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A SUPPLY CHAIN PARADIGM TO MODEL BUSINESS PPROCESSES AT THE Y-12 NATIONAL SECURITY COMPLEX

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ABSTRACT

The NNSA's Y-12 National Security Complex is a manufacturing facility operated by BWXT Y-12. Y-12's missions include ensuring the US' nuclear weapons deterrent, storing nuclear materials, and fueling US naval reactors. In order to understand the impacts of these diverse missions on its numerous functional divisions, Y-12 has relied on simulation modeling. Traditional discrete-event simulation modeling has proven to be an indispensable tool for Y-12; however, this paper will discuss Y-12's use of a supply chain paradigm to model its entire business processes. The supply chain model executes very quickly and is versatile enough to model all of the nuances of Y-12's complex business. It can model equipment, labor, facility, or other constraints and provides a rough-cut estimate of schedule compliance over many years (even decades). This paper describes how the model is implemented and presents simple results from a representative process.

1 INTRODUCTION

The Y-12 National Security Complex is a premier manufacturing facility dedicated to making our nation and the world a safer place. Operated by BWXT Y-12 for the National Nuclear Security Administration, Y-12 plays a vital role in the Department of Energy's Nuclear Weapons Complex. Y-12 helps ensure a safe and reliable U.S. nuclear weapons deterrent, retrieves and stores nuclear materials, fuels the nation's naval reactors, and performs work for other government and private-sector entities. As a consequence of this mission, Y-12 makes dozens of products, having hundreds of parts, each with many different process steps associated with manufacturing components, building sub-assemblies, or assembling a final product. In addition, Y-12 disassembles weapons in order to support stockpile reduction efforts and to retrieve high-value materials and components. Y-12's technology-based missions can be distributed into the following broad categories:

- Production and rework of complex nuclear weapon components and secondaries;
- Receipt, storage, and protection of special nuclear materials;
- Quality evaluation and enhanced surveillance of the nation's nuclear stockpile;
- Dismantlement of weapon secondaries and disposition of weapon components;
- Prevention of the spread of weapons of mass destruction; and
- Support work for DOE and other federal agencies.

All of these efforts must be coordinated not only within the Y-12 complex (811 acres, 500 buildings, 7 million square feet of laboratory, machining, dismantlement, and research and development areas), but also within the nation-wide nuclear weapons complex. In addition, DOE and other government managers often request schedule evaluations, equipment justifications, or new facility plans that take a multi-year look at schedule compliance, payback, and implementation. (In fact, sometimes the horizon is multi-decade in the context of very expensive new facilities or upgrades.) The only way for Y-12 managers and planning organizations to evaluate the impact of plant changes over multiple programs and products, spanning multiple-year production runs, involving multiple interacting organizations is to develop detailed simulations of the bulk of Y-12's processes.

A short review of some recent supply chain papers helps to place this work in the appropriate context. A general discussion of the use of simulation in supply chain optimization is presented in a paper by Padmos et al. (1999). One point the authors make is that because of the dynamic nature of new business models and the resulting demands on the supply chain, traditional modeling

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paradigms are not flexible nor are they sufficiently scalable to render appropriate solutions. Rather, decision support tools have to provide strategic decisions at all stages of the supply chain, from raw material suppliers through finished goods distribution. This supports Y-12's objective of utilizing supply chain simulation to support decisions within the local complex as well as within the broader Nuclear Weapons Complex (NWC). Banks, Buckley, Jain, Lendermann, and Manivannan (2002) discuss the future of simulation related to supply chain management. Buckley, from IBM Thomas J. Watson Research Center, first reviews IBM's Supply Chain Analyzer (SCA). SCA was a standalone Windows tool with a Graphical User Interface (GUI) that interfaced with various databases through fixed-format flat files. IBM is developing new operational supply chain simulators that exhibit the following characteristics: 1) model data are integrated with the enterprise IT system; 2) the simulator is integrated into the enterprise business process; 3) the tool is web-enabled; and 4) the simulation is formulated to execute quickly (all characteristics of Y-12's supply chain simulator except for web-enabled). Jain, from Virginia Polytechnic Institute and State University, discusses using a Virtual Supply Chain (VSC) during several phases of a project including the design phase, the operational phase, and the termination phase. Y-12 tends to focus supply chain simulation on operational models but certainly plans to use supply chain simulation for design and termination. Lendermann, from the Singapore Institute of Manufacturing Technology, points out that there are two alternative implementation approaches for distributed supply chain simulation: top-down and bottom-up approach. The top-down approach takes a simple simulation model and continues to add layers of granularity over time. The bottom-up approach takes detailed process models and integrates them into a single, larger-scale model. Y-12 is taking both the top-down and bottom-up approach to supply chain modeling. Many detailed process models exist at Y-12 and efforts are underway to integrate detailed process models with Y-12's supply chain simulation. Manivannan, of Vector SCM, notes that key opportunities for simulation in supply chain analysis are the following: 1) validation of existing supply chains; 2) investigating the impact of demand changes; 3) evaluating the impact of infrastructure or operational changes; 4) choosing alternatives for parts and raw materials; 5) studying the merging of supply chains; 6) investigating relationships between suppliers; 7) developing standards,; and 8) comparing inventory strategies. One very important point he makes is that a supply chain model needs adequate levels of aggregation or decomposition to be useful for various analyses. Y-12 views supply chain simulation as useful in all these areas of opportunity and especially in investigating demand, infrastructure, and operational changes. Many other studies on supply chain and simulation exist. One excellent source for recent work is the Supply-Chain Council (2007).

Semini et al. (2006) have written a survey paper on the use of discrete-event simulation in real-world manufacturing logistics decision making. They looked at recent Winter Simulation conference proceedings. The conclusion of the paper was that "… the majority of applications has been reported in production plant design and in the evaluation of production policies, lot sizes, WIP levels, and production plans/schedules." Considering that the Y-12 plant repeatedly fields numerous requests to evaluate throughput, production policies, WIP, material movement and handling policies, and production schedules it not surprising that Y-12 uses simulation modeling and specifically developed a supply chain paradigm to understand its business environment. This paper will focus on the approach used by Y-12's simulation modeling team to implement a supply chain simulation modeling paradigm and provide some examples of how the supply chain model is currently being used.

2 APPROACH

2.1 Software

Simulation modeling at Y-12 is used as a production support tool. As a consequence, commercial off-the-shelf (COTS) tools are preferred to custom software. Y-12's simulation modeling group relies on three primary COTS packages. These are EXTEND™, Supply Chain Builder™, and FlexSim™ (refer to references by Imagine That Inc., Simulation Dynamics Inc., and Flexsim Inc. respectively). With each of these tools, Y-12's simulation modeling group relies heavily on database-intensive models; refer to Kress et al., (2006).

EXTEND™ from Imagine That Inc., is a discrete-event simulation package that is widely used across many industries. It is easy to learn, has a graphical user interface, a custom programming language, and is linked to a built-in database. EXTEND™ has a custom programming language that allows one to develop custom blocks that can then be stored in a user-named library and employed in any model in the future. EXTEND™ can be coupled with Microsoft Excel™ and executed from an Active X control embedded within the Excel spreadsheet so that models can be run even by a less-experienced analyst. Y-12 makes extensive use of EXTEND™ in its process models, and has at least fifty models of various processes within the plant ranging from training, to transportation, to manufacturing, to storage of materials. Kress et al. (2006) discusses how Y-12's modeling team makes extensive use of the built-in database capabilities of EXTEND™ by developing models that are database-intensive and completely specified and driven from the built-in database.

The Integrated Resource Planning Model (IRPM) is created in the Supply Chain Builder™ COTS software from Simulation Dynamics Inc (2006). This discrete-event model is completely database driven, in fact, there are no items at all in the model, which Phelps et al. (2002) shows has many advantages. The model has a limited number of blocks with a large amount of functionality programmed into each block. Being completely database driven has an important additional benefit. It facilitates the development of a custom Graphical User Interface (GUI) for the simulation in Microsoft Access™. This GUI serves several purposes. First, it establishes a connection between the model database and existing corporate databases such as scheduling data, human resource data, and equipment availability data. This keeps model data current. Second, critical measures such as utilization, resource requirements, operation costs, etc. can be calculated either in the model or in the Access™ GUI, depending on which is easier for the programmer to implement. New programs, products, processes, operations, resource requirements, etc. can be added in Access™ and are automatically transferred to the supply chain model. A run button starts the model and, upon completion, simulation data are transferred back to Access™. Post-processing and data analysis are done in Access™.

2.2 Bicycle Model

Consider the following easy-to-understand example as a context within which to present Y-12's business as it relates to the IRPM model. Suppose Y-12 wished to build bicycles from a pre-defined set of plans. Each bicycle requires a frame (made of two parts, A and B) and two wheels (made of a tire, rim, and 60 spokes). Some of the bicycle frames are fabricated from an expensive high-strength, low-density alloy which is called a "key material." The bicycle factory also makes some specialty frames from the "key material" and provides them to a secondary customer as "alternative products." In addition to assembling bicycles from parts, in this fictitious example, Y-12 takes old bicycles apart and 1) directly reuses some of the parts in new bicycles; or 2) repairs/refurbishes the parts if possible and then reuses them in new bicycles; or 3) removes key materials for use in future bicycle components. This basic business function described in terms of the IRPM's supply chain model is shown in figure 1 on the following page.

The model implemented in figure 1 is described in the following paragraphs but first, consider a note about terminology. Taking a bicycle apart to obtain parts for reuse is termed disassembly. Disassembly will yield both reusable parts and key materials. Taking apart a bicycle solely to obtain key materials is called dismantlement. Parts from disassembly are reused, whereas, parts from dismantlement are only used for materials; therefore, disassembly must be done more carefully to avoid damage to the parts resulting in a longer processing time.

Part flow is critical to understanding the operation of the supply chain model. Some queues have push flow indicated, some have pull, and others have no flow indicated. Some queues have schedules and some do not. This requires explanation. Begin with bicycles entering the model intended for retirement. Retirement bicycles are pushed into the bicycle factory according to a receipt schedule. They are placed into storage and they remain there until they are pulled from either the dismantlement program which has its own internal schedule or from disassembly which is driven by customer demand modeled as a pull schedule at the primary product customer (customer 1). Key materials resulting from dismantlement or disassembly are pushed into interim or long-term storage where they remain until removed as a result of alternative customer demand modeled as a pull schedule at the alternate product customer (customer 2).

Fictitious reservoirs exist in two locations in the diagram; for bicycles entering disassembly and for key material entering recycle and recovery. These fictitious reserves were conceived to allow the model to continue running, even if it is starved for materials. Whenever the fictitious reserve is tapped, it indicates conditions when the model lacked material; either stored old bicycles or key materials from old bicycles. This concept has not been fully implemented at this point.

The primary table describing the details of a model in the IRPM is the Bill of Materials (BOM) table. Unlike a traditional BOM, the IRPM BOM not only has a materials list, but it also has the operations associated with the materials. A BOM for the bicycle model example is shown in figure 2 on page 5.

The BOM can represent an assembly (see assemble bicycle at the bottom of the table) and it can also represent disassembly, inspection, repair, and other operations. As long as there is an input and an output to an operation it can be represented in the BOM. For example, to simulate a movement of material from location A to B simply have a BOM operation that has as an operation called "Move from A to B" and has an input "Material at A" and an output "Material at B." In addition, having the model built within data tables enables further investigation of the supply chain via ordering policy and order amounts in the inventory table.

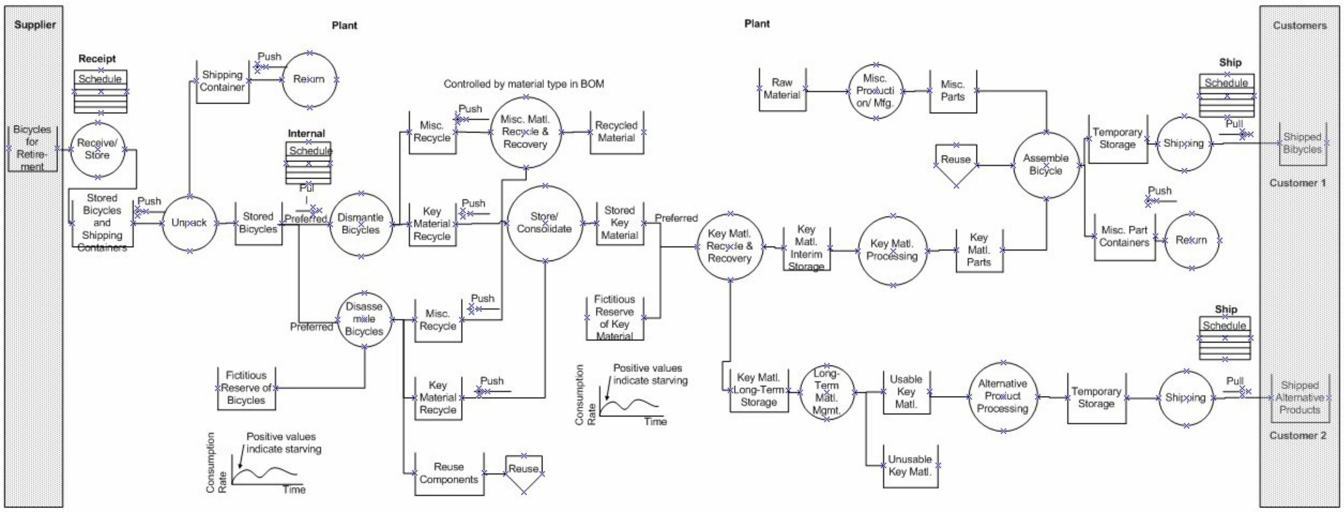

Figure 1. The bicycle model basic business functions as described in a supply-chain paradigm for implementation in the Integrated Resource Planning Model (IRPM).

Bill of Materials

Operation	Part	Quantity	Output	Output Quantity	Rule	Primary
string	string	real	string	real	integer	string
Take bike apart		0.00	Untested frame	1.00	0	Yes
Take bike apart		0.00	Untested wheel	2.00	0	Yes
Take bike apart	Broken bicycle	1.00		0.00	0	
Frame is Scrap		0.00	Scrap frame	1.00	0	Yes
Frame is Scrap	Untested frame	1.00		0.00	3	
Frame is broken		0.00	Broken frame	1.00	0	Yes
Frame is broken	Untested frame	1.00		0.00	4	
Frame is OK		0.00	OK frame	1.00	-1	
Frame is OK	Untested frame	1.00		0.00	0	
Repair frame		0.00	OK frame	1.00	-1	
Repair frame	Broken frame	1.00		0.00	0	
Assemble frame		0.00	OK frame	1.00	0	Yes
Assemble frame	Frame part A	1.00		0.00	0	
Assemble frame	Frame part B	1.00		0.00	0	
Wheel is Scrap		0.00	Scrap wheel	1.00	0	Yes
Wheel is Scrap	Untested wheel	1.00		0.00	1	
Wheel is broken		0.00	Broken wheel	1.00	0	Yes
Wheel is broken	Untested wheel	1.00		0.00	2	
Wheel is OK		0.00	OK wheel	1.00	-1	
Wheel is OK	Untested wheel	1.00		0.00	0	
Repair Wheel		0.00	OK wheel	1.00	-1	
Repair Wheel	Broken wheel	1.00		0.00	0	
Assemble Wheel		0.00	OK wheel	1.00	0	Yes
Assemble Wheel	Spoke	60.00		0.00	0	
Assemble Wheel	Rim	1.00		0.00	0	
Assemble Wheel	Tire	1.00		0.00	0	
Assemble bicycle		0.00	Bicycle	1.00	0	Yes
Assemble bicycle	OK frame	1.00		0.00	0	
Assemble bicycle	OK wheel	2.00		0.00	0	
		0.00		1.00	0	
	Pgm 1 Budget	1.00		0.00	0	
		0.00		1.00	0	
	Pgm 2 Budget	1.00		0.00	0	

Figure 2. The Bill Of Materials (BOM) table for the Integrated Resource Planning Model (IRPM) that establishes assembly, part, and operation relationships as well as rules to determine which source or destination for a product is primary.

2.3 Data Collection

Data collection is perhaps the most difficult and important part of the simulation model building process. Almost no one builds a model that does not run (at least once the model is finished), but the quality of the output is heavily dependent upon the quality of the input data. There are many sources of data including but not limited to corporate program- and product-specific data including drawings, pictures, routings, shop-floor schedules, Bills of Material, procedures, Subject Matter Experts (SMEs), and other sources. One helpful data-collection aid has been a data review meeting template. An example template for the bicycle model built in Excel™ is shown in figure 3 on the following page.

It is very important during the data collection phase to record the contributing expert and the time information was added to the dataset. Often, assumptions are questioned in future reviews, especially when modeling future processes where data are either sparse or nonexistent. Associating an SME with a piece of data will provide confidence in the validity of the value. It is also important to have an integration person working with the modeling team and data-collection team. This person coordinates the collection and introduction of data into the model database. S/He can determine what data are required, which experts should be called to a meeting (not all experts need to be at all meetings every time), and when particular portions of the data set need to be refined or reviewed.

2.4 Simulation Model Runs

Section 2.1 described the simulation modeling software from Simulation Dynamics Inc (2006) that is at the core of the IRPM. This software is run completely from the custom-designed GUI including the management of various what-if scenarios and reporting of results. The IRPM is commonly used to provide quick, rough order of magnitude answers to NNSA directives or requests, therefore, many replications of the model for statistical analyses are generally not done. Often, results from just a few runs are compared and a decision is made that is simply yes/no we believe that Y-12 can support the request. Statistical analysis will become more important for answers to future what-if questions concerning staffing levels, equipment needs, system availability, etc. Since the IRPM can execute so quickly, 50 to 100 runs may be used to develop appropriate statistical distributions for these types of results.

3 RESULTS

Typical results from the bicycle development model are shown in figures 4 and 5 on the following page. This simulation of the bicycle factory used a customer with an initial inventory of 100 bicycles and an estimated sales rate (consumption) of one bicycle per day. Sales that reduced the inventory below 100 bicycles were immediately followed by orders for new bicycles in batches of five. The simulation was run for 70 days and it was assumed that each operation in the assembly required one of the same pieces of equipment (e.g. an assembly fixture or stand). Figure 4 shows orders, shipments, sales, and inventory at the customer's location. Notice how initial sales cause a drop in inventory until production is able to increase to meet sales and replenish inventory. Figure 5 shows the maximum number of concurrent operations required to fulfill the customer's demands.

Note the set of operations includes both assembly and disassembly as well as "decision" operations where the disassembled parts are assessed relative to their reusability (e.g. Frame is Scrap operation). The IRPM also determined the utilization of equipment assuming that every operation requires one piece of equipment (e.g. a support stand or fixture) and that there are 30 pieces of equipment available in the pool.

Bicycle Data Collection Meeting
Date: 6/19/2007

Part	Material	Weight	/Assembl	Expert	Comments	Date
Frame A	Steel	8 lbs	1	Eng1		6/15/2007
Frame B	Steel	8 lbs	1	Eng1		6/15/2007
Tire	Rubber	2 lbs	1	Staff1		6/22/2007
Rim	Steel	4 lbs	1	Staff1		6/22/2007
Spokes	Steel	2 oz	60	Staff1	Tighten to 0.05-in deflection	6/22/2007

Assembly	Hours	Equipmer	Expert	Comments	Date
Assemble Wheel	10	Stand	Staff1		6/25/2007
Assemble Frame	10	Welder	Eng2		6/18/2007
Assemble Bicycle	8	Stand	Eng3	Refer to procedure 07-a	6/25/2007

Figure 3. Typical review meeting template showing a figure of the product, relevant product data, Subject Matter Expert's name, data entry date, data units, etc. (The product figure is from Wikipedia Bicycle 2007.)

Note: 28 is maximum number used at any one time. Utilization was found to be a little greater than 50%. The supply chain model was able to model disassembly, manufacturing, shipping, and delivery of bicycles in a manner very similar to Y-12's business processes.

The IRPM can be used in unconstrained and constrained modes meaning that resources and/or inventories can be limited or unlimited alone or in combination with one another. Typical simulation results show inventories of products, parts, etc. versus time at different locations such as the supplier, the bicycle shop, and the customer. Order and shipment times and performance are tracked. Figure 6 is a screen capture of several of the data tables from a typical simulation. In the case of figure 6, 10 bicycles are ordered per day at the customer and 1 broken bicycle is received per day at the bicycle shop for disassembly. Due to the time required to disassemble bikes, make new parts, and assemble a bicycle, only 294 bicycles were produced in 500 days (see the "Current Amount" field in the "Inventories" table in the upper right corner of figure 6). There were 10 "Labor 1" and 10 "Labor 2" persons available (see the "Initial Amount" field in the "Labor Pools" table in the lower right corner of figure 6). Note that the "Assemble Wheel" operation in the "Labor Requirements" table of figure 6 (see the lower left corner) shows that 1 "Labor 1" and 1 "Labor 2" are required to assemble a wheel.

Figure 7 shows the same simulation with only 1 "Labor 1" and 1 "Labor 2" person available (see the "Initial Amount" field in the "Labor Pools" table in the lower right corner of figure 7). In this more constrained simulation, fewer bicycles were produced. Even though 10 bicycles were ordered per day at the customer and 1 broken bicycle was received per day at the bicycle shop for disassembly, only 261 bicycles were produced in 500 days (see the "Current Amount" field in the "Inventories" table in the upper right corner of figure 7). These results indicate how the IRPM is used to evaluate schedules, estimate labor requirements, and gauge production needs.

The IRPM has been applied at Y-12 to specific production programs. Not only has it been tested in evaluation of schedule performance, it has also been used to look at cost performance and production alternatives. Currently, Y-12's dismantlement program is a primary customer. One important aspect of a dismantlement model is storage. The IRPM can model storage in several ways including as a resource and as a part. To model storage as a part, storage requirements will appear in the BOM as an additional "part".

This approach to modeling storage has been utilized and the predicted production can be constrained by inadequate storage. Note also that storage requirements do not have to be integer values. Fractional storage spaces can be consumed as well. This easily accommodates situations where various sized containers are placed in standardized storage bins or where different sized bins can be modeled based on store room design and layout.

Finally, the IRPM is a very fast running simulation model. A typical bicycle model as shown here executes in seconds. Larger runs with several programs, having hundreds of parts, having hundreds of operations, and spanning many years (even decades) require 5 to 15 minutes depending on the simulation time period. This is very reasonable compared to large, item-intensive discrete-event simulations.

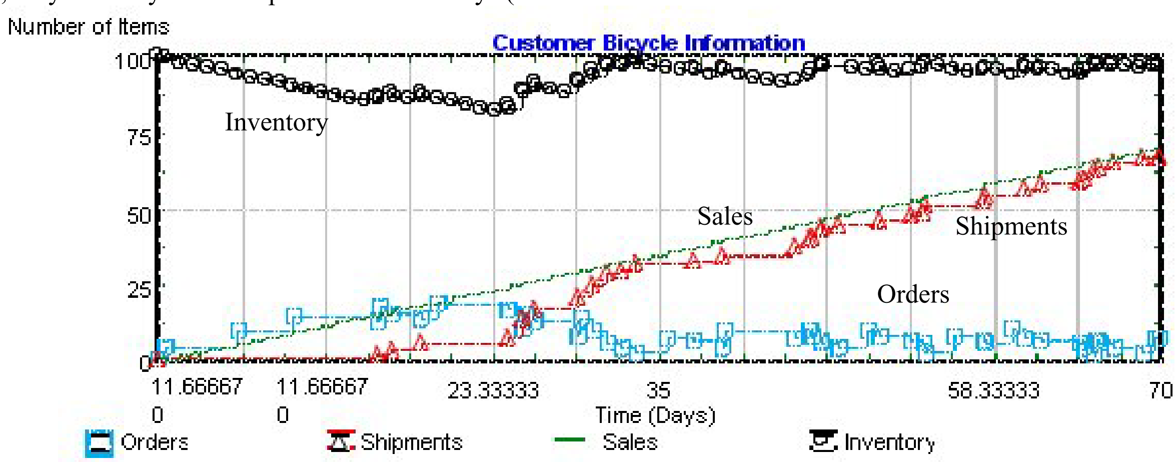

Figure 4. Orders, shipments, sales, and inventory at the customer location in the bicycle shop model.

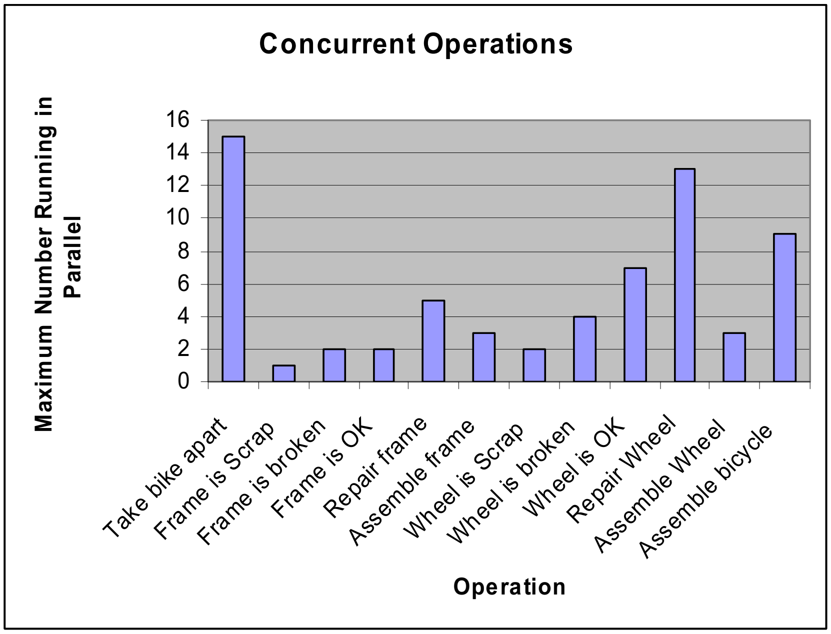

Figure 5. Maximum number of concurrent operations in the bicycle shop model.

Labor Utilization Report

string	real	real	real	real
Category	Productive Hours	Total Hours Utilized	Utillization	Total Hours Shift 1
TOTAL	119,667	3,580	3.6%	3,580
Labor 1	29,917	1,790	7.2%	1,790
Labor 2	29,917	1,790	7.2%	1,790
Security Guard	29,917	0	0.0%	0
Safety Inspector	29,917	0	0.0%	0

Inventories

string	string	real	real	real
Location	*Material*	Initial Amount	Current Amount	Amount In
Customer	Bicycle	0.0	294.0	294.00
Bicycle Shop	Bicycle	0.0	0.0	294.00
Bicycle Shop	OK frame	0.0	0.0	333.00
Bicycle Shop	Broken frame	0.0	0.0	91.00
Bicycle Shop	Frame part A	10,000.0	9,872.0	0.00
Bicycle Shop	Frame part B	10,000.0	9,872.0	0.00
Bicycle Shop	Scrap frame	0.0	100.0	100.00
Bicycle Shop	Untested frame	0.0	0.0	381.00
Bicycle Shop	OK wheel	0.0	7.0	673.00
Bicycle Shop	Broken wheel	0.0	0.0	292.00
Bicycle Shop	Spoke	1,800,000.0	1,786,560.0	0.00

Labor Requirements

string	string	real
Operation	*Labor*	Quantity
Take bike apart	Labor 1	0
Frame is Scrap	Labor 1	0
Frame is broken	Labor 1	0
Frame is OK	Labor 1	0
Repair frame	Labor 1	0
Assemble frame	Labor 1	0
Wheel is Scrap	Labor 1	0
Wheel is broken	Labor 1	0
Wheel is OK	Labor 1	0
Repair Wheel	Labor 1	0
Assemble Wheel	Labor 1	1
Assemble Wheel	Labor 2	1
Assemble bicycle	Labor 1	0
Frame Repair Shop -	Security Gu	0
Frame Repair Shop -	Safety Inspe	0

Labor Pools

string	string	real
Location	*Labor*	Initial Amount
Bicycle Shop	Labor 1	10
Bicycle Shop	Labor 2	10
Bicycle Shop	Security Guard	10
Bicycle Shop	Safety Inspector	10

Figure 6. Production throughput and utilization of bicycle assembly persons (Labor 1 and Labor 2) with no constraint (i.e.; 10 available) on the number of available labor resources.

Labor Utilization Report

Category	Productive Hours	Total Hours Utilized	Utillization	Total Hours Shift 1
string	real	real	real	real
TOTAL	65,817	3,040	4.6%	3,040
Labor 1	2,992	1,520	50.8%	1,520
Labor 2	2,992	1,520	50.8%	1,520
Security Guard	29,917	0	0.0%	0
Safety Inspector	29,917	0	0.0%	0

Inventories

Location	Material	Initial Amount	Current Amount	Amount In
string	string	real	real	real
Customer	Bicycle	0.0	261.0	261.00
Bicycle Shop	Bicycle	0.0	0.0	294.00
Bicycle Shop	OK frame	0.0	0.0	333.00
Bicycle Shop	Broken frame	0.0	0.0	91.00
Bicycle Shop	Frame part A	10,000.0	9,872.0	0.00
Bicycle Shop	Frame part B	10,000.0	9,872.0	0.00
Bicycle Shop	Scrap frame	0.0	100.0	100.00
Bicycle Shop	Untested frame	0.0	0.0	381.00
Bicycle Shop	OK wheel	0.0	7.0	673.00
Bicycle Shop	Broken wheel	0.0	0.0	292.00
Bicycle Shop	Spoke	1,800,000.0	1,786,560.0	0.00

Labor Requirements

Operation	Labor	Quantity
string	string	real
Take bike apart	Labor 1	0
Frame is Scrap	Labor 1	0
Frame is broken	Labor 1	0
Frame is OK	Labor 1	0
Repair frame	Labor 1	0
Assemble frame	Labor 1	0
Wheel is Scrap	Labor 1	0
Wheel is broken	Labor 1	0
Wheel is OK	Labor 1	0
Repair Wheel	Labor 1	0
Assemble Wheel	Labor 1	1
Assemble Wheel	Labor 2	1
Assemble bicycle	Labor 1	0
Frame Repair Shop -	Security Gua	0
Frame Repair Shop -	Safety Inspe	0

Labor Pools

Location	Labor	Initial Amount
string	string	real
Bicycle Shop	Labor 1	1
Bicycle Shop	Labor 2	1
Bicycle Shop	Security Guard	10
Bicycle Shop	Safety Inspector	10

Figure 7. Production throughput and utilization of bicycle assembly persons (Labor 1 and Labor 2) with a constraint (i.e.; 1 available) on the number of available labor resources.

4 CONCLUSIONS

The supply chain paradigm and Simulation Dynamic's Supply Chain Builder™ software work as a model for Y-12's business environment. Simulation has proven to be an indispensable tool at Y-12 and Y-12's supply chain model is named the Integrated Resource Planning Model (IRPM). The IRPM has been applied at Y-12 to specific production programs. Not only has it been tested in evaluation of schedule performance, it has also been used to look at cost performance and production alternatives. The supply chain perspective provides a different business picture. It also enables a long-term look at business issues because it is a fast running model (orders of magnitude faster than typical discrete-event simulation model). In addition, because the vast majority of the model set-up is done in the database (~99%) the model is easily reconfigurable, it is very maintainable (it has been connected to existing corporate databases), it is user-friendly (we have developed a graphical user interface between the supply chain model and Microsoft Access™), and its results are easy to interpret. In the future, Y-12's modeling group will apply the IRPM to all of Y-12's programs. The IRPM will also be used to help Y-12 develop plans for the modernization of its factory infrastructure.

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