tri-Star plant at Lansing Michigan has devoted one manufacturing line to exclusively support Cranston, Inc., a parts supplier to General Motors and Ford. Specifically, Tri-Star makes two models of a single product, the Belle-Regal-X, on a dedicated manufacturing line for Cranston at the Lansing facility. Products flow through the line sequentially with current batch size of 20 units, a batch size that Mark Redmond had recently implemented which is down from the 100-unit batch size that the company had been using previously. A batch may consist of a mix of the two models. Figure 1 shows the production layout.

Figure 1
Tri-Star Manufacturing Layout

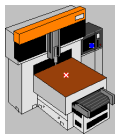


Materials Inventory:



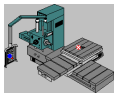
Tri-Star's Belle-Regal-X product begins its journey to the customer as a raw material that is received from the supplier at a location called Materials Inventory. Materials are delivered according to a predetermined *order file* (see discussion below.) Materials are always available on-time and defect free. Because of a "shrewd" agreement that Tri-Star's purchasing manager had negotiated, the materials inventory is owned by the supplier until the parts are released from inventory and moved to the **Stamping** work station. This material release occurs at the scheduled release time (see Time column in the Order File), or as soon as the WIP storage area in front of Stamping has available room. Initial capacity of this WIP area is 20 units. Note, materials are batched into the current lot size (initially 20 units) prior to being released to the Stamping work station.

Stamping:



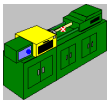
At the Stamping work center, the raw material is stamped to the customer specification for the Belle-Regal-X product. The Stamping machine must be setup each time a new model arrives at Stamping. Current setup time at this work center is a constant 25 minutes. Processing time for the two models is variable and normally distributed with a mean of 10 minutes and a standard deviation of 3 minutes. Currently Tri-Star has only one Stamping machine which can process one unit of the Belle-Regal-X

at time. When the Stamping process is completed, the unit is moved into a WIP storage area in front of the **Drill Press.** It takes one-minute to move each unit into this area where the units are then accumulated into their original batch and await processing at the Drill Press. Current WIP capacity in front of the Drill Press is 300 units.



Drill Press:

Each unit of the stamped material is moved from the WIP area in front of the Drill Press (1 minute per unit move time). If the model to be made differs from the previous model, the Drill Press must be setup. Drill Press setups currently require 20 minutes with virtually no variation. Tri-Star currently has only one Drill Press which can work on a single unit. Processing time varies with a standard deviation of 4 minutes and have tended to be normally distributed around the mean time of 15 minutes. As units complete the Drill Press process, they are moved into a WIP storage area in front of the **Paint Booth** where they are again accumulated into their original batch. Currently, *move time* is 1 minute per unit. (Note, all move times into and out of WIP storage areas currently require 1 minute per unit.) The capacity of this WIP storage area is 300 units



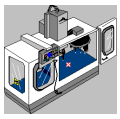
Paint Booth:

Tri-Star has a single Paint Booth which must be set up to process each new model of the Belle-Regal-X product. Setup time for the Paint Booth is currently a constant 30 minutes. The Paint Booth's current capacity is one unit. Painting time averages 20 minutes with a standard deviation of 5 minutes and tends to be approximately normally distributed. Units exit the Paint Booth and proceed to the WIP storage area in front of the first of two in-line inspection stations where the products dry. Current drying time is 45 minutes. Mark Redmond is passionate about shipping only *perfect quality* to his customers and, based on input from Stacy Bleadsoe, Cranston's production manager, installed two in-line inspection stations. Not a single defect has been reported by Cranston since this was instituted.

Inspection Station 1:

After drying, the products are moved to **Inspection Station #1.** Currently Tri-Star has one inspector at this station who is responsible for performing a 100% inspection. The inspector can inspect one unit at a time and has a perfect record for catching defects. Currently roughly one in ten products is found to have some form of defect that will require re-work. Inspection time has been approximately normally distributed around a 5 minutes per mean with a standard deviation equal to 1 minute. No setup time is required from model to model at inspection. Following inspection, units are moved to the WIP area in front of the **Polish** work station Up to 300 units can be stored in this WIP area at any one time. Defective units are reworked in-line by a technician and units are grouped into their original batch. Batches cannot move forward until any defective units in the batch have been reworked. Rework time has

been a constant 50 minutes and is one-hundred percent successful. Units are then moved from this WIP area to **Polish.**



Polish:

Products are polished and finished at the **Polish** work station. Setup time is currently 15 minutes when switching between model 1 and 2 of the Belle-Regal-X product. Tri-Star currently has a single Polish machine and it is capable of polishing one unit at a time. The polish time is normally distributed with a mean equal to 10 minutes and a standard deviation equal to 3 minutes.

When polishing is completed, units are transferred to a WIP storage area in front of the second in-line inspection station. This WIP area has a capacity for up to 300 units. Units are accumulated into their original batch here before moving on to **Inspection Station 2.**

Inspection Station 2:

This second inspection station was installed in the process to catch any cosmetic defects that might occur at the Polish station. Historically about five percent of all units have a cosmetic defect that will need to be reworked before moving on to **Packaging.** The inspector is perfect in her ability to catch the defects. She takes an average of 8 minutes per unit to perform the inspection with a standard deviation of 2 minutes. Inspection times are normally distributed. No setup time is required at the inspection station.

Following inspection, products are moved to the WIP storage area in front of Packaging where the defects are reworked by a technician. No setup time is required by the rework tech but it does take a fairly constant 20 minutes per unit to perform the rework. All reworked items meet quality standards. Units are grouped into their original batches prior to being moved to the **Packaging** area.

Packaging:

The Belle-Regal-X products are put in packages at the **Package** work station. Currently, the Package station has capacity to package one unit at a time. Processing times tend to average 5 minutes with a standard deviation of 2 minutes. No setup time is required at Packaging. From Packaging, units are grouped into their original batch and moved to **Finished Goods Inventory.**

Finished Goods Inventory:

Once the batches reach Finished Goods Inventory, they are bar coded, processed, and placed on pallets to be stored or moved directly to a waiting truck for deliver across the street to Cranston. This process has averaged about 60 minutes per unit with a standard deviation equal to 10 minutes. If the current time is equal to or greater than the time the product is due, the item is immediately sent to a

waiting truck. At this point, ownership of the product transfers to the customer and the manufacturing process for that product is completed. If the product finishes ahead of schedule, it waits in FGI until the its required shipping time. Table 1 summarizes the processing, setup, and rework times for the Tri-Star Manufacturing line.

Table 1
Processing, Setup and Rework Times

Work Station	Mean Processing Time (Minutes)	Standard Deviation (Minutes)	Setup Time (minutes)	Rework Time (minutes)
Stamping	10	3	25	
Drill Press	15	4	20	
Painting	20	5	30	
Drying *	45	0	0	
Inspection 1	5	1	0	50
Polish	10	3	15	
Inspection 2	8	2	0	20
Packaging	5	2	0	
Finish Goods	60	10	0	

* Drying is done in WIP Storage Area following after the Paint Booth

Tri-Star Work Schedule:

The Tri-Star plant operates 24 hours a day, five days a week (120 hours per week). All maintenance is completed by a weekend crew and because of the high quality maintenance, no machine downtime occurs during the week. Supervisors and "floaters" are used during lunch and break times to keep the plant running continuously. However, because of the maintenance schedule and the lack of available machine operators, it is not considered an option to produce parts on the weekend. This 120 hour per week work schedule also matches the Cranston work schedule. However, Cranston begins its work week 90 minutes after Tri-Star.

The Order File:

Under the new arrangement that Cranston has with GM, each week Cranston will provides Tri-Star with an Excel order file [called Order File.xls] for 3,560 total parts to be delivered. The file shows the model number and the time (in minutes) during the week that the parts are due to be delivered to Cranston. Because of Cranston's arrangements with its customers, the order file is expected to be identical every week for the foreseeable future. Figure 2 illustrates a portion of this order file.

Figure 2
Order File From Cranston, Inc.

Entity	Location	Quantity	Time	Number	Frequency	Model	Quality_Status	Time_Due
Belle_Regal_X	Order_Entry	10	0	1	1	1	0	90
Belle_Regal_X	Order_Entry	10	10	1	1	2	0	110
Belle_Regal_X	Order_Entry	10	20	1	1	1	0	130
Belle_Regal_X	Order_Entry	10	30	1	1	2	0	150
Belle_Regal_X	Order_Entry	10	40	1	1	1	0	170
Belle_Regal_X	Order_Entry	10	50	1	1	1	0	190
Belle_Regal_X	Order_Entry	10	60	1	1	1	0	210
Belle_Regal_X	Order_Entry	10	70	1	1	2	0	230
Belle_Regal_X	Order_Entry	10	80	1	1	2	0	250
Belle_Regal_X	Order_Entry	10	90	1	1	2	0	270

The column descriptions for the order file are:

- Column A: Try-Star is supplying Belle_Regal_X to Cranston.
  [No changes are allowed to this column.]
- Column B: the order originates at a location called “Order Entry.”
  [No changes are allowed to this column.]
- Column C: “Quantity” equal to 10 indicates that each row constitutes an order for ten parts.
  [No changes are allowed to this column.]
- Column D: “Time” indicates the time clock time (in minutes) at which the order is released to Tri-Star’s production system – this is the time when the basic material for a Belle-Regal-X product is pulled from materials inventory and is readied to be used in the production process. For example, at time 0, the first order is released. At time 10 (10 minutes later) the second order is released and so forth.
- Column E: “Number” indicates that each order is to occur one time.
  [No changes are allowed to this column.]
- Column F: “Frequency” = 1 indicates that a new part is released to the materials inventory every minute from the release time until the 10 parts in the order have been released. **[No changes are allowed to this column.]**
- Column G: The model (1 or 2) of Product A that is to be produced.
- Column H: “Quality Status” = 0 indicates that all products released start with a non-defect status. **[No Changes can be made to this column.]**
- Column I: “Time Due” indicates the time during the week when the order is due to be delivered to Cranston. For example, the first order of ten units of Belle-Regal-X, Model 1 is due at time 90 or 90 minutes into Tri-Star’s week. The second order for ten units of Model 2 is due at time 110 (110 minutes into the shift.) and so forth. Cranston requires ten units to be delivered every 10 minutes with the last unit delivered at time 7,200 minutes.

Note that the Excel order file may be modified in only the following way:
The sequence of orders can be modified by sorting the file as desired. If this is done, the "Time" values in Column D will need to be re-ordered to reflect the new sequence – always from low to high. The current gap between "Time" values is 10 minutes. This can be increased or decreased, but the column of values must always be kept in order from low to high.

[Note: if the order file is re-ordered in any way, the "Time-Due" values must continue to be tied the original "Model". For instance, if just the orders shown in Figure 2 were to be re-ordered such that all Model 1's were to be produced first and then all Model 2's next, the resulting order file would look like that shown in Figure 3. Notice that the first order for Model 2 is still due at the original time of 110 minutes into the week. The second order for Model 2 is still due at time 150. Thus, the "Time-Due" must be preserved in all cases. Also, note that the "Time" column is in correct order from low to high.]

Figure 3
Revised Order File – Example

Entity	Location	Quantity	Time	Number	Frequency	Model	Quality_Status	Time_Due
Belle_Regal_X	Order_Entry	10	0	1	1	1	0	90
Belle_Regal_X	Order_Entry	10	10	1	1	1	0	130
Belle_Regal_X	Order_Entry	10	20	1	1	1	0	170
Belle_Regal_X	Order_Entry	10	30	1	1	1	0	190
Belle_Regal_X	Order_Entry	10	40	1	1	1	0	210
Belle_Regal_X	Order_Entry	10	50	1	1	2	0	110
Belle_Regal_X	Order_Entry	10	60	1	1	2	0	150
Belle_Regal_X	Order_Entry	10	70	1	1	2	0	230
Belle_Regal_X	Order_Entry	10	80	1	1	2	0	250
Belle_Regal_X	Order_Entry	10	90	1	1	2	0	270

