Instructions for the Lego
Simulation Using Standard Blocks

A. GENERAL:

This hands-on simulation is designed to introduce several basic concepts of the Lean System and the closely related Toyota Production System. * It requires 4 runs (with an optional 5th run); in which LEGO®(1) brand block assemblies are produced by 2 operators and shipped by a third person. Total run time is about 60-75 minutes. Discussion time and review may increase the activity time up to 120 minutes.

B. PARTICIPANTS:

1. **Primary**
   - **Operator A**
   - **Operator B**
   - **Shipper**
   - **Supervisor**
   - **Plant Manager (simulation facilitator)**

2. **Secondary**
   - **Material Handler** (a person to transport product between processes)
   - **Accountant** (a person designated to calculate financial returns; this is a way to involve more attendees, but it is not an essential job.)
   - **Observer's** additional participants who observe the production runs and are part of the de-briefing for lessons learned and suggestion for improvements for future runs.

C. MATERIALS:

- **Red, White, and Blue LEGO® brand blocks.** This simulation, including the time allowed to perform each, is designed for the small blocks.

  For each color, the kits will need the following minimum quantities:

  20 2 x 4 -peg blocks
  40 1 x 4 -peg blocks
  20 2 x 2 -peg blocks
  4 1 x 8-peg blocks

- **Miscellaneous sizes and shapes used to create disorder and inefficiency in Run 1 (minimum quantity of 80 pieces).**
- **Raw Material inventory with various sizes and shapes used for parts shortages (minimum quantity of 80 pieces).**

  It is desirable to have twice the above quantity so that time can be saved in setup between Runs 1 and 2.

  The blocks will be used to make the following:

  Subassemblies of a 1 x 4-peg placed on a 2 x 4-peg. (These are produced by Operator A.)

Final assemblies in which a 1 x 4-peg and a 2 x 2-peg are added to the above subassemblies, resulting in a part having a total of 4 blocks. (These are produced by Operator B.)

- **Flip chart, dry erase board with markers or overhead transparency** is filled out to show goals, actual results and financials for each run (see attachment, file resultstemplates.xls). The flip chart or dry erase board is preferable to an overhead transparency, because it keeps the results in front of the participants from run to run.
- **Stop watch**
- **Calculator and pencil for financial calculations after each run**
- **1 Large bin each for operator A and B, Run 1 for Raw Materials**
- **6 Small bins each for operator A and B, Run 2 – 5 for Raw Materials**
- **"Today's Production Schedule",** for operator A to use in Run 1
- **"Today's Production Schedule",** for operator A to use in Run 2
- **"Today's Production Schedule",** for operator B to use in Run 1
- **"Today's Production Schedule",** for operator B to use in Run 2
- **2 KanBan Areas** that will be used in Run 3 - 5. This area is a sheet of paper showing a Red, White and Blue box for the purpose of containing a single subassembly. This conveys the idea of Pull/Kanban/Visual Control in a very rudimentary fashion.
- **Shipping dock -** 6 Trucks, 2 trucks for each color and capable of containing 5 completed units each.
- **"Standardized Work Instructions",** for operator A and B to use in Run 2 - 5
- **Financial Results** for each team

D. TUTORIAL

- **A brief tutorial on Lean Production System concepts can be used to introduce this simulation. A one-page flip chart sheet listing some concepts and including a simple diagram defining a Pull System can be useful. The tutorial should be geared for less than 5 minutes. The page can be referred to after each run to reinforce the ideas that were illustrated. The following is an example of what a tutorial sheet may contain (other versions are possible, depending on the points to be emphasized):**

(The comments in parentheses are for the purpose of this write-up only and do not go on the flip chart.)

5s - Sort, Store, Shine, Standardize, Sustain *(Run 1 production is chaotic. Run 2 illustrates more organization and hence output goes up.)*

WASTE of OVERPRODUCTION *(In both Runs, Operator A overproduces and creates costly inventory. The situation may worsen in Run 2. The topic can also be discussed under a heading of Inventory.)*

PULL SYSTEM
(A simple diagram showing two processes, A and B, and a withdrawal loop connecting them and the statement defining a Pull System as "The Following Process B Pulls from a Preceding Process A" is useful to put on the chart.)

-Small Lots *(Or Small Batches - ideal lot size of 1.)*

-Takt Time *(Or, depending on the audience, working to a "Rhythm".)*
-Leveling *(Seen as less lumpy production with single piece flow in Run 3.)*

VISUAL CONTROLS *(Evident in Run 3. The use of the staging areas to provide a Pull signal simulates some of the functions of Kanbans. Also, the fact that a schedule is released to only one point in Run 3, versus multiple locations in Runs 1 and 2, is a concept that can be discussed, use of visual schedule in Run 3.)*

CHANGEOVER REDUCTIONS (Evident in runs 1 and 2 that changeovers are one of the factors that create a bottleneck situation around operator station B. Workload balancing and having the shipper help with reducing the downtime associated with changeovers is instrumental in the ability to meet the customer requirements.)

PROFIT *(Illustrated in each Run. The simulation teaches about some of the key components of cost buildup. Run 3 may be highly profitable, in contrast to Runs 1 and 2. Run 4 may be more costly due to Finished Goods inventory buildup. Run 5 becomes the level of performance that the "plant" requires.)*

RELIABILITY *(Exercise after Run 3 to illustrate the impact of unreliable processes in the pull system and use of Safety Stock as a temporary countermeasure)*

E. SIMULATION RUNS:

1. RUN 1:

- **Have the raw materials inventory available as necessary for all runs. If using material handler he runs to get raw material, otherwise the operator in need goes for raw material.**

- **All blocks are in two open bins described earlier (one for Operator A and the other for Operator B), with Reds, Whites and Blues intermixed with other colors and block shapes**. (These other pieces create disorder and inefficiency during production in Run 1.)

  The boxes should be sufficiently small and the amount of extraneous material sufficiently large so that the operators are hampered from finding the needed blocks with ease. It is also important to make sure in advance that each operator's box contains the needed components (e.g., 8-peg blocks are in the box for Operator A; 2-peg blocks in the Operator B box).

- **Operator A stands at table as far as possible away from Operator B. Operator B sits at far end of table from Shipper. Operator A must stand; Operator B and Shipper may be seated.**

- **Instructions from Lead Facilitator** (The words given are meant to convey the recommended flow of ideas, but individual facilitators may adapt these to suit the situation.):

- "Welcome to <Company Name>. We produce a number of products for use around the world and have very demanding customers."
- "Our product is as follows: It is a two step process - the first step consists of Operator A assembling an 8-peg block and a 4-peg block - the second step consists of Operator B first adding

another 4-peg block and then completing the assembly with a 2-peg block. Operator B may not pre-assemble his blocks."

- "In addition, Operator B must complete a changeover process before each color change. This consists of assembling 4 1x8 blocks of the appropriate color as shown."
- "Each product is then staged and shipped by the Shipping Dept."
- "You are each responsible for production in your area - and by the way your performance will be individually measured by how much work you get done."
- "We just received a greatly increased order from our customers and we need to see if we can produce it economically and on time."
- "We usually can make 10-12 block assemblies per shift."
- "However, our new orders are for 30 assemblies per shift! 10 Reds, 10 Whites, 10 Blues."
- "Because we've tried to minimize changeovers and due to other constraints in our equipment, we like to make batches although not always the same size."
- "However, our customers want us to ship in groups of 5 as this is a full truckload and minimizes shipping costs."
- "As is the case with any business, we must make money. So far we have succeeded by serving our customers well through your efforts as excellent, dedicated employees."
- "We pay our suppliers $50 for each individual piece and we pay each of you for your efforts $200 per shift. Our customers pay us $350 for each completed assembly."
- "We will use this information as well as your production data to record information on Customer Satisfaction (Delivery Performance) as well as Financial Performance on the charts next to each of your areas."
- "For those of you not directly involved in the production process, we want you to be observers and be prepared to help collect lessons learned and offer suggestions for improvements for future runs."
- "Supervisors – please prepare your production teams and be ready when the shift starts."
- "A separate copy of Today's Production Schedule will be given to both Operators A and B. Notice that it tells you to make the assemblies in various size batches from quantities of 1 to 5 and what order to make them in."
- "Once Operator A makes a batch, it is passed on to Operator B. Once Operator B makes a batch they go to Shipping. Shipping arranges them in lots of 5 to go to the customer. That's the way the customer wants them."
- **"This entire shift lasts 4 minutes. Start your shift."**

- **Evaluating the run and discussion**

- **Record all the results on Financial sheet.** The number of units produced probably exceeded 12 by a small number; if so, compliment the team on improved performance. However, point out the fact that production was far below the goal of 30. (**Turn in your results to the Lead Facilitator as quickly as possible.)**
- **Debrief the team, use the observer guidelines for structure (if needed), and quickly get the most important points captured. Ask for ideas to improve the output.** Quickly settle on the notion of organizing the workplace (5s) to sort the components into the right sizes and colors and get rid of the extraneous blocks.

- **Lead Facilitator will call the group to attention to the front; review the delivery performance and financial data. Collect comments from each table. Congratulate the group on a good effort and for producing more than ever before - but point out that this falls far short of meeting customer requirements and that we cannot continue this financial performance**

and stay in business. We trust that your ideas for improvement will make a big difference. Instruct the team leaders to proceed with Run 2.

2. RUN 2:

- **Organize the blocks by color and peg count at the work areas of both operators.**

Both operators should have the needed items to make 20 units of each color. The duplicate quantity of blocks that was recommended in the list of materials will save considerable time at this point by avoiding the tedious sorting step.

- **Express confidence about reaching the goal** of 10 Reds, 10 Whites and 10 Blues now that the 5s activity was completed and the workplace was organized. Ask the operators to work faster.

- **Allow Operators to move closer and be seated IF identified as an improvement.**

- **Let the Operators organize their workspace IF they request the improvement.**

- **Include work instructions for changeover and assembly at each station.**

- **Repeat the run using the new schedule** to both Operators A and B. Note the use of color to simplify schedule adherence.

- **Evaluating the run and discussion**

- **Stop the run at 4 minutes of elapsed time.**

- **Record all the results on Financial sheet.** The number of units produced probably exceeded 12 by a small number; if so, compliment the team on improved performance. However, point out the fact that production was far below the goal of 30. (**Turn in your results to the Lead Facilitator as quickly as possible.)**

- **Debrief the team similar to after Run 1.** Discuss the delivery performance and financial results in terms of relevant concepts in the Tutorial. Discuss the components of cost and how they were affected, particularly the build-up of inventory from overproduction. Discuss why overproduction is undesirable (e.g., raises costs, creates congestion, can keep us from making the right products for our customers). Lead the group to the improvement suggestion of getting the shipper to help with the changeover process as he has the least amount of work to do. The shipper can pre-build the changeover device; Operator B must tear it down when finished with that color. The shipper can rebuild it (as a task external to the changeover itself per SMED techniques) for its next use. **Note: if the team comes up with another viable way of balancing the workload that seems feasible consider their idea and improvise as appropriate.**

- **Lead Facilitator** - bring the attention back to the front. Review the Delivery Performance and Financial Results - compare them to Run 1 and commend them for any improvements. Get comments from each table. Challenge them that while this may be a substantial improvement, it still does not meet the Customer Satisfaction or the Financial Goals of the business. We must make some additional improvements in our manufacturing system.

- **Set the stage for Run 3**

- **Using the Tutorial sheet revisit the definition of a Pull System.** It is useful to contrast this with a Push System which existed in Runs 1 and 2. Also, point out the scheduling in Runs 1 and 2 was done from centrally generated list that did not link the operations together (i.e., each process was trying to optimize its own performance, not that of the "system". The term for this condition is "isolated islands".

RUN 3:

- **This run will primarily teach about the Kanban.**

- **Preparations**

- Provide enhanced work instructions to each process.

- Between Operators A and B place the Kanban sheet and load each square with a sub assembly. These will serve as a "store" to supply Operator B and the Visual Controls for Pull Scheduling signals between Operator A and Operator B. When Operator B needs a particular color sub-assembly, he pulls from the "store" after Process A and completes the assembly. As soon as Operator A sees an empty square, that serves as his instruction to produce another sub-assembly of that color - that is to produce in accordance with what his customer needs or "Make To Use".

- **Instructions from Lead Facilitator**

- "We will now produce the same as before for delivery to the Shipper, but due to customer requirements still ship in batches of 5."

- "The sheet of paper between A and B with the three marked squares represents both a Store and a Visual Control that will send a Pull signal to Operator A."

- **"Notice that we have placed some strategic inventory on each square."**
  (The 3 squares between Operators A and B should contain partial assemblies.)

- **Once the participants understand the rules, start the run.**

- **Evaluating the run and discussion**

- **Stop the run at 4 minutes.**

- **Record all the results on Financial sheet.** Point out the fact that production was still below the goal of 30. (**Turn in your results to the Lead Facilitator as quickly as possible.)**

- **Debrief the team.** Chances are slim that all goals have been reached and the run was profitable. Note if productivity improved, Work-In-Process inventory was greatly reduced, and delivery performance was 100%. **Stress the need for improved profitability. Ask for their ideas that would make even further improvements.**

- **"Process B has just developed a changeover reduction solution to balance work load. The process has now utilized SMED (represented by a multicolored change over)."**

- **Lead Facilitator - bring attention to the front**
- **Review the delivery performance and financials and point out the contrasts between all 3 runs.**

- **Show diagram of work content for each operator and how it changed for each run.**

- **Introduce the notion of Takt Time (show overhead).**

RUN 4:

- **This run will primarily teach about the Pull System and Visual Control.**

- **Preparations**

- Changeover is no longer necessary at Operator B.

- To balance work load Shipper will now place 2-peg block on the assembly and load finished assembly on trucks.

- Place new Truck schedule at Shipper.

- Between Operator B and Shipper place the Kanban sheet and load each square with an assembly. These will serve as a "store" to supply Shipper and the Visual Controls for Pull Scheduling signals between Operator B and Shipper. When Shipper needs a particular color finished assembly, he pulls from the "store" after Process B and completes the assembly. Operator B pulls from the "store" after Process A and completes his portion of the assembly to fill the now empty square. As soon as Operator A sees an empty square, that serves as his instruction to produce another sub-assembly of that color - that is to produce in accordance with what his customer needs or "Make To Use".

- **Instructions from Lead Facilitator**

- "Our customers will now let us mix shipments so we have a new truck schedule."

- "Kanban worked well between A and B so we will implement between B and Shipper. Shipper will now use truck schedule as the factory production schedule."

- **"Place strategic inventory on each square."**
  (The 3 squares between Operators A and B, and operator B and Shipper should contain partial assemblies.)

- **Once the participants understand the rules, start the run.**
- **Let the team overbuild finished goods if time remains (all teams should achieve excess finished goods). Utilize raw material inventory if necessary.**

- **Evaluating the run and discussion**

- **Stop the run at 4 minutes.**

- **Record all the results on Financial sheet.** Be sure to capture all finished goods expense beyond the 30 units of customer demand. (**Turn in your results to the Lead Facilitator as quickly as possible.)**

- **Debrief the team.** Chances are slim that all goals have been reached and the run was profitable. Note productivity improved, Work-In-Process inventory was greatly reduced, and delivery performance was 100%. **Stress the impact of finished goods cost. Compare this run to traditional manufacturers attempting to use Lean Tools only, not Lean Strategy. Ask for their ideas that would make even further improvements.**

- **Lead Facilitator - bring attention to the front**
- **Review the delivery performance and financials and point out the contrasts between all runs.**

- **Reinforce the notion of Takt Time (show overhead) and point out that to match the workload to the time available, we really needed to operate at a "rhythm" of about 8 seconds per assembly.**

RUN 5:

- **This run will primarily teach about TAKT time and customer demand.**

- **Preparations**

- If available, use the timer function on a stopwatch to pace every 8 seconds.

- Make sure operators only build one part every eight seconds to visualize the time available.

- **Once the participants understand the rules, start the run.**

- **Evaluating the run and discussion**

- **Stop the run at 4 minutes.**

- **Record all the results on Financial sheet.** Note the even production. (**Turn in your results to the Lead Facilitator as quickly as possible.)**

- **Debrief the team.** Depending on the number of participants, each team will achieve the same results: improved productivity, Work-In-Process inventory was greatly reduced, and delivery performance was 100%, and desired profit attained.

- **Lead Facilitator - bring attention to the front**

- **Review the delivery performance and financials and point out the contrasts between all runs.**

- **Review Takt Time and point out how long 8 seconds truly is in a Lean environment.**

F. OTHER PROBLEMS THAT HAVE BEEN ENCOUNTERED:

- **Operator B may try to pre-assemble by combining 2-peg and 4-peg blocks into ready to add-on units to then attach to the subassemblies coming from Operator A.** This should not be allowed, because it significantly departs from the intended work. Explain to the Operator that the sequence of the process is to add a 4-peg to the subassembly and only then to add the 2-peg.

- **In Run 1 the Operators may start organizing the work before the Run start.** This should not occur.

- **In Run 1 the Operators may dump their boxes to get at the blocks more readily**. This should be allowed. It will affect their material costs, as each block outside the container is now WIP when the shift ends.

- **Participants may want to try other conditions "on the fly" during the simulation. This can include different batch sizes, different withdrawal sequences in Run 3 (e.g., Pull 3 Reds, 1 White, 4 Blues), etc.** Such experiments are strongly discouraged, because they introduce unknown conditions and consequences to the simulation. If you want to be responsive and try any other ideas, then add them as a separate Run after the five establish runs.