A SIMIO LIBRARY FOR VALUE STREAM MAPPING

Jason D. Ceresoli

Department of Industrial and Systems Engineering
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA

Nick J. Morris

Department of Industrial and Systems Engineering
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA

ABSTRACT

The use of Value Stream Mapping (VSM) with simulation has been proven to increase the effectiveness and accuracy of lean implementation, but requires a strong simulation background to apply. This paper describes a custom object library that was created in the Simio simulation software that makes simulation based VSM more accessible, and helps to reduce the investment that is typically required to utilize simulation with VSM. By using our library to map a process from a case study, we found that the library reduced the simulation time and effort required, and also enhanced simulation based VSM by creating a more accurate display of a traditional VSM.

1 INTRODUCTION

Value stream mapping (VSM) is the process of understanding the flow of material and information as a product completes all of the required actions, both value added and non-value added, in its creation (Rother et al, 2003). Additionally, VSM summarizes a process visually, and provides a vision for the future system with improved performance (Jones et al, 2000). VSM is one of the many tools used in the implementation of lean manufacturing, with the ultimate goal of eliminating waste from a system. However, VSM is a very manual process that only produces a snapshot of a system. While it can be created quite quickly by an experienced practitioner, it is static in nature (Standridge and Marvel 2006).

Simulation is defined as the electronic modeling of a system or process with an focus on material, and information flow and logic (Woehrle et al. 2010). The implementation of simulation with VSM has been identified as good approach to account for this loss of system variability that is inherent with paper and pencil VSM. However, to fully utilize simulation based VSM, a great deal of simulation knowledge is necessary (Solding and Gullander 2009).

To decrease the knowledge and skillset required to apply simulation based VSM, we have created a custom object library for all the key icons used in VSM. Our library will make simulation based VSM more accessible, and help to reduce the investment that is typically required to utilize simulation with VSM. This paper also will review the VSM methodology and how it is integrated into our library. Additionally, the custom library will be applied to a case study to show its implementation against a paper and pencil VSM.

2 VSM BACKGROUND

Lean manufacturing is a methodology of actively looking for opportunities to constantly improve a process by eliminating waste, in the form of non-value added activities (Adams 1999). One of the many tools utilized to implement lean is VSM. Traditional VSM are constructed by observing a process and recording process statistics like cycle times, buffer sizes, inventory and then creating the VSM using paper and pencil (Solding and Gullander 2009). Beginning with a current state map (CSM), a practitioner categorizes tasks as value-added, required non-value added, and non-value added. From this classification, the practitioner is able to identify the key areas for improvement, or the non-value added activities. From these improvements, a future state map (FSM) is created, detailing the changes (Ali et al 2015).

While VSM is an important tool for adopting lean, it has some limitations. VSM portrays only a static snapshot of a system, modeling processes with constant values. Moreover, VSM can only account for one type of product, so the dynamic behavior of a process between types of products is neglected. Also, batch size might not have a linear correlation with the processing time, or how different products might require different sequence of tasks. The snapshot nature of VSM can also fail to accurately capture the true current state of a system, and could compromise the actual simulation statistics being generated (Schoneman et al. 2016). Lastly, VSM is unable to handle some of the complexity in systems, and that utilizing VSM alone does not allow for an effective evaluation of a leanness level (Mahfouz and Arisha, 2013).

2.1 Simulation Based VSM

The use of simulation with VSM has been identified as a method to reduce the limitations of traditional VSM. Simulation allows VSM to address the dynamic nature of most systems (Mahfouz and Arisha, 2013). This can generate a more accurate representation of the system, which can allow for better analysis and comparison with the FSM. Also, simulation based VSM reduces the uncertainty of implementing improvements in a process because it helps to provide a visual depiction of FSM. Simulation based VSM can further help to boost confidence in employing lean by quantifying the expected results in the future state. In other words, simulation based VSM can provide a benchmark to measure the value of applying lean (Woehrle et al. 2010).

2.2 VSM Icons

VSM utilizes a set of standard icons that each represent the functions in an operation. According to Rother and Shook, The standard VSM icons are inventory, process , customer and supplier, truck shipment, push arrow, manual information, electronic information, schedule, plane, shipment, train shipment, and control center. A quick review of the key icons follows.

The inventory icon, shown in Figure 1, is simply the queue of material that has built up at a station. This material can be both raw material as well as finished goods. The process icon symbolizes an operation, process, or department where material is involved (Figure 2). Consumer and Supplier icons create orders and supplies accordingly (Figure 4). The movement of material in a process is depicted via the truck, plane, and train icon, shown in Figures 4, 9 and 10 respectively. Figure 5 represents the moving of information and material that is pushed. Figures 6 and 7 signifies the flow of information by manual or electronic means. The schedule icon is simply a status label to identify the type of information that is being transmitted on a flow path icon (Figure 8). Lastly, the control center icon represents the flow of information within a system (Figure 11), where the information is passed into the control center and determined what operation should be actioned.

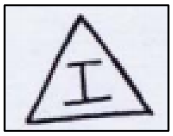

Figure 1: Inventory Icon

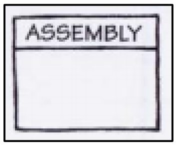

Figure 2: Process Icon

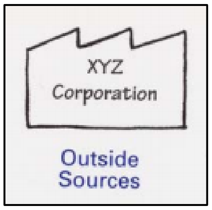

Figure 3: Customer and Supplier Icon

Figure 4: Truck Shipment Icon

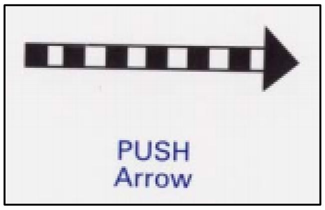

Figure 5: Push Arrow Icon

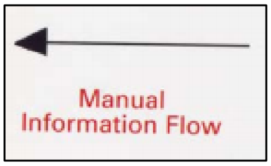

Figure 6: Manual Information Flow Icon

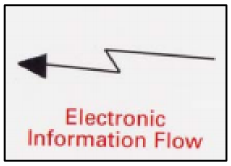

Figure 7: Electronic Information Flow Icon

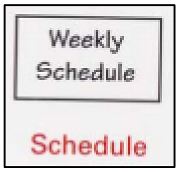

Figure 8: Schedule/Information Icon

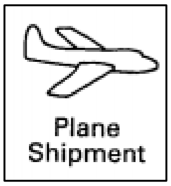

Figure 9: Plane Shipment Icon

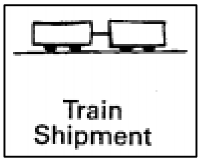

Figure 10: Train Shipment Icon

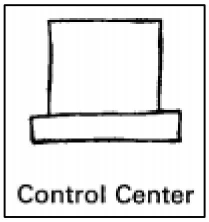

Figure 11: Control Center Icon

3 CUSTOM SIMIO VSM LIBRARY

The library we built in Simio consists of the VSM icons of Process, Customer, Supplier, Production Control, Truck, Plane, Train, Push Arrow, Manual Information Flow, Electronic Information Flow, Information, and Shipping. These icons can be found in Figure 12. Each of the objects was designed to mimic the standard objects described above.

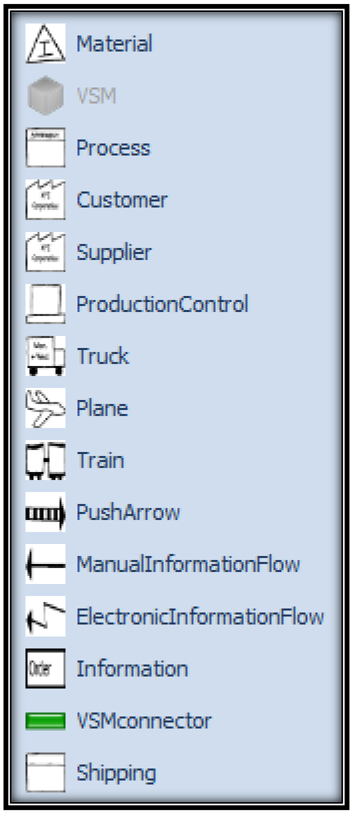

Figure 12: Custom objects created in VSM Library

3.1 Description of Custom objects

The Material and Information icons above in Figure 12 represent the entities that flow through the system. The Material entity may be raw material from the supplier, work in process, or finished goods for the customer. The Information entity may be an order from the customer or a forecast from the production control system. The Process icon above is an object that requires one Material entity and one Information entity before sending the Material entity downstream. The Customer icon above is an object that produces Information entities at a rate defined by the user, and consumes Material entities at rate dependent on the performance of the entire system. The Supplier icon above is an object that produces one Material entity for every Information entity it receives. The Production Control icon above is an object that produces a forecast for every Information entity that it receives and for every forecast that it needs to send. An example would be that the Customer sends ten Information entities (ie. orders) to Production Control and there are five forecasts that it must send, therefore fifty Information entities are produced. After producing forecasts, Production Control sends all of the orders it receives to Shipping. The Shipping icon is an object that acts like the Process object where it requires one Information entity before sending the Material entity to the Customer. The remaining icons are objects that allow the Material and Information entities to flow through the system. The Truck, Plane, and Train allow flow to occur at discrete instances based on a user define frequency (ie. once a week) whereas the others allow flow to occur at any time.

3.2 Applying our Library to VSM

The custom objects created were designed to mimic the traditional VSM method, and allow for easier adaption of VSM in simulation. The user is simply able to drag and drop the needed symbols to visual represent the VSM. However, some simulation knowledge is still required to obtain the true benefits of our library. Once the objects are inserted into Simio, the user must connect them using paths, and also insert in the specific information associated with the process they are mapping. From there, the user can fast forward the model for a given amount of time and obtain the standard metrics that would be inserted into a VSM. These metrics are displayed with their corresponding confidence intervals, as to give a more accurate representation of the system.

4 APPLICATION TO A CASE STUDY

The case study is from a lean production systems course of a value stream mapping assignment (Shown in Appendix 1). The objects in the case study include one Customer, one Production Control, one Supplier, five Processes, one Shipping, and two Trucks. The case study itself doesn't include any stochastic elements so random distributions were chosen, with their parameters based on the deterministic values given in the case study. The case study in general is a components manufacturing plant that builds subassemblies for other companies that build small engines (ie. lawn mowers, generators). The objective of the case study is to create a complete value stream map of the current state including all material and information flows, all objects, and data boxes to show the performance of each Process object and the system as a whole. Figure 13 below depicts the VSM for the case study using the custom library.

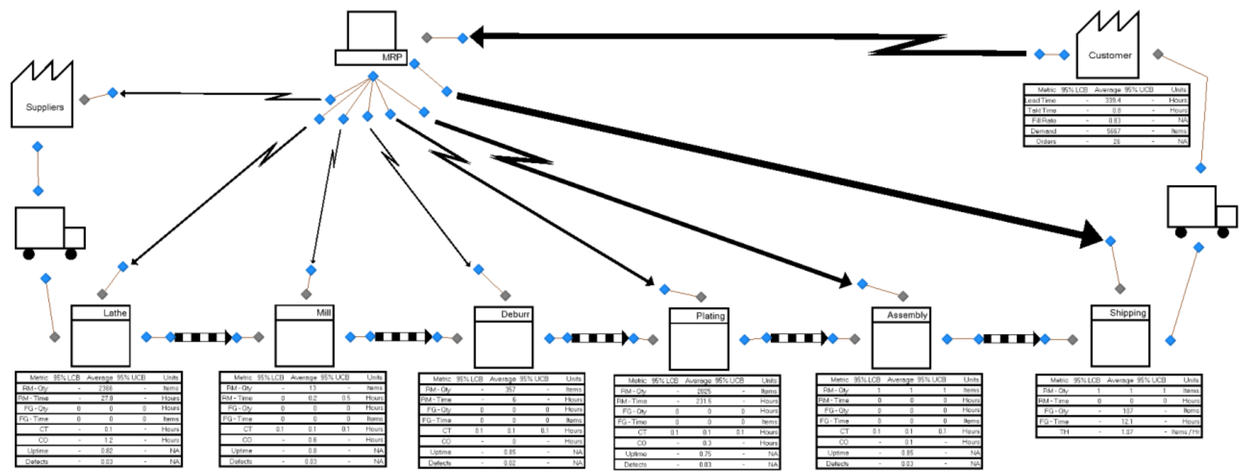

Figure 13: Case Study VSM utilizing Custom Objects

4.1 Process for Using VSM Library

The first step is to create a Customer object in the top right corner, a Production Control object in the top center, a Supplier object in the top left corner, Process objects along the bottom, and a Shipping object in the bottom right corner. The next step is to position a Manual or Electronic Information Flow arrow from the Customer to Production Control, Production Control to Supplier, Production Control to each Process (ie. one arrow for each process), and Production Control to Shipping. The Production Control object has one input node and two output nodes, the output node to the left is for the arrows going to the Supplier and Processes. The output node to the right is for the arrow going to Shipping. The third step is to position a Push Arrow, a Truck, a Plane, or a Train between Supplier and the first Process, between each Process, between the last process and Shipping, and between Shipping and the Customer. The fourth step is to use the VSMconnector to connect all of the objects together, every object has at least one input node and one output node. The fifth step is to go to each VSMconnector that connects the left output node of Production Control to an information flow arrow, and give each VSMconnector a “Forecast Identity”. An example would be that Production Control sends out six forecasts between the Supplier and Processes, so there are six VSMconnectors with a “Forecast Identity” that must be labeled uniquely with any number from one to six. The last step is to click through each object and fill out all of the input information shown.

4.2 Evaluation and Interpretation of results

The simulation model of the case study was run for a 26 week period in simulation time, a few seconds in real time. The results of the model are shown in the data box under each Process, the data box under Shipping, and the data box under the Customer. Each data box has five columns in the following order: metric, 95% lower confidence bound, average, 95% upper confidence bound, and units. The metrics for each Process object, which make up the rows of their data box, include: raw material quantity, raw material time (ie. how long raw material waits before being processed), finished goods quantity, finished goods time, cycle time, changeover time, uptime, and defects. The metrics for the Shipping object include: raw material quantity, raw material time, finished goods quantity, finished goods time, and throughput. The metrics for the Customer include: lead time, takt time, fill rate (ie. the percent of demand satisfied), demand, and orders.

When evaluating results, look at the raw material quantity and raw material time at each process, ideally these numbers should be similar which shows a characteristic of a balanced system. Another step is to go to each Process and look at the width of every metric's confidence interval, and compare these widths between each Process object. Ideally, these widths individually wouldn't be too large and moreover the widths comparatively should be similar to show that variance is equivalent across the system. The next step would be to compare the cycle time metrics between each Process, ideally these would be similar which is a characteristic of a continuous flow system. The key step is to go to the Customer's data box and look at the difference between lead time and takt time, while keeping in mind the value of the fill rate. Ideally the lead time and takt time would be similar to show a characteristic of a make to order system and the fill rate should be at least 90%. If the difference between lead time and takt time is large but the fill rate is fine, then this is a characteristic of a forecast driven push system that is likely to have at least one batch process with a lot of material. This batch process can be verified by the raw material quantity/time and/or finished goods quantity/time metrics for each Process object.

5 CONCLUSION

The use of VSM is an important tool in the implementation of lean. The use of simulation with VSM has been identified as a method to enhance VSM, but often requires vast simulation experience and knowledge. The Simio Library for VSM that was created helps to reduce this barrier and allow more practitioners to utilize simulation based VSM.

The Simio Library for VSM provided many benefits over the traditional VSM. For example, by employing many replication, the custom library VSM can provide more accurate performance measure for a process. Also, the confidence intervals can be obtained, which can give the practitioner more information about the system, and help to avoid the errors that can be created when a process abnormality is observed as normal in a system, which can more easily occur when viewing a snapshot of the system. This simulation based VSM reduces the barriers to using simulation to aid VSM. By developing a custom library of the standard VSM icons, most novice simulationists can easily adapt their traditional VSM into an electronic media.

While the ultimate goal of this library was to eliminate the prerequisite simulation background, some simulation experience is still required to implement this library. The user must be familiar with creating Simio models and how to connect objects using the various methods. The library was designed to minimize this required knowledge, but we believe the information that can be obtained by using this library is valuable enough to justify the simulation training that would be necessary.

This VSM library is only a stepping stone to a complete simulation based VSM tool. The icons and functionality that were modeled only allow for push system to be mapped, and work still remains in creating a library that could map both push and pull system. Furthermore, the model is lacking the prior system information for past order to develop the first forecast. Currently, the Production Control object must track the first set of Customer orders before developing the first forecast, which can lead to logically errors in Simio. Additional work can be completed to enhance this technique by feeding in previous system information via data tables in Simio.

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7 APPENDIX

7.1 Case Study Assignment

Use an 11 x 17 sheet of paper to draw a current state value stream map for the following. This should be done by hand in pencil. No excel or autocad or visio or …

Company Information

Engine Components Manufacturing (ECM) is a small company that manufactures mechanical subassemblies for companies that build small engines - lawn mowers, generators, etc. Their customers (about 20 companies) are original equipment manufacturers mostly. ECM also does some repair and service work for these companies.

Production Control

Because of the variety of products and customers, and fluctuating sales volumes, ECM has historically been a make to order business with long lead times. They quote 5 week lead times from receipt of order to customer availability. They have an MRP system that manages their production and inventory. Communications around this system include:

Customer orders entered in as received

Orders are sent to shipping daily

Schedules are sent to each work center and suppliers weekly

Production rate forecasts are done each month looking out 6 months (rolling horizon)
An expedited shipment service is also offered - 1 week lead time for a 60% price premium.

The product

The products are mechanical subassemblies shipped in shipping containers of 6 pieces each. Containers (cartons) are one product only - no mixed containers are shipped. Product leaves shipping after cartons going to a customer are placed on wooden pallets and are picked up by a "less-than-truckload" (LTL) carrier (trucking co.) and shipped. Pallets may contain mixed products, but are for one customer only.

Customer requirements

Typical order is 32 pieces
Daily shipments average 640 pieces (approx. 20 orders)
Pallets typically hold 3 to 5 orders

Production work time

One 8 hour shift per day, use overtime as needed to handle volume fluctuations.

Process Information

The current layout is by process type - lathes, mills, grinders, deburring, finishing, assembly, etc. each in their own area. The following process steps occur in the sequence listed.

1. Lathe

Cycle time 5.2 minutes Setup (changeover) time 70 minutes
Uptime = 82%
Inventory: 9 days of raw material - bar stock and castings
5 days of machined parts (turned)

2. Mill

Cycle time 6.1 minutes Setup time 40 minutes
Uptime = 80% Inventory: 4 days of machined parts (milled)

3. Deburr, hand finish

Cycle time 0.8 minutes Setup time = 2 minutes
Uptime = 85% Inventory = 1 day of deburred parts

4. Finishing (Plating)

Cycle time 128 minutes for a batch of 24 parts Setup time 18 minutes
NOTE: Cycle time (120 min) is machine time + load/unload = 8 minutes
Uptime = 75% Inventory: 3 days of finished parts

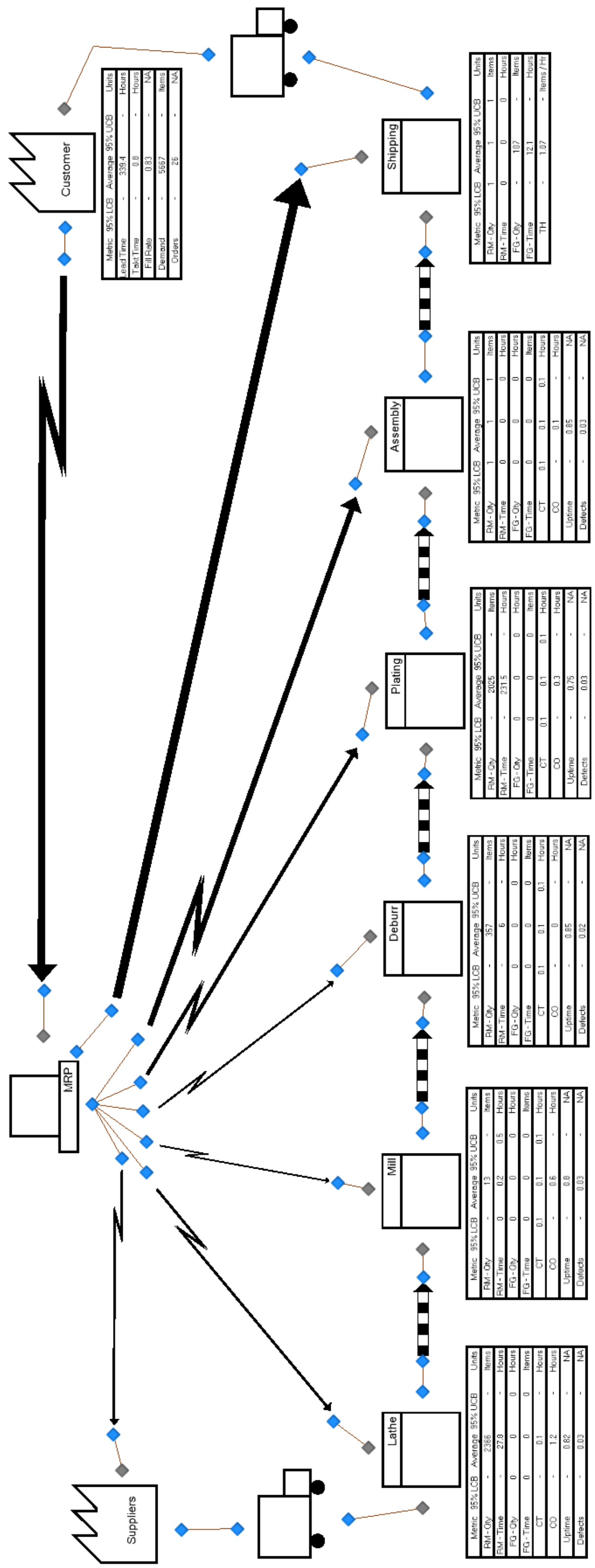
5. Assembly and Test

Cycle time 6.5 minutes (machine) + operator load/unload time 2.8 minutes
Changeover time 4 minutes
Uptime = 85% Inventory: 1 day of completed assemblies
Shipping: Packages and palletizes product for shipment
Suppliers: Metal supplier delivers once weekly via truck

Task

Draw a complete value stream map of the current state, including the material and information flows, data boxes, customer and supplier info, and lead time bar. Draw by hand, in pencil.

7.2 Figure 13 Enlarged



AUTHOR BIOGRAPHIES

Jason D Ceresoli is an undergraduate Industrial and System Engineering student at the Rochester Institute of Technology. His email address is jdc1625@rit.edu.

Nick Morris is an undergraduate Industrial and System Engineering student at the Rochester Institute of Technology. His email address is njm2868@rit.edu.