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A STRUCTURED DEFINITION OF THE MODELING PROCESS

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ABSTRACT

This research uses the IDEF0 methodology to develop a structured functional model of the modeling process. It ties together multiple views of this process from current literature and field experience from successful modeling projects. The motivation for this project is to describe the process for discrete event simulation models, but the process can be used for other modeling techniques. The basis for this work was a panel discussion at the 1991 Winter Simulation Conference. (Pritsker, 91). This formal representation of the modeling process offers opportunities for further research to refine the art of problem resolution using models.

1 INTRODUCTION

This paper provides a structured representation of the modeling process. The idea for this work stemmed from a figure describing how a model is used to solve a problem (Pritsker, 91) in a format similar to IDEF0 process modeling (ICAM, 81). The figure described inputs, constraints, resources, and outputs for the modeling process. This global definition of the modeling problem-solving process at the highest level prompted a search for a structured representation of the modeling process. The authors each had process definitions they used in day-to-day modeling work, but these had been developed ad hoc and did not provide a structured definition. Such a definition could be used as a benchmark for other researchers as well as a base for teaching the modeling process.

A search of the pertinent literature revealed only one reference to a functional model of the modeling process using the IDEF0 methodology (Wichmann, 90). Wichmann developed an IDEF0 model to explain his methodology for a simulation-based scheduler. Wichmann did not expand his functional model for neither the general case nor the detailed case, as this was not the focus of his paper.

This paper decomposes a top-level modeling process description into more detailed descriptions. It incorporates recommendations from prior model process descriptions. The process model as described here is being used for commercial applications (Withers, 92).

2 BACKGROUND

The modeling process for simulation is well documented. Most simulation texts devote a section or chapter to the process that surrounds the programming of the model. These brief overviews of the modeling process do not provide the reader with an adequate focus for the other activities in the problem-solving process. Typically only 30 - 40% of the total effort in most successful simulations studies is spent doing the actual coding (Law, 91). This is supported by Musselman who suggests one spend more time modeling and experimenting than building the actual model (Musselman, 92). General texts on model building abound; two are notable in the context of this paper, (Rivett, 80) for a practical approach and (Ziegler, 84) for a new object-oriented approach.

In our research, we have developed a model of the modeling process based on the simulation literature. However the model developed has general characteristics suitable for other types of analysis/communication such as optimization, spreadsheet, and visualization.

We have reviewed recent publications that included an outline of the modeling process and summarized the steps they recommend as shown in Table 1. (Musselman,92), (Pritsker, 89), (Law,91), and (Balci,90). Both a first and second level of detail for our recommended modeling process are shown as the first two columns of Table 1.

Musselman probably has the most direct view of what steps should be involved in a modeling/simulation project. Although Musselman did not discuss these steps at length it is a good place for us to start to look at what functions are involved in the modeling process.

Pritsker, Sigal, and Hammesfahr describe their steps in detail and add an experimental control step after validation to Musselman's view of the modeling process. Law adds another validation step after the conceptual model has been built. Balci adds four new steps including a feasibility assessment before the project is started. He adds a system investigation step after problem formulation, and Balci also suggests an investigation of solution techniques before coding begins. In addition, Balci recommends that the model can be redefined so that it can be used again.

At the general level, all of the suggested steps are included in our model. A key step we added is an independent assessment, which the Department of Defense (DoD) feels is an important aspect of modeling. "The DoD has spent over $250 million for quantitative studies since 1980... The General Accounting Office suggests that a formal evaluation procedure be applied to the analysis and the related model may soon become commonplace.", (Fossett, 91).

3 IDEF0 MODELING METHODOLOGY

IDEF0 is a modeling technique used frequently in Computer Integrated Manufacturing systems analysis to get a good understanding of the system before process re-engineering begins. We feel that it is a good way to represent the modeling process itself. IDEF0 is a formal method to define a subprocess in a manner that further defines higher level processes.

Function Nodes as shown in Figure 1 are the focus of this methodology. A node is an activity or function that transforms inputs to outputs under constraints using mechanisms. For additional information on IDEF0 modeling, see (ICAM, 81).

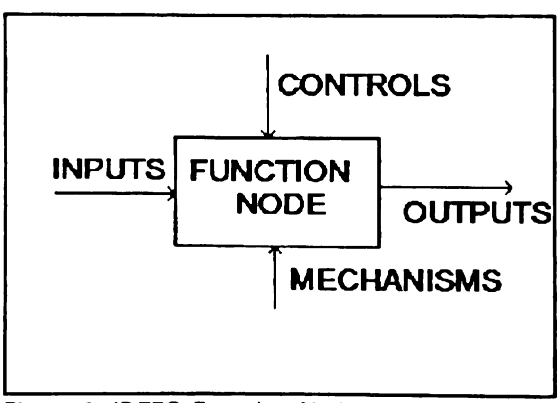

Figure 1: IDEFO Function Node

4 THE MODELING PROCESS DESCRIPTION

The formal representation of the process is presented as IDEF0 diagrams in Figures 2 through 9. The first two levels of decomposition are summarized in Table 1 to align this process definition to prior work. We describe the high-level activities in the next section, and refer the interested reader to a complete report (Withers, 93) for a decomposition to all the individual activities. Withers also includes a descriptive glossary of all activities and information flows. Note in Table 1 that none of the prior process descriptions included all of the required steps. Additionally, a key step has been added as shown in Figure 9, ASSESS USE of MODEL. This step allows a comparison of performance measures from the operational system and the model to improve the system. This step also gives an independent assessment of the usefulness of the model.

4.1 Key Activities in the Modeling Process

A good way to examine the main steps of our structured definition of the modeling process is to look at the Figure 4. The major process steps: UNDERSTAND SYSTEM and CUSTOMER, PRODUCE CONCEPTUAL MODEL, PRODUCE MODEL, USE MODEL, and ASSESS MODEL USE are shown in this figure.

The modeling process begins with the step UNDERSTAND SYSTEM and CUSTOMER. In this step the modeling team, the customer, and management examine the information about the system. The customer requirements and resource constraints are considered and the problem to be solved is defined. The output of this process step is a definition of the system, a contract, and a statement of work.

The system definition is used as an input to PRODUCE CONCEPTUAL MODEL. This step is where the customer and modeling team work together to define model objectives, a conceptual model, and data requirements for the model. A conceptual model is developed to ensure the modeling team has an accurate understanding of the system to be modeled. The output of this process is an approved conceptual model, any changes to the customer contract, and possibly some understanding of the system that would cause the customer make a change in the system.

The approved conceptual model is the main input to PRODUCE MODEL. In addition to the actual model programming, there are a number of other activities in this step. Before programming begins,

Withers, Pritsker, & Withers: 1st Level	Withers, Pritsker, & Withers: Next Level of Detail	Pritsker, Sigal, and Hammesfahr	Balci	Law	Musselman
1. UNDERSTAND SYSTEM and CUSTOMER	1.1 Define Modeling Team		Feasibility Assessment		
	1.2 Define Problem to be Solved	1. Formulate Problem	1. Problem Formulation	1. Formulate Problem and Plan Study	1. Problem Formulation
	1.3 Determine Customer Constraints and Develop Plan				
2. PRODUCE CONCEPTUAL MODEL	2.1 Understand System	2. Specify Model	3. System Investigation		
	2.2 Develop/ Update Conceptual Model		4. Model Formulation 5. Model Representation	2. Collect Data and Define Model	2. Model Conceptualization
	2.3 Develop Data Requirements				
	2.4 Validate Conceptual Model and Data Requirements			3. Validate	
3. PRODUCE MODEL	3.1 Determine Class of Model		2. Investigate Solution Techniques		
	3.2 Develop Model, Data, and Documentation	3.1 Develop Model 3.2 Collect Data 4.1 Run Model	6. Programming	4. Construct Computer Program and Verify	3. Data Collection 4. Model Building 8. Documentation
	3.3 Verify Model to Specifications	4.2 Verify Model		5. Make Pilot Runs	5. Verification
	3.4 Validate Model to Requirements	4.3 Validate Model		6. Validation	6. Validation
	3.5 Release Model				
4. USE MODEL	4.1 Design Experiment	3.3 Define Experimental Controls	7. Design of Experiments	7. Design Experiments	
	4.2 Execute Experiments		8. Experimentation	8. Make Production Runs	
	4.3 Validate Results	5. Use Model		9. Analysze Output Data	7. Analysis
	4.4 Make Decision on System Change	6. Support Decision Making	10. Presentation of Results	10. Document, Present, Implement Results	9. Implementation
5. ASSESS MODEL USE	5.1 Run Operation				
	5.2 Assess Operations Environemnt and Performance				
	5.3 Operate Model				
	5.4 Compare Performance Measures Model: Operations				
	5.5 Assess Documented Use of Model		9. Redefinition		

TABLE 1: Comparison of steps in the modeling process

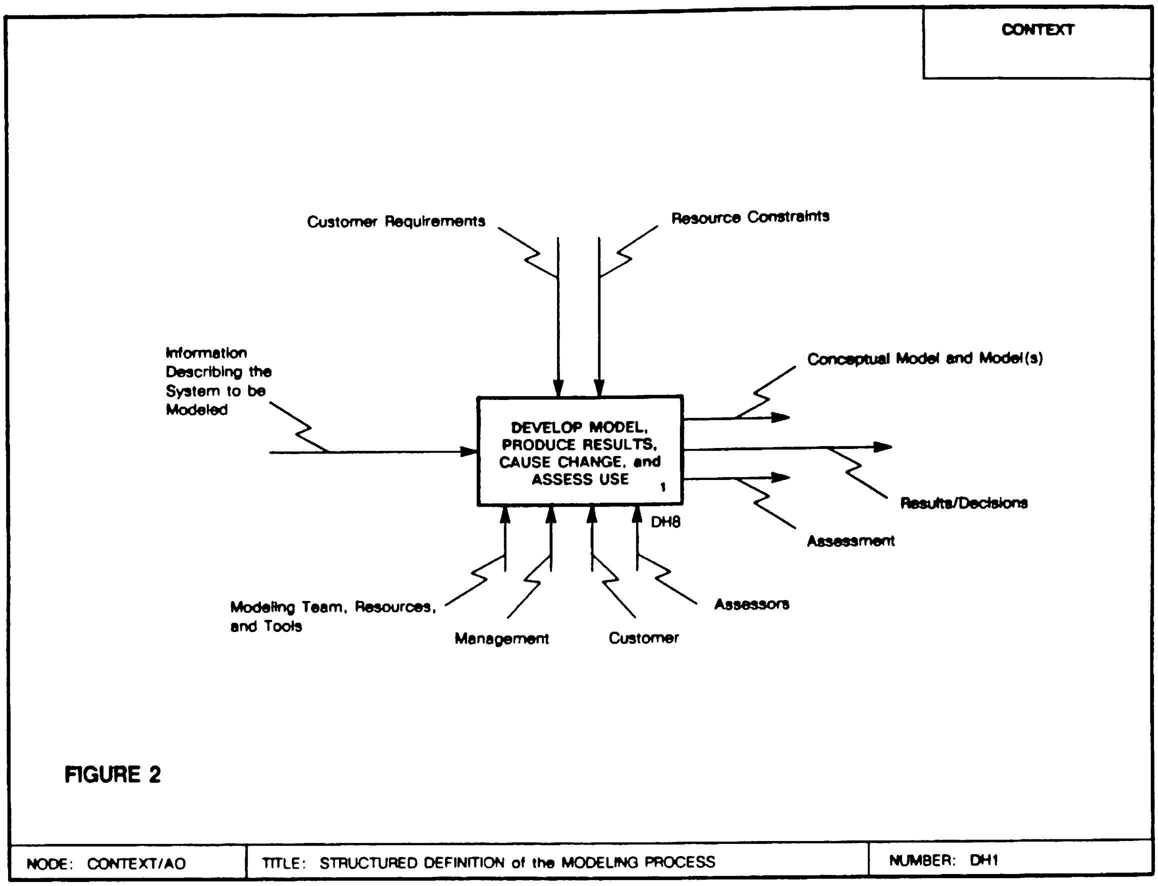

FIGURE 2

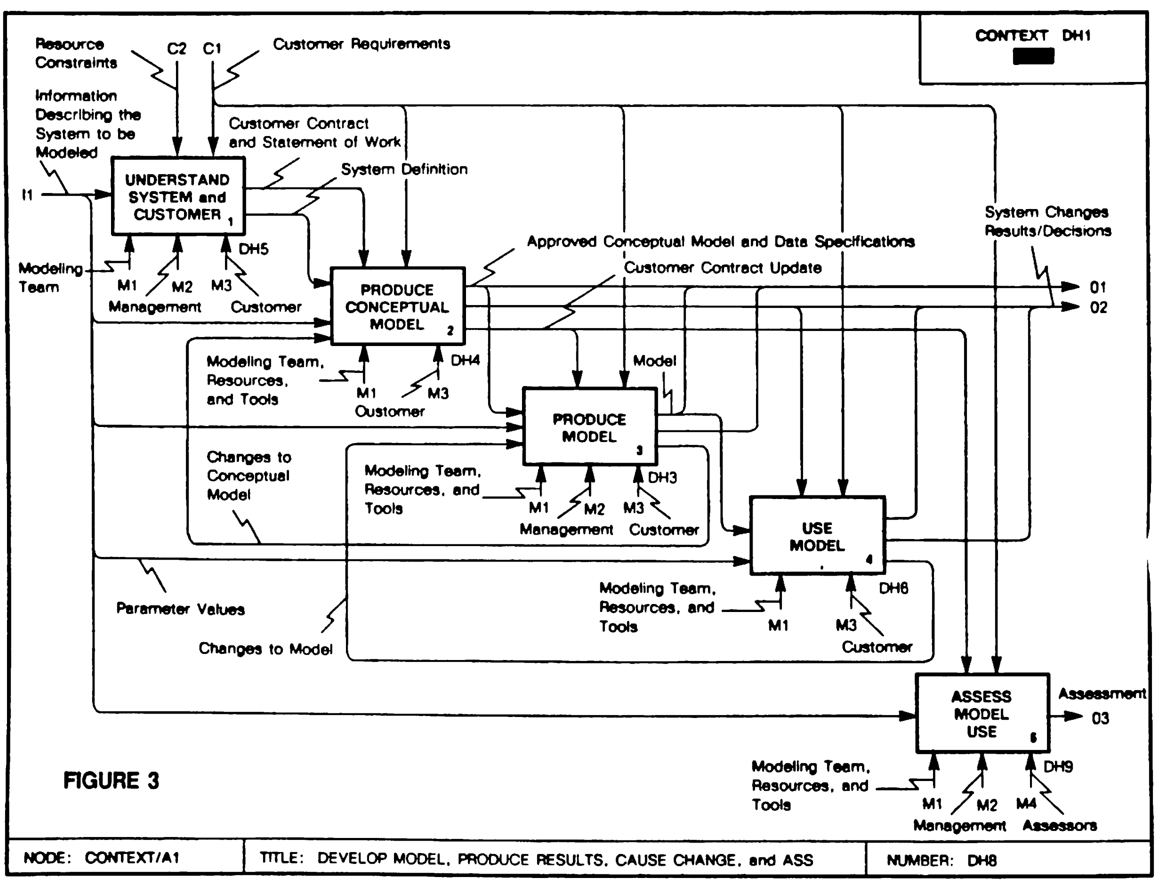

FIGURE 3

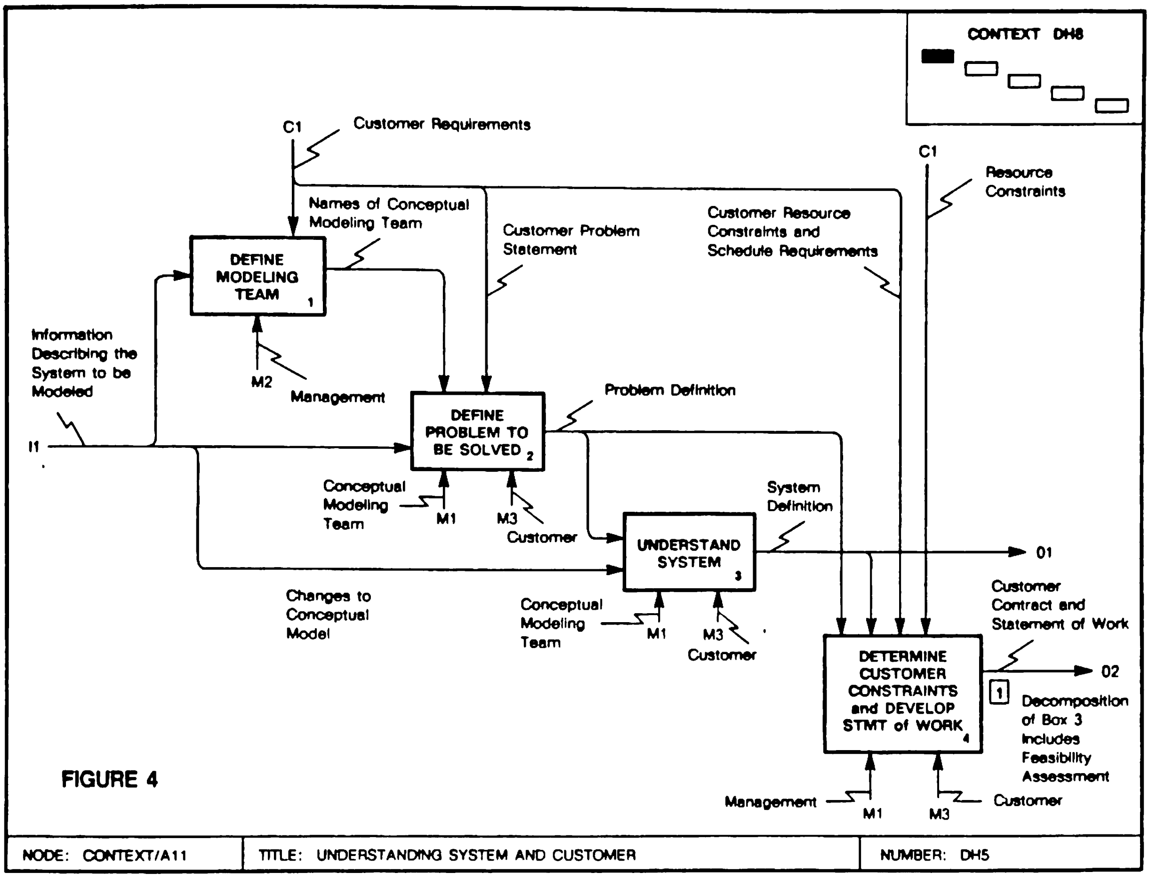

FIGURE 4

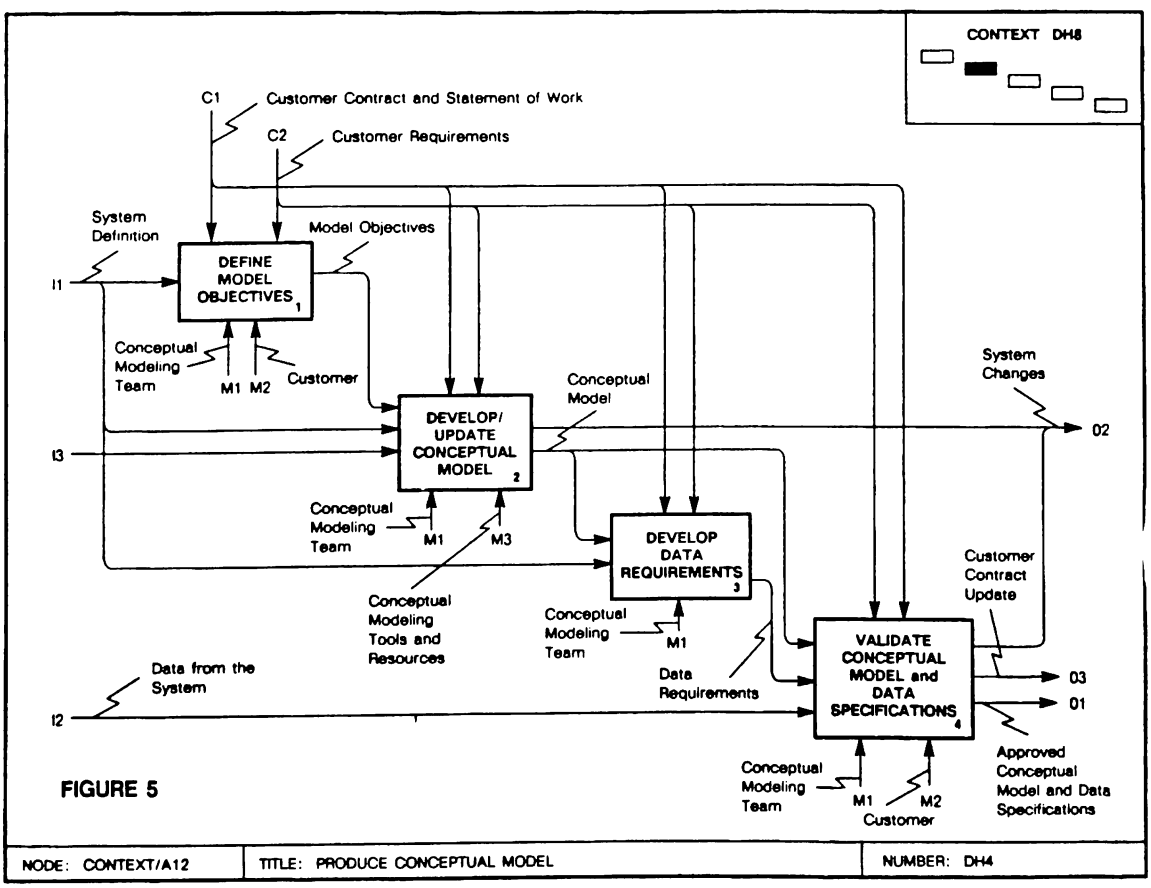

FIGURE 5

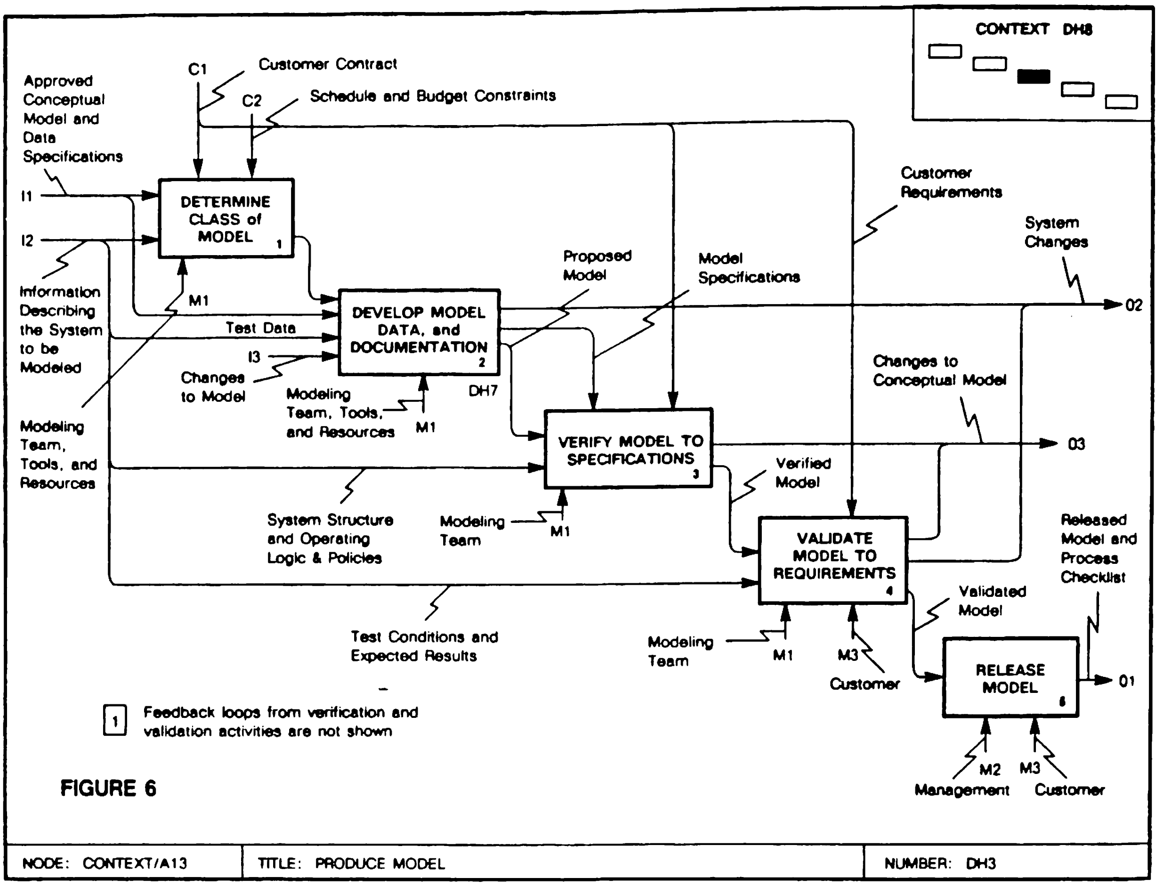

FIGURE 6

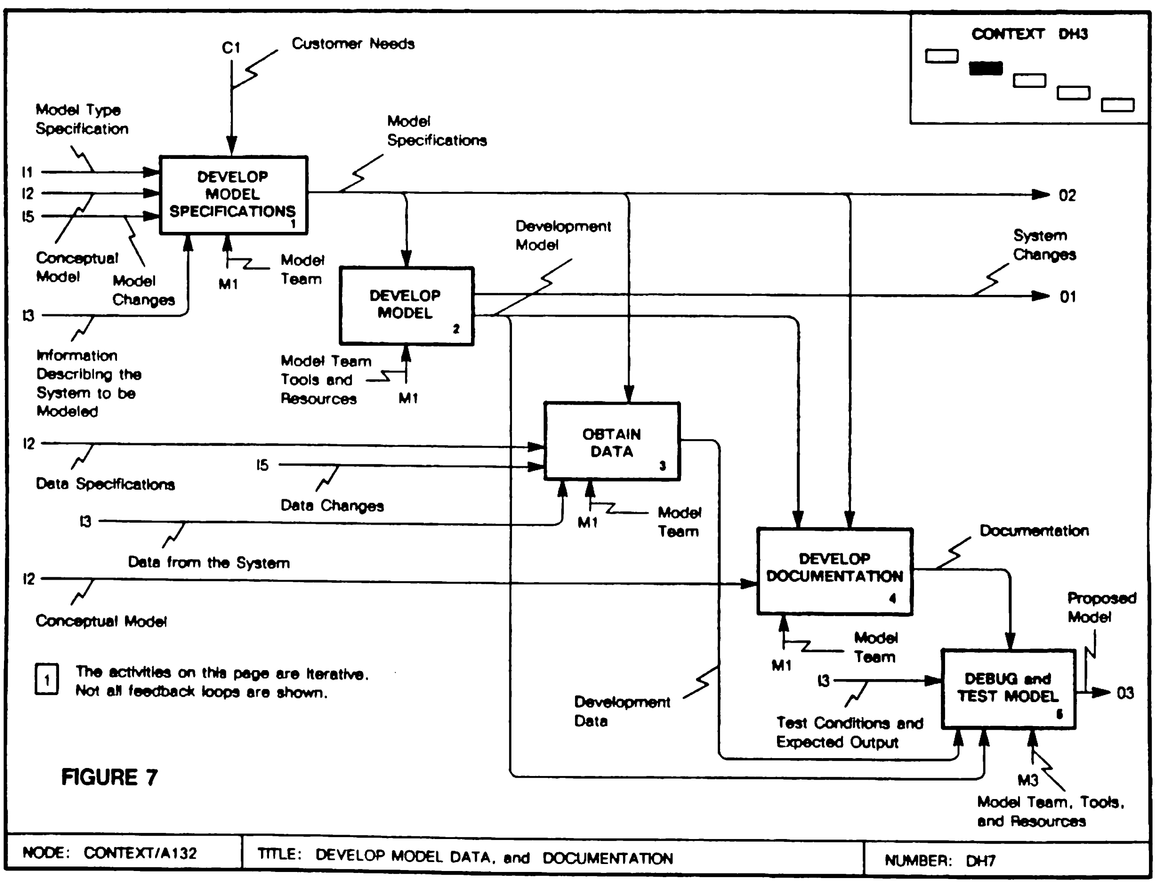

FIGURE 7

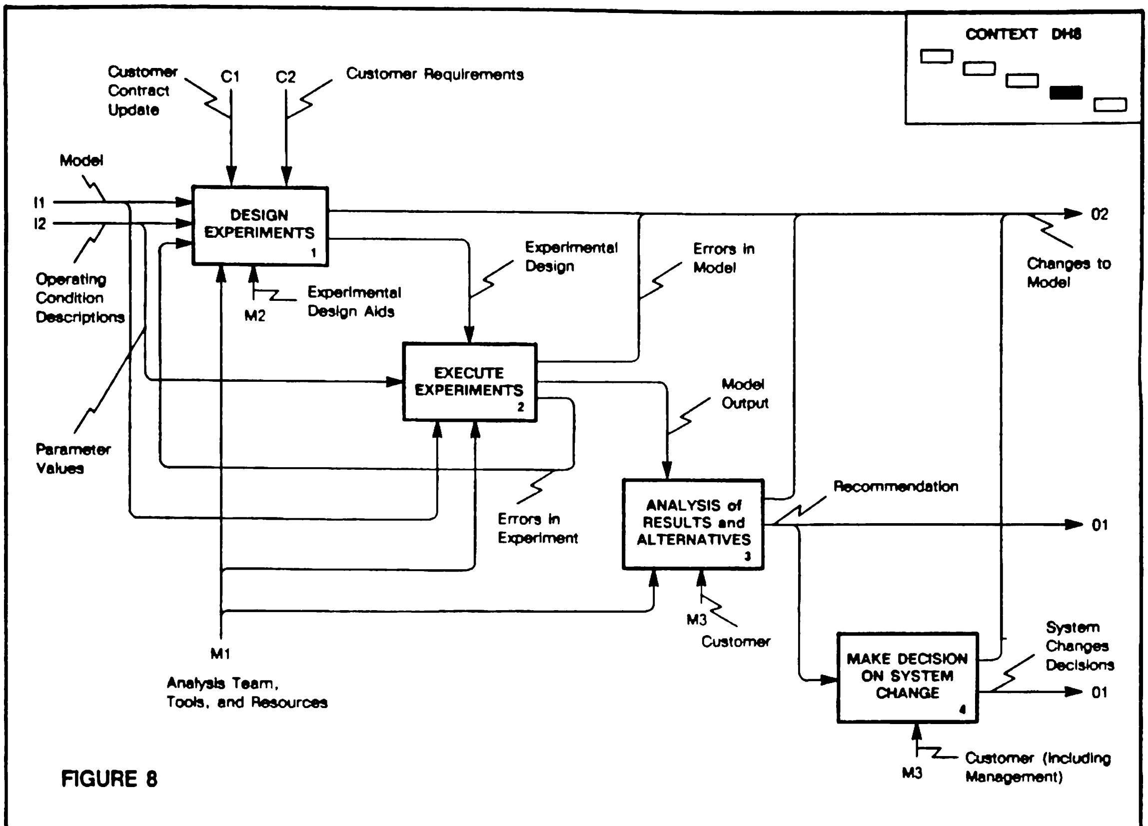

FIGURE 8

NODE: CONTEXT/A14 | TITLE: USE MODEL | NUMBER: DH6

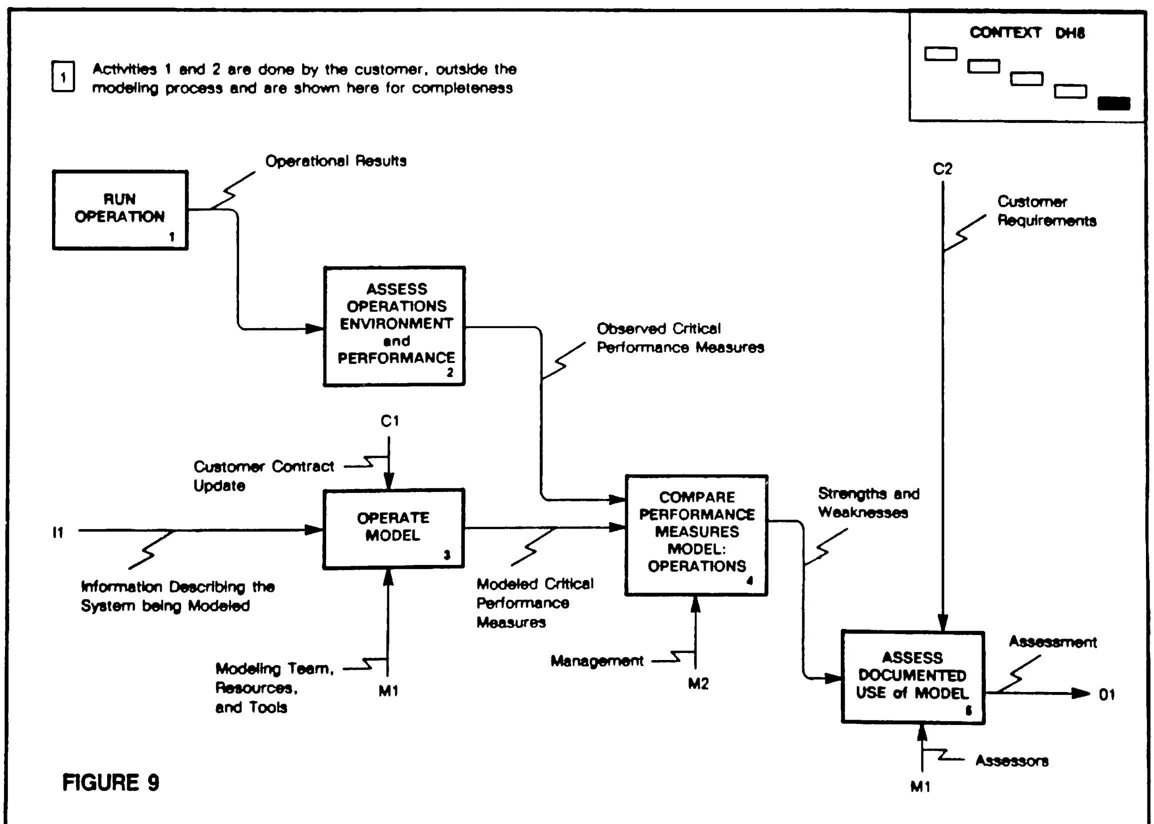

FIGURE 9

NODE: CONTEXT/A15 | TITLE: ASSESS MODEL USE | NUMBER: DH9 the class of model is determined to see if simulation is the right way to address the problem or whether another modeling method would provide a better solution. Once programming and documentation are complete, the model is verified to specifications and validated to requirements, which includes an output analysis. Finally the model is released to be used for system analysis.

The released model is a key input to the USE MODEL process. In this step, experiments are designed and carried out using the model to estimate how the real system would respond to various changes. The result of the experimentation is analyzed and alternatives are developed for how to improve the system. The end result of this step is the decision as to how to alter the system to improve performance.

Once the initial study has been completed, the model can be used to compare predicted to actual operational performance. This comparison is described in the ASSESS MODEL USE activity. An assessment is made on the value, adequacy and utility of the model.

5 VALIDATION OF THE PROCESS DESCRIPTION

The representation given here is based on a summary of noted prior work by practitioners and researchers in simulation modeling. It has been enhanced by practical experiences in problem solving. At this time, validation of the model has been accomplished solely by the authors who represent users (non-academic) of the technology.

6 CONCLUSION

A functional model of the modeling process is presented as a benchmark for use in practice, research, and teaching, and as a base for continuous improvement for those involved in building and using models. The authors solicit comments and will present updated models if warranted. This formal representation of the modeling process offers opportunities for further research to refine the art of problem resolution using models.

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