Demand Activated Manufacturing Architecture

An Evaluation Framework for Supply Chain Analysis Methods and Tools

DAMA-I-1-97
LA-UR-97-246
January 1997
Version 1.0

Issued by Los Alamos National Laboratory, operated for the United States Department of Energy by The University of California.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof or any of their contractors.

Demand Activated Manufacturing Architecture

An Evaluation Framework for Supply Chain Analysis Methods and Tools
DAMA-I-1-97
LA-UR-97-246

William R. Oakes
Dennis R. Powell
Joseph W. Jackson
Joseph H. Fasel, III
James K. Ostic
Kathryn R. Burris

Technology and Safety Assessment Division
Los Alamos National Laboratory
Los Alamos, NM 87545

January 1997
Version 1.0

This report was prepared by the DAMA Enterprise Modeling and Simulation Task Force. For copies of this document, contact Rob Oakes, Los Alamos National Laboratory, (505) 667-6852.

1 Introduction

The purpose of this document is to elaborate a framework in which to evaluate potential methods and tools for assisting analyses of supply chains. A checklist of *functional elements* required for supply chain analysis is presented, and open literature references that discuss the functional elements are provided. Dynamic simulation is the context surrounding the functional elements in the literature. More specifically, the literature discusses the use of dynamic simulation in evaluating alternative activities, processes, control policies, and supply chain coordination strategies. Our use of the functional elements in supply chain analysis is somewhat broader. We seek a combination of compatible methods to be used collectively to enable supply chain analysis. Furthermore, we seek tools (which might include anything from check lists to computer aided support) for the selected methods. This combination of methods and tools for supply chain analysis will comprise our *supply chain analysis methodology*. We use the functional elements as indicators of the desired domain of discourse within our methodology. We construct an evaluation matrix that facilitates objective scoring of methods and tools considered for use within the supply chain analysis methodology. Finally, we suggest specific scoring techniques for use with the evaluation matrix.

2 The Methodology

A methodology intended to improve analysis of supply chains is being developed based upon the functional elements listed in section 6. Briefly, this methodology is designed to help the analyst "create an (analysis) structure, install proper controls, and implement principles of optimization to synchronize the supply-chain"[3]. Methods of information capture, development, and analysis within the methodology have been assigned to seven methodology categories:

- *Step 1: Describing System Components:*
  The "current" (or *as-is*) supply-chain system is described as a collection of systems and related activities performed by its Members (Sectors), in the delivery of the end-product. A standard system component *template* is utilized for the purpose.

- *Step 2: Investigating Work Design and Methods Improvement:*
  In this step, relationships between methods, time standards, and costs; on the operation of the enterprise are investigated. That is, for activities described in Step 1 above, inter-dependencies between time and cost measurements, and the impact of methods employed are analyzed.

- *Step 3: System Flow Charting:*
  In this step, the enterprise structure is aggregated or dis-aggregated at various levels of decomposition. The selection of levels is discretionary and is problem specific. Decomposition enables representing the enterprise at various levels of detail. In this manner, it is easy to break-down a complex problem into manageable problem-solving pieces.

- *Step 4: Implementing Waste Elimination Through Methods Engineering:*
  System analysis in this step seeks to identify ways to eliminate any process that does not add value to the product. Methods improvement approaches applied in this step seek to eliminate, combine and rearrange, and simplify activities.

- *Step 5: Implementing Activity-Based Costing:*
  This system analysis step seeks to trace costs to a particular product or customer that triggers various activities in the supply chain. The design of an activity-based costing model enables, (a) identifying cost hierarchies, (b) creating the cost database, and (c) costing the product.

- *Step 6: Performing PERT Network Analysis:*

A network graphic representation of interdependent activities in the supply-chain system is developed. The approach is to concentrate on the *critical operation path* for each of the constituent Members of the product pipeline, thus removing bottleneck activities.

- *Step 7: System Performance Simulation:*
  The normalized network obtained in Step 6 is simulated based on the pre-defined *performance criteria* for the system. These criteria were identified in Step 1, both at the Member and the Group levels of the pipeline. The simulation is iterated until a satisfactory solution to the problem is obtained. The characteristics of the solution set are then incorporated in the system, to deliver a "to be" system.

There are a great number of analysis activities required among the seven categories. Possibly, there are other methodologies that identify the same activities and, yet, categorize them differently. It is certainly true that there are analysis "experts" in supply chain analysis or related analysis domains who successfully apply an extensive collection of analysis activities on a daily basis. One goal of the developing methodology is to understand and convey the analytical expertise to individuals who are less accomplished as analysts. The seven-category system is simply a mechanism to facilitate understanding and dissemination of analytical expertise.

3 Purpose of the Checklist

The checklist presented here is for use in evaluating the applicability of a candidate method or tool for any or all of the above seven categories of supply chain analysis. In other words, each time the checklist is used to evaluate a method (or tool), it quantifies the method's ability to support the activities in one of the seven categories. This structure allows the checklist to be very general but it also requires the evaluator to be familiar with the categories of supply chain analysis. For example, one checklist functional element is "transformation of materials from inputs (raw materials) to outputs (finished goods or partially manufactured goods.)" The applicability and meaning of this functional element relative to "Describe System Components" are distinct from the applicability and meaning relative to "System Performance Simulation." There is no restriction on the number of methodology categories for which a particular method or tool may be evaluated. For each evaluation, we recommend that the "Priority" field of the matrix reflect the evaluator's priorities.

There is a second possible use for this evaluation matrix. Each supply chain analysis may be unique in its area of investigation, its intended fidelity, or in other aspects. The evaluation matrix may be useful in helping an analyst to prioritize analysis activities relative to supply chain functional elements commonly discussed in the open literature.

Methods and tools (computer-based or otherwise) to facilitate analysis in each of the seven methodology categories will be sought. The objective is to identify a suite of methods and tools that improve supply chain analysis within and between the categories of the seven-category methodology. Furthermore, the methods and tools sought are those that can and will be applied to the most demanding supply chain analyses. Tools that support demanding analyses requirements are assumed to be suitable for less demanding analyses. This search-and-identify activity will be conducted by (thus, the evaluation matrix will be used by) experienced supply chain analysts who are knowledgeable about the seven-category supply chain analysis methodology being developed.

4 Using the Checklist

The rows of the checklist are partitioned into multiple *topical categories*. Within each category, a set of related functional elements is listed. The checklist contains five columns of evaluation data that relate to the functional elements. The column headings are Implementation Quality, Priority, Estimated Implementation Time, Reference, and Score. We present specific suggestions about how to rate and score functional elements. However, other users may chose alternate scoring criteria.

The "Priority" field for each functional element is assigned a value (between 1 and 100) based upon two factors: the category for which the method or tool in question is being evaluated and upon the decision-making environment (e.g. the analysis fidelity intended or the analysis goal).

The "Implementation Quality" field is assigned one of five values depending on how well the functional element is implemented or expressed in the tool being evaluated. The five values are N (not implemented), P (poor), F (fair), G (good), or DK (don't know.)

The "Estimated Implementation Time" field is the most difficult field to supply. The metric to be supplied in this column is the implementation time, in full-time-equivalent employee-months, required to bring the associated functional element up to "good" quality. It may well be just as useful to estimate implementation time for each topical category, rather than attempt to estimate for each functional element.

5 Scoring

Here we suggest one scoring technique. However, other techniques may be designed and used depending on circumstances surrounding the evaluation.

For each row, *Score = V(Quality)*, where "V" is a function assigning a numeric value given one of the five possible alphameric value for "Quality." Compute the *Score* for each topical category as the Priority-weighted average of all Scores within the category. A total Score comprising a weighted average of the category Scores can be used to compare competing methods or tools. One possible category waiting is suggested as part of the topical category headers.

6 The Next Step

It would now be appropriate to apply the requirements listed in the framework developed here to evaluate a short list of methods and tools. We suggest evaluating IDEF0, IDEF3, ProSim, ITEMS/NJPSim, SCIP, ARM, and the proposed SCCAM (Supply Chain Coordination Architecture Model).

When the evaluation framework is applied to specific evaluation tasks, we will adapt it for the evaluators' convenience. We will remove columns from the matrix that do not require evaluator input. Also, we will adopt a select-one-of-five check box presentation for the Function Quality column.

7 The Checklist

	Name the Method or Tool Being Evaluated:					
	Circle which category to evaluate for: 1. Describe System Components 2. Work Design/Methods Improvement 3. System Flowcharting	4. Waste Elimination via Methods Engineer 5. Activity-Based Costing 6. PERT Network Analysis 7. System Performance Simulation				
	Functions/Capabilities	**In (N,P,F, Qua**	**(scal Pri**	**Impl (FTE mor E Time:**	**Reference**	**Sc**
A.	**Material transformation -- 15%**					
A.1	**transformation of materials from inputs (raw materials) to outputs (finished goods or partially manufactured goods)**				1,3	8.3333
	company (a collection of processes) level	A				25
	process (a collection of activities) level					0
	activity (a fundamental operation) level					0
A.2	**material stockpiles and inventories**				4	
A.3	**characterization of transformation processes**				1,3	0
	sequence of value-added and non-value adde activities				3	
	conversion factors, i.e., X1, X2, ..., Xn input yie Y output				9	
	chemical combinations and reactions				9	
	waste production					
	standards in methods, times, and resources				3	
	time to perform (probability characterization)				4	
	batch requirements, capacity limitations				1,2	
	resource dependencies: resources required & resource conflicts				1,2,9	
	failure rates, modes, & consequences				8,9	
	capacity limits				1,2	
	stochastic effects				4	
	exception processing (i.e., expediting an order)				4	
A.4	**multiple constraints affect transformations**				1,2	
	capacity					
	limits due to measures of materials, e.g., criticality, safety, toxicity...				9	
	operating schedules				9	
	unforeseen schedule interruptions				9	
	customer and product priority					
	scheduled maintenance					
	utilization				3	
	efficiency				1,4	
	cost/required resources				2,3,4,5,9	
A.5	**multiple material paths**				1,3	
	rework cycles					
	material recycling					
	waste streams					

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
B.	**Material transport -- 15%**					
B.1	**material flow internal to a factory (intra-company flow)**				1,3	
B.2	**material flow among companies (inter-company flow)**				1,3	
B.3	**dynamic routing**				1,2	
B.4	**explicit routing**					
B.5	**transport times (stochastic)**				1,4	
B.6	**resource acquisition & movement**				3,9	
B.6	**failure modes & consequences**				8,9	

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
C.	**Information flow -- 15%**					
C.1	**information flow between pipeline companies (inter-company flow)**				1,2, 3,4	
C.2	**information flow within a company (intra-company flow)**				1,2, 3,4	
C.3	**propagate changes in demand estimates**				2	
C.4	**propagate supply information (order completion times, quantities,...)**				1	
C.5	**process time in information movement**				4	
C.6	**process time in information processing**				4	
C.7	**failure rates, modes, & consequences**				8	
C.8	**process time to make decisions**				2,3	
C.9	**inter-company content: forecasts, orders, point-of-sale data, capacity, supply-info,...**				2,4,5	
C.10	**intra-company content: forecasts, orders, schedules, bill-of-materials, order status,...**				2,4,5	
C.11	**cost accounting at activity, process, business, and company levels**				2,3, 4,5	
	activity based costing					
	arbitrary costing models					
C.12	**computation of process (and activity) metrics and decision factors**				1,2, 3,4	
	utilization				3	
	customer-oriented metrics such as fill-rate, order accuracy, on-time deliveries, and delivery latency				1,4	
	efficiency				1,4	
	cycle time				1,4	
	backorder level (sku/customer)				4	
	lost sales				4	
	service levels (sku/style/product/customer)				1,4	
	revenues, costs, profits, roi, gmroi,...				6	
	track composition for material flows				9	
	track adjunct material utilization, i.e., water				9	
	track resource utilization and conflicts				9	

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
D.	**Cognitive Capabilities -- 30%**					
D.1	**planning**				1,2	
	supply chain level planning					
	company planning					
	distribution (transport) planning					
D.2	**scheduling**				1,2	
	intra-company manufacturing operations (activ level)					
	customer order completion					
	maintenance operations					
	customer priority scheduling					
	product priority scheduling					
	manufacturing efficiency scheduling, minimiza of work in process, etc.					
	satisfy multiple constraints (time, cost, batch requirements)					
D.3	**coordination and control**				3,4	
	negotiation between company members for coordination in supply chain (may be rule based)					
	compromise with a member company to foster supply chain goal (may be rule based)					
	represent behavioral rules (allocation, compromise, negotiation, coordination, synchronization)				3	
	supplier selection criteria/rules					
	represent goals, objectives, policies				3	
	logical congruence between goals, objectives, and policies				3	
D.4	**marketing (price, promotion)**					
D.5	**forecasting (demand estimation)**				2,5	
	trend effects (long-term directional movement)					
	seasonal effects					
	cyclical factors (long-term swings)					
	judgment techniques (qualitative based on marketing surveys and expert opinion)					
	time series (quantitative, sales-history based)					
	associative (quantitative, econometrics based)					
	estimate effect of marketing					
	dynamic response to changes in orders, status, availability					
	aggregation of shared forecasts					
D.6	**optimization of selected processes or activities**				3	
	supply chain level coordination					
	company-level processes					
D.7	**inventory control**				4,5	
	material acquisition (policy based)					
	replenishment schedules					
	safety stock					
	predict target inventory levels					
	maintain target inventory levels					

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
E.	**General -- 10%**					
E.1	represent multiple supply chains					
E.2	represent an arbitrary number of companies in a supply chain					
E.3	represent an arbitrary number of business functions in a company					
E.4	represent an arbitrary number of processes i a company					
E.5	represent an arbitrary number of activities in a process					
E.6	represent an arbitrary number of suppliers and customers for a company					
E.7	represent an arbitrary number of skus, styles and products					

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don’t know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
F.	**Non Manufacturing -- 10%**					
F.1	represent consumer behavior				6	
F.2	effect of marketing on demand				6	
F.3	product life cycle activities, e.g., design, prototyping, etc.				3,6	
F.4	price elasticity				6	
F.5	promotions and markdown schedules				6	
F.6	sku mix (color, size)				6	

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

	Functions/Capabilities	Quality:	Priority:	Imp. Time:	Ref:	Score
G.	**Software Factors -- 5%**					
G.1	**usability**				7	
	well organized and facile input					
	"natural" graphic interface					
	available on acceptable platforms					
	well designed user documentation					
	integrated on-line documentation/help					
	correctness/validity					
	interface with other computing tools					
	interoperable with desktop tools					
	output sensitivity and uncertainty analysis					
	output charts and graphics					
G.2	**performance**				7	
	acceptable run time					
	efficient use of compute resources					
G.3	**change management**				7	
	extensibility - is it easily extended					
	flexibility - is easy to change					
	portability					
	maintainability - how easy/expensive is it to maintain					

Function Quality: N (not implemented), P (poor), F (fair), G (good), DK (don't know)

8 Glossary

activity - an elemental step in a process

bill-of-materials - a data structure that defines the required materials for a manufactured item and specifies the required quantities of each material

extensible - if a system being evaluated can be extended to accommodate a feature or capability, the system is extensible with respect to the feature

forecast - a data structure that represents the expected demand for a set of skus as a function of time, typically a finite time interval

forecasting - a dynamic process that generates a forecast

integratible - a functional element is "integratible" into the system being evaluated if there is a known package that supports the element, and the package can be integrated into the system

objective - a data structure representing a quantitative measure of achievement according to one or more measures of effectiveness

plan - a data structure that represents a sequence of actions intended to achieve a specified set of goals or objectives

planning - a dynamic process that generates a plan

policy - data structure representing an officially sanctioned method of achieving an end result

process - a sequence of activities required to produce an intended change in materials or information

product - an equivalence class of items, such that any members of the class are functionally interchangeable

rule - a data structure representing a potential action and the conditions which invoke it

schedule - a data structure that defines a sequence of actions that achieves a specific goal and observes the limitations imposed by a set of constraints

scheduling - a dynamic process that creates a schedule

sku - a stock keeping unit, i.e., a specific realization of a given style (e.g., size 12 lime-green bellbottom polyester slacks)

sku-mix - a specification of the mixture of skus by size and color for a given style, e.g., if a style is available in two sizes (S, L) and two colors (B, W) then the sku mix might be

Size \ Color	Black	White
Small	0.15	0.25
Large	0.12	0.48

style - a collection of manufactured items that are identical in design except for size and color

9 References

[1] Layden, John E., "Supply Chain Management Creates New Roles for IEs," IIE Solutions, July 1996, pp 36-39.

[2] Sengupta, Sumantra, and Turnbull, John, "Seamless Optimization," IIE Solutions, October 1996, pp 28-33.

[3] Chandra, Charu, "Enterprise Architectural Framework for Supply-Chain Integration," Los Alamos National Laboratory report LA-UR-97-245, January, 1997.

[4] Lee, H.L., and Billington, C., "Managing Supply Chain Inventory: Pitfalls and Opportunities," Sloan Management Review, spring 1992, pp 65-73.

[5] Hotchkiss, D'anne, "Foodservice Needs to Diet," Consumer Goods Manufacturer, Vol. 5, No. 4, July/August, 1996.

[6] Steve Freudenthal, Presentation at EM&S Quarterly Meeting (Pipeline Analysis Training), November 21, 1996.

[7] Jensen, Randall W. (Ed), "Software Quality Engineering A Total Technical and Management Approach", Prentice Hall, Inc., Englewood Cliffs, NJ, 1988.

[8] Mayer, Richard J., et al., "A Framework and a Suite of Methods for Business Process Reengineering", from Grover, Varun and Kettinger, William J. "Business Process Change: Concepts, Methods and Technologies", Idea Group Publishing, Harrisburg, USA, London, UK, 1995.

[9] Discussions with J. Jackson, N. DeMuth, and S. Boerigter on requirements for processing nuclear materials for the DOE Nuclear Weapons Complex, 1994-1997.