The Tri-Star Simulation Model

After Mark Redmond and his former colleague, Hal Brookings, finished a nice dinner at Mark's country club and a lengthy discussion of Hal's experiences with lean manufacturing, Mark felt that he had a reasonable feel for what Hal was talking about and he was ready to develop a strategy that would hopefully improve his company's performance and meet Cranston's deliver schedules.

In what may have been a very fortuitous event, it turns out that Mark had only a few weeks ago agreed to let a nearby university class develop a computer simulation model of Tri-Star's production line. The model, developed using an animated simulation software package called *ProModel*, (see www.promodel.com) has been validity tested and is believed to accurately model the production process for the Belle-Regal-X product. Mark has decided to ask the class to now use the model to explore various lean implementation steps in an effort to determine which steps will be most effective in driving waste from his process thereby reducing lead time and improving the on-time delivery of products to Cranston. The model will be used to simulate one-week's production based on the actual order file that Cranston will giving Tri-Star.

Mark knows that in reality, lean implementation requires time commitment as well as financial commitment. In addition to development of a *current value-stream map*, which he now knows is the starting point, the actual transition to a *future value-stream map* will require involvement from many people within his organization. For instance, reducing setup time at a machine center would require the involvement of the setup team, and others, to analyze the current setup process and to brainstorm how to move internal tasks to external tasks, how to do internal setup tasks in parallel rather than in series, and so forth. The advantage of a simulation environment is that Mark can determine, for instance, whether reducing setup time at a particular work station will have the desired positive affect on the end result before the team actually puts forth the time and effort in the real world. This will allow Mark to better allocate his scarce resources as he initiates Lean implementation at Tri-Star.

Recognizing that people's time and other resources are not unlimited, for the purposes of the simulation, Mark has decided to use money as a surrogate measure of these resources and effort, and has provided a list of constraints and costs associated with an array of possible lean improvements that can be tested using the simulation model.

Setup Time Reduction: Table 2 shows this information for setup time reduction efforts at the various work stations. For instance, the current setup time at Stamping is 25 minutes per setup. This setup time can be reduced at a cost of $500 per minute (which simulates the relative effort required to reduce the setup time.) A five-minute reduction will cost 2,500. The minimum possible setup time is 1 minute.

Table 2
Setup Time Reductions

Work Station	Setup Time (minutes)	Cost Per Minute Reduced
Stamping	25	$500
Drill Press	20	$700
Painting	30	$1,000
Polish	15	$400

Processing Time Reduction: Mark has also assigned costs associated with processing times (both means and standard deviations) as shown in Table 3. For example, a two-minute reduction in mean stamping time will cost $600 x 2 = $1,200 while reducing the standard deviation by 2 minutes would cost $1,500 x 2 = $3,000 reflecting the difficulty required to reduce variability. Reducing standard deviations to zero-minutes results in the processing time being turned into a constant time equal to the mean time. Reduction of fractional minutes is allowed and is achieved at a cost proportional to the per minute cost. Finally, due to practical limitations, work center and inspection mean times can be no less than 2 minutes

Table 3
Processing Time Reductions

Work Station	Mean Processing Time (Minutes)	Mean Process Time (Cost Per Minute Reduced)	Standard Deviation (Minutes)	Standard Deviation (Cost Per Minute Reduced)
Stamping	10	$600	3	$1,500
Drill Press	15	$800	4	$1,200
Painting	20	$900	5	$1,800
Drying	45	$500	NA	NA
Inspection 1	5	$300	1	$500
Polish	10	$1,000	3	$2,000
Inspection 2	8	$200	2	$400
Packaging	5	$2,000	2	$1,500
Finish Goods	60	$100	10	$200

Rework Time Reduction: Rework times can be reduced at a cost of $600 per minute but the minimum rework time can be no less than 10 minutes.

Move Time Reduction: At the present time, the time required to move each unit into and out of a WIP storage area is 1 minute. However, Mark believes that through an intensive Kaizen effort, all move times could be reduced. Time reductions come in 0.10 minute increments at a cost of $1,000 per 0.10 minutes. For instance, for an expenditure of $2,000, all move times would simultaneously be reduced from 1.0 minutes to 0.80 minutes. Such improvements apply simultaneously to all move times.

Quality Improvement: Currently, defects are identified at Inspection Station 1at a 10 percent rate. Defect rates at Inspection Station 1 can be reduced at a cost of $1,500 per percentage point reduction. For example, for $3,000, the defect rate at Inspection Station 1 can be reduced from 10 percent to 8 percent. Likewise, at Inspection Station 2, the defect rate can be reduced at a cost of $2,000 per percentage point. The current rate of defects at Inspection Station 2 is 5 percent. Quality improvements can reduce the defect rate to a 6-sigma quality (3.4 parts per million) level.
Batch Size Reduction: Currently, Tri-Star has been running with a batch size of 20 units. Batch size is a management decision and can be increased or reduced at no cost.
Increasing Work Center Capacity: Currently Tri-Star has one machine (or inspector) at each work center. Each machine (or inspector) can process one product at a time. Both of these limitations can be improved through capital investment. Table 4 shows the costs for each work center. For example, for an investment of $15,000 Tri-Star

Table 4
Work Center Capital Investment Costs

Work Station	Cost Per Machine/Inspector	Cost Per Unit of Increased Capapcity
Stamping	$15,000	$10,000
Drill Press	$24,000	$17,000
Painting	$11,000	$5,000
Inspection 1	$1,500	$1,000
Polish	$20,000	$15,000
Inspection 2	$1,500	$1,200
Packaging	$5,000	$2,000

can add a second Stamping machine. If this is done, products will be moved into the first available Stamping machine. Likewise, for an investment of $10,000, the current Stamping machine can be converted to handle two products simultaneously. Thus, when the Stamping machine is empty, two products will be moved in to be processed at the same time. Note, both products must be in the machine before it will begin processing. [Note, if you first add capacity to a machine center, from 1 to 2 units, and then later add a second machine, the new machine will have the added capacity.]

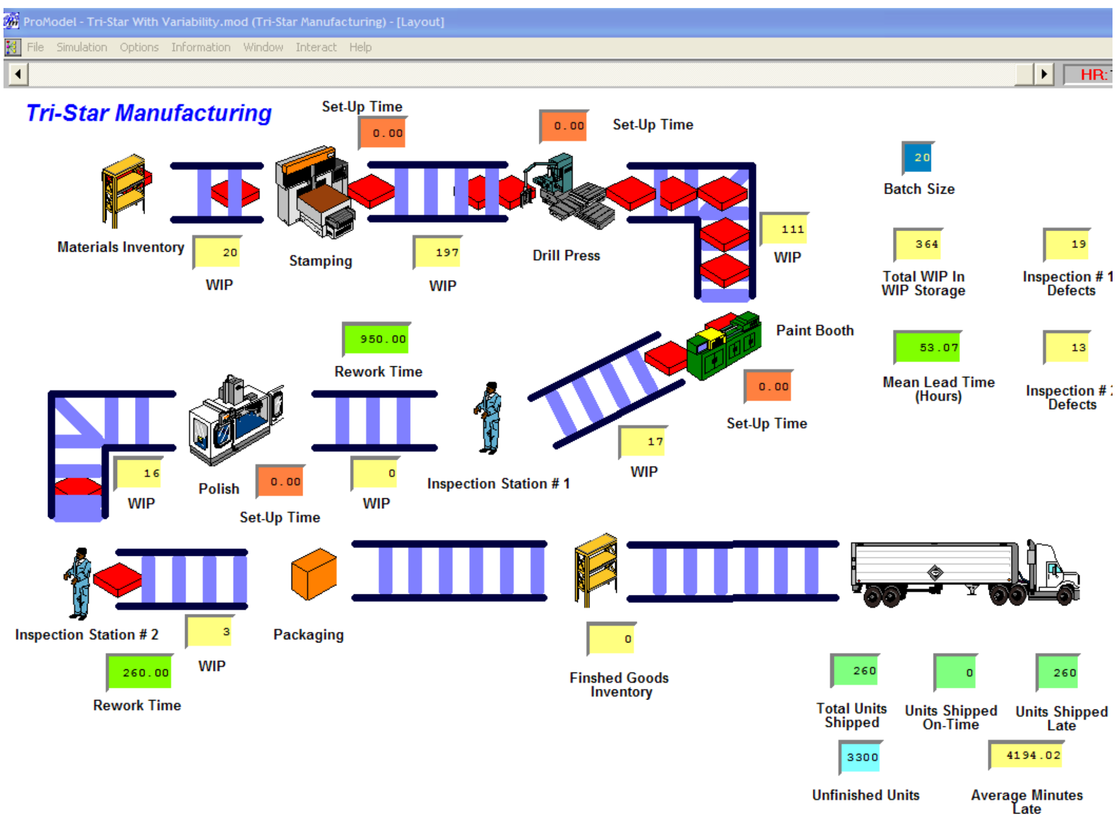
Due to space limitations, the maximum number of machines/inspectors at a work station is two and the maximum capacity for any machine/inspector is two products.

WIP Storage Reduction: The WIP Storage areas between all work centers currently have capacities of 300 units. These cannot be increased. However, the capacities can be decreased by management directive at no cost. Minimum WIP capacity is 1 unit. Once again, with the exception of the values in Table 4, which are capital investment costs, all other costs provided above are surrogates for the time and effort that kaizen teams would put in making process changes. Mark is interested in developing a lean implementation strategy which in reality would be constrained by both dollars and available time to do kaizen projects. He wants the class to use the ProModel simulation to develop this strategy. Because in the model, kaizen time has been translated to dollar costs, <u>Mark wants to determine which lean improvements should be undertaken to improve the ability of Tri-Star to meet Cranston's delivery schedule at the least possible cost.</u>

The Baseline Run:

The simulation model has been designed to process the order file submitted by Cranston (see Figure 2) assuming all current processing, rework, setup and move times and quality levels are in affect. Mark and his staff at Tri-Star have verified that the model results are valid and closely replicate what is currently happing in the real Tri-Star plant. Figure 4 shows results of a one-week (120 hours) run of the model. Keep in mind that the order file calls for 3,560 products, mixed between models 1 and 2, to be delivered by the end of the week. Ten units are to be delivered every 20 minutes beginning 90 minutes into the work week.

Figure 4
Tri-Star Baseline Simulation Run



The simulation results shown in Figure 4, reveal how inadequate Tri-Star's process is with respect to its ability to meet the Cranston delivery schedule. Of the 3,560 units required, only 260 were shipped, all of which were shipped late. A total of 3,300 units were still in process and not completed at the end of the 120 hour week. The average late time for those unites that were delivered was 4,194 minutes (nearly 70 hours). On average, products had about 54 hours lead time. A total of 364 units were still in WIP storage and 2,936 (3,300 – 364 = 2,936) had not yet been released into the production system. This is the baseline against which the lean implementation strategy will be compared. No wonder that Cranston's management team is threatening to seek a new supplier!

