UNIVERSITY OF ALBERTA

A CONFIGURATION-BASED MODELING METHODOLOGY FOR THE AUTOMATED GENERATION OF SIMULATION MODELS IN CONSTRUCTION

BY

MOHAN RAJ MANAVAZHI ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN CONSTRUCTION ENGINEERING AND MANAGEMENT.**

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **A CONFIGURATION-BASED MODELING METHODOLOGY FOR THE AUTOMATED GENERATION OF SIMULATION MODELS IN CONSTRUCTION** submitted by **MOHAN RAJ MANAVAZHI** in partial fulfillment for the degree of **DOCTOR OF PHILOSOPHY IN** CONSTRUCTION ENGINEERING AND MANAGEMENT.

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ABSTRACT

Although simulation provides a powerful tool for the analysis of construction operations, its use in construction has been mainly restricted to academic research. One of the reasons for this phenomenon is the steep learning curve associated with becoming proficient in the use of simulation in general and simulation modeling in particular.

A number of research efforts have been directed at simplifying the model-building process but very little research has been directed at automating this process in the construction field. Previous research work in the area of the automated generation of simulation models in construction has focused on operations involving movement of material without taking into consideration the constraints imposed by the configuration of the structure to be built.

This research presents a configuration-based simulation modeling (CBSM) methodology, which addresses the issue of complexities imposed by the configuration of the structure while automatically generating the simulation model.

The CBSM methodology consists of a structural decomposition phase and a model generation phase. In the structural decomposition phase, structural decomposition criteria (SDC) are used for the systematic and product-centric decomposition of the structure to a level that facilitates the application of one or more simulation processes. Logical constraints provide links between the elements of the final level of the decomposition.

A proof-of-concept prototype (CONFIGSIM_2), based on the CBSM methodology was developed and tested for earth-filled dam structures. CONFIGSIM_2 was developed using the object-oriented programming paradigm.

The main contributions of this research are (a) the development of a methodology for the automated generation of simulation models of the operations required to construct a structure with a specified configuration; (b) the development of structural decomposition criteria for facilitating the systematic decomposition of the structure to be built; (c) demonstration of the feasibility of combining object orientation with discrete event simulation to automatically generate simulation models; (d) development of the concept of a SIMOBJECT – a modular and reusable representation of simulation and software entities which could be organized into a working program; and (e) development of a system architecture for an object-oriented, model-generation tool for the automated generation of simulation models in construction.

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OBJECTIVES AND SCOPE OF RESEARCH

1.1 BACKGROUND

In an increasingly competitive global economy, construction projects have to be conceived, planned, designed and executed under very restrictive budget and time constraints. Developments in the past two decades in the construction industry point to increasing size and technological complexity of the typical construction project. The successful completion of such a construction project involves an organized and well-planned execution of the operations that make up the project. Thus, it is essential for the modern day construction manager, project engineer or job superintendent to utilize new and improved methods and/or tools in the planning and analysis of construction operations in order to stay abreast of the competition.

Traditionally, the construction practitioner has relied on tools like the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) for planning construction projects and operations. However, construction operations are characterized by dynamic interactions between resources and the processes that utilize them (AbouRizk and Shi 1994, Paulson et. al. 1987). Furthermore, it is difficult to precisely quantify all the factors that affect construction operations with any degree of certainty. The combination of the dynamic nature of construction projects and the uncertainty inherent in quantifying the factors affecting construction processes makes the modeling of construction operations in general, a complex undertaking. Although tools like PERT and CPM are extremely useful tools for project planning and control, they provide a static world-view of the construction operation and limit the scope of the analysis of the operation being studied. It is clear, therefore, that a more powerful tool for the analysis of construction operations is required.

Shannon (1992) states:

> "Simulation is one of the most powerful analysis tools available to those responsible for the design and operation of complex processes or systems. In an increasingly competitive world, simulation has become a very powerful tool for the planning, design and control of complex systems. No longer regarded as the approach of "last resort" it is today viewed as an indispensable problem solving methodology for engineers, designers and managers."

Although it is a fairly well established fact that simulation provides a powerful tool for the modeling and analysis of construction operations (AbouRizk and Shi 1994), its use has thus far been restricted mainly to academic research. The commercial availability of a number of generic, yet powerful computer-based simulation systems has provided the impetus for the introduction of computer-based simulation modeling and analysis in the manufacturing industry. However, in keeping with the prevailing trend with regard to the introduction of any new and relatively sophisticated computer-based technology in the construction industry, there is a marked reluctance to accept and adopt this technology in practice. The principal reason for this phenomenon is that the use of commercially available computer simulation tools like SLAM, GPSS etc. demand a high degree of computer and simulation literacy from the end-users of such systems. Such literacy is scarce in the construction industry. Furthermore, studies (Shi and AbouRizk 1994) have revealed that simulation modeling of construction projects and operations, using these simulation tools, is not cost effective.

To gain acceptance in the construction industry, computer simulation tools must be packaged in a manner that would enable end-users to access their full power and capabilities without having to resort to the often laborious process of developing and testing complex models of the operations that they would like to simulate. Thus, it is clear that one of the primary directions of research in the field of construction simulation should be the development of methodologies that would facilitate the automation of the model generation process.

The relative importance of developing such methodologies can be gleaned from the conclusions arrived at in a simulation workshop of the National Science Foundation (NSF) which identified seven of the eleven future research issues as those related to simplifying simulation and making it an operational tool for the construction site (Ibbs 1987, McCahill and Bernold 1993).

Detailed planning for execution of construction operations involves a formal, organized exercise in ascertaining minute details of the nature, number and utilization of the various resources required to complete the operation. According to Oglesby, Parker and Howell (Oglesby et. al. 1989), construction involves the conversion of ideas depicted on plans and in specifications into a completed structure or plant by assembling, combining, and erecting a number of parts and pieces. For this to be done effectively, safely, on time and with suitable quality, extensive planning off site and on site at individual workfaces is required.

Although network techniques like CPM and PERT are very good tools for project-level planning and control in the construction industry today, they have a number of disadvantages that have been well documented in Pritsker (1989) and Sawhney (1994). From the perspective of this research, the principal shortcoming of network techniques is that they use a static world-view of a construction process. This shortcoming abstracts away a lot of the dynamic process-to-process interactions and resource-to-process interactions that take place in construction operations.

At a very fundamental level, simulation helps model a construction process by directly recognizing the randomness inherent in these processes. More importantly, it facilitates the observance of the dynamics of the system in operation, locates bottlenecks, determines the utilization of resources and estimates the production of the system that is simulated. To achieve this, the construction practitioner must first develop a working simulation model of the operation he or she wishes to analyze. However, building simulation models is both an art and a science and requires specialized training (Shannon 1992). This fact combined with the steep learning curve associated with proficiency in simulation poses a significant obstacle to the widespread use of simulation in the construction industry. The solution to this problem therefore, lies in the development of simulation systems that would free the end user from having to build complex simulation models. Prior research (Shi 1995) in the area of automating the model-building process resulted in the development of a methodology for automatically generating simulation models for simple earth-moving operations *without* configurational constraints. This research, on the other hand, will focus on developing a framework for generating simulation models for more complex projects *with* configurational constraints.

1.2 RESEARCH OBJECTIVES

The *primary objective* of this research is to develop a methodology for automating the process of generating simulation models of the operations involved in the construction of structures with specific configurations.

The *secondary objective* of this research is to demonstrate the feasibility of combining object-oriented technology with discrete event simulation to produce frameworks that would facilitate the development of simulation tools capable of automatically generating simulation models of the construction operations that need to be analyzed.

Although the methodology developed could be applied to other structures in construction, this research will focus primarily on its application to earth-filled dams.

1.3 SCOPE OF RESEARCH

The principal area of focus of this research is the development of a methodology for automating the process of generating simulation models of construction operations aimed at building structures with well-defined configurations using object-oriented technology. To achieve the objectives stated in Section 1.2, the scope of work was delineated as comprising of the following major phases:

1) **Development of a product-oriented decomposition framework**

The framework facilitates the systematic decomposition of the structure that is to be built. Structural decompositions developed using the product-oriented decomposition framework satisfy the following conditions:

a) The product-centric framework for the structural decomposition is of sufficient generality to encompass a range of structural configurations.

b) The final level of the decomposition hierarchy is such that it can be simulated on a computer.

c) The results of the simulation are aggregated up the decomposition hierarchy to arrive at the required results for the entire structure.

2) **Development of a generic system architecture**

The generic system architecture will describe the principal components of the system in terms of their functionalities, the inter-relationship between these components and the integration of the various components to facilitate their functioning as a single system. The typical inputs to the system in the form of high-level descriptions of the project and the outputs produced will also be presented.

A project within the context of this thesis includes the structure that is to be built, the physical environment in which the structure is to be built, the resources available and the resources required for the structure to be built.

3) Development of a proof-of-concept prototype

An object-oriented proof-of-concept prototype simulation software system was developed in the domain of earth-filled dams using MODSIM II® - an object-oriented simulation programming environment - to test the feasibility of the approach suggested in this research. The inputs to the system, the outputs produced by the system and the system verification and validation experiments conducted will be presented.

1.4 THESIS ORGANIZATION

This thesis consists of six chapters. Chapter 2 gives a comprehensive overview of the state-of-the art in simulation and the work done in the field of simulation that is related to this research. Chapter 3 provides a description of the configuration-based simulation modeling methodology developed in this research. Chapter 4 describes the use of object-oriented simulation modeling concepts in the development of the automated model generator. Chapter 5 presents the development and testing process of the proof-of-concept prototype. Finally, Chapter 6 presents the conclusions of this research and recommendations for future work.

2

STATE OF THE ART

2.1 INTRODUCTION

In many parts of the world, construction constitutes a significant part of the national economy. In the United States, construction is nearly its largest industry (Oglesby 1989). The same applies to Canada (Shi 1995). As reported by the "Construction Industry Cost Effectiveness Project" of the Business Roundtable (Business Roundtable 1983):

> "By common consensus and every available measure, the United States no longer gets its money's worth in construction, the nation's largest industry ... The creeping erosion of construction efficiency and productivity is bad news for the entire U.S. economy. Construction is a particularly seminal industry. The price of every factory, office building, hotel or power plant that is built affects the price that must be charged for the goods or services produced in it or by it. And that effect generally persists for decades ..."

It follows then, that changes in the productivity of construction operations have far-reaching consequences on national and global economies. The importance of improving the productivity of construction operations has often been stressed in literature (Hendrickson 1989, Oglesby 1989, Choromockos 1981, Arditi 1985, Koehn and Caplan 1987) on the subject.

2.2 METHODS OF PLANNING AND ANALYSIS IN CONSTRUCTION

A number of methods have been developed for planning and analysis of operations on construction projects. From the perspective of this research, these methods could be classified into two groups:

(a) Static methods

(b) Dynamic methods

2.2.1 STATIC METHODS

Static methods are methods in which the state of the system that is being modeled *does not* change with respect to simulated time. Dynamic methods on the other hand are methods in which the state of the system that is being modeled *does* change with respect to simulated time. The majority of the methods used in construction today are static methods.

Since the days of organized planning in construction, a number of static methods or techniques have been developed for use on construction projects. One of the oldest and by far the most popular of these methods is the bar chart method. Other static methods could be classified under two main groups:

a) Linear construction methods

b) Network diagramming methods

Linear construction methods include such methods as the Linear Scheduling Method (Johnston 1981, Chrzanowski and Johnston 1986), Time Space Scheduling

Method (Stradal and Cacha 1982), Velocity Diagram Method (Roech 1972), Vertical Production Method (O'Brien 1975) and Line of Balance Method (Carr and Meyer 1974), Halpin and Woodhead (1976), Arditi and Albulak (1986), and Sarraj (1990).

Network diagramming methods were developed in the late 1950s. Since then they have become increasingly the method of choice especially on large projects. The most commonly used network diagramming method today is the Critical Path Method (CPM) followed by the Program Evaluation and Review Technique (PERT). A number of successful research projects in the area of network scheduling have been reported in the literature (Paulson 1973, McCough 1982, Jaafari 1984, Russell 1985, Cohenca 1989, and Sidwell and Cole 1989).

The Monte Carlo simulation technique (Ahuja and Nandakumar 1985, Crandall 1977, Crandall and Woolery 1982) has been used to overcome the deficiency of deterministic estimation of activity durations used in traditional network-based scheduling techniques.

The static methods of planning in construction have been listed in the preceding paragraphs for the sake of completeness of the review of the state of the art in methods and techniques used in planning of construction projects. The interested reader is referred to the literature quoted above for further information on these methods. Also, an overview of linear scheduling and network scheduling methods for planning in construction is presented in Shi (1995).

2.2.2 DYNAMIC METHODS

Construction operations are often characterized by dynamic interactions between resources and the operations and processes that utilize them. Although static methods such as those listed in Section 2.2.1 are excellent tools for the purposes of project scheduling and control, they cannot satisfactorily capture dynamic interactions. Therefore, in order to properly analyze these operations, it is essential to employ dynamic methods that facilitate not only the adequate representation of an operation but also the dynamic interactions inherent in these operations. Simulation provides us with just such a method and is the broad area of research of this thesis.

2.3 STATE OF THE ART IN SIMULATION

In the 1950s, computer simulations were directly coded in machine language, assembly language or high level languages such as FORTRAN. This method proved to be quite tedious and was further constrained by prohibitive hardware costs, lack of suitable software tools and slow processing speeds.

The concept of computer simulation was made a practical reality when a simulation language called General Purpose Simulation System (GPSS) was developed (Gordon 1961). As computer systems became increasingly more powerful, a number of other flexible, general-purpose simulation languages like SIMSCRIPT (Markowitz 1963), SIMULA (Dahl 1963), SLAM II (O'Reilly 1988) and SIMAN (Pegden 1987) were developed by researchers.

General-purpose simulation languages offer some definite advantages like ease of use, facilitating quick development of simulation models and good reporting capabilities. However, the user still has the burden of formulating the model and therefore has to be proficient both in the use of the particular system being used and in simulation theory.

A number of different approaches have been directed at addressing the issue of simplification of the modeling process. The principal approaches in this direction have been:

a) Model reusability approach

b) Hierarchical and modular modeling approach

c) Computer-aided modeling approach

2.3.1 MODEL REUSABILITY APPROACH

The model-reusability approach (Bortscheller and Saulnier 1992) attempts to address the simplification issue by recycling previously created models and using them in new situations. However, this approach has a number of drawbacks, the most important among them being the limited capabilities in handling variability in the level of detail required for different applications.

2.3.2 HIERARCHICAL AND MODULAR MODELING APPROACH

Zeigler (1976, 1984, 1985, and 1987) developed and presented hierarchical and modular modeling concepts for simplifying the process of constructing simulation models. Luna (1992) adapted these concepts for large and complex systems.

In this approach, a module is a self-contained and independent unit that interacts with other modules only through predefined communication ports. Individual modules may be coupled to form larger coupled modules. The resulting larger coupled modules can be interfaced to form even larger coupled modules. Thus, a system can be modeled using a set of individual modules or coupled modules.

2.3.3 COMPUTER-AIDED MODELING APPROACH

In its most generic sense, the computer-aided modeling approach attempts to construct a simulation model based on inputs specified by the user within a highly structured input user interface. Researchers in simulation have developed a number of different methods of simplifying the modeling process using computer-aided modeling. These methods could be classified under the following categories:

i. Activity cycle diagram approach

ii. Interactive model generation approach

iii. Visual interactive modeling approach

In the activity cycle or flow diagram systems approach such as the one adopted in HOCUS (Szymankiewicz 1988), the user develops a flow diagram or activity cycle diagram, and then uses a pre-defined command set to represent the operation to be modeled in a manner intelligible to the system. Although this approach facilitates rapid model development, it is very difficult to model complex systems without considerable effort (Pidd 1994).

The interactive program generation approach attempts to combine the benefits of rapid model development of the activity cycle diagram approach and the flexibility of programming in a programming language like C, C++ or PASCAL. The user initially interacts with the system just as if it were an activity cycle diagram system. However, instead of treating the input diagram description as data for model generation, it is used to generate a working program in some target language by linking together edited pre-written fragments of program code. The code may then be edited so as to facilitate the modeling of complex systems.

Visual interactive modeling systems are basically activity cycle diagram systems with much more sophisticated graphical user interfaces (GUIs) for describing the operation to be modeled. Examples of simulation environments which facilitate visual interactive modeling, are ProModel (Baird and Leavy 1994), WITNESS (Thompson 1994) and SIMFACTORY (Goble 1991). However, to use these systems, the modeler must conceptualize the operation that is to be modeled as a network around which elements flow, changing their state at the nodes of the network. Color-coded icons are often used in the models to intimate to the user status changes within the system.

The approaches outlined in Sections 2.3.1, 2.3.2 and 2.3.3, namely the model reusability approach, the hierarchical and modular modeling approach, and the computer-aided modeling approach simplify the model building process to a greater or lesser extent (depending on the particular approach used) for the sophisticated computer user or simulation practitioner. However, it does not totally free the user from the need to understand simulation, become proficient in using the system or in some cases even modifying computer generated program code in order to arrive at the desired simulation model. For these reasons and those cited in Section 1.1, such a system would be inadequate in the construction environment.

2.4 STATE OF THE ART IN CONSTRUCTION SIMULATION

Simulation systems such as SLAM II, MODSIM, SES, SIMSCRIPT and SIMAN, have been used in industrial engineering for the modeling and analysis of operations in the manufacturing industry. However, the steep learning curve associated with becoming proficient with these systems is a major obstacle in their widespread use in the construction industry.

A number of research efforts have been directed at reducing these complexities, to make them suitable for use by construction personnel. Following the early work of Teicholz (1963) and Gaarslev (1969), in the field of construction simulation, Halpin and Woodhead (Halpin et. al. 1973) developed the Cyclic Operation Network (CYCLONE) methodology. CYCLONE uses a graphical modeling format to model work states and the flow of entities through the system. It facilitates ease-of-use for modeling construction operations. The development of the CYCLONE modeling methodology inspired a number of other simulation systems based on the same methodology. Notable among them were INSIGHT (Paulson 1978), RESQUE (Chang 1987), UM-CYCLONE (Ioannou 1989) and DISCO (Huang et. al. 1994).

More recently, researchers in construction have focussed their attention on the use of object-oriented technology and object-oriented concepts in construction simulation. Liu and Ioannou (1992) developed the Construction Object-Oriented Process Simulation System (COOPS). COOPS demonstrated the benefits of using object orientation in implementing graphical modeling for the simulation of construction processes. Tommelein and Odeh (1994) developed an interactive object-oriented simulation system which uses the concept of hierarchy and matching resource properties to model construction operations. Oloufa (1993) used object-oriented programming for simulating a simple earth-moving operation. Sawhney and AbouRizk (1996) developed a computerized tool for hierarchical simulation modeling using object-oriented concepts and event driven programming.

2.5 AUTOMATED GENERATION OF SIMULATION MODELS

Most of the major research efforts outside the construction field have focused on the development of increasingly powerful, general purpose simulation systems or enhancements to existing simulation systems (Baird and Leavy 1994, Balci and Nance 1992, Bortscheller and Saulnier 1992, Goble 1991, Luna 1992, O'Reilly and Lilegdon 1988, Paul 1992, Pegden 1987 and Thompson 1994).

There have also been a number of research efforts within the field of construction simulation, directed at making it easier for construction practitioners to develop simulation models (Halpin (1973), Paulson (1978), Chang (1987), Ioannou (1989), Liu and Ioannou (1992), Huang et. al. (1994), Tommelein and Odeh (1994), Martinez and Ioannou (1994) and Sawhney and AbouRizk (1996)).

However, in spite of the fact that modeling is one the most difficult and time-consuming processes in simulation, very little research has been conducted to automate the model building process. Furthermore, the widespread use of simulation in construction has been hampered by the "complexities involved in the construction of simulation models and the resultant time requirement" (Shi and AbouRizk 1997).

One of the first attempts at automating the process of the generation of simulation models in the field of construction was the Resource Based Modeling

(RBM) approach developed by Shi and AbouRizk (1997). In this approach, basic processes of resources are defined as atomic models and stored in a model library. Based on user input, these atomic models are modified to form project-specific models. Through linking structures that have been previously defined, the models are assembled into a working simulation model.

Although the RBM approach works well for simple operations, for example moving earth from one location to another, the large number of atomic models that have to be created for more complex operations with a large number of resources and resource types makes the RBM approach difficult to be employed in operations that are relatively more complex. Furthermore, the RBM approach does not take into consideration the constraints associated with the automated generation of simulation models for the process of construction of structures with well-defined configurations. It also does not make any provisions for dealing with the issue of the concurrency of construction operations.

This thesis focuses on the automated generation of simulation models through the integration of the concepts of product-centric decomposition, modularity and object-orientation.

3

CONFIGURATION-BASED SIMULATION MODELING

3.1 INTRODUCTION

Based on the discussions in Chapters 1 and 2, it is clear that:

1) Although computer simulation has been extensively developed and widely used as a tool for the planning and analysis of operations in the manufacturing sector, its use in the construction field has thus far been limited mainly to academic research and experimental work. This is in spite of the well-known fact that simulation provides a powerful tool for the study and analysis of construction operations.
2) A number of research efforts have been directed at *simplifying* the modeling process but there has been very little research directed at *automating* the model generation process.

Earlier work done in the area of the automated generation of simulation models in construction by Shi and AbouRizk (1997) looked at the issue of automating the model generation process for relatively simple operations through the use of resource-based atomic models and combining these atomic models to represent a whole operation. However, the resource-based modeling approach does not address the following issues:

1) The construction of structures with specific configurations.

2) Sequencing and concurrency of operations.

This research attempts to address these issues in developing a Configuration-Based Simulation Modeling (CBSM) methodology for automating the generation of simulation models.

3.2 BASIC SIMULATION TERMINOLOGY

This section lists and explains basic simulation terminology in the context of this thesis.

3.2.1 SYSTEM

According to Pritsker (1997):

"A system is a collection of items from a circumscribed sector of reality that is the object of study or interest."

In the context of this thesis, a system will be defined as a well-identified set of interdependent entities that act together in a coordinated effort with the intent to achieve some previously established goal.

3.2.2 SIMULATION

Shannon (1992) defines simulation as:

"...the process of designing a model of a real system and conducting experiments with this model with the purpose of either understanding the behavior of the system and /or evaluating various strategies for the operation of the system."

More specifically, simulation involves the modeling of a system such that the model portrays the behavior of the actual system in response to events that take place over a specified period of time.

Simulation may be categorized under two main groups:

a) Continuous simulation

b) Discrete event simulation

The primary focus of this thesis is discrete-event simulation.

3.2.2.1 CONTINUOUS SIMULATION

Continuous simulation involves modeling a set of equations that represent a system over time. The system may consist of mathematical equations set up to change continuously over time. A distinguishing characteristic of continuous systems is that the states of these systems undergo smooth, continuous changes with respect to time. Examples of continuous simulation systems are the biological predator-prey model in nature, and the population growth models of microorganisms in a body of water.

3.2.2.2 DISCRETE EVENT SIMULATION

Discrete event simulation is characterized by the passage of time in discrete chunks. Typically the "starts" and "ends" of these chunks of time represent events and the times at which these events take place are called event times. The interval of time between events represents the time duration for an activity. Figure 3.1 shows the use of the main concepts in discrete-event simulation for modeling a process. In particular it depicts the relationships between events, activities and processes.

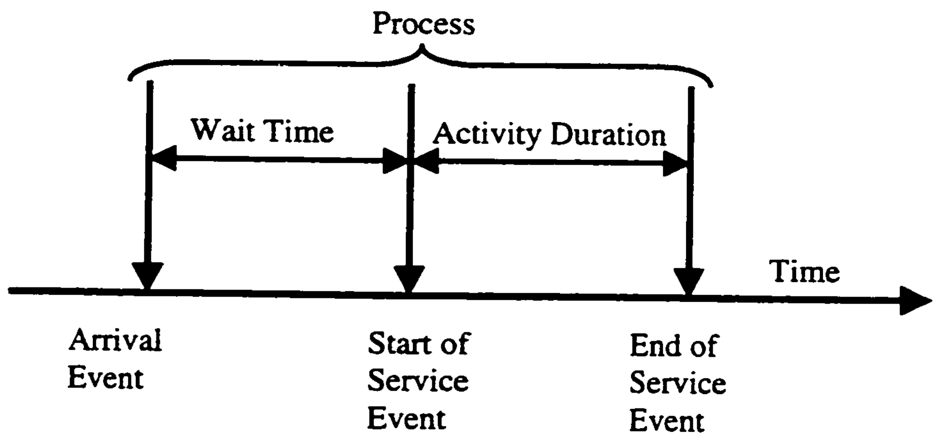

Figure 3.1. Relationship between events, activities and processes (Adapted and modified from Pritsker (1997)).

Discrete event simulation could be considered as consisting of a sequence of events occurring at specific event times. In other words,

If (x_1, t_1) (x_2, t_2) (x_3, t_3) .... (x_n, t_n) are a collection of tuples

where,

x_n is an event which occurs at time t_n, and,

$t_1 \leq t_2 \leq t_3 \ldots \leq t_n$

$\forall n \in N, n > 0$

Set $t = t_1$, where t is the current time. Therefore, the current event is x_1. Execution of the event logic associated with the event x_1 may cause the generation of new (x_n, t_n) tuples (i.e., scheduling of additional events), and/or removal of existing tuples (i.e., cancellation of pending events). Upon completion of the execution of the event logic associated with event x_1, we set $t = t_2$, and the whole cycle is repeated again.

3.2.2.3 SIMULATION MODELING

A model is an abstracted representation of a system (Pritsker 1997) and simulation is the process of mimicking important facets of the behavior of the system by constructing and experimenting with the model of the system. A model adapted for simulation on a computer should consist of the following:

a) Representations of the entities taking part in the activities of the system

b) Constraints imposed by logical relations and operational rules

c) Representations of elements of the environment which affect the operation of the system

Such a model is known as a computer simulation model or simply simulation model. The process of constructing and experimenting with a simulation model is called simulation modeling.

The basic assumption in simulation modeling is that we can describe the system in terms of a system state description – a characterization of a system by a set of variables, with each combination of variable values representing a unique state or condition of the system (Pritsker 1997). The implication then, is that by manipulating the system state description we can in effect move the system from one state to another. In discrete event simulation, changes in the state of the system occur at discrete points in time.

3.3 CONFIGURATION-BASED SIMULATION MODELING (CBSM) METHODOLOGY

3.3.1 FUNCTIONAL REQUIREMENT ISSUES

The need to take into explicit consideration the configuration of the structure while generating the simulation model introduces additional complexities in the process of the *automated* generation of the model. These have not been addressed in earlier work in construction simulation. The complexities introduced are the following:

1) Structures with configuration are far too complex for simulation to be executed directly without some form of structural decomposition.

2) The components of the simulation model must be automatically generated in a manner that would ensure that they have the states and behaviors correspond to the states and functionality of the components of the actual system.

3) Changes in the configuration of the system as required by the user should be reflected automatically in the form of a modified simulation model, without the benefit of any intervention from the user. However, such changes are limited to quantitative changes in the components of the system and not the boundaries of the system. For example, the automatically generated simulation model should be able to react to an increase in the number of trucks used, in the form of increased output. On the other hand, if an automated simulation-modeling tool is developed for modeling the construction of an earth-filled dam, it cannot be used for

simulating the construction of a high-rise frame structure. However, the configuration-based simulation modeling methodology developed in this research could be applied to develop a separate automated simulation-modeling tool for high-rise frame structures.

4) Logical constraints within the system being modeled have to be explicitly represented and automatically generated.

5) Construction of components of structures with configurations can proceed sequentially and/or concurrently. Furthermore, components that have been constructed should have the operations responsible for constructing them terminated. Concurrent with the termination of operations of component(s) completed, the operations responsible for the construction of component(s) next in line have to be commenced. This functionality has to be reflected in the behaviors of the simulation model that is automatically generated and the simulations have to be so orchestrated that it proceeds to its completion without user intervention at any stage in the running of the simulation.

3.3.2 CONCEPTUAL SCHEME

The CBSM approach developed in this thesis is intended to serve as a vehicle for the transformation of high level descriptions of the project provided by the user into a working simulation model. The user supplies high level inputs based on the characteristics of the operation he/she wishes to simulate. Examples of the content of such high level inputs are volumes of the structure, components of the structure, number of trucks, number of dozers, etc. The user then utilizes the CBSM methodology to achieve the transformation of the high level inputs into a working simulation model.

Figure 3.2 shows conceptually, the relative position of the CBSM methodology with respect to the user, the system that is being modeled and the simulation model itself. It also shows the simulation model containing representations of the interacting components of the system, the environment and the system itself.

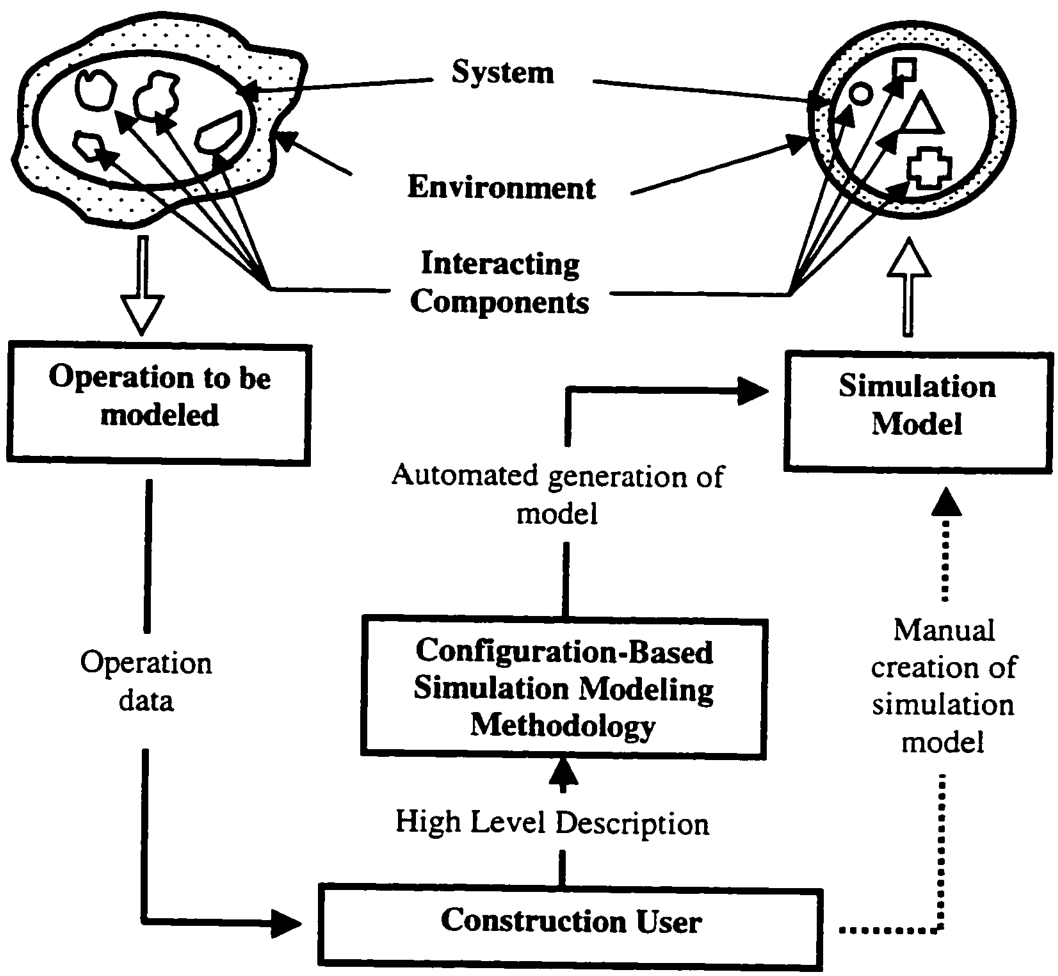

Figure 3.2. Conceptual scheme of CBSM framework.

3.3.3 METHODOLOGY OF CBSM

Configuration-Based Simulation Modeling (CBSM) methodology addresses the functional requirement issues raised in Section 3.3.1 in relation to the automated generation of simulation models for the operations involved in the construction of structures with well-defined configurations.

The application of the CBSM methodology involves two distinct phases - the Structural Decomposition Phase and the Model Generation Phase as shown in Figure 3.3.

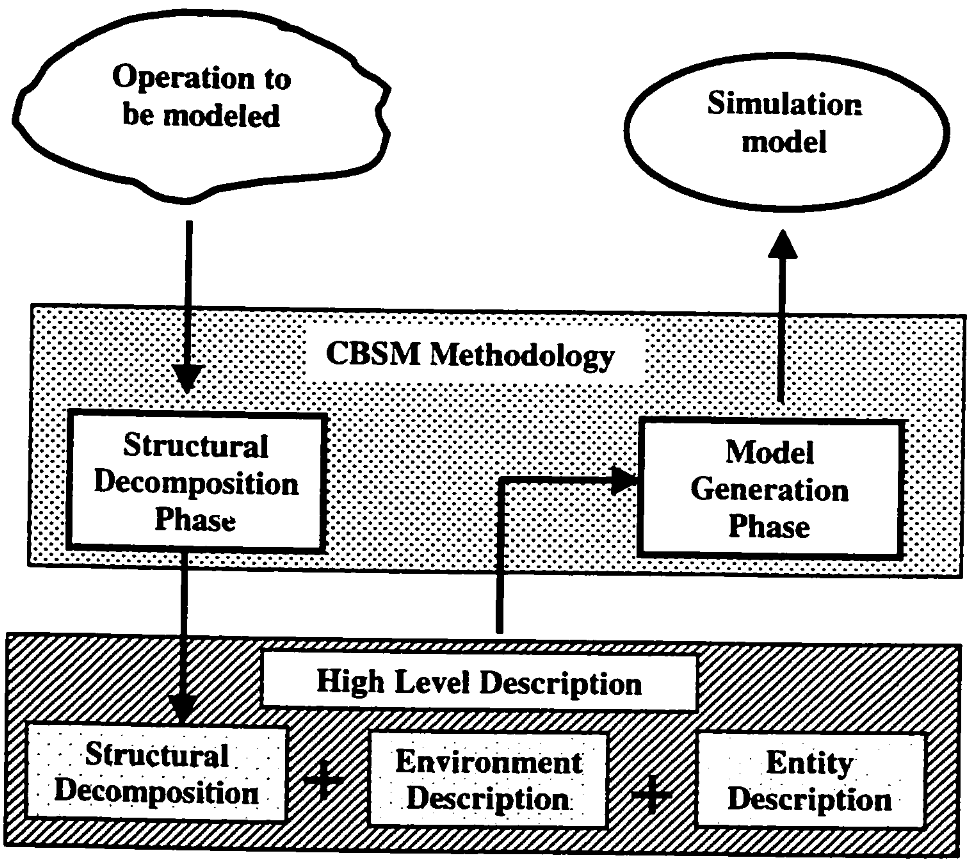

Figure 3.3. High level input to the model generation phase.

3.3.4 STRUCTURAL DECOMPOSITION PHASE

In the Structural Decomposition Phase, the structure is broken down into its components using the Structural Decomposition Criteria as a guide. Structural Decomposition Criteria (SDC) is a set of criteria that serves as an aid for the systematic and hierarchical decomposition of a structure to a level that will facilitate the meaningful application of one or more discrete event simulation processes. The simulation processes are similar to the one explained in Section 3.2.2.2 and are applied to the leaf nodes of the structural decomposition hierarchy in an ordered sequence that is dictated by pre-defined constraints.

The structural decomposition hierarchy, or simply structural decomposition, is essentially a product-centric breakdown of the structure. The focus during the development of a structural decomposition is on identifying suitable SDC for the decomposition that would help define discrete and modular components of the structure at every level of the decomposition hierarchy.

The ultimate aim of developing a structural decomposition hierarchy is to achieve a decomposition of the structure down to its elemental level. Each component of the structure at the elemental level is called an element. The structural decomposition also shows logical constraints that exist between elements.

For the purposes of this thesis, the following definitions of "element," "activity" and "component" apply:

An *element* is defined as the smallest component of the structure that can be installed through identifiable activities of each and every entity that participates in the construction of the component.

An *activity* is the smallest unit of work accomplished by an entity consistent with the user's view of the system. Examples of activities are loading, hauling, dumping, etc.

A *component* is any part of the structure that is to be built and that can be identified on the structural decomposition hierarchy of that structure.

The Structural Decomposition Criteria are described below:

Modularity: Planes of modularity can be used to break down a structure into sub-structures. Sub-structures are made up of identical components and are spatially separated.

Jurisdictional separation: Jurisdictional separation produces sub-assemblies which are clearly identifiable, units of sets of components that have significant differences functionally, structurally, and/or in their installation procedures. The components typically have spatial separation.

Resource requirement: Decomposition using this criterion is achieved based on planned transitions in the requirement of resources at various cross-sections, longitudinal -sections or levels (elevations) of the structure.

Technology: Technology and/or contractual criteria are used to identify sections. Sections are the largest permissible components of a structure that can be installed consistent with technological and contractual constraints. Two or more sections may form blocks.

Material: Decomposition at this level is based on the material used in different parts of the structure.

Block Level: Components at this level form the final level of decomposition based on non-operational level criteria. Blocks are typically complete yet basic structural components. An example of a block is a shear wall. Blocks can form either sub-assemblies, sub-structures, or the structure itself.

Activity Level: This level represents the final level of the structural decomposition hierarchy. It is at the operational level that activities for the construction of the structure are executed.

Figure 3.4 shows a six-criteria structural decomposition developed for a reinforced cement concrete high-rise frame structure.

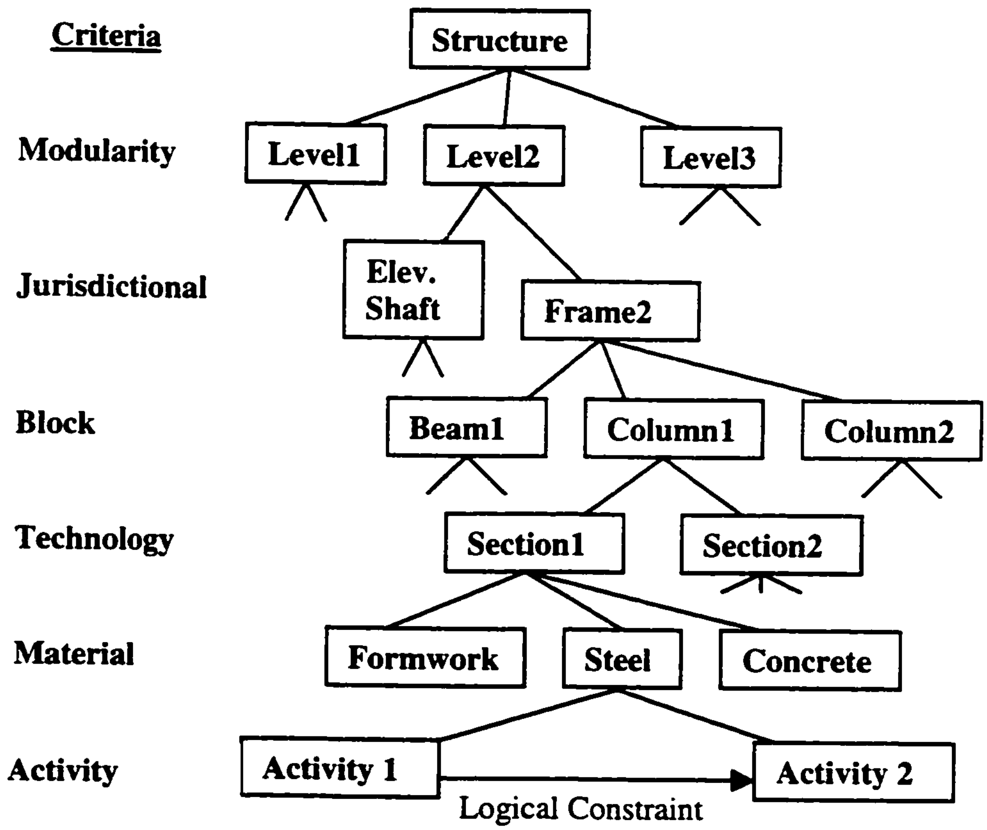

Figure 3.4. A six-criteria structural decomposition hierarchy for a concrete high-rise frame structure.

A structural decomposition can be developed using any or all of the seven criteria mentioned above. The criteria need not be applied in any specific order.

3.3.5 MODEL GENERATION PHASE

In the model generation phase, high level descriptions of the operation that have to be analyzed are fed to a model generator. The model generator converts the high-level descriptions into a working simulation model.

3.3.5.1 FUNCTIONAL REQUIREMENTS OF MODEL GENERATOR

The basic assumptions underlying the development of the model generator are:

a) The required structure is produced by the interaction of a construction plan with the existing environment under certain constraints.

b) For this interaction to occur, the necessary resources should be available and free for utilization. Figure 3.5 shows a graphical representation of these concepts.

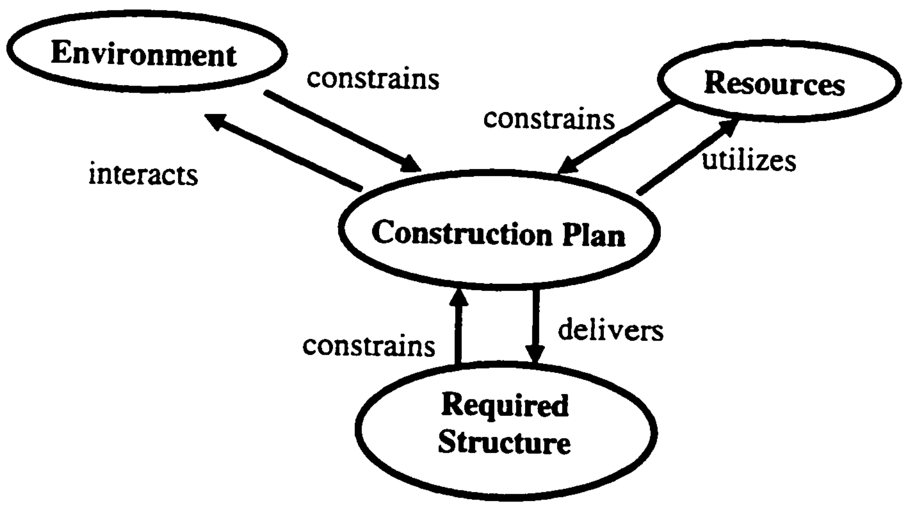

Figure 3.5. Basic assumptions underlying development of model generator.

A description of the existing environment essentially consists of a listing of the conditions under which the construction plan has to be executed. This listing comprises of a description of the location of sources of the materials required for the construction of the structure, location of destinations, layout of haul and return roads and those characteristics of the environment that have a bearing on the efficiency of the construction operations required to build the structure.

The construction plan consists of: (a) information as to the final form and size of the required structure; and (b) detailed stage-wise information required to produce the final form and size of the structure that is to be built.

In addition to descriptions of the construction plan and the existing environment, descriptions of the resources that are available to be utilized are also required. Such resources include materials and equipment needed to build the structure.

Based on the issues discussed in this section it is clear that the model generator must possess the following functionality:

1) It must be able to read the high-level descriptions provided by the user.
2) It must generate an internal representation of the environment consistent with the system being analyzed.
3) It must generate active representations of simulation entities like trucks, loaders, dozers, etc. These simulation entities must possess the properties provided by the user in his/her high level description.
4) It must generate an internal representation of the structure that is to be built, its components, and the states and behaviors of these components.

5) It must have the ability to create active internal representations of logical constraints in the system being modeled.

6) The model generator must also embed in the simulation model the functionality required to automatically commence, sustain and terminate execution of simulation as required.

In this research, the model generator was implemented using the object-oriented programming paradigm. A detailed discussion of the configuration of the model generator and its components is dealt with in Chapter 4 of this thesis.

4

AUTOMATED OBJECT-ORIENTED SIMULATION MODELING

4.1 INTRODUCTION

The concept of object-oriented simulation has great appeal in simulation applications because it is very intuitive to view the model of a system as composed of objects. This is especially so in simulation, where a system itself is viewed as a collection of interacting objects (Pritsker 1997).

This research work draws heavily upon the concepts of the object-oriented programming paradigm because in addition to the natural one-to-one correspondence between system objects and their computer-based representations, the configuration-based simulation modeling approach focuses on the structure that is to be built and its components.

This research also draws upon the concepts of hierarchy and modularity (Luna 1992) in the process of the automated generation of simulation models. The concept of modularity is also used in the configuration of the automated simulation model generator developed in this research. Due to the complexity of the development process of the model generator, modularity was found to be a necessity.

4.2 OBJECT-ORIENTED PROGRAMMING CONCEPTS

In this section, an overview of some of the important object-oriented programming concepts used in this research is presented.

Classes and objects:

An object consists of a collection of information (data) and a set of procedures that represents the object's behavior. The procedures are normally called methods. Methods can access and modify an object's state (data). A class is a generic definition of an object. Each object is an instance of its respective class. MODSIM II® uses the concept of an object type from which objects can be instantiated. Figure 4.1 shows the object type definition for a "Truck". Figure 4.2 shows the load method of the truck object.

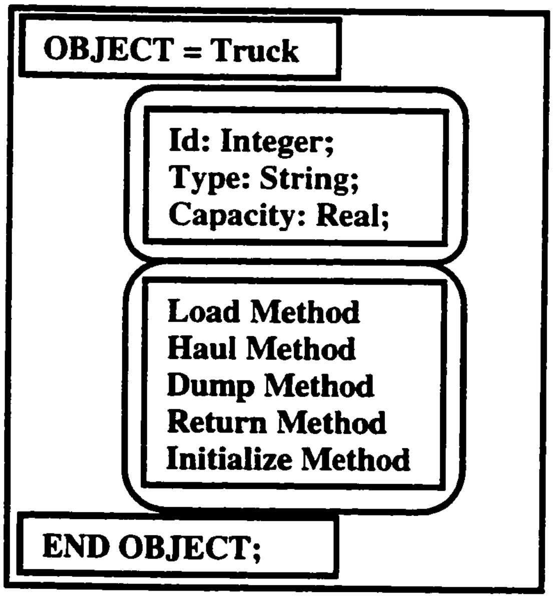

Figure 4.1. Object type definition of a "Truck" object in pseudo-code.

```
Load Method
        Begin
                Output Current Time;
                Output("At Loader - ","Trk-",Typ,"-",Id);
                Output ("At Loader - ");
                Output (Module Name);
                Output ("- Trk ");
                Output (Typ);
                If the volume prepared < allowable volume
                        Wait till the volume prepared
                        >= allowable volume
                End If
                If Loader is busy
                        Wait for loader to be free
                End If;
                Start Time := Current Time
                Request Loader to Decrement Resources by 1 ;
                Loadtime := UniformReal(High, Low);
                Output("Acquired by ",Mod.Name,"-Trk",Typ,"-",Id);
                Output("Loading-Trk-",Typ,"-",Id);
                Output(Mod.Name);
                Output ("Acquired by ");
                Output (Module .Name);
                Output ("-Trk ");
                Output (Typ);
                Output ("Loading-Trk-");
                Output (Typ);
                Output (Module Name);
                Output("Load Time: ",Loadtime);
                Output ("Load Time: ");
                Wait for the duration Loadtime
                Request Loader Take Back(Self,1);
                        EndTime:=Current Time;
                        BusyTime := (EndTime - StartTime);
                        Request Loader to Update(BusyTime);
                        Output("Released by ",Mod.Name,"Trk ",Typ,"",Id);
                        Output ("Released by ");
                        Output (Mod.Name);
                        Output ("-Trk ");
                        Request Loader to Increment ResourcesBy 1;
                        Haul
        End Method;
```

Figure 4.2. Load Method of the truck object in pseudocode.

Encapsulation:

The property of binding both data and methods in a single object or class is called encapsulation. The significance of the concept of encapsulation is that the information contained in the object is privy to the object's methods and thus can be modified only by those methods. An object can therefore be used without actually knowing its implementation details.

Figure 4.1 shows the fields and methods any object (say Truck1) that is instantiated from "Truck" will possess. In the object Truck1, the fields of the object namely, "Id", "Type" and "Capacity" and the methods "Load Method", "Haul Method", "Dump Method" and "Return Method" are tied together. Further the fields of an object can be only be modified through its methods.

Data Abstraction:

Classes of objects are defined in terms of the features that are of importance in the context of the system being modeled. These definitions form abstract representations of the objects rather than their actual physical representations.

Inheritance:

Classes can be organized into hierarchies, i.e., once a class has been defined, children of that class can be defined based on the existing class. A class that is subordinate to another, automatically inherits the entire instance variables and methods of the superior class. Each member of the object hierarchy can add its own fields and methods to those of its ancestors.

In MODSIM II®, inheritance is achieved by defining new types based on existing types. Each descendant in the hierarchy can add its own fields and methods to those of its ancestors. For example, in Figure 4.3, the object Loader is defined in terms of ResourceObj. Here, ResourceObj is the parent object and Loader is the descendant of this parent object.

```
Loader =
Object (ResourceObj)
        Name: String
        Typ:   String;
        Num:  Integer;
        BusyTime:      Real;
        Initialize Method;
        Update Method;
End Object;
```

Figure 4.3. The property of inheritance in pseudocode.

Message passing:

An object's methods are invoked by sending a message to the object asking it to perform a specific method.

Polymorphism:

Polymorphism facilitates the definition of flexible entities that may refer to different classes, all of which offer an operation with the same external specification but different implementations. The application of an operation to the entity will result in the appropriate implementation being selected, depending on the particular object associated with the entity at the time the operation is executed.

4.3 OBJECT-ORIENTED MODEL GENERATOR

4.3.1 SIMOBJECT CONCEPT

Zeigler (1984) defined a module as follows:

"... program text that can function as a self-contained autonomous unit in the following sense: Interactions of such a module with other modules can only occur through pre-declared input and output ports."

For the purposes of this thesis, modules and simulation entities will be given the generic name SIMOBJECT. Each SIMOBJECT links to other SIMOBJECTS through communication ports. Typically, a SIMOBJECT is equipped with two types of communication ports – "IN" communication ports or INCOM ports and "OUT" communication ports or OUTCOM ports. As the names imply, an OUTCOM port is generally used to *send* messages to other SIMOBJECTS and an INCOM port is generally used to *receive* messages from other SIMOBJECTS. However, a SIMOBJECT can send a message directly from its OUTCOM port to its own INCOM port. Figure 4.4 shows a representation of the structure of a typical SIMOBJECT that is made up of properties, methods, an INCOM port and an OUTCOM port. It also shows the mechanism of communication between two SIMOBJECTS. To ensure modularity, communication between SIMOBJECTS is through INCOM and OUTCOM ports. Figure 4.5 is a SIMOBJECT representation of a truck.

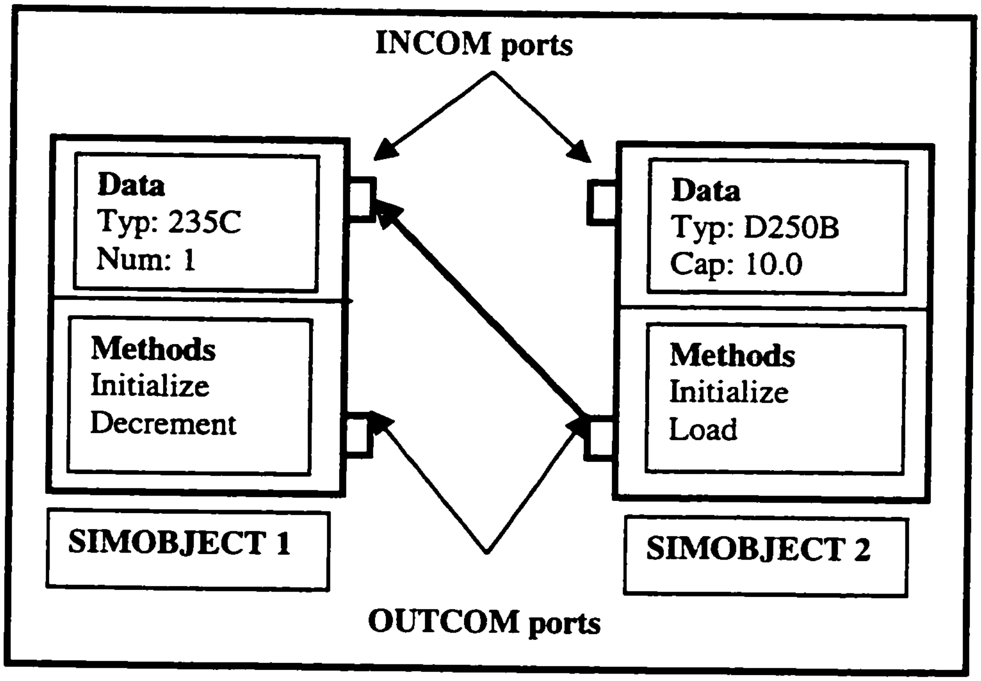

Figure 4.4. Representation of the structure of a typical SIMOBJECT.

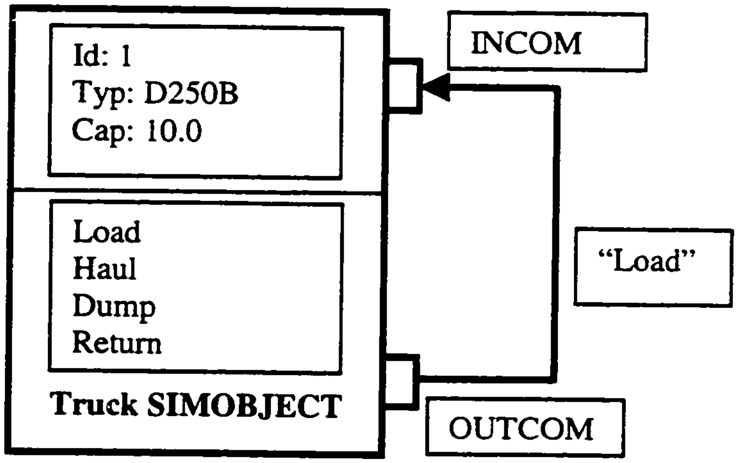

Figure 4.5. SIMOBJECT representation of a truck simulation entity.

To satisfy the functionality required in the simulation model generator outlined in Section 3.3.5.1 the following modules were developed:

a) Controller Module

b) Structure Generator Module

c) Environment Creator Module

d) Constraint Generator Module

e) Utilities Module

In addition to the modules listed above, a Simulation Initiator and Entity Generators complete the picture for the purpose of satisfying functionality requirements.

4.3.2 MODEL GENERATOR COMPONENTS

The model generator can be viewed as a collection of interacting SIMOBJECTS with the common goal of producing a working simulation model of the system that is being analyzed. The different components of the model generator and the role they play in the model generation process is discussed below:

Simulation Initiator Module:

The Simulation Initiator creates SIMOBJECT shells for the structure and the environment and also prepares them for receiving information from the user. However, the primary function of the simulation initiator is to commence simulation once representations of the structure, the environment and the simulation entities that are to take part in the simulation have been created and initialized. Figure 4.6 shows the Simulation Initiator program in pseudocode.

```
Create Controller;

Request Controller to Initialize
System;

Request Structure to begin
Simulation;

Start Simulation;

Character := ReadKey();
```

Figure 4.6. Simulation Initiator program in pseudocode.

Controller Module:

The Controller is a master module that controls the invocation of the structure generation module, the constraint generator module and the environment creator module. It also delegates responsibility for conducting the simulation to other components of the model generator. If required, it also provides an output of the logical representation of the structure and its components for the purpose of verification by the user. Figure 4.7 shows the Controller program in pseudocode.

```
Object Control Object
        Initialize System Method;
        Begin
                Generate Environment;
                Create Structure;
                Ask Structure to Initialize;
                Generate Project Resource Pool;
                Ask Structure to produce output;
                Get the current time and output as
                Total Time;
        End Method;
End Object
```

Figure 4.7. The Controller program in pseudocode.

Environment Creator Module:

As the name implies the environment creator module, creates and initializes a representation of the environment, which may consist of such things as roads, sources of materials etc. Figure 4.8. shows the environment creator program in pseudocode.

```
Object Environment
        Ask Environment to Initialize;
        Begin
                Create Material Sources;
                Create Roads
                For Each Road
                        Initialize the Road
                End For;
        End Method;
End Object;
```

Figure 4.8. The Environment Creator program in pseudocode.

Structure Generator Module:

The structure generator module consists of a set of generic SIMOBJECTS whose purpose is to generate and initialize the structure that is to be built and the components of the structure when invoked.

Constraint Generator Module:

The constraint generator module generates representations of logical constraints between components of the structure normally at the final level of the structural decomposition hierarchy.

Utilities Module:

The Utilities Module is a support module and provides utility services to other modules like string concatenation routines, initialization routines etc.

Entity Generator Module:

The purpose of the entity generator is to generate active simulation entities like trucks, loaders, dozers, etc.

4.4 MODEL GENERATION

The process of automatically generating the simulation model revolves around the concepts of reusability and flexibility, which are the strengths of object-oriented programming.

The computer-based automated simulation modeling system was implemented in an object-oriented programming environment called MODSIM II® (CACI 1994). MODSIM II® supports the concept of modularity, by separating the user interface from the implementation details. It also supports almost all the other object-oriented programming concepts like inheritance, polymorphism, data encapsulation, message passing, etc. In addition, it provides constructs for implementing concurrent and interacting behaviors in simulation time.

Model generation is essentially accomplished by instantiating generic SIMOBJECTS at runtime. The generic SIMOBJECTS are modified to suit the requirements of the system through user inputs. Thus, based on the inputs provided by the user, and SIMOBJECTS which can be reused and tailored to suit the current needs of the modeling process, a string of such SIMOBJECTS can be put together to represent the environment, the structure, components of the structure and the simulation entities. Once such a representation of the system is available in the memory of the computer, the MODSIM II® simulation engine is invoked to execute the simulation.

This form of model generation is facilitated by the construction of the system around abstracted representations of system entities in terms of their states and behaviors. However, the most crucial characteristic of SIMOBJECTS that facilitates automated model generation is that SIMOBJECTS can communicate with each other through pre-defined OUTCOM and INCOM ports.

The generic system architecture for the computer-based automated simulation modeling system is shown in Figure 4.9.

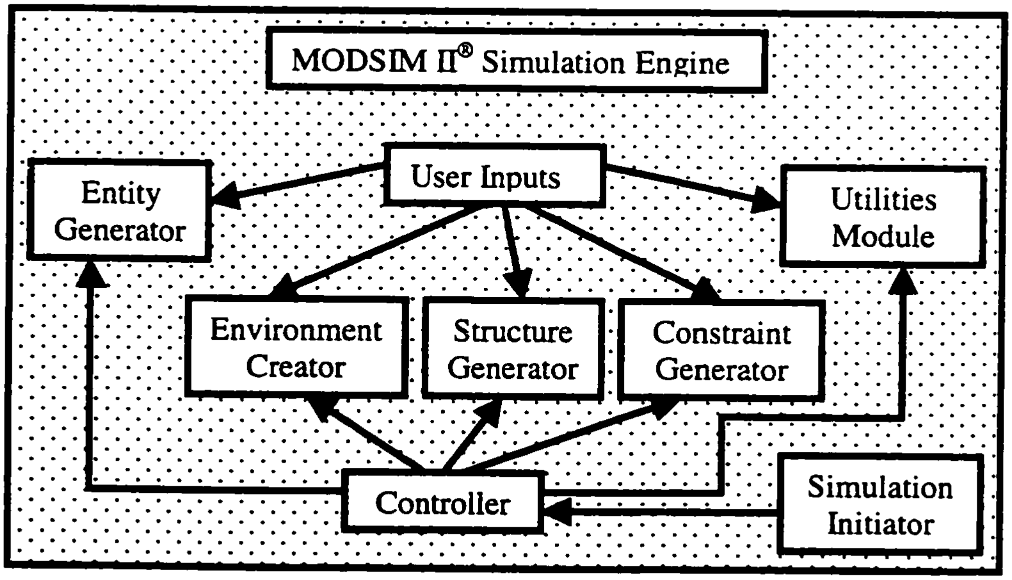

Figure 4.9. Generic system architecture for the automated model generator.

Chapter 5 describes the development and testing of the automated simulation model generator. It also describes the use of the computer based CBSM system for a sample application.

5

PROTOTYPE DEVELOPMENT AND TESTING

5.1 INTRODUCTION

In order to test the Configuration-Based Simulation Modeling approach, a proof-of-concept prototype implementation work was undertaken. In developing a computer-based tool in the field of simulation, it is essential to bear in mind the limitations imposed on the development of such a tool. In this context, Paul (1992) states that it is impossible to develop a simulation-modeling tool that can model any system that one might wish to model. Therefore, the person analyzing the system is restricted to one of the following two options:

1) Develop special purpose simulation tools geared to specific problems.
2) Use a tool that provides programming code that can be modified by the user to tailor the tool to the needs of the problem at hand.

In the context of construction simulation and for reasons cited in Chapter 1, the second option had to be ruled out.

The primary aim of the prototype-development and testing phase was to test the feasibility of simulating the operations necessary to install a structure that has a specific configuration within the domain of earth-filled dams. The functional requirements of a computer-based system to effectively address the complexities introduced into a simulation exercise due to the incorporation of the configuration of the structure have been described in Section 3.3.1.

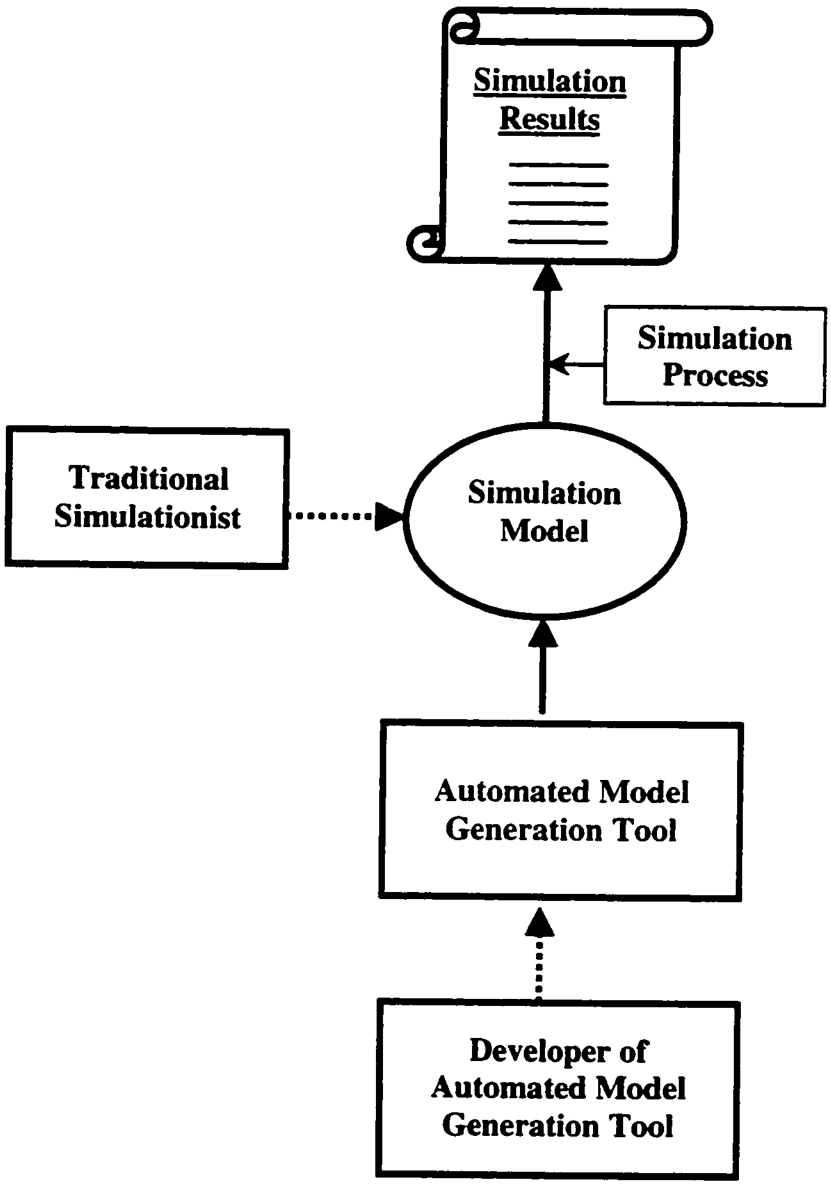

Figure 5.1. Complexity of the automated model generation process.

The complexities involved in developing a tool for the automated generation of a working simulation model can be appreciated from the fact that the developer of such a tool is separated by one level of abstraction from the actual simulation model and two levels from the running of the simulation itself as shown in Figure 5.1. The broken arrows represent development activity of the simulationist in developing a simulation model and that of the automated model generation developer in developing a tool that would automatically generate simulation models.

The developer of an automated model-generation tool is two levels of abstraction removed from the simulationist who uses traditional simulation tools like SLAM II or AWESIM. The developer has no direct link to the simulation model. This is unlike the traditional simulationist who directly develops the simulation model itself.

The development work of the proof-of-concept prototype was undertaken in two stages. The first stage involved gaining an understanding of the system and building a prototype implementation of a scaled-down version of the system. The second stage involved the development of the prototype for the full-scale version of the system based on the experience gained in the course of development work done in the first stage. The proof-of-concept prototypes developed in stages 1 and 2 were named CONFIGSIM_1 and CONFIGSIM_2 respectively.

5.2 PROTOTYPE DEVELOPMENT – STAGE 1

The first task in Stage 1 was the definition of a system that was conceptually representative of earth-filled dams. Although in the ideal case, a real world system would be the problem of choice, obtaining information and data about such a system at a level of detail required for this research would be prohibitively expensive. Instead it was decided that a suitable problem that would demonstrate the concepts would be defined. Such a system would be based on a real-world system for which discussions with knowledgeable construction industry representatives were conducted. The essential characteristics of such a system were identified and are listed below:

1) The system consists of (a) the structure that is to be built, (b) the environment consisting of roads and material locations, and (c) equipment that would be used to transport material from the sources of such material to the site of the structure.

2) The structure is modular along the predominant line of development. For example, earth-filled embankments are typically modular along the horizontal (length) direction.

3) Material locations are static, i.e., for any particular system, the locations of sources of material to be utilized for building the structure are fixed.

4) Components of the structure may be logically constrained by other components within the structure. For example, if component C2 is constrained by component C1 of the structure, then construction of component C2 can commence only after the construction of component C1 is complete. This is shown graphically in Figure 5.2. Previous research work in the area of automated generation of simulation models has not addressed this issue.

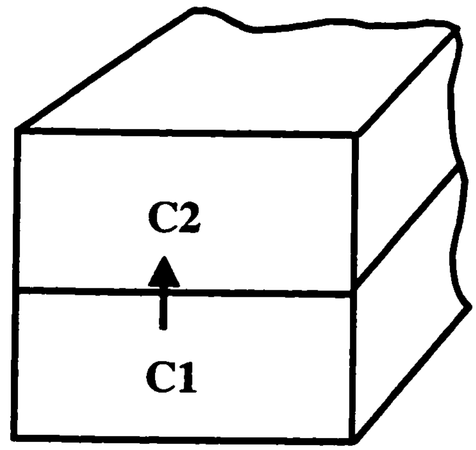

Figure 5.2. Component C2 is logically constrained by component C1.

The structure has three zones as shown in Figure 5.3. The two outer zones are built up with material from Source A, and the inner zone is built up with material from Source B. Material from the sources is brought to the respective zones using a truck and loader operation.

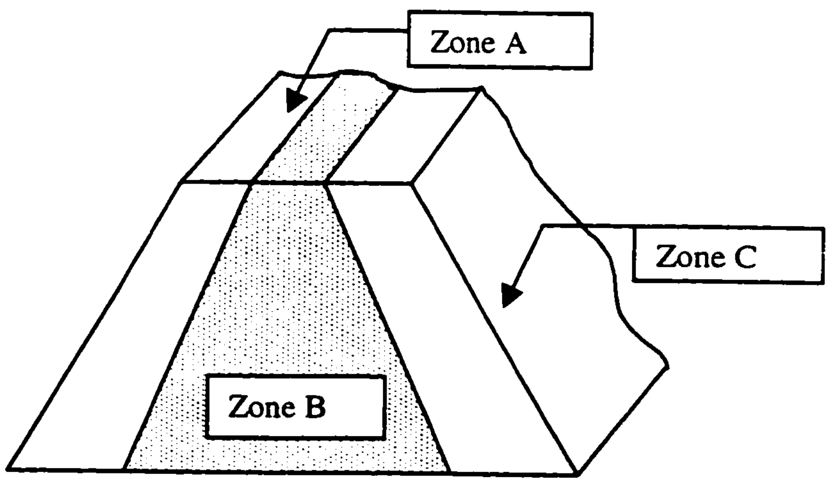

Figure 5.3. Three-dimensional schematic of the structure showing zones.

The schematic (plan view) of the system that was defined for the purpose of building the prototype is shown in Figure 5.4.

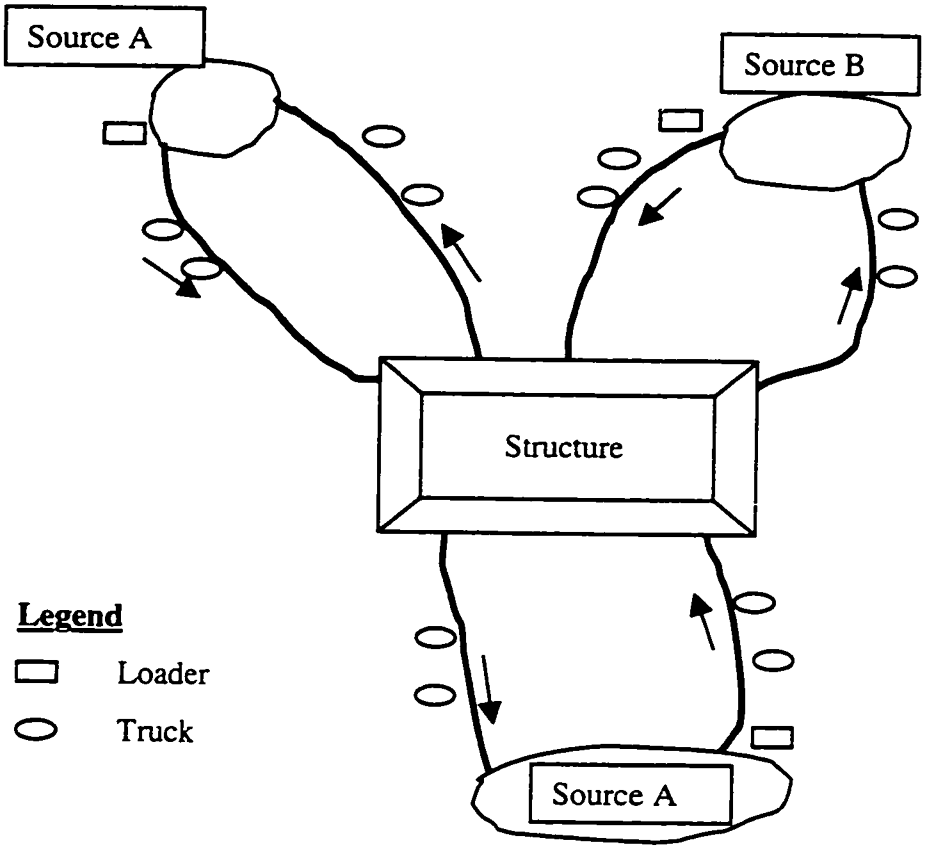

Figure 5.4. Schematic (plan view) of system defined for prototype development.

Each material source location has a loader and a fleet of trucks for transporting material from the source to the destination. The destination refers to the component that is to be constructed using material from that particular source.

Existing tools in the field of construction simulation cannot be used for automatically generating a working simulation model of the operations required to construct the structure.

The first step in the use of the CBSM methodology is the application of the Structural Decomposition Criteria to arrive at a level of decomposition that would facilitate the application of simulation processes.

Based on discussions with representatives in the construction industry familiar with the construction of similar structures, planes of transition in resource allocation were identified for the purposes of developing the prototype. Furthermore, each such level was divided into two lifts. In actual practice these numbers may vary, but were found to be sufficient to test the concepts in the CBSM methodology. The planes of transition of resource allocation and lifts are marked in Figure 5.5.

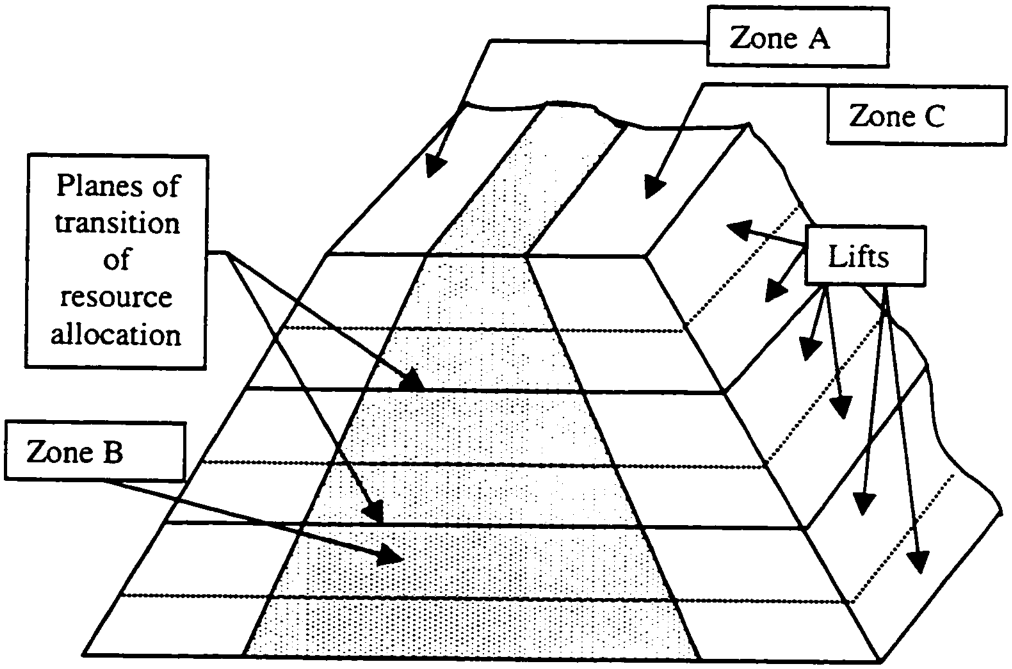

Figure 5.5. Decomposition of the structure based on the Structural Decomposition Criteria.

The Structural Decomposition Criteria identified were the following:

a) Resource requirement

b) Material

c) Technology

d) Activity

Figure 5.6. shows a four-criteria structural decomposition hierarchy for the problem defined above.

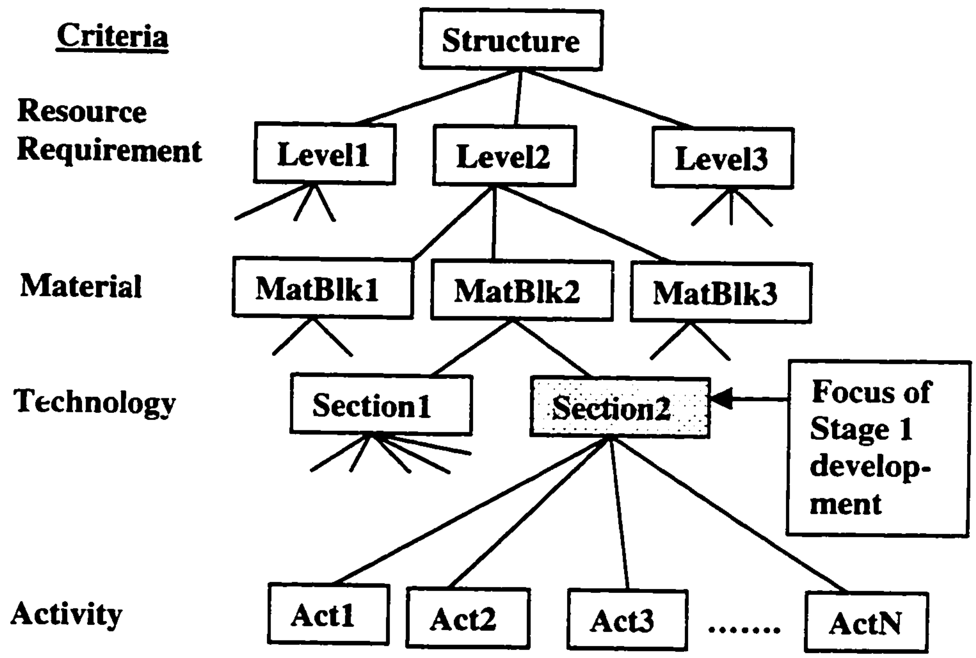

Figure 5.6. A four-criteria structural decomposition hierarchy.

The Stage 1 prototype, CONFIGSIM_1, was developed using a general-purpose simulation engine called Simpack. Simpack is basically a collection of C libraries and executables developed specifically for simulation. It provides the user with a set of utilities with which a simulationist can construct special purpose simulation tools tailored to the system that the user wishes to model.

The focus of the development in Stage 1 was a "Section" identified in the Structural Decomposition hierarchy shown in Figure 5.6. The main purpose behind the selection of a "Section" was to gain an understanding of the complexities involved in the development of the simulation modeling concepts and the programming constructs required for the implementation. The user interface was developed in Microsoft Access. Figures 5.7 and 5.8 shows the user interface developed for the computer-based implementation. Similar screens were used for obtaining other required information from the user.

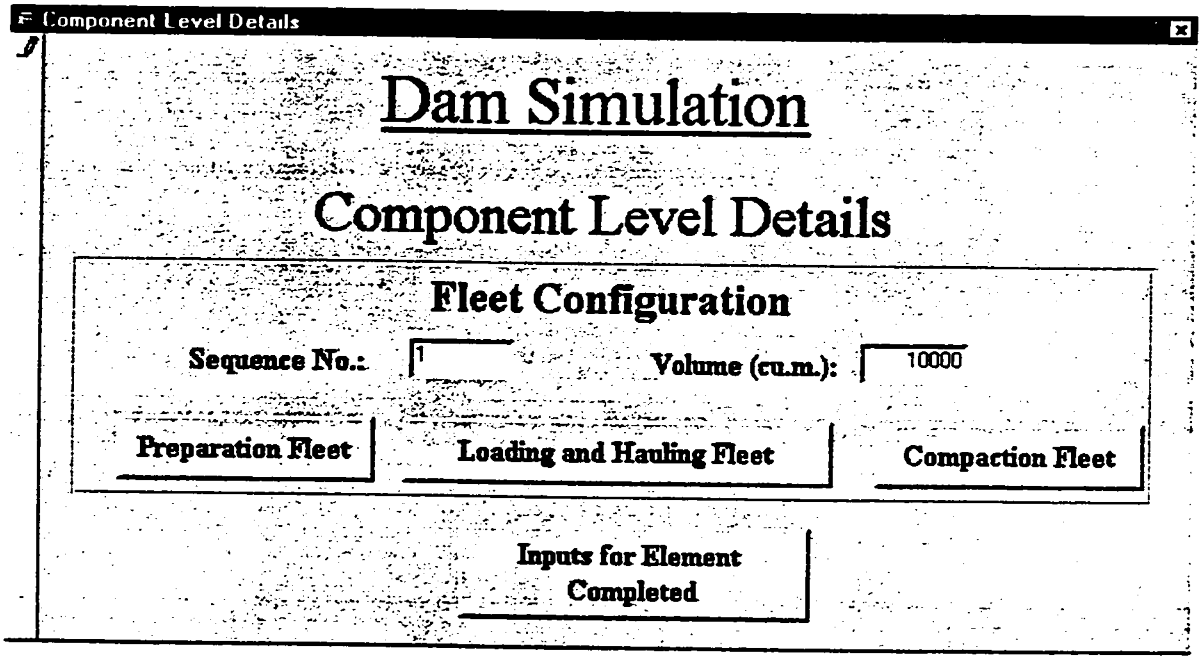

Figure 5.7. User interface for obtaining component level details in CONFIGSIM_1.

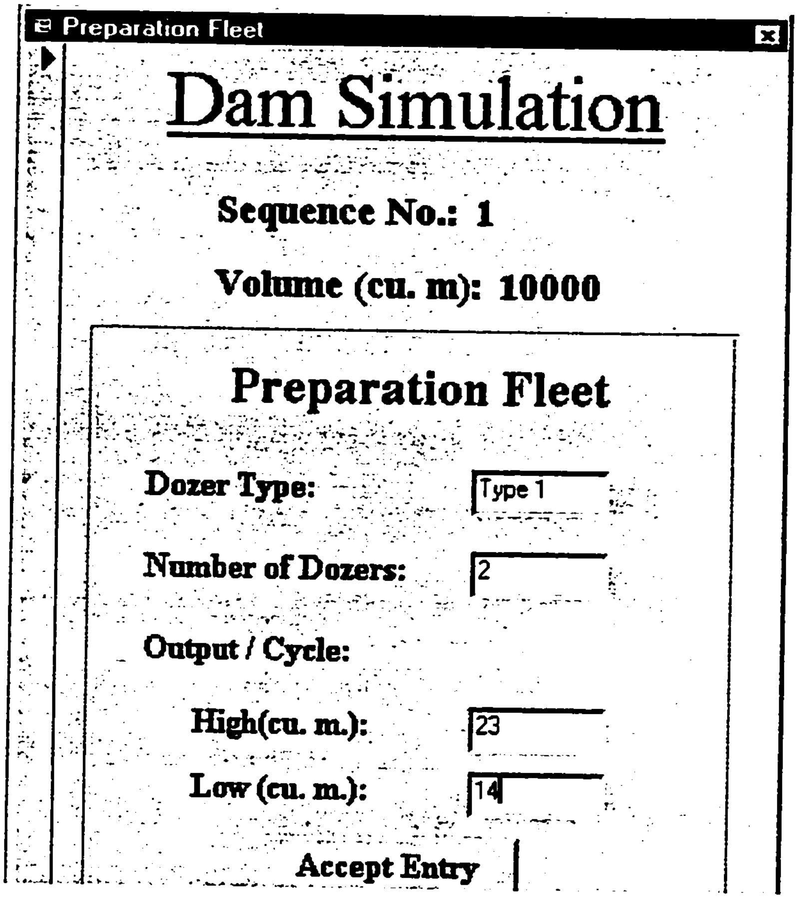

Figure 5.8. User interface developed for obtaining preparation task information from the user.

A complete listing of the source code for CONFIGSIM_1 written in the C programming language is presented in Appendix A. The results from a sample simulation run of CONFIGSIM_1 are presented in Table 5.1.

SIMULATION RESULTS FOR ELEMENT NUMBER 1
****
Total Simulation Time: 136.542908 Total System Arrivals: 11
System Wide Statistics System Utilization: 57.4% Facility Statistics -------------------
F 1 (EMBANKMENT): Idle: 72.1%, Util: 27.9%, Preemptions: 0 F 2 (LOADER): Idle: 13.1%, Util: 86.9%, Preemptions: 0

Table 5.1. Simulation output Generated by CONFIGSIM_1

The lessons learned in the course of development of CONFIGSIM_1 were:

a) Automatic generation of simulation entities based on user inputs could be accomplished.

b) Although an indirect representation of one component of the structure was achieved, it was difficult to obtain a satisfactory representation of the structure as a whole and its components.

c) There was no explicit representation of the environment.

d) While the approach used in CONFIGSIM_1 could work well if the operations were performed sequentially, it does not cater to the concurrency of operations that is common in construction projects.

The next step in the process of prototype development was an extension of the concepts and ideas developed in this exercise to simulate the construction of the entire structure in a seamless manner. It became evident during Stage 1 of the prototype development process that object-oriented programming concepts would facilitate a more intuitive implementation of the structure (Manavazhi and AbouRizk 1997).

5.3. PROTOTYPE DEVELOPMENT – STAGE 2

The experience gained during the development of the prototype in Stage 1 played a big part in the decision to use object-oriented technology for Stage 2 of the prototype development. The advantage of using object-oriented technology in this research has been covered in Chapter 4 and will not be repeated here.

As is the case whenever the CBSM methodology is to be applied, the first step is the decomposition of the structure using the Structural Decomposition Criteria. A four-criteria structural decomposition for the problem defined in Stage 1 of prototype development is shown in Figure 5.6.

The development of CONFIGSIM_2 in Stage 2 was undertaken using MODSIM II®, an object-oriented simulation environment for developing discrete-event simulation models. MODSIM II® provides a strongly typed, block-structured programming language with object-oriented features.

Since the primary aim of this research was to address the complexity issues that arise when the configuration of the structure has to be taken into consideration while automatically developing a simulation model, the work focused more on the development of the object-oriented, modularity and reusability concepts rather than the development of a sophisticated user interface. Interaction with the user, for both input to the system and output from the system was accomplished by text files.

5.3.1. WORKING OF PROTOTYPE

The development of CONFIGSIM_2 was done entirely using the object-oriented programming paradigm. CONFIGSIM_2 obtains its input information from two sources: (a) text files; and (b) program code. Almost all the inputs that have to be supplied to CONFIGSIM_2 by the user are to be provided in the form of previously compiled text files. Typical information that has to be provided by the user is shown in Figures 5.9 and 5.10. Explanations of the inputs shown in the figures are provided in parentheses. In addition to inputs provided by the user in text files, the current version of CONFIGSIM_2 utilizes input information provided as part of the code itself and is not provided by the user in this version. However, since the goal of developing CONFIGSIM_2 was only to demonstrate the concepts developed in this research and to keep the length of the code within the limitations of the program text editor, some of the input information was moved into the code itself. The input information, moved into the code, consisted of the following: (a) load times for trucks; (b) dump times for trucks; (c) cut times for dozers; and (d) pile times for dozers.

Once the text-based inputs are compiled, the model generator program can be executed. The program commences the model generation process by invoking the Controller, which in turn invokes the necessary functional elements of the model generator to create internal representations of the system that is being modeled. The first functional element that is invoked is the "Environment Creator", followed by the "Structure Generator". When invoked the "Environment Creator" develops a representation of the "Environment". Creation of the environment involves developing representations of the "Roads" and "Material Sources" in the system.

1. (Information about the structure)
Total Volume : 500 cu. m.

2. (Information about resources available. Under each item, the information is provided in the format [Type, Number])

Dozers	Loaders	Trucks
D9N 3	235C 2	D250B 3
D8N 3	245B 2	D300B 3

3. (Information about resources required. Under each item, the information is provided in the format [Type, Capacity (cu. m.), Number] for trucks and dozers and [Type, Number] for loaders. The integer number under each item represents the number of types of each item)

Dozers	Loaders	Trucks
2	2	2
D9N 10.0 1	235C 1	D250B 10.0 1
D8N 9.0 1	245B 1	D300B 12.0 1

4. (Information about structural components)
MatBlock Details
(Lifts) 1
(Logical Constraint):
Block 21-Section 1 - Block 11-Section 1
(Section Details)
(Name) Mod1
(Volume) 500 cu. m.

5. (Truck Times (in minutes))
(Haul – High) 5.0; (Haul – Low) 3.0
(Return – High) 4.0; (Return – Low) 2.0

6. (Dozer Times (in minutes))
(Haul – High) 5.0; (Haul – Low) 4.0
(Return – High) 4.0; (Return – Low) 2.0

Figure 5.9. Typical text-based structural and resource information provided as input to the model generator.

```
1. (Information about sources of material)
        (Number of sources) 3

        (Source_1)
        (Volume) 2000

        (Source_2)
        (Volume) 2000

        (Source_3)
        (Volume) 2000

2. (Information about roads)
        Source: Source1
        Destination: Module1

        (Details of trucks)
        (Truck Type) D250B
        (Speed when loaded) 14
        (Speed when empty) 20

        (Truck Type) D300B
        (Speed when loaded) 10
        (Speed when empty) 14
```

Figure 5.10. Typical text-based material and road information provided as input to the model generator.

The "Structure Generator" then creates internal representations of the structure that is to be built and its components. At this stage, the representations are "empty shells". Next, based on the information provided by the user, the shells are initialized. The Controller also creates and initializes the "Project Resource Pool" which is the total collection of resources that is available to the operations planned for constructing the project. The "Simulation Initiator" then commences the simulation process by invoking the MODSIM II® simulation engine.

During the simulation process, each "Section" level component or module, first conducts a resource level check against the available resources in the project resource pool. If the resource requirement in a module cannot be satisfied by the resources available in the project resource pool the program issues a warning message pointing out the particular module that does not have the required resources and terminates the simulation. The user can then rectify the problem before initiating the simulation again. However, if the resources available in the project resource pool can satisfy the resource requirement for the module, then the simulation process is continued. The basic simulation process modeled at the activity level for sample runs of the prototype involves a dozer-loader-truck operation. A schematic representation of these interacting cycles is shown in Figure 5.11.

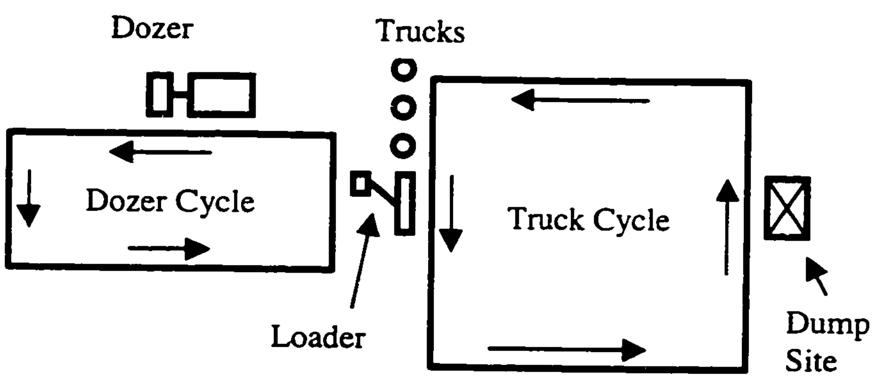

Figure 5.11. Interacting dozer-truck cycles.

The bulldozer dozes earth and piles it for the loader. It then returns to doze more earth and transport it to the earth pile. This is the dozer-cycle. The loader scoops up the piled earth and dumps it into waiting trucks. The trucks haul the earth away to the destination where they dump the earth and return for another load. This is the truck cycle. CONFIGSIM_2 uses a uniform distribution for its loading, travel, piling and dumping times. A uniform distribution not only provides a good distribution for testing proof-of-concept simulation systems like CONFIGSIM_2, but also provides a convenient and easy method of making the model deterministic. This can be achieved by simply making the "high" and "low" parameters of the uniform distribution equal. However, MODSIM II® supports a number of other commonly used distributions like the exponential, normal, gamma, beta and triangular distributions and the choice of which distribution to use in a particular scenario in a full-fledged automated model generator could be left to the user.

Once a module in the structure completes simulation, i.e., it is "constructed" which is signified by the volume completed in the module becoming equal to the planned volume then that particular module stops and the next module takes over. This process is repeated until the entire structure is completed.

5.4. VERIFICATION AND VALIDATION

Pritsker (1997) defines verification as the process of determining that a simulation run is executing as intended. Other experts consider verification as the process of ensuring that the simulation model matches the simulation analyst's concept of the system and say that debugging is a big part of this process (McHaney 1991).

According to Bratley et. al. (1983) verification is "checking that the simulation program operates in the way that the model implementer thinks it does; that is, is the program free of bugs and consistent with the model? Such checks are rarely exhaustive." Again, in the context of verifying a program, Bratley et. al (1983) state that "all the standard tools for debugging any computer program apply to debugging a simulation. A useful technique is to include throughout the program, at the outset, statements which can all be turned on with a single "switch." These statements show in detail (either numerically or, via a plotter, graphically), how the system state changes over time. Sometimes this is called a trace."

Bratley et. al., (1983) define validation as, "checking that the simulation model, correctly implemented, is a sufficiently close approximation to reality for the intended application." They go on to further state that "no recipe exists for doing this." A similar definition by (Pritsker 1997 and MacDougall 1987) states that validation is the process of determining if the simulation model developed is a reasonable representation of the system. The best available method seems to be to compare the working of the system with that of the model. However, for systems that are not available for such comparisons, validation in the strictest sense becomes extremely difficult. This is especially so for construction projects which are few and far between. Obtaining information from these projects for conducting simulation experiments can be prohibitively expensive. In the context of simulation validation, Knepell and Arangno (1993) state:

> "Given the extraordinary level of complexity and detail in system-level simulation, as well as the intrinsic ambiguity of the physical phenomenon and strategies typically being represented, the creation of an authentically objective and rigorous methodology is a formidable challenge."

In situations where there are no systems that can be readily employed for purposes of comparison with simulation models, the following two techniques have been suggested as possible validation methods by Brown (1975):

1) Simplify the input to the model so that the values can be easily calculated and then these values are compared to the output of the simulation-model.
2) Manual verification of model behavior through step-by-step trace.

For the purposes of this research work, validation of the simulation model will be done based on the comparison of simulation models generated by the automated model generator and that developed manually using AWESIM (Pritsker 1997), a general purpose, simulation software environment. Verification of the simulation model generated by the automated model generator will be performed by observation of a step-by-step trace.

A complete listing of the program code for CONFIGSIM_2 developed in the MODSIM II® environment is presented in Appendix F. In its present version, CONFIGSIM_2 is specifically geared to generating simulation models of earth-filled dams.

5.4.1. VERIFICATION AND VALIDATION TESTS

Scenario for Test #1

The structure for test #1 consisted of two MatBlocks (MatBlock1 and MatBlock2), each made up of one section. The total volume of the structure chosen was 500 cu. m. The volume of material required to fill up the section in MatBlock1 was 300 cu. m. and that to fill up the section in MatBlock2 was 200 cu. m. The material for the two MatBlocks came from two separate sources. Each source had a front dumping, CAT-235C front shovel loader. The 235C loads 3.0 cu. m. of material on to the truck per (loader) cycle. The duration of each loader cycle was 0.5 min. The hauling units for each section consisted of two CAT-D250B and two CAT-D300B articulated dump trucks. The D250B carries 10.0 cu. m. of material per trip and the D300B carries 12.0 cu. m. of material per trip. The resource and structural details for the exercise are specified in Figure 5.12. The environment details are specified in Figure 5.13.

Using this scenario, a verification test was carried out by observing a step-by-step trace produced by CONFIGSIM_2. The validation test was carried out by first executing the simulation model developed by CONFIGSIM_2 and then running a manually generated simulation model developed using AWESIM. The results obtained using the two approaches were compared. All task durations used in test were deterministic.

1. (Information about the structure)
Total Volume : 500 cu. m.

2. (Information about resources available. Under each item, the information is provided in the format [Type, Number])

Dozers	Loaders	Trucks
D9N 3	235C 3	D250B 3
D8N 3		D300B 3

3. (Truck Times (in minutes))
(Haul – High) 5.0; (Haul – Low) 5.0
(Return – High) 3.0; (Return – Low) 3.0

4. (Information about resources required. Under each item, the information is provided in the format [Type, Capacity (cu. m.), Number] for trucks and [Type, Number] for loaders. The integer number under each item represents the number of types of each item)

Loaders	Trucks
1	2
235C 2	D250B 10.0 2
	D300B 12.0 2

4. (Information about structural components)
MatBlock1
(Lifts) 1
(Section Details)
(Name) Mod1
(Volume) 300
(Logical Constraint):
Block 2-Section 1 - Block 1-Section 1
MatBlock2
(Lifts) 1
(Section Details)
(Name) Mod1
(Volume) 200

Figure 5.12. Text-based structural and resource information for test # 1.

1. (Information about sources of material)
    (Number of sources) 2

    (Source_1)
    (Volume) 2000

    (Source_2)
    (Volume) 2500

2. (Information about roads)
    Source: Source1
    Destination: MatBlock1

    Source: Source2
    Destination: MatBlock2

    (Details of trucks)
    (Truck Type) D250B
    (Speed when loaded) 24 kmph
    (Speed when empty) 30 kmph

    (Truck Type) D300B
    (Speed when loaded) 20 kmph
    (Speed when empty) 28 kmph

Figure 5.13. Text-based environment information for test # 1.

The AWESIM model developed for comparison with the simulation model developed by CONFIGSIM_2 for test # 1 is shown in Sections I and II in Figures 5.14a and 5.14b respectively. In the AWESIM model, "Create1" is a "CREATE" node that generates two trucks at time 0.0. The two trucks are created at the same time, since the time interval between creation of the two trucks has been specified as 0.0. Node "Create1" directs two trucks on to each of the two branches emanating from the node. Attribute 1 of two of the trucks (D250Bs) is assigned the value 10.0, which is the volume of material in cubic meters that the D250B carries per trip.

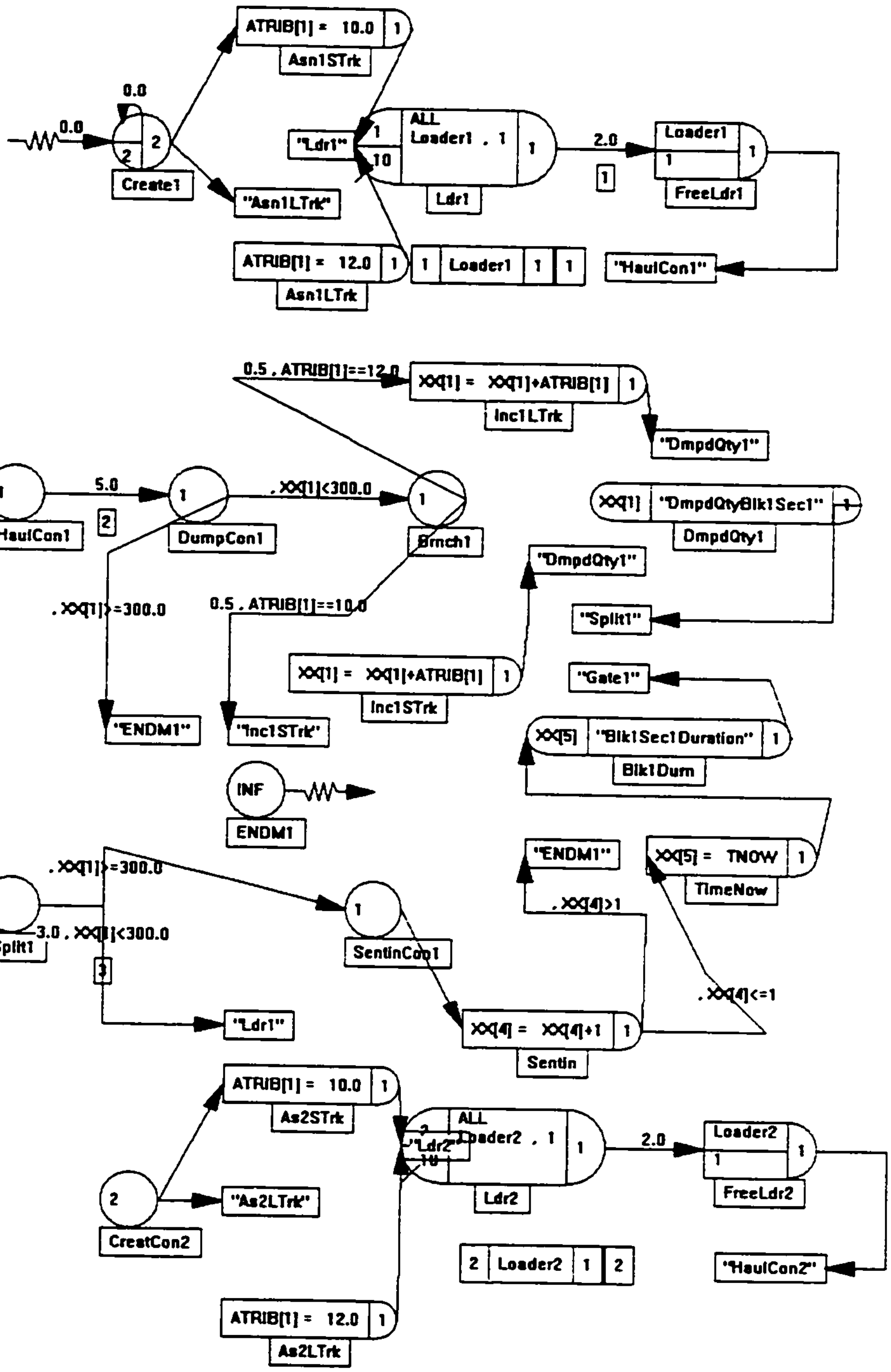

Figure 5.14a. Section I of the AWESIM simulation model developed for test # 1.

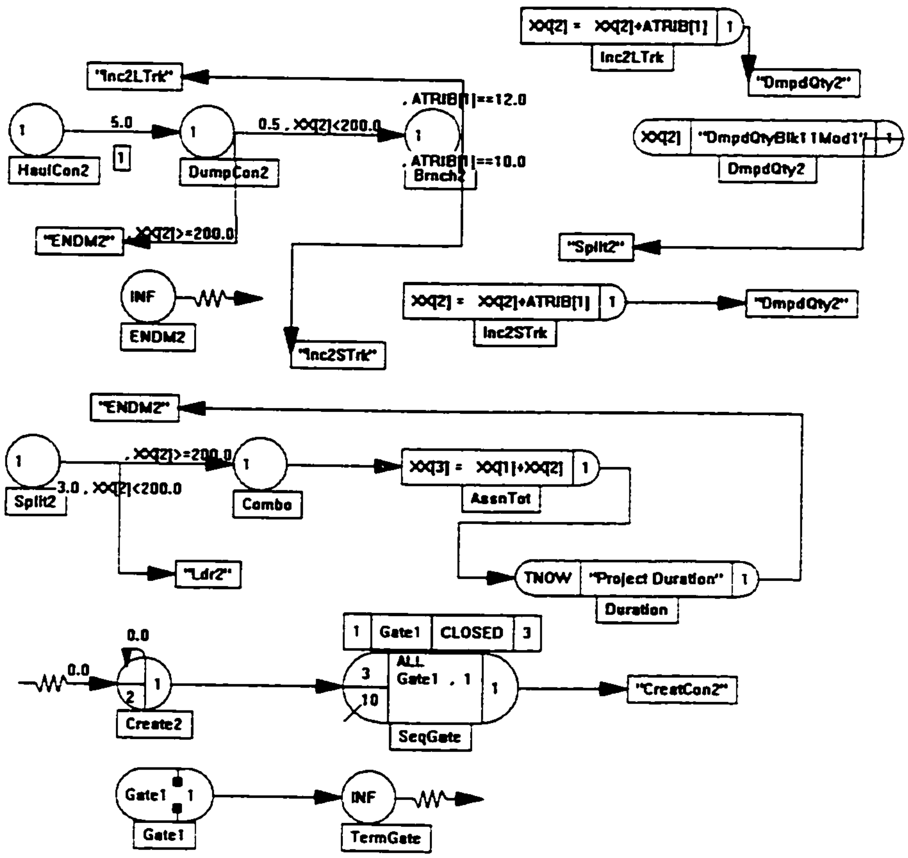

Figure 5.14b. Section II of the AWESIM simulation model developed for test # 1.

Attribute 1 of the other two trucks (D300Bs) is assigned the value 12.0 which is the volume of material in cubic meters that the D300B carries per trip. If the loader is free, a truck which arrives at the "AWAIT" node "Ldr1" is served by the loader and the loading of the truck takes place. The load time is 2.0 minutes. If the loader is not free, the truck enters a queue and waits for the loader to be free. After loading is completed the loader is released by the truck at the "FREE" node "FreeLdr1". The truck then performs the haul activity. Next, based on the type of truck, branching takes place to enable the proper collection of the quantity of material dumped. The truck performs the dumping activity. If the volume of material dumped is greater than or equal to the planned volume of the Section, then the truck entity is directed to a "GATE" node "Gate1" where it signals the start of operations involved for building the next Section. If the volume of material dumped is less than the planned volume of the Section, then the truck executes the return activity and goes to the "AWAIT" node. Once the signal to start the operations involved in the construction of the next section is received by "Gate1", it releases all the trucks waiting at the "AWAIT" node "SeqGate" and the sequence of operations described in constructing the previous section is repeated.

Appendices C and E present the complete standard AWESIM summary reports for test #1 and test #2 respectively. The format of the standard AWESIM summary report is fixed and cannot be modified from within AWESIM. As a result some of the information presented in these reports is neither applicable nor relevant to the validation exercises presented in this thesis. An edited version of the AWESIM summary report is presented in Table 5.2. It contains the categories of information that is relevant to test # 1. Although the results presented in the table pertain to test # 1, the categories of the information presented are applicable to test # 2 also.

** AweSim! SUMMARY REPORT **
Mon Dec 15 03:13:12 1997
Simulation Project : CONFIGSIM_2 Validation Test # 1
Modeler : Mohan Raj Manavazhi
Date : 10/24/97

Run number 1 of 1
Current simulation time : 138.000000

** OBSERVED STATISTICS REPORT **

Label	Maximum Value
DmpdQtyBlk1Sec1	308.0000000
Blk1Sec1Duration	76.5000000
DmpdQtyBlk2Sec1	208.0000000
Project Duration	130.0000000

** RESOURCE STATISTICS REPORT **

Resource Number	Resource Label	Average Util.
1	LOADER1	0.4492754
2	LOADER2	0.3188406

Table 5.2. Condensed AWESIM summary report showing categories of information relevant to validation tests.

Verification in Test # 1

As mentioned in section 5.4, verification will be done by observation of a step-by-step trace. Figure 5.15 shows a partial trace generated by CONFIGSIM_2 during the running of test # 1. Line numbers have been added to facilitate the explanation of the trace. A complete listing of the trace produced by CONFIGSIM_2 is provided in Appendix B.

```
S Y S T E M     V A L I D A T I O N
-----------------------------------

1. Checking Resource Sufficiency for
BlkR21-Mod1.....
2.                                          .......OKAY
3. Proceeding with Simulation.....

4. Current Time: 0.000000
5. At Loader - BlkR21-Mod1- Trk D250B-1
6. Acquired by BlkR21-Mod1-Trk D250B-1
7. Loading-Trk-D250B-1-BlkR21-Mod1
8. Load Time: 2.000000


9. Current Time: 0.000000
10. At Loader - BlkR21-Mod1- Trk D250B-2

11. Current Time: 0.000000
12. At Loader - BlkR21-Mod1- Trk D300B-1

13. Current Time: 0.000000
14. At Loader - BlkR21-Mod1- Trk D300B-2
15. Released by BlkR21-Mod1-Trk D250B-1

16. Acquired by BlkR21-Mod1-Trk D250B-2
17. Loading-Trk-D250B-2-BlkR21-Mod1
18. Load Time: 2.000000

19. Current Time: 2.000000
20. Hauling-Trk-BlkR21-Mod1-Trk D250B-1
21. Haul Time: 5.000000

22. Released by BlkR21-Mod1-Trk D250B-2

23. Acquired by BlkR21-Mod1-Trk D300B-1
24. Loading-Trk-D300B-1-BlkR21-Mod1
25. Load Time: 2.000000

26. Current Time: 4.000000
27. Hauling-Trk-BlkR21-Mod1-Trk D250B-2
28. Haul Time: 5.000000

29. Released by BlkR21-Mod1-Trk D300B-1

30. Acquired by BlkR21-Mod1-Trk D300B-2
31. Loading-Trk-D300B-2-BlkR21-Mod1
32. Load Time: 2.000000
```

Figure 5.15. Partial trace produced by CONFIGSIM_2 during test # 1.

When reading the trace the following points should be kept in mind:

(a) To clearly distinguish the trucks, the two D250B trucks will be identified as D250B-1 and D250B-2. Similarly, the two D300B trucks will be identified as D300B-1 and D300B-2.

(b) The term "Mod" is synonymous with "Section" and the term "Blk" is synonymous with "MatBlock".

Line 1: CONFIGSIM_2 is informing the user that it is checking the sufficiency of resources for conducting the simulation of Section1 of MatBlock1.

Line 2: CONFIGSIM_2 confirms resources are sufficient.

Line 3: CONFIGSIM_2 informs the user that it is proceeding with the simulation of Section1 of MatBlock1.

Line 4: Current time is 0.000000 minutes into simulation.

Line 5: Truck D250B-1 arrives at the loader.

Line 6: Truck D250B –1 acquires the loader.

Line 7: Truck D250B-1 is being loaded.

Line 8: The load time for loading truck D250B-1 is 2 minutes.

Line 9: Current Time is 0.000000 minutes into simulation.

Line 10: Truck D250B-2 has arrived at the loader.

Line 11: Current Time is 0.000000 minutes into simulation.

Line 12: Truck D300B-1 has arrived at the loader.

Line 13: Current Time is 0.000000 minutes into simulation.

Line 14: Truck D300B-2 has arrived at the loader.

Line 15: Truck D250B-1 has completed loading and released loader (@ Time 2.000000 minutes).

Line 16: Truck D250B-2 has acquired the loader.

Line 17: Truck D250B-2 is being loaded.

Line 18: Load Time is 2.0 minutes.

Line 19: Current Time is 2.000000 minutes into simulation.

Line 20: Truck D250B-1 is hauling.

Line 21: Haul Time is 5.0 minutes.

Line 22: Truck D250B-2 has completed loading and has released loader (@ 4.000000 minutes).

Line 23: Truck D300B-1 has acquired the loader.

Line 24: Truck D300B-1 is loading.

Line 25: Loading Time is 2.0 minutes.

Line 26: Current Time is 4.000000 minutes into simulation.

Line 27: Truck D250B-2 is hauling.

Line 28: Haul Time is 5.000000 minutes.

Line 29: Truck D300B-1 has completed loading and released loader (@ 6.000000 minutes).

Line 30: Truck D300B-2 has acquired loader.

Line 31: Truck D300B-2 is loading.

Line 32: Load Time is 2.0 minutes.

Validation - Comparison of Results in Test # 1

The results of test # 1 are tabulated in Table 5.3. The information presented in this table were obtained from the CONFIGSIM_2 trace report for test # 1 presented in Appendix B and the AWESIM Summary Report for test # 1 presented in Appendix C.

Item	CONFIGSIM_2	AWESIM
Project Duration	130 minutes	130 minutes
MatBlock1-Section1 Duration	76.5 minutes	76.5 minutes
MatBlock2-Section1 Duration	53.5 minutes	53.5 minutes
Dumped Quantity MatBlock1-Section1	308 cubic meters	308 cubic meters
Dumped Quantity MatBlock2-Section1	208 cubic meters	208 cubic meters
Resource Utilization Loader1	0.76	0.45 (Uncorrected) 0.45 x CF1 = 0.81 (Corrected)
Resource Utilization Loader2	0.75	0.31 (Uncorrected) 0.31 x CF2 = 0.80 (Corrected)

Table 5.3.Comparison of CONFIGSIM_2 and AWESIM simulation results in test # 1.

Table 5.3 shows that the results from the simulation model obtained from CONFIGSIM_2 exactly matches the results obtained from the manually generated simulation model developed using AWESIM in five of the seven items. The discrepancy in the values of resource utilizations for Loader1 and Loader2 is mainly due to the resource utilization for the manually generated simulation model being calculated based on the total simulation time instead of the durations for the completion of the individual MatBlocks. Therefore, a correction factor has to be applied which is given by:

Correction Factor (CF) = (Total simulation time / Duration of MatBlock)

Thus,

CF1 (for first MatBlock) = 138 / 76.5

= 1.8

CF2 (for second MatBlock2) = 138/53.5

= 2.58

A complete, standard summary report generated by AWESIM for this test is provided in Appendix C.

Scenario for Test #2

For the second test, the aim was to check whether with substantially larger volumes of material being used, the results obtained when using the simulation model created by the automated model generator agreed with those obtained when using the AWESIM model.

The structure for test #2 consisted of two MatBlocks, each made up of one section. The total volume of the structure chosen was 2000 cu. m. The volume of material in the first MatBlock was 1200 cu. m. and that in the second MatBlock was 800 cu.m. The material for the two MatBlocks came from two separate sources. Each source had a front dumping, CAT-235C front shovel loader. The 235C loads 3.0 cu. m. of material on to the truck per (loader) cycle. The hauling units for each section consisted of two CAT-D250B and two CAT-D300B articulated dump trucks. The D250B carries 10.0 cu. m. of material per trip and the D300B carries 12.0 cu. m. of material per trip. The resource and structural details for the exercise are specified in Figure 5.16. The environment details are specified in Figure 5.17.

1. (Information about the structure)
Total Volume : 2000 cu.m.

2. (Information about resources available. Under each item, the information is provided in the format [Type, Number])

Dozers	Loaders	Trucks
D9N 3	235C 3	D250B 3
D8N 3		D300B 3

3. (Truck Times (in minutes))
(Haul – High) 5.0; (Haul – Low) 5.0
(Return – High) 3.0; (Return – Low) 3.0

4. (Information about resources required. Under each item, the information is provided in the format [Type, Capacity (cu. m.), Number] for trucks and [Type, Number] for loaders. The integer number under each item represents the number of types of each item)

Loaders	Trucks
1	2
235C 2	D250B 10.0 2
	D300B 12.0 2

5. (Information about structural components)
MatBlock1
(Lifts) 1
(Section Details)
(Name) Mod1
(Volume) 1200
(Logical Constraint):
Block 2-Section 1 - Block 1-Section 1
MatBlock2
(Lifts) 1
(Section Details)
(Name) Mod1
(Volume) 800

Figure 5.16. Text-based resource and structural details for test #2.

1. (Information about sources of material)
   (Number of sources) 2

   (Source_1)
   (Volume) 2000

   (Source_2)
   (Volume) 2500

2. (Information about roads)
   Source: Source1
   Destination: MatBlock1

   Source: Source2
   Destination: MatBlock2

   (Details of trucks)
   (Truck Type) D250B
   (Speed when loaded) 24 kmph
   (Speed when empty) 30 kmph

   (Truck Type) D300B
   (Speed when loaded) 20 kmph
   (Speed when empty) 28 kmph

Figure 5.17. Text-based environment information for test # 2.

Using this scenario, a verification test was carried out by observing a step-by-step trace produced by CONFIGSIM_2. The validation test was carried out by first executing the simulation model developed by CONFIGSIM_2 and then running a manually generated simulation model developed using AWESIM. The results obtained using the two approaches were compared. All task durations used in test were deterministic. The manually generated AWESIM simulation model is similar to that shown in Figures 5.14a and 5.14b.

Verification in Test # 2

As in the case of test # 1, verification is done by observation of a step-by-step trace. Figure 5.18 presents a partial trace developed by CONFIGSIM_2 for the scenario in test # 2. A complete listing of the trace is presented in Appendix D.

```
S Y S T E M     V A L I D A T I O N
-----------------------------------

Checking Resource Sufficiency for BlkR21-Modl.....
                                      .......OKAY
Proceeding with Simulation.....

Current Time: 0.000000
At Loader - BlkR21-Modl- Trk T1-1
Acquired by BlkR21-Modl-Trk T1-1
Loading-Trk-T1-1-BlkR21-Modl
Load Time: 2.000000


Current Time: 0.000000
At Loader - BlkR21-Modl- Trk T1-2

Current Time: 0.000000
At Loader - BlkR21-Modl- Trk T2-1

Current Time: 0.000000
At Loader - BlkR21-Modl- Trk T2-2
Released by BlkR21-Modl-Trk T1-1

Acquired by BlkR21-Modl-Trk T1-2
Loading-Trk-T1-2-BlkR21-Modl
Load Time: 2.000000

Current Time: 2.000000
Hauling-Trk-BlkR21-Modl-Trk T1-1
Haul Time: 5.000000

Released by BlkR21-Modl-Trk T1-2

Acquired by BlkR21-Modl-Trk T2-1
Loading-Trk-T2-1-BlkR21-Modl
Load Time: 2.000000
```

Figure 5.18. Partial trace produced by CONFIGSIM_2 during test # 2.

Validation - Comparison of Results in Test # 2

The results of the test # 2 conducted are tabulated in Table 5.4. The information presented in this table were obtained from the CONFIGSIM_2 trace report for test # 2 presented in Appendix D and the AWESIM Summary Report for test # 2 presented in Appendix E.

Item	CONFIGSIM_2	AWESIM
Project Duration	489.5 minutes	489.5 minutes
MatBlock1-Section1 Duration	293 minutes	293 minutes
MatBlock2-Section1 Duration	196.5 minutes	196.5 minutes
Dumped Quantity MatBlock1-Section1	1208 cubic meters	1208 cubic meters
Dumped Quantity MatBlock2-Section1	802 cubic meters	802 cubic meters
Resource Utilization Loader1	0.77	0.46 (Uncorrected) 0.45 x CF1 = 0.78 (Corrected)
Resource Utilization Loader2	0.76	0.31 (Uncorrected) 0.31 x CF2 = 0.78 (Corrected)

Table 5.4.Comparison of CONFIGSIM_2 and AWESIM simulation results in test # 2.

Table 5.4 shows that the results from the simulation model obtained from CONFIGSIM_2 exactly matches the results obtained from the manually generated simulation model developed in AWESIM in five of the seven items. The complete, standard AWESIM summary report for test # 2 is presented in Appendix E.

The discrepancy in the values of resource utilizations for Loader1 and Loader2 is mainly due to the resource utilizations for the manually generated simulation model being calculated based on the total simulation time instead of the durations for the completion of the individual MatBlocks. Therefore, a correction factor has to be applied which is given by:

Correction Factor (CF) = (Total simulation time / Duration of MatBlock)

Thus,

CF1 (for first MatBlock) = 495 / 293

= 1.7

CF2 (for second MatBlock2) = 495/202

= 2.5

The results obtained by the manual and automated model generation method in both tests 1 and 2 were in almost total agreement.

5.4.2 SAMPLE APPLICATION

The automated model generator is capable of handling far more complicated structures than presented in tests 1 and 2. However, generating simulation models manually in AWESIM would be extremely difficult for such scenarios.

The structure chosen for the sample application consists of six MatBlocks. Each MatBlock is made up of two sections. The total volume of the structure is 900 cubic meters. The volume of material in each of MatBlocks 1, 2 and 3 is 100 cubic meters while that in each of MatBlocks 4, 5 and 6 is 200 cubic meters.

The material for the MatBlocks comes from three separate sources. Material for MatBlocks 1 and 4, which form Zone A comes from Source A, that for MatBlocks 2 and 5, which form Zone B from Source B and for MatBlocks 3 and 6 which form Zone C from Source C. The operations involved for constructing Zones A, B and C take place concurrently. However, Zones A and C lag behind Zone B by one lift.

Each source has a front dumping, CAT-235C front shovel loader. The 235C loads 3.0 cu. m. of material on to the truck per (loader) cycle. Each source also has a CAT-D9N bulldozer which piles material for the loader. The D9N piles 10 cu. m. of material per cycle. The hauling fleet for each section consists of two CAT-D250B and two CAT-D300B articulated dump trucks. The D250B carries 10.0 cu. m. of material per trip and the D300B carries 12.0 cu. m. of material per trip.

Structure and resource details for the exercise are specified in Figure 5.19, structural component details are specified in Table 5.5, travel times for trucks and dozers are presented in Table 5.6 and environment details are specified in Figure 5.20. Travel times used in the sample application are non-deterministic and uniform distributions have been assumed.

The objectives of this exercise are: (1) arrive at the project duration, (2) obtain loader utilization efficiencies, (3) obtain cumulative production estimates, and (4) estimate the rate of production within the system.

1. (Information about the structure)
Total Volume : 900 cu.m.

2. (Information about resources available. Under each item, the information is provided in the format [Type, Number])

Dozers	Loaders	Trucks
D9N 5	235C 5	D250B 10
D8N 3		D300B 10

3. (Information about resources required. Under each item, the information is provided in the format [Type, Capacity (cu. m.), Number] for trucks and [Type, Number] for loaders. The integer number under each item represents the number of types of each item)

Loaders	Trucks	Dozers
1	2	1
235C 3	D250B 10.0 6	D9N 10.0 3
	D300B 12.0 6	

Figure 5.19. Structure and resource information for sample application.

(Information about structural components) MatBlock1 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 50 (Name) Mod2 (Volume) 50 (Logical Constraints): Block 1-Section 2 – Block 1-Section 1	(Information about structural components) MatBlock2 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 50 (Name) Mod2 (Volume) 50 (Logical Constraint): Block 2-Section 2 – Block 2-Section 1
(Information about structural components) MatBlock3 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 50 (Name) Mod2 (Volume) 50 (Logical Constraint): Block 3-Section 2 – Block 3-Section 1	(Information about structural components) MatBlock4 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 100 (Name) Mod2 (Volume) 100 (Logical Constraint): Block 4-Section 2 – Block 4-Section 1 Block4 – Block1
(Information about structural components) MatBlock5 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 100 (Name) Mod2 (Volume) 100 (Logical Constraint): Block 5-Section 2 – Block 5-Section 1 Block5 – Block2	(Information about structural components) MatBlock6 (Lifts) 2 (Section Details) (Name) Mod1 (Volume) 100 (Name) Mod2 (Volume) 100 (Logical Constraint): Block 6-Section 2 – Block 6-Section 1 Block6 – Block3

Table 5.5. Structural component details (MatBlocks 1 to 6) for sample application.

MatBlock1 Truck Times Haul-Low: 5.0 Haul-High: 6.0 Return-Low 4.0 Return-High 5.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4	**MatBlock4** Truck Times Haul-Low: 4.0 Haul-High: 5.0 Return-Low 3.0 Return-High 4.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4
MatBlock2 Truck Times Haul-Low: 5.0 Haul-High: 6.0 Return-Low: 4.0 Return-High: 5.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4	**MatBlock5** Truck Times Haul-Low: 4.0 Haul-High: 5.0 Return-Low 3.0 Return-High 4.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4
MatBlock3 Truck Times Haul-Low: 5.0 Haul-High: 6.0 Return-Low 4.0 Return-High 5.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4	**MatBlock6** Truck Times Haul-Low: 4.0 Haul-High: 5.0 Return-Low 3.0 Return-High 4.0 Dozer Times Haul-Low: 0.4 Haul-High: 0.5 Return-Low: 0.3 Return-High: 0.4

Table 5.6. Truck and dozer travel times for sample application.

1. (Information about sources of material)
(Number of sources) 3
(Source_1)
(Volume) 3000 cu. m.

(Source_2)
(Volume) 2000 cu. m.

(Source_3)
(Volume) 2000 cu. m.

2. (Information about roads)
Source: Source_1
Destinations: MatBlock1, MatBlock4

Source: Source_2
Destination: MatBlock2, MatBlock5

Source: Source_3
Destination: MatBlock3, MatBlock6

(Details of trucks)
(Truck Type) D250B
(Speed when loaded) 24 kmph
(Speed when empty) 30 kmph

(Truck Type) D300B
(Speed when loaded) 20 kmph
(Speed when empty) 28 kmph

Figure 5.20. Environment information for sample application.

Results

The results of running the simulation with the automatically generated simulation model for the sample application is shown in Table 5.7. Durations and loader utilization values for each of the six MatBlocks as well as for the whole structure were obtained. The total time required to construct the structure was found to be 116.28 minutes. The time taken to construct each of the MatBlocks was also calculated and is presented in the same table.

A loader utilization factor (UF) for the entire project was calculated. The UF could serve as a measure of the efficiency of the use of resources in the project. In the case of the sample application, the UF was found to be 0.43. The higher the UF value the more efficient is the utilization of resources on the project. In addition, UF values for each MatBlock was calculated. Restructuring the fleet configurations to obtain higher UF values would help realize more efficient utilization of resources. In the case of the sample application, this could be achieved by increasing the number of trucks used.

Item	**Duration (Minutes)**	**Average Loader Utilization**
Structure	116.28	0.43
MatBlock1	39.84	0.41
MatBlock2	38.99	0.42
MatBlock3	39.67	0.40
MatBlock4	53.67	0.46
MatBlock5	56.68	0.42
MatBlock6	54.57	0.44

Table 5.7. Duration and resource utilization values for sample application simulation using CONFIGSIM_2.

A study of the simulation results will also provide the user with information about the following:

1) Cumulative production achieved over time.

2) The rate of production achieved over time.

Cumulative Production Curve

A typical cumulative production curve for a Matblock is shown in Figure 5.21. The cumulative production curve provides the user with a graphical representation of the total production achieved at the point in time at which such a determination is made. The user can also assess the volume of work that will have to be done to complete the particular component of the structure or the structure itself at any particular point in time. Production figures for a typical MatBlock (MatBlock4 in this case) are presented in Table 5.8. Cumulative production and rate of production curves were developed based on these production figures.

Time (mins.)	Volume Completed (cu. m.)	Production Rate (cu. m.)
0.00	0.0	0.00
7.29	12.0	1.65
7.65	24.0	3.14
9.10	34.0	3.74
10.44	44.0	4.21
16.96	56.0	3.30
17.81	68.0	3.82
18.76	78.0	4.16
19.52	88.0	4.51
27.10	100.0	3.69
35.33	112.0	3.17
35.69	124.0	3.47
37.14	134.0	3.61
38.30	144.0	3.76
45.04	156.0	3.46
46.00	168.0	3.65
46.83	178.0	3.80
47.43	188.0	3.96
54.62	200.0	3.66

Table 5.8. Production figures for a typical MatBlock in the sample application.

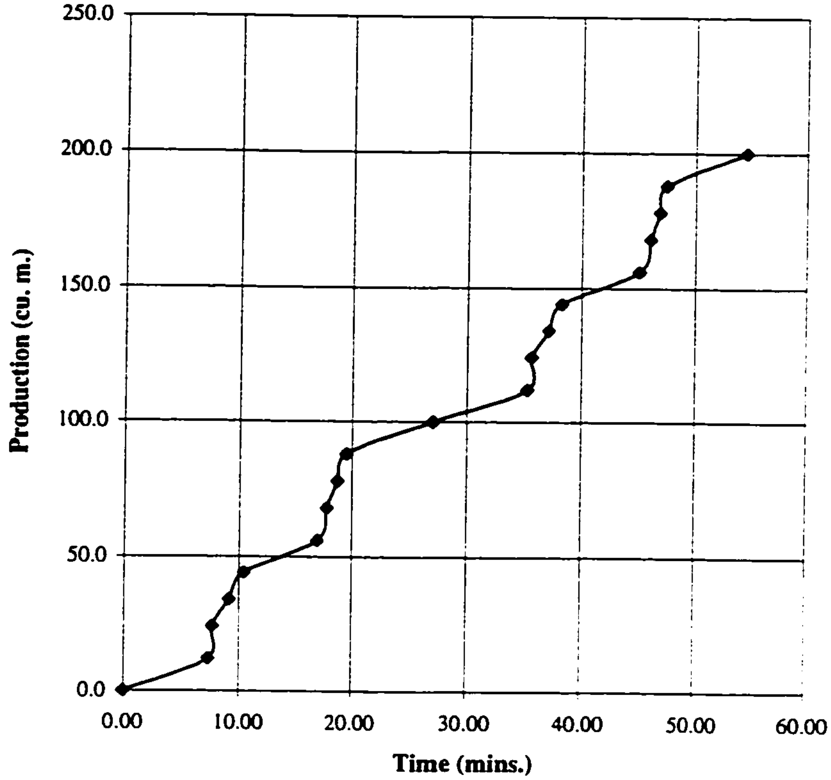

Figure 5.21. Typical cumulative production curve for MatBlocks.

Rate of Production Curve

The rate of production curve provides the user with information about the production achieved over time, for example, the volume of material deposited at a specified destination, in a unit of time. Figure 5.22 shows a typical rate of production curve for MatBlocks.

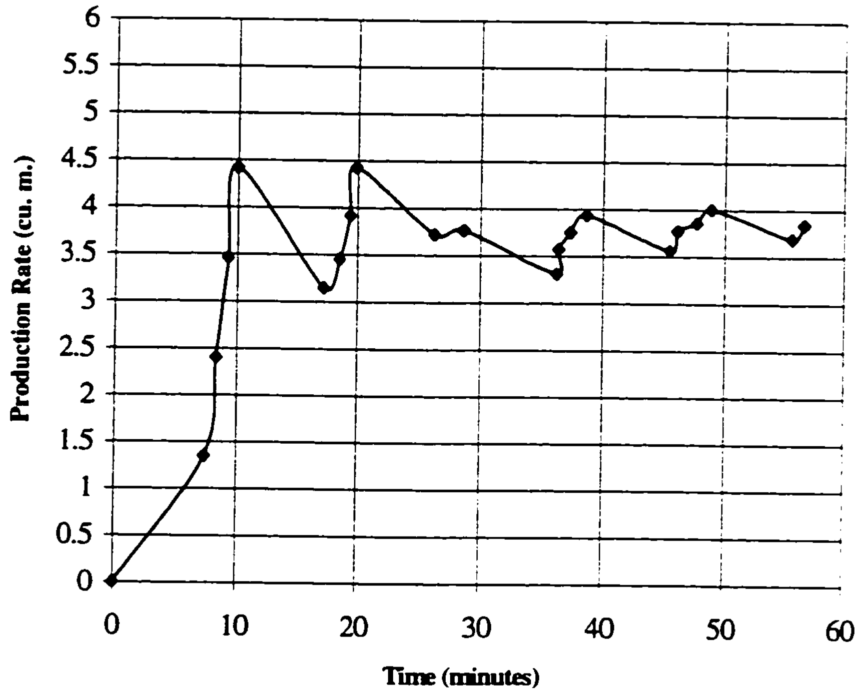

Figure 5.22 Typical rate of production curve for MatBlocks.

This rate of production is normally specific for a particular scenario. Thus, for any particular scenario the rate of production of the system can be obtained by simulation experiments and a determination made whether such a rate of production is consistent with the project objectives. Necessary action can then be initiated to address any potential shortfalls in total production. In Figure 5.22, some transient behavior in the system can be clearly observed. This behavior gradually reduces with the passage of time and approaches steady state behavior. From the graph, it is clear that the sample application system is converging to a rate of production of approximately 3.7 cubic meters per minute.

The production statistics have been collected for one MatBlock (MatBlock4) for purposes of illustration. However, similar statistics could be collected for other components of the structure.

5.5 LIMITATIONS OF CONFIGSIM_2

The current version of CONFIGSIM_2 has the following limitations:

1) CONFIGSIM_2 is a special-purpose simulation software tool. It is geared specifically to generate simulation models of earth-filled dams and does not possess the flexibility to generate simulation models of other projects like high-rise building projects, pipeline projects etc.
2) It does not have a sophisticated user interface. The present user interface is largely based on ASCII-files for input and output.
3) In the current version of CONFIGSIM_2, production information has to be exported to spreadsheets manually for processing and generation of graphs. A seamless interface between the model generator and spreadsheets and / or database applications would make it more user-friendly.
4) At present, CONFIGSIM_2 uses only the uniform distribution. It does not provide the user with a choice of distributions from which a suitable selection could be made.

A complete listing of the computer source code for CONFIGSIM_2 is presented in Appendix F.

5.6 CONCLUSIONS

This chapter presented the details of development and testing of a prototype aimed at demonstrating the validity of the configuration-based modeling methodology for automatically generating simulation models of structures with specific configurations. In particular, it demonstrated the use of the prototype developed in this research for simulating the operations involved in the construction of earth-filled dams. It also demonstrated the power of combining object-oriented programming with discrete-event simulation for developing complex computer-based simulation tools for automatically generating simulation models.

6

CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

This thesis presented an automated simulation modeling methodology called Configuration-Based Simulation Modeling (CBSM) which is based on the configuration of the structure that is to be constructed. The CBSM methodology serves as a vehicle for the transformation of high-level descriptions of a construction operation required to construct a structure with a specific configuration. The CBSM methodology addresses the issue of automatically generating the simulation model while explicitly taking into consideration the configuration of the structure.

The CBSM methodology is made up of two distinct phases:

1) The Structural Decomposition Phase, and

2) The Automated Model Generation Phase

In the Structural Decomposition Phase, specially formulated Structural Decomposition Criteria (SDC) are utilized for the systematic and hierarchical decomposition of a structure to a level that will facilitate the application of one or more simulation processes. The output of the Structural Decomposition Phase, is the Structural Decomposition hierarchy, which is essentially a product-centric breakdown of the structure.

The object-oriented programming paradigm is ideally suited for the development of computer-based, automated simulation model generators. The automated model generator is made up of a well-defined group of SIMOBJECTS. From the perspective of automated model generation, SIMOBJECTS provide modularity and reusability – properties essential for the automated generation of simulation models.

6.1.1 REALIZATION OF OBJECTIVES

The *primary objective* of this research was to develop a methodology for automating the process of generating simulation models of construction operations required for building a structure with a specific configuration.

Realization of the primary research objective involved achieving the following sub-objectives:

1) Development of a framework for the systematic and hierarchical decomposition of the structure that is to be constructed.
2) Development of a computer-based, object-oriented simulation-modeling tool for transforming high-level descriptions of a project into a working simulation model.

The first sub-objective was realized in Chapter 3 with the development of the Structural Decomposition Criteria (SDC). The Structural Decomposition Criteria provides a flexible set of guidelines to systematically develop a structural decomposition hierarchy. The main purpose of the structural decomposition hierarchy is to provide a level of decomposition of the structure at which simulation processes can be meaningfully applied.

The second sub-objective was realized in Chapter 4 with the development of the concept of a SIMOBJECT and the System Architecture for putting together a tool that would automatically generate a working simulation model from high-level descriptions of the project without user intervention. In the work described in Chapter 6, actual development of simulation models with AWESIM showed that the ratio of the time spent in developing a simulation model using CONFIGSIM_2 to that using AWESIM was in the region of 1:30.

The *secondary objective* of this research was to demonstrate the feasibility of combining object-oriented technology with discrete event simulation to produce frameworks that would facilitate the development of simulation tools capable of automatically generating simulation models of the construction operations. This objective was realized in Chapters 4 and 5. Chapter 4 laid the foundation for the realization of this objective with development of the theoretical framework and concepts for the object-oriented automated simulation-modeling tool. Chapter 5 described the development and testing of CONFIGSIM_2 - an automated model generation tool for simulating the construction process of earth-filled dams using the concepts laid down in Chapter 4.

6.2. RESEARCH CONTRIBUTIONS

The primary contributions of this research are:

1) Development of a methodology for the automated generation of simulation models of the operations required for the construction of a structure with a specified configuration.
2) Development of the product-centric Structural Decomposition Criteria (SDC) for facilitating the systematic and hierarchical decomposition of the structure to a level that will afford the meaningful application of simulation processes to the components of that level.
3) Demonstration of the feasibility of combining object-oriented technology with discrete event simulation to produce frameworks that would facilitate the development of simulation tools capable of automatically generating simulation models of the construction operations that need to be analyzed.
4) Development of the concept of a SIMOBJECT – a modular and reusable representation of simulation and software entities which could be organized into a working program.
5) Development of a system-architecture for an object-oriented, model-generation tool for the automated generation of simulation models in construction.
6) Development of an object-oriented, simulation-modeling tool for the automated generation of simulation models for the construction of earth filled dams.

6.3. RECOMMENDATIONS

The following is a list of recommendations for further research:

1) **Integration with CAD**

   Much of the information provided in the form of text files can be directly obtained from CAD. SIMOBJECTS developed in this application could be linked to objects in CAD drawings and information obtained directly from such files.

2) **Animation**

   Providing animation capabilities will significantly enhance the value of the tool to the construction practitioner. It will also be a good method for verification of the simulation models generated.

3) **Validation**

   A more powerful method of validation than the one used in this research is required. The best approach would be to obtain actual information from the site and compare it with the results provided by the simulation model. However, currently available simulation literature does not cover practical methods of performing validation of computer-based simulation systems geared towards simulating construction operations involved in building a structure with specific configurations.

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APPENDIX A

Computer Program Code for CONFIGSIM_1

```
#include <stdio.h>
#include <iostream.h>
#include "queuing.h"
#include <ctype.h>
#include <string.h>
#include <stdlib.h>

const int N=5;     //iterno
const int lag=10;
const int N_SCRP=1;
const int N_TRK=5;
const int N_LDR=1;
const int N_DOZ=1;
const int N_CMPCT=1;
const int SCRP_PRIO=10;
const int DOZ_PRIO1=15;
const int DOZ_PRIO2=4;
const int DUMTRK_PRIO=4;
const int TRK_PRIO=10;
const int INCR_TRK_PRIO=10;
const int CMPCT_PRIO=1;
const double CMPCT_RAT=1; // m3/min
const double MAX_CAP_TRK=20.0; // {used to check min load avail
const double PRESNT_LF=0.5;    // at pile}
const double CMPCT_STRT_PT=15; //m3
const double CMPCT_END_PT=20;
const double CMPCT_SPRED_LEAD=5.0; //m3
const double COMPVOL=0.0;
const double SUBSTRVOL=1000.0;

/*double SubStrMod(*/

enum{
      GenDoz,GenTrk,GenLdr,GenScrp,GenCmpct,GenWtrTrk,StrtPil,
      ReqDozPil,RelDozPil,EndPil,StrtRet,EndRet,ConvenRelDozPil,
      ReqPil,RelPil,ChkPil,ReqLdr,RelLdr,StrtLd,EndLd,StrtHl,
      ReqIntL,EntIntL,ExitIntL,RelIntL,EndHl,StrtTrkRet,
      EndTrkRet,ReqLayr,StrtDmp,EndDmp,StrtSLd,ReqPsher,
      SpotPsher,RelPsher,StrtSPLd,EndSLd,EndSPLd,
      StrtSHl,EndSHl,StrtSSpred,EndSSpred,StrtSPSpred,
      EndSPSpred,StrtSPHl,EndSPHl,ReqSLayr,RelSLayr,
      StrtSRet,EndSRet,StrtSPRet,EndSPRet,ReqIntE,EntIntE,
      ExitIntE,RelIntE,StrtWtrng,EndWtrng,StrtCmpct,EndCmpct,
      ChkLayr,ReqCmpctLayr,RelLayr,RelCmpctLayr
      };
```

```
TOKEN vehicle;
int ElemNo;

void main(){
      FILE *fpL, *fpT, *fpC,*fpD, *fp;
      int i=0,j=0,event,psher,cmpct,ldr,VehNum,TrkOut=0;
      char VehConfig[10];
      int tripno=1,intsecn,layr,stat,pil,dozprio,TotElems;
      int NumLoad, NumComp, NumTruck,NumDoz;
      double ScrpOut=0.0,dmpdqty=0.0,balqty=0.0;
      double newspredqty=0.0,DozCycOut=0.0; //dozer output/cycle
      double cmpctime=0.0,cmpctqty=0.0,cmpctrat=0.0;
      double pildqty=0.0,tnow=0.0;
      int Hi=0, Lo=0;
      char prep,eqpmt,pusher;
      double ComplVol;
      int SubStrVol;
      double DozHlPrmA=2.0;
      double DozHlPrmB=4.0;
      double DozMnvrPrmA=0.5;
      double DozMnvrPrmB=1.0;
      double DozRetPrmA=1.5;
      double DozRetPrmB=2.5;
      double LdrPrmA=3.0;
      double LdrPrmB=4.0;
      double TrkHl1LPrmA=4.0;
      double TrkHl1LPrmB=5.0;
      double TrkHl2LPrmA=4.0;
      double TrkHl2LPrmB=5.0;
      double TrkDmpPrmA=0.5;
      double TrkDmpPrmB=1.0;
      double TrkRet1EPrmA=3.0;
      double TrkRet1EPrmB=4.0;
      double TrkRet2EPrmA=2.0;
      double TrkRet2EPrmB=3.0;
      double CmpctPrmA=2.0;
      double CmpctPrmB=15.0;
      double BldCapPrmA=3.0; //Doz/m3
      double BldCapPrmB=6.0; //Doz/m3
      double CmpctMnvrPrmA=0.5;
      double CmpctMnvrPrmB=1.5;
      double ScrpLdPrmA=1.5;
      double ScrpLdPrmB=2.0;
      double ScrpHlPrmA=4.5;
      double ScrpHlPrmB=5.5;
      double ScrpSRetPrmA=3.5;
      double ScrpSRetPrmB=4.5;
      double ScrpSPLdPrmA=2.0;
      double ScrpSPLdPrmB=2.5;
      double ScrpSPRetPrmA=3.5;
      double ScrpSPRetPrmB=4.5;
      double ScrpSPHlPrmA=3.0;
      double ScrpSPHlPrmB=3.5;
      double SpotPrmA=0.7;
      double SpotPrmB=1.0;
```

```
        double ScrpSSpredPrmA=2.0;
        double ScrpSSpredPrmB=2.5;
        double ScrpSPSpredPrmA=2.0;
        double ScrpSPSpredPrmB=2.5;
        double PsherRetPrmA=0.7;
        double PsherRetPrmB=1.0;
      char Dozfilnam[23]="d:/OSimp/DozDet";
      char *filnam, *Elem1;
      int Num=5;
      char Elem[10];
      Elem1=Elem;
      char ElemNum[5]="5";
      _itoa(Num,Elem1,10);
      //ElemNo+=1;
        filnam=strcat(Dozfilnam,ElemNum);

        init_simpack();
        //psher=create_facility("PUSHER",1);
        //ldr=create_facility("LOADER",N_LDR);
        //intsecn=create_facility("INTERSECTION",1);
        //pil=create_facility("PREPSOIL",N_LDR);
        layr=create_facility("EMBANKMENT",1);
        cmpctrat=uniform(CmpctPrmA,CmpctPrmB);
        //printf("Preparation? (Y/N): ");
        //scanf("%c",&prep);
        //printf("\n\n");
        //printf("\n\nEqpmt.used for haul [(S)craper/(T)ruck &
Loader/)]: ");
        //scanf("%c",&eqpmt);
        //printf("\n\n");
        //printf("Compactor?(Y/N): ");
        //scanf("%c",&cmpctr);
        //printf("\n\n");
        //eqpmt='t';
        prep='y';
        cmpct='y';

        /*vehicle.attr[0]=0;
        vehicle.attr[1]=DUMTRK_PRIO;
        schedule(GenDumTrk,0.0,vehicle);*/
        fp=fopen("d:/OSimp/tempest","w");
        fpD=fopen("d:/OSimp/DozDet","r");
        while(fscanf(fpD,"%c %d %d %d %s %d %d %d",
&eqpmt,&SubStrVol,&TotElems,&ElemNo,VehConfig,&VehNum,&Hi,&Lo)!=EOF){
        NumDoz=VehNum;
//      ElemNum=ElemNo;
        if(toupper(eqpmt)=='D'){
                for(i=1;i<=VehNum;i++){
                        vehicle.attr[0]=(float)i;
                        vehicle.attr[1]=DOZ_PRIO1;
                        vehicle.attr[2]=uniform(Hi,Lo);  //change this
                        schedule(GenDoz,0.0,vehicle);
                        }
                }
        }
```

```
	fclose(fpD);

	fpC=fopen("d:/OSimp/CompDet","r");
	while(fscanf(fpC,"%c %d %d %d %d %d",
&eqpmt,&SubStrVol,&TotElems,&ElemNo,VehConfig,&VehNum)!=EOF){
	NumComp=VehNum;
	if(toupper(eqpmt)=='C'){
		for(i=1;i<=VehNum;i++){
			vehicle.attr[0]=(float)i;
			vehicle.attr[1]=CMPCT_PRIO;
			vehicle.attr[2]=CMPCT_RAT;
			schedule(GenCmpct,0.0,vehicle);
			}

		}

	}
	fclose(fpC);

	fpL=fopen("d:/OSimp/LoadDet","r");
	while(fscanf(fpL,"%c %d %d %d %d",
&eqpmt,&SubStrVol,&TotElems,&ElemNo,&VehNum)!=EOF){
	NumLoad=VehNum;
	if(toupper(eqpmt)=='L'){
		ldr=create_facility("LOADER",VehNum);
		}
	}
	fclose(fpL);

/*	if (toupper(eqpmt)=='S') {
		printf("Pusher?(Y/N): ");
		scanf("%c",&pusher);
		for(i=1;i<=N_SCRP;i++){
			vehicle.attr[0]=(float)i;
			if(toupper(pusher)=='Y'){
				vehicle.attr[3]=1.0;	//pusher reqd
				vehicle.attr[1]=SCRP_PRIO;
				vehicle.attr[2]=20.0;
				schedule(GenScrp,0.0,vehicle);
				}
			else {
					vehicle.attr[3]=0.0;
					vehicle.attr[1]=SCRP_PRIO;
					vehicle.attr[2]=20.0;
					schedule(GenScrp,0.0,vehicle);
				}
			}
		}*/

	fpT=fopen("d:/OSimp/TrkDet","r");
	while(fscanf(fpT,"%c %d %d %d %s %d %d %d %d",
&eqpmt,&SubStrVol,&TotElems,&ElemNo,VehConfig,&TrkOut,&VehNum,&Hi,&Lo
)!=EOF){
	NumTruck=VehNum;
	if(toupper(eqpmt)=='T') {
```

```
        //trknum=N_TRK+1;
        for(i=1;i<=VehNum;i++){
              vehicle.attr[0]=(float)i;
              vehicle.attr[1]=TRK_PRIO;
              vehicle.attr[2]=TrkOut;
              schedule(GenTrk,0.0,vehicle);
              }
        }
 }
 fclose(fpT);

 /*if(toupper(eqpmt)=='D'){
       for(i=1;i<=N_DOZ;i++){
             vehicle.attr[0]=(float)i;
             vehicle.attr[1]=DOZ_PRIO1;
             vehicle.attr[2]=20.0;
             schedule(GenDoz,0.0,vehicle);
             }
       } */

 /*if(toupper(cmpct)=='Y'){
       for(i=1;i<=N_CMPCT;i++){
             vehicle.attr[0]=(float)i;
             vehicle.attr[1]=CMPCT_PRIO;
             vehicle.attr[2]=CMPCT_RAT;
             schedule(GenCmpct,0.0,vehicle);
       }

 }*/

 ComplVol=COMPVOL;
 //SubStrVol=SUBSTRVOL;
 //printf("VolLag:%f\n", PRESNT_LF*MAX_CAP_TRK);
 fprintf(fp,"Volume of earthwork required.:%f\n",SubStrVol);
 fprintf(fp,"Volume of earthwork transported:%f\n",ComplVol);
 while(ComplVol<SubStrVol){
 tnow=sim_time();
 //while((tnow=sim_time())<=27){
       next_event(&event,&vehicle);
       fprintf(fp,"\nTNOW:%f\n",tnow);
       //printf("Event: %d\n",event);
       switch(event){

       //dozer events
             case GenDoz:
                   schedule(StrtPil,0.0,vehicle);
                   update_arrivals();

 fprintf(fp,"GenDoz:Doz%d\n\n",(int)vehicle.attr[0]);
             break;

             case StrtPil:
             /*  if(pildqty<=PRESNT_LF*MAX_CAP_TRK){
                   dozprio=DOZ_PRIO1;
             //    release(pil,vehicle);
```

```
                        fprintf(fp,"PilReld\n");
        //              stat=request(pil,vehicle,dozprio);
                //      if(stat)
fprintf(fp,"Doz%dQd\n",(int)vehicle.attr[0]);
                        }else
                        if(pildqty>PRESNT_LF*MAX_CAP_TRK) */
                        schedule(ReqDozPil,0.0,vehicle);

    fprintf(fp,"StrtPil:Doz%d\n\n",(int)vehicle.attr[0]);
                break;

                case ReqDozPil:

    if((stat=(request(pil,vehicle,dozprio)))==FREE)

    schedule(EndPil,uniform(DozHlPrmA,DozHlPrmB),vehicle);
                        fprintf(fp,"DOZPRIO:%d\n",dozprio);
                        if(stat)
fprintf(fp,"Doz%dQd\n",(int)vehicle.attr[0]);

    fprintf(fp,"ReqDozPil:Doz%d\n\n",(int)vehicle.attr[0]);
                break;

                case EndPil:

    //schedule(StrtRet,uniform(DozMnvrPrmA,DozMnvrPrmB),vehicle);
                        pildqty+=uniform(BldCapPrmA,BldCapPrmB);
                        //if(pildqty>PRESNT_LF*MAX_CAP_TRK)
                                schedule(RelDozPil,0.0,vehicle);

    fprintf(fp,"EndDozPil:Doz%d\n",(int)vehicle.attr[0]);

    fprintf(fp,"MinPilQtyReqd:%f\n",PRESNT_LF*MAX_CAP_TRK);
                        fprintf(fp,"PildQty:%f\n\n",pildqty);
                break;

                case RelDozPil:
                        release(pil,vehicle);

    fprintf(fp,"PilReldDoz%d\n\n",(int)vehicle.attr[0]);
                        schedule(StrtRet,0.0,vehicle);
                break;

                case StrtRet:

    schedule(EndRet,uniform(DozRetPrmA,DozRetPrmB),vehicle);

    fprintf(fp,"StrtRetDoz%d\n\n",(int)vehicle.attr[0]);
                break;

                case EndRet:
                        /*if(pildqty<PRESNT_LF*MAX_CAP_TRK)
                                schedule(ConvenRelDozPil,0.0,vehicle);
                        else*/
                        schedule(StrtPil,0.0,vehicle);
```

```
        fprintf(fp,"EndRetDoz%d\n\n",(int)vehicle.attr[0]);
                  break;

                  case ConvenRelDozPil:
                       release(pil,vehicle);
                       schedule(StrtPil,0.0,vehicle);

 fprintf(fp,"ConvenRelDozPil%d\n\n",(int)vehicle.attr[0]);
                  break;


            //truck events
                  case GenTrk:
                        if(pildqty>PRESNT_LF*MAX_CAP_TRK)
                              schedule(ReqPil,0.1,vehicle);
//Truck's request after
                        else                                    //dozer's
request
                              schedule(ChkPil,0.0,vehicle);
                        update_arrivals();
                        //tripno=1;
                  break;

                  /*case GenDumTrk;
                        if(pildqty<=PRESNT_LF*MAX_CAP_TRK)
                              schedule(ReqPil,0.0,vehicle);
                  break; */

                  case ReqPil:
                        if((stat=request(pil,vehicle,0.0))==FREE)
                        schedule(ReqLdr,0.0,vehicle);

      fprintf(fp,"ReqPil:Trk%d\n",(int)vehicle.attr[0]);

      fprintf(fp,"TrkPrio:%d\n",(int)vehicle.attr[1]);
                        if(stat)
fprintf(fp,"TrkQd@Pil:Trk%d\n\n",(int)vehicle.attr[0]);
                  break;

                  case RelPil:
                        release(pil,vehicle);
                        schedule(StrtHl,0.0,vehicle);

      fprintf(fp,"PilReld@Pil:Trk%d\n\n",(int)vehicle.attr[0]);
                  break;

                  case ChkPil:
                        if(pildqty<=PRESNT_LF*MAX_CAP_TRK)
                              schedule(ChkPil,1.0,vehicle);
                        else
                              schedule(ReqPil,0.0,vehicle);

      fprintf(fp,"ChkPil:Trk%d\n\n",(int)vehicle.attr[0]);
                  break;
```

```
                    /*case ReqPil:
                          if(request(pil,vehicle,0.0)==FREE)
                                schedule(ReqLdr,0.0,vehicle);
                      break;*/

                    case ReqLdr:

       if((stat=request(ldr,vehicle,TRK_PRIO))==FREE)
                                schedule(StrtLd,0.0,vehicle);

       fprintf(fp,"ReqLdr:Trk%d\n",(int)vehicle.attr[0]);
                          if(stat)
 fprintf(fp,"TrkQd@Ldr:Trk%d\n\n",(int)vehicle.attr[0]);

                    break;

                    case StrtLd:

       schedule(EndLd,uniform(LdrPrmA,LdrPrmB),vehicle);

       fprintf(fp,"StrtLd:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;

                    case EndLd:
                          schedule(RelLdr,0.0,vehicle);

       fprintf(fp,"EndLd:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;

                    case RelLdr:
                        release(ldr,vehicle);
                        schedule(RelPil,0.0,vehicle);

fprintf(fp,"RelLdr:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;


                    case StrtHl:
                          schedule(EndHl,uniform(4.0,5.0),vehicle);

      fprintf(fp,"StrtHl:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;

                    /*case ReqIntL:
                          if(request(intsecn,vehicle,TRK_PRIO))

      schedule(EntIntL,uniform(TrkHl1LPrmA,TrkHl1LPrmB),vehicle);

      //schedule(ExitIntL,uniform(TrkHl1LPrmA,TrkHl1LPrmB),vehicle);/
/Trk Haul1 Loaded
                    break;
//as haul split by

//intersect
```

```
                    case EntIntL:
                           schedule(ExitIntL,uniform(0.5,1.5),vehicle);
                    break;

                    case ExitIntL:

      //schedule(EndHl,uniform(TrkHlPrmA,TrkHlPrmB),vehicle);
                           schedule(RelIntL,0.0,vehicle);
                    break;*/


                    case EndHl:
                           schedule(ReqLayr,0.0,vehicle);

      fprintf(fp,"EndHl:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;

             /*     case RelIntL:
                           release(intsecn,vehicle);

 schedule(EndHl,uniform(TrkHl2LPrmA,TrkHl2LPrmB),vehicle);
                    break;  */

                    case ReqLayr:

      if((stat=preempt(layr,vehicle,TRK_PRIO))==FREE)
                                  schedule(StrtDmp,0.0,vehicle);

      fprintf(fp,"ReqLayr:Trk%d\n",(int)vehicle.attr[0]);
                           if(stat)
 fprintf(fp,"ReqLayr:Trk%d\n\n",(int)vehicle.attr[0]);
                           break;

                    case StrtDmp:

      schedule(EndDmp,uniform(TrkDmpPrmA,TrkDmpPrmB),vehicle);

      fprintf(fp,"StrtDmp:Trk%d\n\n",(int)vehicle.attr[0]);
                    break;

                    case EndDmp:
                           //newspredqty=0.0;
                           schedule(RelLayr,0.0,vehicle);
                           //schedule(ChkLayr,0.0,vehicle);
                           ComplVol=dmpdqty+=vehicle.attr[2];

      if(dmpdqty<=CMPCT_STRT_PT||dmpdqty>=CMPCT_END_PT)
                           balqty=0; //bal to be cmpctd
                           else if(!((int)cmpctqty))
                           {balqty=dmpdqty-CMPCT_STRT_PT;   //bef 1st
 cyc of cmpct
                                  //tripno=0;
                                  }
                           else
                           balqty=(dmpdqty-CMPCT_STRT_PT-cmpctqty);
```

```
                        //newspredqty+=vehicle.attr[2]; //use till
spreading ops @ dump site incl
                        //schedule(StrtRet,0.0,vehicle);

    fprintf(fp,"EndDmp:Trk%d\n",(int)vehicle.attr[0]);
                        fprintf(fp,"dmpdqty:%f\n",dmpdqty);
                        fprintf(fp,"balqty:%f\n\n",balqty);
                break;

                case RelLayr:
                        release(layr,vehicle);
                        schedule(StrtTrkRet,0.0,vehicle);

    fprintf(fp,"RelLayr:Trk%d\n\n",(int)vehicle.attr[0]);
                break;

                case StrtTrkRet:

    //schedule(ReqIntE,uniform(TrkRet1EPrmA,TrkRet1EPrmB),vehicle);

    schedule(EndTrkRet,uniform(TrkRet1EPrmA,TrkRet1EPrmB),vehicle);

    fprintf(fp,"StrtTrkRet:Trk%d\n\n",(int)vehicle.attr[0]);
                break;

          /*    case ReqIntE:
                      if(request(intsecn,vehicle,TRK_PRIO)==FREE)
                        schedule(EntIntE,0.0,vehicle);
                break;


                case EntIntE:
                        schedule(ExitIntE,uniform(0.5,1.5),vehicle);
                break;

                case ExitIntE:

    //schedule(EndTrkRet,uniform(TrkRet2PrmA,TrkRet2PrmB),vehicle);
                        schedule(RelIntE,0.0,vehicle);
                break;

                case RelIntE:
                        release(intsecn,vehicle);

schedule(EndTrkRet,uniform(TrkRet2EPrmA,TrkRet2EPrmB),vehicle);
                break;*/

                case EndTrkRet:

    //if((stat=request(ldr,vehicle,TRK_PRIO))==FREE)
                        schedule(ChkPil,0.0,vehicle);

    fprintf(fp,"EndTrkRet:Trk%d\n",(int)vehicle.attr[0]);
```

```
                    //if(stat)
fprintf(fp,"RelLdr:Trk%d\n\n",(int)vehicle.attr[0]);
                break;



                //compactor events

                case GenCmpct:
                    /*if(CMPCT_SPRED_LEAD<=balqty)
                        schedule(ChkLayr,0.0,vehicle);
                    else
                        schedule(ReqCmpctLayr,0.0,vehicle);*/
                    schedule(ChkLayr,0.0,vehicle);
                    update_arrivals();

    fprintf(fp,"GenCmpct:Cmpctr%d\n",(int)vehicle.attr[0]);
                    fprintf(fp,"balqty:%f\n",balqty);

    fprintf(fp,"CmpctSpredLd:%f\n\n",CMPCT_SPRED_LEAD);
                break;

                case ChkLayr:

    fprintf(fp,"ChkLayr:Cmpctr%d\n\n",(int)vehicle.attr[0]);
                    if(CMPCT_SPRED_LEAD<=balqty)
                        schedule(ReqCmpctLayr,0.0,vehicle);
                    else
                        schedule(ChkLayr,1.0,vehicle);
                break;

                case ReqCmpctLayr:

    if((stat=request(layr,vehicle,CMPCT_PRIO)==FREE))
                        schedule(StrtCmpct,0.0,vehicle);

    fprintf(fp,"GenCmpct:Cmpctr%d\n",(int)vehicle.attr[0]);
                    if(stat)
fprintf(fp,"CmpctQd@Layr%d\n\n",(int)vehicle.attr[0]);
                break;

                case StrtCmpct:
                    //cmpctime=uniform(CmpctPrmA,CmpctPrmB);
                    cmpctime=balqty/cmpctrat+uniform(0.0,1.0);
                    schedule(EndCmpct,cmpctime,vehicle);

    fprintf(fp,"StrtCmpct:Cmpctr%d\n\n",(int)vehicle.attr[0]);
                break;

                case EndCmpct:
                    //newspredqty-=CMPCT_RAT*cmpctime;
                    cmpctqty+=balqty;//cmpctrat*cmpctime since

        //dmpdqty-cmpctqty might change
                    schedule(RelCmpctLayr,0.0,vehicle);
```

```
        fprintf(fp,"EndCmpct:Cmpctr%d\n\n",(int)vehicle.attr[0]);
                        balqty=0;
                break;

                        case RelCmpctLayr:
                             release(layr,vehicle);
                             if(dmpdqty<=CMPCT_END_PT)
                                    schedule(ChkLayr,0.0,vehicle);
                               else{
                                    update_completions();
                                    fprintf(fp,"EndCmpct\n");
                                    }
                               fprintf(fp,"ComplVol:%f\n\n",ComplVol);
                               fprintf(fp,"CompctEndPt%f\n",CMPCT_END_PT);

        fprintf(fp,"RelCmpct@Layr:Cmpctr%d\n\n",(int)vehicle.attr[0]);
                        break;

                        //scraper events

                        case GenScrp:
                               if (!(int) vehicle.attr[3])
schedule(StrtSLd,0.0,vehicle);
                               else schedule(ReqPsher,0.0,vehicle);
                        break;

                        case StrtSLd:

schedule(EndLd,uniform(ScrpLdPrmA,ScrpLdPrmB),vehicle);
                        break;

                        case EndSLd:
                               schedule(StrtSHl,0.0,vehicle);
                        break;

                        case StrtSHl:

schedule(EndHl,uniform(ScrpHlPrmA,ScrpHlPrmB),vehicle);
                        break;

                        case EndSHl:
                               schedule(ReqSLayr,0.0,vehicle);
                            //schedule(StrtSRet,0.0,vehicle);
                        break;

                        case ReqSLayr:
                            if(preempt(layr,vehicle,SCRP_PRIO)==FREE)
                               schedule(StrtSSpred,0.0,vehicle);
                        break;

                        case StrtSSpred:

schedule(EndSSpred,uniform(ScrpSSpredPrmA,ScrpSSpredPrmB),vehicle);
                        break;
```

```
                    case EndSSpred:
                          release(layr,vehicle);
                         schedule(StrtSRet,0.0,vehicle);
                         dmpdqty+=vehicle.attr[2];
                    break;

                    case StrtSRet:

        schedule(EndSRet,uniform(ScrpSRetPrmA,ScrpSRetPrmB),vehicle);
                    break;

                    case EndSRet:
                        schedule(StrtSLd,0.0,vehicle);
                    break;

                    case ReqPsher:
                          if(request(psher,vehicle,SCRP_PRIO)==FREE)

        schedule(SpotPsher,uniform(SpotPrmA,SpotPrmB),vehicle);
                    break;

                    case SpotPsher:
                        schedule(StrtSPLd,0.0,vehicle);
                    break;

                    case StrtSPLd:

schedule(EndSPLd,uniform(ScrpSPLdPrmA,ScrpSPLdPrmB),vehicle);
                    break;

                    case EndSPLd:

        schedule(RelPsher,uniform(PsherRetPrmA,PsherRetPrmB),vehicle);
                    break;

                    case RelPsher:
                        release(psher,vehicle);
                        schedule(StrtSPHl,0.0,vehicle);
                    break;

                    case StrtSPHl:

schedule(EndSPHl,uniform(ScrpSPHlPrmA,ScrpSPHlPrmB),vehicle);
                    break;

                    case EndSPHl:
                          if(preempt(layr,vehicle,SCRP_PRIO)==FREE)
                                schedule(StrtSPSpred,0.0,vehicle);
                    break;

                    case StrtSPSpred:

schedule(EndSPSpred,uniform(ScrpSPSpredPrmA,ScrpSPSpredPrmB),vehicle)
;
```

```
                    break;

                    case EndSPSpred:
                        schedule(StrtSPRet,0.0,vehicle);
                    break;

                    case StrtSPRet:

schedule(EndSPRet,uniform(ScrpSPRetPrmA,ScrpSPRetPrmB),vehicle);
                    break;

                    case EndSPRet:
                        schedule(ReqPsher,0.0,vehicle);
                    break;


                          }
                    }

                    report_stats();
                    //printf("\n\n************ MOHAN'S CUSTOMIZED
REPORT *************\n\n");
                    /*fprintf(fpout,"Trucks: %d\n",NumTruck);
                    printf(fpout,"Loaders: %d\n",NumLoad);
                    printf(fpout,"Dozers: %d\n",NumDoz);
                    printf(fpout,"Compactors: %d\n",NumComp);
                    printf(fpout,"Volume of earthwork
required.:%d\n\n\n\n\n",SubStrVol);
                    //printf("Volume of earthwork
transported:%d\n",ComplVol);
                    fprintf(fp,"Volume of earthwork
compacted:%f\n\n",cmpctqty);*/
                    fclose(fp);


              }
```

APPENDIX B

Simulation Trace Report Generated by CONFIGSIM_2 for Test # 1

```
S Y S T E M     V A L I D A T I O N
-----------------------------------

Checking Resource Sufficiency for BlkR21-Mod1.....
                                    .......OKAY
Proceeding with Simulation.....

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000


Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk D250B-2

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk D300B-1

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk D300B-2
Released by BlkR21-Mod1-Trk D250B-1

Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 2.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D250B-2

Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 4.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1

Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 6.000000
```

```
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 7.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 10.000000

Current Time: 7.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 8.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 9.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 20.000000

Current Time: 9.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000


Current Time: 10.500000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 11.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 32.000000

Current Time: 11.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1


Current Time: 12.500000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000
```

Current Time: 12.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 13.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 44.000000

Current Time: 13.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2

Current Time: 14.500000
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 14.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1

Current Time: 16.500000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 16.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 17.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 54.000000

Current Time: 18.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 18.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

```
Current Time: 19.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 64.000000

Current Time: 20.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000


Current Time: 21.000000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 21.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 76.000000

Current Time: 22.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1


Current Time: 23.000000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 23.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 23.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 88.000000

Current Time: 24.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2


Current Time: 25.000000
```

```
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 25.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1


Current Time: 27.000000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 27.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 28.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 98.000000

Current Time: 28.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 29.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 30.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 108.000000

Current Time: 30.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000


Current Time: 31.500000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000
```

```
Current Time: 32.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 120.000000

Current Time: 32.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1


Current Time: 33.500000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 33.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 34.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 132.000000

Current Time: 34.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2


Current Time: 35.500000
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 35.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1


Current Time: 37.500000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000
```

Current Time: 37.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 38.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 142.000000

Current Time: 39.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 39.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 40.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 152.000000

Current Time: 41.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 42.000000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 42.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 164.000000

Current Time: 43.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1

Current Time: 44.000000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 44.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 44.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 176.000000

Current Time: 45.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2

Current Time: 46.000000
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 46.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1

Current Time: 48.000000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 48.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 49.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 186.000000

Current Time: 49.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 50.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2

Haul Time: 5.000000

Current Time: 51.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 196.000000

Current Time: 51.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 52.500000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 53.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 208.000000

Current Time: 53.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1

Current Time: 54.500000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 54.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 55.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 220.000000

Current Time: 55.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2

```
Current Time: 56.500000
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 56.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1


Current Time: 58.500000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 58.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 59.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 230.000000

Current Time: 60.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 60.500000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 61.500000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 240.000000

Current Time: 62.000000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000


Current Time: 63.000000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000
```

Current Time: 63.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 252.000000

Current Time: 64.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1

Current Time: 65.000000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 65.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 65.500000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 264.000000

Current Time: 66.000000
Returning-Trk-BlkR21-Mod1-Trk D300B-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-2

Current Time: 67.000000
At Loader - BlkR21-Mod1- Trk D300B-1
Acquired by BlkR21-Mod1-Trk D300B-1
Loading-Trk-D300B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 67.000000
Hauling-Trk-BlkR21-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk D300B-1

Current Time: 69.000000
At Loader - BlkR21-Mod1- Trk D300B-2
Acquired by BlkR21-Mod1-Trk D300B-2
Loading-Trk-D300B-2-BlkR21-Mod1
Load Time: 2.000000

```
Current Time: 69.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 70.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 274.000000

Current Time: 70.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D300B-2

Current Time: 71.000000
Hauling-Trk-BlkR21-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 72.000000
Dumping-Trk-BlkR21-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 284.000000

Current Time: 72.500000
Returning-Trk-BlkR21-Mod1-Trk D250B-2
Return Time: 3.000000


Current Time: 73.500000
At Loader - BlkR21-Mod1- Trk D250B-1
Acquired by BlkR21-Mod1-Trk D250B-1
Loading-Trk-D250B-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 74.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 296.000000

Current Time: 74.500000
Returning-Trk-BlkR21-Mod1-Trk D300B-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk D250B-1


Current Time: 75.500000
At Loader - BlkR21-Mod1- Trk D250B-2
Acquired by BlkR21-Mod1-Trk D250B-2
Loading-Trk-D250B-2-BlkR21-Mod1
```

```
Load Time: 2.000000

Current Time: 75.500000
Hauling-Trk-BlkR21-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 76.000000
Dumping-Trk-BlkR21-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 308.000000

Simulation of BlkR21-Mod1 complete...

Loader Utilization for BlkR21-Mod1
--------------------------------
Max. Number Waiting: 3
Mean Number Waiting: 1.500000
Total Percent Utilization: 75.816993

Checking Resource Sufficiency for Blk11-Mod1.....
                                  .......OKAY
Proceeding with Simulation.....

Current Time: 76.500000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000


Current Time: 76.500000
At Loader - Blk11-Mod1- Trk D250B-2

Current Time: 76.500000
At Loader - Blk11-Mod1- Trk D300B-1

Current Time: 76.500000
At Loader - Blk11-Mod1- Trk D300B-2
Released by Blk11-Mod1-Trk D250B-1

Acquired by Blk11-Mod1-Trk D250B-2
Loading-Trk-D250B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 78.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-1
Haul Time: 5.000000

Released by Blk11-Mod1-Trk D250B-2

Acquired by Blk11-Mod1-Trk D300B-1
Loading-Trk-D300B-1-Blk11-Mod1
Load Time: 2.000000
```

Current Time: 80.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk D300B-1

Acquired by Blk11-Mod1-Trk D300B-2
Loading-Trk-D300B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 82.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 83.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 10.000000

Current Time: 84.000000
Returning-Trk-Blk11-Mod1-Trk D250B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D300B-2

Current Time: 84.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 85.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 20.000000

Current Time: 86.000000
Returning-Trk-Blk11-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 87.000000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 87.500000
Dumping-Trk-Blk11-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 32.000000

Current Time: 88.000000
Returning-Trk-Blk11-Mod1-Trk D300B-1

Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-1

Current Time: 89.000000
At Loader - Blk11-Mod1- Trk D250B-2
Acquired by Blk11-Mod1-Trk D250B-2
Loading-Trk-D250B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 89.000000
Hauling-Trk-Blk11-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 89.500000
Dumping-Trk-Blk11-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 44.000000

Current Time: 90.000000
Returning-Trk-Blk11-Mod1-Trk D300B-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-2

Current Time: 91.000000
At Loader - Blk11-Mod1- Trk D300B-1
Acquired by Blk11-Mod1-Trk D300B-1
Loading-Trk-D300B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 91.000000
Hauling-Trk-Blk11-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk D300B-1

Current Time: 93.000000
At Loader - Blk11-Mod1- Trk D300B-2
Acquired by Blk11-Mod1-Trk D300B-2
Loading-Trk-D300B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 93.000000
Hauling-Trk-Blk11-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 94.000000
Dumping-Trk-Blk11-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 54.000000

Current Time: 94.500000
Returning-Trk-Blk11-Mod1-Trk D250B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D300B-2

Current Time: 95.000000
Hauling-Trk-Blk11-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 96.000000
Dumping-Trk-Blk11-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 64.000000

Current Time: 96.500000
Returning-Trk-Blk11-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 97.500000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 98.000000
Dumping-Trk-Blk11-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 76.000000

Current Time: 98.500000
Returning-Trk-Blk11-Mod1-Trk D300B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-1

Current Time: 99.500000
At Loader - Blk11-Mod1- Trk D250B-2
Acquired by Blk11-Mod1-Trk D250B-2
Loading-Trk-D250B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 99.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 100.000000
Dumping-Trk-Blk11-Mod1-Trk D300B-2
Dump Time: 0.500000

```
Vol. Completed in Blk11-Mod1 is 88.000000

Current Time: 100.500000
Returning-Trk-Blk11-Mod1-Trk D300B-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-2


Current Time: 101.500000
At Loader - Blk11-Mod1- Trk D300B-1
Acquired by Blk11-Mod1-Trk D300B-1
Loading-Trk-D300B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 101.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk D300B-1


Current Time: 103.500000
At Loader - Blk11-Mod1- Trk D300B-2
Acquired by Blk11-Mod1-Trk D300B-2
Loading-Trk-D300B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 103.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 104.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 98.000000

Current Time: 105.000000
Returning-Trk-Blk11-Mod1-Trk D250B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D300B-2

Current Time: 105.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 106.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 108.000000
```

Current Time: 107.000000
Returning-Trk-Blk11-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 108.000000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 108.500000
Dumping-Trk-Blk11-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 120.000000

Current Time: 109.000000
Returning-Trk-Blk11-Mod1-Trk D300B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-1

Current Time: 110.000000
At Loader - Blk11-Mod1- Trk D250B-2
Acquired by Blk11-Mod1-Trk D250B-2
Loading-Trk-D250B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 110.000000
Hauling-Trk-Blk11-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 110.500000
Dumping-Trk-Blk11-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 132.000000

Current Time: 111.000000
Returning-Trk-Blk11-Mod1-Trk D300B-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-2

Current Time: 112.000000
At Loader - Blk11-Mod1- Trk D300B-1
Acquired by Blk11-Mod1-Trk D300B-1
Loading-Trk-D300B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 112.000000
Hauling-Trk-Blk11-Mod1-Trk D250B-2

Haul Time: 5.000000

Released by Blk11-Mod1-Trk D300B-1

Current Time: 114.000000
At Loader - Blk11-Mod1- Trk D300B-2
Acquired by Blk11-Mod1-Trk D300B-2
Loading-Trk-D300B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 114.000000
Hauling-Trk-Blk11-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 115.000000
Dumping-Trk-Blk11-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 142.000000

Current Time: 115.500000
Returning-Trk-Blk11-Mod1-Trk D250B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D300B-2

Current Time: 116.000000
Hauling-Trk-Blk11-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 117.000000
Dumping-Trk-Blk11-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 152.000000

Current Time: 117.500000
Returning-Trk-Blk11-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 118.500000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 119.000000
Dumping-Trk-Blk11-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 164.000000

Current Time: 119.500000

Returning-Trk-Blk11-Mod1-Trk D300B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-1

Current Time: 120.500000
At Loader - Blk11-Mod1- Trk D250B-2
Acquired by Blk11-Mod1-Trk D250B-2
Loading-Trk-D250B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 120.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-1
Haul Time: 5.000000

Current Time: 121.000000
Dumping-Trk-Blk11-Mod1-Trk D300B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 176.000000

Current Time: 121.500000
Returning-Trk-Blk11-Mod1-Trk D300B-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk D250B-2

Current Time: 122.500000
At Loader - Blk11-Mod1- Trk D300B-1
Acquired by Blk11-Mod1-Trk D300B-1
Loading-Trk-D300B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 122.500000
Hauling-Trk-Blk11-Mod1-Trk D250B-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk D300B-1

Current Time: 124.500000
At Loader - Blk11-Mod1- Trk D300B-2
Acquired by Blk11-Mod1-Trk D300B-2
Loading-Trk-D300B-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 124.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-1
Haul Time: 5.000000

Current Time: 125.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 186.000000

Current Time: 126.000000
Returning-Trk-Blk11-Mod1-Trk D250B-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk D300B-2

Current Time: 126.500000
Hauling-Trk-Blk11-Mod1-Trk D300B-2
Haul Time: 5.000000

Current Time: 127.500000
Dumping-Trk-Blk11-Mod1-Trk D250B-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 196.000000

Current Time: 128.000000
Returning-Trk-Blk11-Mod1-Trk D250B-2
Return Time: 3.000000

Current Time: 129.000000
At Loader - Blk11-Mod1- Trk D250B-1
Acquired by Blk11-Mod1-Trk D250B-1
Loading-Trk-D250B-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 129.500000
Dumping-Trk-Blk11-Mod1-Trk D300B-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 208.000000

Simulation of Blk11-Mod1 complete...

Loader Utilization for Blk11-Mod1

Max. Number Waiting: 3
Mean Number Waiting: 1.500000
Total Percent Utilization: 74.766355
Project Duration: 130.000000

APPENDIX C

Standard AWESIM Summary Report for Validation Test # 1

** AweSim! SUMMARY REPORT **
Mon Dec 15 03:13:12 1997
Simulation Project : CONFIGSIM_2 - Validation Test # 1
Modeler : Mohan Raj Manavazhi
Date : 10/24/97

Run number 1 of 1
Current simulation time : 138.000000
Statistics cleared at time : 0.000000

** OBSERVED STATISTICS REPORT **

Label	Mean Value	Standard Deviation	Coeff. of Variation
DmpdQtyBlk1Sec1	158.5000000	90.5516018	0.5713035
Blk1Sec1Duration	76.5000000	0.0000000	0.0000000
DmpdQtyBlk2Sec1	109.4736842	61.9025833	0.5654563
Project Duration	130.0000000	0.0000000	0.0000000

Label	Minimum Value	Maximum Value	Number of Observations
DmpdQtyBlk1Sec1	10.0000000	308.0000000	28
Blk1Sec1Duration	76.5000000	76.5000000	1
DmpdQtyBlk2Sec1	10.0000000	208.0000000	19
Project Duration	130.0000000	130.0000000	1

** FILE STATISTICS REPORT **

File Number	Where Created	Average Length	Standard Deviation
1	RESOURCE LOADER1	0.0869565	0.4419696
2	RESOURCE LOADER2	0.0869565	0.4419696
3	GATE GATE1	1.1086957	0.9940751
0	Event Calendar	4.8369565	0.7010940

File Number	Maximum Length	Current Length	Average Wait Time
1	3	0	0.3870968
2	3	0	0.5454545
3	2	0	76.5000000
0	7	1	3.1635071

** ACTIVITY STATISTICS REPORT **

Activity Number	Label	Average Utilization	Standard Deviation
1	Multiple defining activities	1.2463768	0.7643468
2	Haul1	1.1231884	1.0628980
3	Retn1	0.5869565	0.7295846

Activity Number	Maximum Utilization	Current Utilization	Entity Count
1	3	0	53
2	3	0	31
3	2	0	27

** RESOURCE STATISTICS REPORT **

Resource Number	Resource Label	Current Capacity	Average Util.	Standard Deviation	Maximum Util.
1	LOADER1	1	0.4492754	0.4974204	1
2	LOADER2	1	0.3188406	0.4660271	1

Resource Number	Current Util.	Current Available	Average Available	Minimum Available	Maximum Available
1	0	1	0.5507246	0	1
2	0	1	0.6811594	0	1

** GATE STATISTICS REPORT **

Gate Number	Gate Label	Current Status	Percent of Time Open
1	GATE1	OPEN	0.4456522

APPENDIX D

Simulation Trace Report Generated by CONFIGSIM_2 for Test # 2

```
S Y S T E M     V A L I D A T I O N
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Checking Resource Sufficiency for BlkR21-Mod1.....
                                         .......OKAY
Proceeding with Simulation.....

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000


Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk T1-2

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk T2-1

Current Time: 0.000000
At Loader - BlkR21-Mod1- Trk T2-2
Released by BlkR21-Mod1-Trk T1-1

Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 2.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T1-2

Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 4.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000
```

```
Current Time: 6.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 7.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 10.000000

Current Time: 7.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 8.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 9.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 20.000000

Current Time: 9.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 10.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 11.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 32.000000

Current Time: 11.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 12.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
```

```
Load Time: 2.000000

Current Time: 12.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 13.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 44.000000

Current Time: 13.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 14.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 14.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 16.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 16.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 17.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 54.000000

Current Time: 18.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 18.500000
```

```
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 19.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 64.000000

Current Time: 20.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 21.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 21.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 76.000000

Current Time: 22.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 23.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 23.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 23.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 88.000000

Current Time: 24.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2
```

Current Time: 25.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 25.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 27.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 27.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 28.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 98.000000

Current Time: 28.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 29.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 30.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 108.000000

Current Time: 30.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 31.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1

Load Time: 2.000000

Current Time: 32.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 120.000000

Current Time: 32.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 33.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 33.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 34.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 132.000000

Current Time: 34.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 35.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 35.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 37.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1

```
Load Time: 2.000000

Current Time: 37.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 38.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 142.000000

Current Time: 39.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 39.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 40.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 152.000000

Current Time: 41.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 42.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 42.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 164.000000

Current Time: 43.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 44.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
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Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 44.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 44.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 176.000000

Current Time: 45.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 46.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 46.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 48.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 48.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 49.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 186.000000

Current Time: 49.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2
```

Current Time: 50.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 51.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 196.000000

Current Time: 51.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 52.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 53.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 208.000000

Current Time: 53.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 54.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 54.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 55.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 220.000000

Current Time: 55.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 56.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 56.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 58.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 58.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 59.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 230.000000

Current Time: 60.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 60.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 61.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 240.000000

Current Time: 62.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 63.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1

Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 63.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 252.000000

Current Time: 64.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 65.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 65.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 65.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 264.000000

Current Time: 66.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 67.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 67.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 69.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2

Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 69.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 70.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 274.000000

Current Time: 70.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 71.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 72.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 284.000000

Current Time: 72.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 73.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 74.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 296.000000

Current Time: 74.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 75.500000
At Loader - BlkR21-Mod1- Trk T1-2

Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 75.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 76.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 308.000000

Current Time: 76.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 77.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 77.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 79.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 79.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 80.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 318.000000

Current Time: 81.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 81.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 82.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 328.000000

Current Time: 83.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 84.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 84.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 340.000000

Current Time: 85.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 86.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 86.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 86.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 352.000000

Current Time: 87.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 88.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 88.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 90.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 90.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 91.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 362.000000

Current Time: 91.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 92.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 93.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 372.000000

Current Time: 93.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 94.500000
At Loader - BlkR21-Mod1- Trk T1-1

Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 95.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 384.000000

Current Time: 95.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 96.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 96.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 97.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 396.000000

Current Time: 97.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 98.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 98.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 100.500000
At Loader - BlkR21-Mod1- Trk T2-2

Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 100.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 101.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 406.000000

Current Time: 102.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 102.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 103.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 416.000000

Current Time: 104.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 105.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 105.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 428.000000

Current Time: 106.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 107.000000

At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 107.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 107.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 440.000000

Current Time: 108.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 109.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 109.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 111.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 111.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 112.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 450.000000

Current Time: 112.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

```
Released by BlkR21-Mod1-Trk T2-2

Current Time: 113.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 114.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 460.000000

Current Time: 114.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 115.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 116.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 472.000000

Current Time: 116.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 117.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 117.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 118.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 484.000000

Current Time: 118.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000
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Released by BlkR21-Mod1-Trk T1-2


Current Time: 119.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 119.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 121.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 121.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 122.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 494.000000

Current Time: 123.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 123.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 124.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 504.000000

Current Time: 125.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 126.000000
```

At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 126.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 516.000000

Current Time: 127.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 128.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 128.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 128.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 528.000000

Current Time: 129.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 130.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 130.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 132.000000

At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 132.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 133.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 538.000000

Current Time: 133.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 134.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 135.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 548.000000

Current Time: 135.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 136.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 137.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 560.000000

Current Time: 137.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

```
Current Time: 138.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 138.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 139.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 572.000000

Current Time: 139.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 140.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 140.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 142.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 142.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 143.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 582.000000

Current Time: 144.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000
```

Released by BlkR21-Mod1-Trk T2-2

Current Time: 144.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 145.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 592.000000

Current Time: 146.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 147.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 147.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 604.000000

Current Time: 148.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 149.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 149.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 149.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 616.000000

Current Time: 150.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2

```
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 151.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 151.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 153.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 153.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 154.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 626.000000

Current Time: 154.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 155.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 156.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 636.000000

Current Time: 156.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000
```

Current Time: 157.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 158.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 648.000000

Current Time: 158.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 159.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 159.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 160.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 660.000000

Current Time: 160.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 161.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 161.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 163.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 163.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 164.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 670.000000

Current Time: 165.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 165.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 166.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 680.000000

Current Time: 167.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 168.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 168.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 692.000000

Current Time: 169.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 170.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 170.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 170.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 704.000000

Current Time: 171.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 172.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 172.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 174.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 174.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 175.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 714.000000

Current Time: 175.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1

```
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 176.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 177.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 724.000000

Current Time: 177.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 178.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 179.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 736.000000

Current Time: 179.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 180.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 180.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 181.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 748.000000

Current Time: 181.500000
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Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 182.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 182.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 184.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 184.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 185.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 758.000000

Current Time: 186.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 186.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 187.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 768.000000

Current Time: 188.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

```
Current Time: 189.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 189.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 780.000000

Current Time: 190.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1


Current Time: 191.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 191.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 191.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 792.000000

Current Time: 192.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 193.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 193.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1
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Current Time: 195.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 195.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 196.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 802.000000

Current Time: 196.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 197.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 198.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 812.000000

Current Time: 198.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 199.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 200.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 824.000000

Current Time: 200.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1
```

Current Time: 201.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 201.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 202.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 836.000000

Current Time: 202.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 203.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 203.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 205.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 205.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 206.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 846.000000

Current Time: 207.000000

Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 207.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 208.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 856.000000

Current Time: 209.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 210.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 210.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 868.000000

Current Time: 211.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 212.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 212.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 212.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 880.000000

Current Time: 213.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 214.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 214.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 216.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 216.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 217.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 890.000000

Current Time: 217.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 218.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 219.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 900.000000

Current Time: 219.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 220.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 221.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 912.000000

Current Time: 221.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 222.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 222.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 223.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 924.000000

Current Time: 223.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 224.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 224.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

```
Current Time: 226.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 226.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 227.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 934.000000

Current Time: 228.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 228.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 229.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 944.000000

Current Time: 230.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 231.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 231.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 956.000000

Current Time: 232.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000
```

```
Released by BlkR21-Mod1-Trk T1-1


Current Time: 233.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 233.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 233.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 968.000000

Current Time: 234.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2


Current Time: 235.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 235.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1


Current Time: 237.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 237.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 238.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 978.000000
```

Current Time: 238.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 239.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 240.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 988.000000

Current Time: 240.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 241.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 242.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1000.000000

Current Time: 242.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 243.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 243.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 244.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1012.000000

Current Time: 244.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 245.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 245.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 247.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 247.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 248.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1022.000000

Current Time: 249.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 249.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 250.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1032.000000

Current Time: 251.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2

Return Time: 3.000000

Current Time: 252.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 252.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1044.000000

Current Time: 253.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 254.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 254.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 254.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1056.000000

Current Time: 255.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 256.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 256.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 258.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 258.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 259.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1066.000000

Current Time: 259.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 260.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 261.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1076.000000

Current Time: 261.500000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 262.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 263.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1088.000000

Current Time: 263.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 264.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 264.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 265.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1100.000000

Current Time: 265.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 266.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 266.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 268.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 268.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 269.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1110.000000

Current Time: 270.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 270.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 271.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1120.000000

Current Time: 272.000000
Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 273.000000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 273.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1132.000000

Current Time: 274.000000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 275.000000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 275.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 275.500000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1144.000000

Current Time: 276.000000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 277.000000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 277.000000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

Released by BlkR21-Mod1-Trk T2-1

Current Time: 279.000000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 279.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 280.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1154.000000

Current Time: 280.500000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 281.000000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 282.000000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1164.000000

Current Time: 282.500000

Returning-Trk-BlkR21-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 283.500000
At Loader - BlkR21-Mod1- Trk T1-1
Acquired by BlkR21-Mod1-Trk T1-1
Loading-Trk-T1-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 284.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1176.000000

Current Time: 284.500000
Returning-Trk-BlkR21-Mod1-Trk T2-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-1

Current Time: 285.500000
At Loader - BlkR21-Mod1- Trk T1-2
Acquired by BlkR21-Mod1-Trk T1-2
Loading-Trk-T1-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 285.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 286.000000
Dumping-Trk-BlkR21-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1188.000000

Current Time: 286.500000
Returning-Trk-BlkR21-Mod1-Trk T2-2
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T1-2

Current Time: 287.500000
At Loader - BlkR21-Mod1- Trk T2-1
Acquired by BlkR21-Mod1-Trk T2-1
Loading-Trk-T2-1-BlkR21-Mod1
Load Time: 2.000000

Current Time: 287.500000
Hauling-Trk-BlkR21-Mod1-Trk T1-2
Haul Time: 5.000000

```
Released by BlkR21-Mod1-Trk T2-1


Current Time: 289.500000
At Loader - BlkR21-Mod1- Trk T2-2
Acquired by BlkR21-Mod1-Trk T2-2
Loading-Trk-T2-2-BlkR21-Mod1
Load Time: 2.000000

Current Time: 289.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 290.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1198.000000

Current Time: 291.000000
Returning-Trk-BlkR21-Mod1-Trk T1-1
Return Time: 3.000000

Released by BlkR21-Mod1-Trk T2-2

Current Time: 291.500000
Hauling-Trk-BlkR21-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 292.500000
Dumping-Trk-BlkR21-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in BlkR21-Mod1 is 1208.000000

Simulation of BlkR21-Mod1 complete...

Loader Utilization for BlkR21-Mod1
--------------------------------
Max. Number Waiting: 3
Mean Number Waiting: 1.500000
Total Percent Utilization: 76.450512

Checking Resource Sufficiency for Blk11-Mod1.....
                                     .......OKAY
Proceeding with Simulation.....

Current Time: 293.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000
```

```
Current Time: 293.000000
At Loader - Blk11-Mod1- Trk T1-2

Current Time: 293.000000
At Loader - Blk11-Mod1- Trk T2-1

Current Time: 293.000000
At Loader - Blk11-Mod1- Trk T2-2
Released by Blk11-Mod1-Trk T1-1

Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 295.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T1-2

Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 297.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 299.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 300.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 10.000000

Current Time: 300.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 301.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 302.000000
```

Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 20.000000

Current Time: 302.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 303.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 304.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 32.000000

Current Time: 304.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 305.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 305.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 306.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 44.000000

Current Time: 306.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 307.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1

```
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 307.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 309.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 309.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 310.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 54.000000

Current Time: 311.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 311.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 312.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 64.000000

Current Time: 313.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 314.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 314.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
```

```
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 76.000000

Current Time: 315.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1


Current Time: 316.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 316.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 316.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 88.000000

Current Time: 317.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2


Current Time: 318.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 318.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 320.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 320.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
```

Haul Time: 5.000000

Current Time: 321.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 98.000000

Current Time: 321.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 322.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 323.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 108.000000

Current Time: 323.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 324.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 325.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 120.000000

Current Time: 325.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 326.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 326.500000

Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 327.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 132.000000

Current Time: 327.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 328.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 328.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 330.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 330.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 331.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 142.000000

Current Time: 332.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 332.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 333.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 152.000000

Current Time: 334.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 335.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 335.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 164.000000

Current Time: 336.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 337.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 337.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 337.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 176.000000

Current Time: 338.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 339.000000
At Loader - Blk11-Mod1- Trk T2-1

```
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 339.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 341.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 341.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 342.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 186.000000

Current Time: 342.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 343.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 344.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 196.000000

Current Time: 344.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 345.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 346.000000
```

Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 208.000000

Current Time: 346.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 347.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 347.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 348.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 220.000000

Current Time: 348.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 349.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 349.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 351.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 351.500000

Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 352.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 230.000000

Current Time: 353.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 353.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 354.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 240.000000

Current Time: 355.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 356.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 356.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 252.000000

Current Time: 357.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 358.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 358.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 358.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 264.000000

Current Time: 359.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 360.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 360.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 362.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 362.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 363.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 274.000000

Current Time: 363.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 364.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 365.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 284.000000

Current Time: 365.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 366.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 367.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 296.000000

Current Time: 367.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 368.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 368.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 369.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 308.000000

Current Time: 369.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 370.500000

At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 370.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 372.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 372.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 373.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 318.000000

Current Time: 374.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 374.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 375.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 328.000000

Current Time: 376.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 377.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 377.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 340.000000

Current Time: 378.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 379.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 379.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 379.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 352.000000

Current Time: 380.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 381.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 381.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 383.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 383.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 384.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 362.000000

Current Time: 384.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 385.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 386.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 372.000000

Current Time: 386.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 387.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 388.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 384.000000

Current Time: 388.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 389.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 389.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 390.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 396.000000

Current Time: 390.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 391.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 391.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 393.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 393.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 394.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 406.000000

Current Time: 395.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 395.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2

Haul Time: 5.000000

Current Time: 396.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 416.000000

Current Time: 397.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 398.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 398.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 428.000000

Current Time: 399.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 400.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 400.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 400.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 440.000000

Current Time: 401.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

```
Current Time: 402.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 402.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 404.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 404.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 405.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 450.000000

Current Time: 405.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 406.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 407.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 460.000000

Current Time: 407.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 408.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000
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Current Time: 409.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 472.000000

Current Time: 409.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1


Current Time: 410.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 410.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 411.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 484.000000

Current Time: 411.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2


Current Time: 412.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 412.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 414.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000
```

Current Time: 414.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 415.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 494.000000

Current Time: 416.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 416.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 417.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 504.000000

Current Time: 418.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 419.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 419.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 516.000000

Current Time: 420.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 421.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1

Load Time: 2.000000

Current Time: 421.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 421.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 528.000000

Current Time: 422.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 423.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 423.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 425.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 425.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 426.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 538.000000

Current Time: 426.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 427.000000

```
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 428.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 548.000000

Current Time: 428.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000


Current Time: 429.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 430.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 560.000000

Current Time: 430.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1


Current Time: 431.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 431.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 432.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 572.000000

Current Time: 432.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2
```

Current Time: 433.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 433.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 435.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 435.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 436.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 582.000000

Current Time: 437.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 437.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 438.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 592.000000

Current Time: 439.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 440.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1

```
Load Time: 2.000000

Current Time: 440.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 604.000000

Current Time: 441.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1


Current Time: 442.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 442.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 442.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 616.000000

Current Time: 443.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2


Current Time: 444.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 444.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1


Current Time: 446.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
```

Load Time: 2.000000

Current Time: 446.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 447.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 626.000000

Current Time: 447.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 448.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 449.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 636.000000

Current Time: 449.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 450.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 451.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 648.000000

Current Time: 451.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 452.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2

Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 452.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 453.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 660.000000

Current Time: 453.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 454.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 454.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 456.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 456.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 457.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 670.000000

Current Time: 458.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 458.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 459.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 680.000000

Current Time: 460.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 461.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 461.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 692.000000

Current Time: 462.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 463.000000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 463.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 463.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 704.000000

Current Time: 464.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 465.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 465.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 467.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 467.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 468.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 714.000000

Current Time: 468.500000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 469.000000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 470.000000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 724.000000

Current Time: 470.500000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 471.500000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1

Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 472.000000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 736.000000

Current Time: 472.500000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 473.500000
At Loader - Blk11-Mod1- Trk T1-2
Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 473.500000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 474.000000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 748.000000

Current Time: 474.500000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 475.500000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 475.500000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 477.500000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2

Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 477.500000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 478.500000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 758.000000

Current Time: 479.000000
Returning-Trk-Blk11-Mod1-Trk T1-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T2-2

Current Time: 479.500000
Hauling-Trk-Blk11-Mod1-Trk T2-2
Haul Time: 5.000000

Current Time: 480.500000
Dumping-Trk-Blk11-Mod1-Trk T1-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 768.000000

Current Time: 481.000000
Returning-Trk-Blk11-Mod1-Trk T1-2
Return Time: 3.000000

Current Time: 482.000000
At Loader - Blk11-Mod1- Trk T1-1
Acquired by Blk11-Mod1-Trk T1-1
Loading-Trk-T1-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 482.500000
Dumping-Trk-Blk11-Mod1-Trk T2-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 780.000000

Current Time: 483.000000
Returning-Trk-Blk11-Mod1-Trk T2-1
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-1

Current Time: 484.000000
At Loader - Blk11-Mod1- Trk T1-2

Acquired by Blk11-Mod1-Trk T1-2
Loading-Trk-T1-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 484.000000
Hauling-Trk-Blk11-Mod1-Trk T1-1
Haul Time: 5.000000

Current Time: 484.500000
Dumping-Trk-Blk11-Mod1-Trk T2-2
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 792.000000

Current Time: 485.000000
Returning-Trk-Blk11-Mod1-Trk T2-2
Return Time: 3.000000

Released by Blk11-Mod1-Trk T1-2

Current Time: 486.000000
At Loader - Blk11-Mod1- Trk T2-1
Acquired by Blk11-Mod1-Trk T2-1
Loading-Trk-T2-1-Blk11-Mod1
Load Time: 2.000000

Current Time: 486.000000
Hauling-Trk-Blk11-Mod1-Trk T1-2
Haul Time: 5.000000

Released by Blk11-Mod1-Trk T2-1

Current Time: 488.000000
At Loader - Blk11-Mod1- Trk T2-2
Acquired by Blk11-Mod1-Trk T2-2
Loading-Trk-T2-2-Blk11-Mod1
Load Time: 2.000000

Current Time: 488.000000
Hauling-Trk-Blk11-Mod1-Trk T2-1
Haul Time: 5.000000

Current Time: 489.000000
Dumping-Trk-Blk11-Mod1-Trk T1-1
Dump Time: 0.500000

Vol. Completed in Blk11-Mod1 is 802.000000

Simulation of Blk11-Mod1 complete...

Loader Utilization for Blk11-Mod1

Max. Number Waiting: 3

```
Mean Number Waiting: 1.500000
Total Percent Utilization: 76.335878
Project Duration: 489.500000
```

APPENDIX E

Standard AWESIM Summary Report for Validation Test # 2

** AweSim! SUMMARY REPORT **
Mon Dec 15 09:45:56 1997
Simulation Project : CONFIGSIM_2 Validation Test # 2
Modeler : Mohan Raj Manavazhi
Date : 10/24/97

Run number 1 of 1
Current simulation time : 495.000000
Statistics cleared at time : 0.000000

** OBSERVED STATISTICS REPORT **

Label	Mean Value	Standard Deviation	Coeff. of Variation
DmpdQtyBlk1Sec1	609.4909091	350.8816091	0.5756962
Blk1Sec1Duration	293.0000000	0.0000000	0.0000000
DmpdQtyBlk2Sec1	406.4931507	233.3889888	0.5741523
Project Duration	489.5000000	0.0000000	0.0000000

Label	Minimum Value	Maximum Value	Number of Observations
DmpdQtyBlk1Sec1	10.0000000	1208.0000000	110
Blk1Sec1Duration	293.0000000	293.0000000	1
DmpdQtyBlk2Sec1	10.0000000	802.0000000	73
Project Duration	489.5000000	489.5000000	1

** FILE STATISTICS REPORT **

File Number	Where Created	Average Length	Standard Deviation
1	RESOURCE LOADER1	0.0242424	0.2365966
2	RESOURCE LOADER2	0.0242424	0.2365966
3	GATE GATE1	1.1838384	0.9829565
0	Event Calendar	4.9545455	0.3407575

File Number	Maximum Length	Current Length	Average Wait Time
1	3	0	0.1061947
2	3	0	0.1578947
3	2	0	293.0000000
0	7	1	3.2483444

** ACTIVITY STATISTICS REPORT **

Activity Number	Label	Average Utilization	Standard Deviation
1	Multiple defining activities	1.2242424	0.7812307
2	Haul1	1.1414141	1.0675196
3	Retn1	0.6606061	0.7426159

Activity Number	Maximum Utilization	Current Utilization	Entity Count
1	3	0	189
2	3	0	113
3	2	0	109

** RESOURCE STATISTICS REPORT **

Resource Number	Resource Label	Current Capacity	Average Util.	Standard Deviation	Maximum Util.
1	LOADER1	1	0.4565657	0.4981099	1
2	LOADER2	1	0.3070707	0.4612790	1

Resource Number	Current Util.	Current Available	Average Available	Minimum Available	Maximum Available
1	0	1	0.5434343	0	1
2	0	1	0.6929293	0	1

** GATE STATISTICS REPORT **

Gate Number	Gate Label	Current Status	Percent of Time Open
1	GATE1	OPEN	0.4080808

APPENDIX F

Dam Simulation - Computer Program Code for CONFIGSIM_2

```
DEFINITION MODULE ProcMod;
FROM CompMod IMPORT LdrPoolTyp, NumResType, DozPoolTyp, TrkPoolTyp,
CmpctrPoolTyp,
DozPoolTyp, SubStrObj, ReqResRec;

PROCEDURE Concat(IN Str1: STRING; IN Str2: STRING; OUT Str: STRING);

PROCEDURE GetNumResTyps(OUT NumResTypArr: NumResType);

PROCEDURE Output;

PROCEDURE OutputInfo;

{PROCEDURE ProcResInfo;}

PROCEDURE ProcMatInfo;

PROCEDURE ProcRoadInfo;

PROCEDURE ReadUserInfo(IN FilNam: STRING);

PROCEDURE GenProjResPool;

PROCEDURE InitMatSrcObjArr;

PROCEDURE GenEnvir;

PROCEDURE InitCmpctrPPool;

PROCEDURE InitTrkPPool;

PROCEDURE InitLdrPPool;

PROCEDURE InitDozPPool;

PROCEDURE CreateHolders;

PROCEDURE GetReqRes(OUT ReqRes: ReqResRec);

END MODULE.


IMPLEMENTATION MODULE ProcMod;
FROM CompMod IMPORT NumResType, NumResTyp, NumResTypArr, EqpmtDb,
NumMatSrcs,
Envir, NumPaths, NumTrkTyps, DozInfo, DozProps, LdrInfo, LdrProps,
TrkInfo,
```

```
TrkProps, CmpctrInfo, CmpctrRecFlds, DozPPoolArr, LdrPPoolArr,
CmpctrPPoolArr,
TrkPPoolArr, MatSrcInfoArr, PathInfo, {ProjResPool,}
TempQ, Struct, MatSrcObjArr, MatSrcObj, CmpctrPoolTyp, TrkPoolTyp,
LdrPoolTyp,
DozPoolTyp, SubStrObj, ReqResRec;
FROM ResMod IMPORT ResourceObj;
FROM IOMod IMPORT StreamObj, FileUseType(Input);


      PROCEDURE Concat(IN Str1: STRING; IN Str2: STRING; OUT Str:
STRING);
      VAR
            i,j, Len1, Len2, Len: INTEGER;
            Arr1, Arr2, Arr: ARRAY INTEGER OF CHAR;

      BEGIN
            j := 1;
            Len1 := STRLEN(Str1);
            Len2 := STRLEN(Str2);
            Len := Len1 + Len2 + 1;
            NEW(Arr1, 1..Len1 + 1);
            NEW(Arr2, 1..Len2 + 1);
            STRTOCHAR(Str1,Arr1);
            STRTOCHAR(Str2, Arr2);
            NEW(Arr, 1..Len);
            FOR i := 1 TO Len1
                  Arr[i] := Arr1[i];
            END FOR;

            FOR i := (Len1 + 1) TO Len
                  Arr[i] := Arr2[j];
                  j := j + 1;
            END FOR;
            Str := CHARTOSTR(Arr);
      END PROCEDURE;

      PROCEDURE GetNumResTyps(OUT NumResTypArr: NumResType);
      VAR
            Strm: StreamObj;
            Str:  STRING;
            i:    INTEGER;
            {test:      INTEGER;}
      BEGIN
            NEW(Strm);
            ASK Strm Open("ResInfo.txt", Input);
            ASK Strm ReadString(Str);
            IF Str = "Resources"
                  ASK Strm ReadString(Str);
                  FOR i := 1 TO NumResTyp
                        NumResTypArr[i] := STRTOINT(Str);
                        {test := NumResTypArr[i];}
                  END FOR;
            END IF;
            ASK Strm Close;
```

```
END PROCEDURE;

PROCEDURE Output;
VAR
       i: INTEGER;
BEGIN
       OUTPUT("Testing Resources");
       OUTPUT;
       OUTPUT("Dozers");
       FOR i := 1 TO NumResTypArr[1]
              OUTPUT("Typ: ", DozPPoolArr[i].Typ);
              {OUTPUT("Cap: ",
                     EqpmtDb.DozDb[i].Cap);}
              OUTPUT("Num: ",
                     DozPPoolArr[i].Num);
       END FOR;
       OUTPUT;
       OUTPUT("Loaders");
       FOR i := 1 TO NumResTypArr[2]
              OUTPUT("Typ: ", LdrPPoolArr[i].Typ);
              {OUTPUT("Cap: ",
                     EqpmtDb.LdrDb[i].Cap);}
              OUTPUT("Num: ",
                     LdrPPoolArr[i].Num);
       END FOR;
       OUTPUT;
       OUTPUT("Trucks");
       FOR i := 1 TO NumResTypArr[1]
              OUTPUT("Typ: ", TrkPPoolArr[i].Typ);
              {OUTPUT("Cap: ",
                     EqpmtDb.TrkDb[i].Cap);}
              OUTPUT("Num: ",
                     TrkPPoolArr[i].Num);
       END FOR;
       OUTPUT;
       OUTPUT("Compactors");
       FOR i := 1 TO NumResTypArr[1]
              OUTPUT("Typ: ", CmpctrPPoolArr[i].Typ);
              {OUTPUT("Cap: ",
                     EqpmtDb.CmpctrDb[i].Cap);}
              OUTPUT("Num: ",
                     CmpctrPPoolArr[i].Num);
       END FOR;
       OUTPUT;
       OUTPUT;
       {ch := ReadKey();}
END PROCEDURE;

PROCEDURE OutputInfo;
VAR
       a,b,i,j:    INTEGER;

BEGIN
       OUTPUT("Testing Environment---Material Sources");
       FOR a := 1 TO NumMatSrcs
```

```
                OUTPUT("Name: ",Envir.MatSrcs[a].Name);
                OUTPUT("Avail Qty: ",Envir.MatSrcs[a].QtyAvail);
                FOR b := 1 TO Envir.MatSrcs[a].NumModsSrvd
                      OUTPUT("Mods: ",Envir.MatSrcs[a].ModNos[b]);
                END FOR;
          END FOR;
          OUTPUT;
          OUTPUT("Testing Environment---Roads");
          FOR i := 1 TO NumPaths
                OUTPUT("Source: ",Envir.Roads[i].Src);
                OUTPUT("Dest: ",Envir.Roads[i].Dest);
                FOR j := 1 TO NumTrkTyps
                      OUTPUT("Loaded:
",Envir.Roads[i].TrkDets[j].SpeedLddModFac);
                      OUTPUT("Empty:
",Envir.Roads[i].TrkDets[j].SpeedMtModFac);
                END FOR;
          END FOR;

    END PROCEDURE;

    PROCEDURE GetReqRes(OUT ReqRes: ReqResRec);
    VAR
          k: INTEGER;
          Strm: StreamObj;
          Str: STRING;
    BEGIN
                      NEW(Strm);
                      ASK Strm Open("ReqRes.txt",Input);
                      ASK Strm ReadString(Str);
                      ASK Strm ReadString(Str);
                      ASK Strm ReadString(Str);
                      ReqRes.NumDozTyp := STRTOINT(Str);
                      NEW(ReqRes.Doz, 1..ReqRes.NumDozTyp);
                      IF ReqRes.NumDozTyp > 0
                            FOR k := 1 TO ReqRes.NumDozTyp
                                  NEW(ReqRes.Doz[k]);
                                  ASK Strm ReadString(Str);
                                  ReqRes.Doz[k].Typ := Str;
                                  ASK Strm ReadString(Str);

    ReqRes.Doz[k].Cap:=STRTOREAL(Str);
                                  ASK Strm ReadString(Str);
                                  ReqRes.Doz[k].Num :=
STRTOINT(Str);
                            END FOR;
                      END IF;
                      ASK Strm ReadString(Str);
                      ReqRes.NumLdrTyp := STRTOINT(Str);
                      {ASK Strm ReadString(Str);}
                      NEW(ReqRes.Ldr, 1..ReqRes.NumLdrTyp);
                      IF ReqRes.NumLdrTyp > 0
                            FOR k := 1 TO ReqRes.NumLdrTyp
                                  NEW(ReqRes.Ldr[k]);
```

```
                                        ASK Strm ReadString(Str);
                                        ReqRes.Ldr[k].Typ := Str;
                                        ASK Strm ReadString(Str);
                                        ReqRes.Ldr[k].Num :=
STRTOINT(Str);

                                END FOR;
                        END IF;
                        ASK Strm ReadString(Str);
                        ReqRes.NumTrkTyp := STRTOINT(Str);
                        {ASK Strm ReadString(Str);}
                        NEW(ReqRes.Trk, 1..ReqRes.NumTrkTyp);
                        IF ReqRes.NumTrkTyp > 0
                                FOR k := 1 TO ReqRes.NumTrkTyp
                                        NEW(ReqRes.Trk[k]);
                                        ASK Strm ReadString(Str);
                                        ReqRes.Trk[k].Typ := Str;
                                        ASK Strm ReadString(Str);

        ReqRes.Trk[k].Cap:=STRTOREAL(Str);
                                        ASK Strm ReadString(Str);
                                        ReqRes.Trk[k].Num :=
STRTOINT(Str);
                                END FOR;
                        END IF;
                        ASK Strm ReadString(Str);
                        ReqRes.NumCmpctrTyp := STRTOINT(Str);
                        {ASK Strm ReadString(Str);}
                        NEW(ReqRes.Cmpctr, 1..ReqRes.NumCmpctrTyp);
                        IF ReqRes.NumCmpctrTyp > 0
                                FOR k := 1 TO ReqRes.NumCmpctrTyp
                                        NEW(ReqRes.Cmpctr[k]);
                                        ASK Strm ReadString(Str);
                                        ReqRes.Cmpctr[k].Typ := Str;
                                        ASK Strm ReadString(Str);

        ReqRes.Cmpctr[k].Cap:=STRTOREAL(Str);
                                        ASK Strm ReadString(Str);
                                        ReqRes.Cmpctr[k].Num :=
STRTOINT(Str);
                                END FOR;
                        END IF;
                        ASK Strm Close;
        END PROCEDURE;


        {PROCEDURE ProcResInfo;
        VAR
                TempResObj: ResourceObj;
                Strm:       StreamObj;
                Str:        STRING;
                {DozNum,
                LdrNum,
                TrkNum,
                CmpctrNum:  INTEGER;}
```

```
            i,j,n:              INTEGER;

        BEGIN
            NEW(Strm);
            ASK Strm Open("ResInfo.txt", Input);
            {ASK Strm Open(ResFil, Input);
            ASK Strm ReadString(Str);}
            {ASK Strm ReadString(Str);
            IF Str = "Resources"
                  ASK Strm ReadString(Str);
                  FOR i := 1 TO NumResTyp
                        NumResTypArr[i] := STRTOINT(Str);
                  END FOR;
            END IF;}
            {NEW(TrkInfo, 1..NumResTypArr[3]);
            NEW(DozInfo, 1..NumResTypArr[1]);
            NEW(LdrInfo, 1..NumResTypArr[2]);
            NEW(CmpctrInfo, 1..NumResTypArr[4]);}
            {NEW(Ldtime, 1..NumResTypArr[3]);}
            {FOR i := 1 TO NumResTypArr[1]
                  NEW(DozDets);
                  DozInfo[i] := DozDets;
            END FOR;}
            WHILE NOT(ASK Strm eof)
                  ASK Strm ReadString(Str);
                  IF Str = "Resources"
                        FOR i := 1 TO NumResTyp {Doz,Ldr,Trk,Cmpctr}
                              ASK Strm ReadString(Str);
                              NumResTypArr[i] := STRTOINT(Str);{no of
each resource typ}
                        END FOR;
                  ELSIF Str = "Dozers"
                        FOR i := 1 TO NumResTypArr[1]
                              NEW(DozInfo[i]);
                              FOR j:= 1 TO DozProps
                                    ASK Strm ReadString(Str);
                                    IF j =1
                                          DozInfo[i].Typ := Str;
                                    ELSIF j = 2
                                          DozInfo[i].Cap :=
STRTOREAL(Str);
                                    ELSE
                                          DozInfo[i].Num :=
STRTOINT(Str);
                                    END IF;
                              END FOR;
                        END FOR;
                  ELSIF Str = "Loaders"
                        FOR i := 1 TO NumResTypArr[2]
                              NEW(LdrInfo[i]);
                              ASK Strm ReadString(Str);
                              ASK Strm ReadString(Str);
                              LdrInfo[i].Typ:=Str;
                              ASK Strm ReadString(Str);
                              LdrInfo[i].Num:=STRTOINT(Str);
```

```
                    END FOR;
                ELSIF Str = "Trucks"
                    FOR i := 1 TO NumResTypArr[3]
                        NEW(TrkInfo[i]);
                        FOR j := 1 TO TrkProps
                            ASK Strm ReadString(Str);
                            IF j = 1
                                TrkInfo[i].Typ := Str;
                            ELSIF j =2
                                TrkInfo[i].Cap :=
STRTOREAL(Str);
                            ELSIF j = 3
                                TrkInfo[i].Num :=
STRTOINT(Str);
                            ELSIF j = 4
                                TrkInfo[i].AgeOpModFac :=
STRTOREAL(Str);

                            ELSIF j = 5
                                TrkInfo[i].MaxSpeedLdd :=
STRTOREAL(Str);
                            ELSE
                                TrkInfo[i].MaxSpeedMt :=
STRTOREAL(Str);
                            END IF;
                        END FOR;
                    END FOR;
                ELSE
                    FOR i := 1 TO NumResTypArr[4]
                        NEW(CmpctrInfo[i]);
                        FOR j := 1 TO CmpctrRecFlds
                            ASK Strm ReadString(Str);
                            IF j = 1
                                CmpctrInfo[i].Typ := Str;
                            ELSIF j =2
                                CmpctrInfo[i].Cap :=
STRTOREAL(Str);
                            ELSE
                                CmpctrInfo[i].Num :=
STRTOINT(Str);
                            END IF;
                        END FOR;
                    END FOR;
                END IF;
                {DozNum := Str;
                TempResObj := ASK TempQ Remove;
                ASK TempResObj Create(STRTOINT(Str));}
            END WHILE;
            {Output(DozInfo);}

        {Output(TrkInfo);
        Output(CmpctrInfo);}
        ASK Strm Close;
        END PROCEDURE;}
```

```
PROCEDURE ProcMatInfo;
VAR
      i,j:  INTEGER;
      Strm: StreamObj;
      Str:  STRING;


BEGIN
      NEW(Strm);
      ASK Strm Open("MatInfo.txt", Input);
      ASK Strm ReadString(Str);
      IF Str = "Material_Sources"
            ASK Strm ReadString(Str);
            NumMatSrcs := STRTOINT(Str);
            NEW(MatSrcInfoArr, 1..NumMatSrcs);
            WHILE NOT (ASK Strm eof)
                  {ASK Strm ReadString(Str);}
                  FOR i := 1 TO NumMatSrcs
                        NEW(MatSrcInfoArr[i]);
                        ASK Strm ReadString(Str);
                        MatSrcInfoArr[i].Name := Str;
                        ASK Strm ReadString(Str);
                        MatSrcInfoArr[i].NumModsSrvd :=
STRTOINT(Str);
                        ASK Strm ReadString(Str);
                        MatSrcInfoArr[i].QtyAvail :=
STRTOREAL(Str);
                        NEW(MatSrcInfoArr[i].ModNos,
1..MatSrcInfoArr[i].NumModsSrvd);
                        FOR j := 1 TO
MatSrcInfoArr[i].NumModsSrvd
                              ASK Strm ReadString(Str);
                              MatSrcInfoArr[i].ModNos[j] :=
STRTOINT(Str);
                        END FOR;
                  END FOR;
            END WHILE;
      END IF;
      ASK Strm Close;
END PROCEDURE;

PROCEDURE ProcRoadInfo;
VAR
      i,j:          INTEGER;
      Strm:         StreamObj;
      Str:          STRING;
      {PathInfo:    ARRAY INTEGER OF TrkPathPropsRec;}
      {TrkDets:     ARRAY INTEGER OF TrkSpeedRec;}

BEGIN
      NEW(Strm);
      ASK Strm Open("RodInfo.txt", Input);
      ASK Strm ReadString(Str);
      IF Str = "RoadInfo"
            ASK Strm ReadString(Str);
```

```
                NumPaths := STRTOINT(Str);
                ASK Strm ReadString(Str);
                NumTrkTyps := STRTOINT(Str);
                NEW(PathInfo, 1..NumPaths);
                WHILE NOT(ASK Strm eof)
                      {ASK Strm ReadString(Str);}
                      FOR i := 1 TO NumPaths
                            NEW(PathInfo[i]);
                            ASK Strm ReadString(Str);
                            PathInfo[i].Src   := Str;
                            ASK Strm ReadString(Str);
                            PathInfo[i].Dest := Str;
                            ASK Strm ReadString(Str);
                            NEW(PathInfo[i].TrkDets,
1..NumTrkTyps);

                            FOR j := 1 TO NumTrkTyps
                                  NEW(PathInfo[i].TrkDets[j]);
                                  ASK Strm ReadString(Str);{read
off "Type"}

                                  ASK Strm ReadString(Str);

      PathInfo[i].TrkDets[j].SpeedLddModFac := STRTOREAL(Str);
                                  ASK Strm ReadString(Str);

      PathInfo[i].TrkDets[j].SpeedMtModFac := STRTOREAL(Str);
                            END FOR;
                      END FOR;
                END WHILE;
          END IF;

      END PROCEDURE;

      {PROCEDURE ProcModInfo;
      VAR
            i: INTEGER;
            Str: STRING;
            Strm: StreamObj;
      BEGIN
            ASK Strm ReadString(Str);
            NumMods := Str;
            FOR i := 1 TO NumMods
                  ASK Strm ReadString(Str);

            END FOR;

      END PROCEDURE;}

      PROCEDURE ReadUserInfo(IN FilNam: STRING);
      VAR
            Str,
            MatchStr:   STRING;
            ch:         CHAR;


      BEGIN
```

```
            {NEW(Strm);}
            MatchStr := SUBSTR(1, 3, FilNam);
                  IF (MatchStr = "Res")
                        {ProcResInfo;}
                  END IF;
                  IF (MatchStr = "Mat")
                        ProcMatInfo;
                  END IF;
                  IF (MatchStr = "Rod")
                        ProcRoadInfo;
                  END IF;
                  {ELSEIF (MatchStr = "Struct")
                        ProcStructInfo(Str);}
                  {IF (MatchStr = "Mod")
                        ASK Struct InitConfig;
                  END IF;}
                  {ASK (ProjResPool.(ASK ProjResQ Remove))
Create(STRTOINT(Str));}
            {OUTPUT(INTTOSTR(ProjResPool.PTrkRes.Resources));
            OUTPUT(INTTOSTR(ProjResPool.PCmpctrRes.Resources));
            ch := ReadKey();}
      END PROCEDURE;

      PROCEDURE GenProjResPool;


      VAR
            i: INTEGER;
            Strm: StreamObj;
            Str: STRING;
      BEGIN
            {InitDozPPool;
            InitLdrPPool;
            InitTrkPPool;
            InitCmpctrPPool;}
            NEW(Strm);
            ASK Strm Open("ResInfo.txt",Input);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            IF NumResTypArr[1]>0
            NEW(DozPPoolArr,1..NumResTypArr[1]);
            ASK Strm ReadString(Str);
            FOR i := 1 TO NumResTypArr[1]
                  NEW(DozPPoolArr[i]);

                  ASK Strm ReadString(Str);
                  DozPPoolArr[i].Typ := Str;
                  ASK Strm ReadString(Str);
                  {ASK Strm ReadString(Str);}
                  DozPPoolArr[i].Num:= STRTOINT(Str);
                  NEW(DozPPoolArr[i].DozPPoolRes);
                  ASK DozPPoolArr[i].DozPPoolRes
```

```
            Create(DozPPoolArr[i].Num);
        END FOR;
        END IF;
        IF NumResTypArr[2]>0
        NEW(LdrPPoolArr,1..NumResTypArr[2]);
        ASK Strm ReadString(Str);
        FOR i := 1 TO NumResTypArr[2]
            NEW(LdrPPoolArr[i]);

            ASK Strm ReadString(Str);
            LdrPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            {ASK Strm ReadString(Str);}
            LdrPPoolArr[i].Num:= STRTOINT(Str);
            NEW(LdrPPoolArr[i].LdrPPoolRes);
            ASK LdrPPoolArr[i].LdrPPoolRes
            Create(LdrPPoolArr[i].Num);
        END FOR;
        END IF;
        IF NumResTypArr[3]>0
        NEW(TrkPPoolArr,1..NumResTypArr[3]);
        ASK Strm ReadString(Str);
        FOR i := 1 TO NumResTypArr[3]
            NEW(TrkPPoolArr[i]);

            ASK Strm ReadString(Str);
            TrkPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            {ASK Strm ReadString(Str);}
            TrkPPoolArr[i].Num:= STRTOINT(Str);
            NEW(TrkPPoolArr[i].TrkPPoolRes);
            ASK TrkPPoolArr[i].TrkPPoolRes
            Create(TrkPPoolArr[i].Num);
        END FOR;
        END IF;
        IF NumResTypArr[4]>0
        NEW(CmpctrPPoolArr,1..NumResTypArr[4]);
        ASK Strm ReadString(Str);
        FOR i := 1 TO NumResTypArr[4]
            NEW(CmpctrPPoolArr[i]);
            ASK Strm ReadString(Str);

            CmpctrPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            {ASK Strm ReadString(Str);}
            CmpctrPPoolArr[i].Num:=STRTOINT(Str);
            NEW(CmpctrPPoolArr[i].CmpctrPPoolRes);
            ASK CmpctrPPoolArr[i].CmpctrPPoolRes
            Create(CmpctrPPoolArr[i].Num);
        END FOR;
        END IF;
        ASK Strm Close;
END PROCEDURE;

PROCEDURE CreateHolders;
```

```
VAR
      Strm: StreamObj;
BEGIN
      NEW(Strm);
      {NEW(ProjResPool);}
      NEW(TempQ);
      {NEW(Envir);}
      NEW(Struct);
      NEW(NumResTypArr, 1..NumResTyp);
      {ASK Strm Open("ResInfo.txt", Input);}
      GetNumResTyps(NumResTypArr);
      NEW(TrkInfo, 1..NumResTypArr[3]);
      NEW(DozInfo, 1..NumResTypArr[1]);
      NEW(LdrInfo, 1..NumResTypArr[2]);
      NEW(CmpctrInfo, 1..NumResTypArr[4]);
END PROCEDURE;

PROCEDURE InitMatSrcObjArr;
VAR
      i: INTEGER;
BEGIN
      FOR i := 1 TO NumMatSrcs
            NEW(MatSrcObjArr[i]);
            ASK MatSrcObjArr[i] InitMatSrcObj(i);
      END FOR;
END PROCEDURE;

PROCEDURE GenEnvir;
BEGIN
      ReadUserInfo("MatInfo.txt");
      NEW(MatSrcObjArr, 1..NumMatSrcs);
      InitMatSrcObjArr;
      ReadUserInfo("RodInfo.txt");
      NEW(Envir);
      ReadUserInfo("ModInfo.txt");
END PROCEDURE;

{PROCEDURE InitCmpctrPPool;
VAR
      i: INTEGER;
      Strm: StreamObj;
      Str: STRING;
BEGIN
      NEW(Strm);
      ASK Strm Open("ResInfo.txt",Input);
      NEW(CmpctrPPoolArr,1..NumResTypArr[4]);
      FOR i := 1 TO NumResTypArr[4]
            NEW(CmpctrPPoolArr[i]);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            CmpctrPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            CmpctrPPoolArr[i].Num:=STRTOINT(Str);
            NEW(CmpctrPPoolArr[i].CmpctrPPoolRes);
```

```
            ASK CmpctrPPoolArr[i].CmpctrPPoolRes
                  Create(CmpctrPPoolArr[i].Num);
      END FOR;
      ASK Strm Close;
END PROCEDURE;}

{PROCEDURE InitTrkPPool;
VAR
      i: INTEGER;
      Strm: StreamObj;
      Str: STRING;
BEGIN
      NEW(Strm);
      ASK Strm Open("ResInfo.txt",Input);
      NEW(TrkPPoolArr,1..NumResTypArr[3]);
      FOR i := 1 TO NumResTypArr[3]
            NEW(TrkPPoolArr[i]);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            TrkPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            TrkPPoolArr[i].Num:= STRTOINT(Str);
            NEW(TrkPPoolArr[i].TrkPPoolRes);
            ASK TrkPPoolArr[i].TrkPPoolRes
                  Create(TrkPPoolArr[i].Num);
      END FOR;
      ASK Strm Close;
END PROCEDURE;}


{PROCEDURE InitLdrPPool;
VAR
      i: INTEGER;
      Strm: StreamObj;
      Str: STRING;
BEGIN
      NEW(Strm);
      ASK Strm Open("ResInfo.txt",Input);
      NEW(LdrPPoolArr,1..NumResTypArr[2]);
      FOR i := 1 TO NumResTypArr[2]
            NEW(LdrPPoolArr[i]);
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            LdrPPoolArr[i].Typ := Str;
            ASK Strm ReadString(Str);
            ASK Strm ReadString(Str);
            LdrPPoolArr[i].Num:= STRTOINT(Str);
            NEW(LdrPPoolArr[i].LdrPPoolRes);
            ASK LdrPPoolArr[i].LdrPPoolRes
                  Create(LdrPPoolArr[i].Num);
      END FOR;
      ASK Strm Close;
END PROCEDURE;}
```

```
        {PROCEDURE InitDozPPool;
        VAR
              i:    INTEGER;
              Strm: StreamObj;
              Str: STRING;
        BEGIN
              NEW(Strm);
              ASK Strm Open("ResInfo.txt",Input);
              NEW(DozPPoolArr,1..NumResTypArr[1]);
              FOR i := 1 TO NumResTypArr[1]
                    NEW(DozPPoolArr[i]);
                    ASK Strm ReadString(Str);
                    ASK Strm ReadString(Str);
                    DozPPoolArr[i].Typ := Str;
                    ASK Strm ReadString(Str);
                    ASK Strm ReadString(Str);
                    DozPPoolArr[i].Num:= STRTOINT(Str);
                    NEW(DozPPoolArr[i].DozPPoolRes);
                    ASK DozPPoolArr[i].DozPPoolRes
                          Create(DozPPoolArr[i].Num);
              END FOR;
              ASK Strm Close;
        END PROCEDURE;}

        {PROCEDURE PrRout;
        BEGIN
              ASK Structure Output;
        END PROCEDURE;}

END MODULE;
```

```
DEFINITION MODULE CompMod;

FROM ResMod IMPORT ResourceObj;
FROM IOMod IMPORT StreamObj, FileUseType(Input);
FROM GrpMod IMPORT QueueObj;
FROM ListMod IMPORT BasicListObj;
FROM SimMod IMPORT TriggerObj;
FROM RandMod IMPORT RandomObj;
CONST
      NumResTyp = 4;
      DozProps = 3; {DozRecFlds}
      LdrProps = 3;
      TrkProps = 6;
      CmpctrRecFlds = 3;
      {YLag = 100;
      ZLag = 150;}
      NumPS = 1;
      NumSS = 1;
      NumConc = 2;
```

```
      NumLC = 1;
      NoLdrs = 1;
      HTimeAPrm1 = 4.5;
      HTimeAPrm2 = 5.0;
      RTimeAPrm1 = 3.5;
      RTimeAPrm2 = 4.0;
      HTimeBPrm1 = 2.5;
      HTimeBPrm2 = 2.0;
      RTimeBPrm1 = 1.5;
      RTimeBPrm2 = 1.0;
      LdTimePrm1 = 1.0;
      LdTimePrm2 = 1.0;
      CutTimePrm1 = 2.0;
      CutTimePrm2 = 2.0;
      DumpTime=0.5;
      PileTime=0.25;
      PilThresh=10.0;
      DozUse=FALSE;

TYPE
      TrkStatusType = (Empty, Loaded);

      StructTyp = (Rt, Cnc, Scc);

      BlkBrdObj =
      OBJECT
            TotModNum,
            ComplModNum:       INTEGER;
            CurrTime,
            ElapsdTime,
            TotVol,
            ComplVol:   REAL;
            {ASK METHOD UpdateComplModNum;
            ASK METHOD UpdateCurrTime;
            ASK METHOD UpdateElapsdTime;
            ASK METHOD UpdateComplVol;}
      END OBJECT;

      CntrlObj =
      OBJECT
            BlkBrd:     BlkBrdObj;
            ASK METHOD InitSystem;
            {ASK METHOD StartConst;}
            {ASK METHOD GenStructModel;
            ASK METHOD GenEnvir;
            ASK METHOD GenProjResPool;
            ASK METHOD GenMods;}
            {TELL METHOD HoldModWork;}
            {ASK METHOD ReadUserInfo;}
      END OBJECT;

      DozerObj =
      OBJECT
            Id:          INTEGER;
            Typ:         STRING;
```

```
            Cap:            REAL;
            ASK METHOD Init(IN InTyp:STRING;IN InCap: REAL; IN Ident:
INTEGER);
            TELL METHOD Cut(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
                        IN DRP2:REAL;IN Mod: ModObj);
            TELL METHOD Haul(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
                        IN DRP2:REAL;IN Mod: ModObj);
            TELL METHOD Pile(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
                        IN DRP2:REAL;IN Mod: ModObj);
            TELL METHOD Rturn(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
                        IN DRP2:REAL;IN Mod: ModObj);

      END OBJECT;

      TruckObj =
      OBJECT
            Id:             INTEGER;
            Typ:            STRING;
            Cap:            REAL;
            Status:               TrkStatusType;
            {Ldtime:        ARRAY INTEGER OF REAL;}
            AgeOpEffModFac:    REAL;
            {TELL METHOD Prepare;}
            ASK METHOD Init(IN InTyp:STRING;IN InCap: REAL; IN Ident:
INTEGER);
            TELL METHOD Load(IN HP1:REAL;IN HP2:REAL;
                        IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                        IN LdrRes:LdrResObj);
            TELL METHOD Haul(IN HP1:REAL;IN HP2:REAL;
                        IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                        IN LdrRes:LdrResObj);
            TELL METHOD Dump(IN HP1:REAL;IN HP2:REAL;
                        IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                        IN LdrRes:LdrResObj);
            TELL METHOD Rturn(IN HP1:REAL;IN HP2:REAL;
                        IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                        IN LdrRes:LdrResObj);
            {ASK METHOD GetActualSpeed;}
      END OBJECT;

      CmpctrObj =
      OBJECT
            Id:             INTEGER;
            Typ:            STRING;
            ProdRate:       REAL;
            ASK METHOD Init(IN InCap: REAL; IN Ident: INTEGER);

      END OBJECT;

      TrkSpeedRec =
      RECORD
            SpeedLddModFac,
            SpeedMtModFac:     REAL;
      END RECORD;
```

```
TrkRec =
RECORD
      Typ:         STRING;
      Cap:         REAL;
      Num:         INTEGER;
      AgeOpModFac,
      MaxSpeedLdd,
      MaxSpeedMt: REAL;
END RECORD;

TrkPathPropsRec =
RECORD
      {Typ:        STRING;}
      Src,
      Dest:        STRING;
      TrkDets:     ARRAY INTEGER OF TrkSpeedRec;
END RECORD;

DozRec =
RECORD
      Typ:         STRING;
      Cap:         REAL;
      Num:         INTEGER;
END RECORD;

LdrRec =
RECORD
      Typ:         STRING;
      {Ldtime:     ARRAY INTEGER OF REAL;}
      Num:         INTEGER;
END RECORD;

CmpctrRec =
RECORD
      Typ:         STRING;
      Cap:         REAL;
      Num:         INTEGER;
END RECORD;

MatSrcRec =
RECORD
      Name:        STRING;
      QtyAvail:    REAL;
      NumModsSrvd:      INTEGER;
      ModNos:           ARRAY INTEGER OF INTEGER;
END RECORD;

{PathRec =
RECORD
      Src:         STRING;
      Dest:        STRING;
      TrkDets:     ARRAY INTEGER OF TrkRec;
END RECORD;}

DozPPoolRec =
```

```
RECORD
      Typ:          STRING;
      Num:          INTEGER;
      DozPPoolRes:        ResourceObj;
END RECORD;

LdrPPoolRec =
RECORD
      Typ:          STRING;
      Num:          INTEGER;
      LdrPPoolRes:        ResourceObj;
END RECORD;

TrkPPoolRec =
RECORD
      Typ:          STRING;
      Num:          INTEGER;
      TrkPPoolRes:        ResourceObj;
END RECORD;

CmpctrPPoolRec =
RECORD
      Typ:          STRING;
      Num:          INTEGER;
      CmpctrPPoolRes:   ResourceObj;
END RECORD;

LdrResObj =
OBJECT(ResourceObj)
      Name,
      Typ:  STRING;
      Num:  INTEGER;
      OccTime:REAL;
      ASK METHOD Init;
      ASK METHOD Update(IN WrkTime:REAL);
END OBJECT;

NumResType = ARRAY INTEGER OF INTEGER;
PrmsTyp = ARRAY INTEGER OF REAL;
DozInfoType = ARRAY INTEGER OF DozRec;
LdrInfoType = ARRAY INTEGER OF LdrRec;
TrkInfoType = ARRAY INTEGER OF TrkRec;
CmpctrInfoType = ARRAY INTEGER OF CmpctrRec;
MatSrcInfoType = ARRAY INTEGER OF MatSrcRec;

DozPoolTyp = ARRAY INTEGER OF DozPPoolRec;
LdrPoolTyp = ARRAY INTEGER OF LdrPPoolRec;
TrkPoolTyp = ARRAY INTEGER OF TrkPPoolRec;
CmpctrPoolTyp = ARRAY INTEGER OF CmpctrPPoolRec;

SubStrLvlTyp = ARRAY INTEGER OF SubStrObj;
StrConfigTyp = ARRAY INTEGER, INTEGER OF BlkObj;
{ElemLvlTyp = ARRAY INTEGER OF ElemObj;
BlkLvlTyp = ARRAY INTEGER OF BlkObj;}
ModLvlTyp = ARRAY INTEGER OF ModObj;
```

```
EqpmtDbObj =
OBJECT
      DozDb:        DozInfoType;
      LdrDb: LdrInfoType;
      TrkDb:        TrkInfoType;
      CmpctrDb: CmpctrInfoType;
      ASK METHOD ObjInit;
END OBJECT;

{ProjResObj =
OBJECT
      DozPPoolArr:        DozPoolTyp;
      LdrPPoolArr:        LdrPoolTyp;
      TrkPPoolArr:        TrkPoolTyp;
      CmpctrPPoolArr:     CmpctrPoolTyp;
      ASK METHOD ObjInit;
END OBJECT;}

ConcDepRec =
RECORD
      Dep:          SubStrObj;
      VolLag:             REAL;
END RECORD;


DozReqRec =
RECORD
      Typ: STRING;
      Cap: REAL;
      Num: INTEGER;
END RECORD;

LdrReqRec =
RECORD
      Typ: STRING;
      Num: INTEGER;
END RECORD;

TrkReqRec =
RECORD
      Typ: STRING;
      Cap: REAL;
      Num: INTEGER;
END RECORD;

CmpctrReqRec =
RECORD
      Typ: STRING;
      Cap: REAL;
      Num: INTEGER;
END RECORD;

ReqResRec =
RECORD
```

```
        NumDozTyp: INTEGER;
        Doz:  ARRAY INTEGER OF DozReqRec;
        NumLdrTyp: INTEGER;
        Ldr:  ARRAY INTEGER OF LdrReqRec;
        NumTrkTyp: INTEGER;
        Trk:  ARRAY INTEGER OF TrkReqRec;
        NumCmpctrTyp: INTEGER;
        Cmpctr:      ARRAY INTEGER OF CmpctrReqRec;
END RECORD;

ModTrkRec =
RECORD
        Typ:  STRING;
        TrkArr:      ARRAY INTEGER OF TruckObj;
END RECORD;

ModDozRec =
RECORD
        Typ:  STRING;
        DozArr:      ARRAY INTEGER OF DozerObj;
END RECORD;


{ConstrChkrObj =
OBJECT
        ASK METHOD ChkResAvail;
END OBJECT;}

MatSrcObj =
OBJECT
        Name:        STRING;
        QtyAvail:    REAL;
        NumModsSrvd:        INTEGER;
        ModNos:             ARRAY INTEGER OF INTEGER;
        ASK METHOD InitMatSrcObj(IN i: INTEGER);
END OBJECT;

MatSrcCollTyp = ARRAY INTEGER OF MatSrcObj;

ModObj =
OBJECT(BlkObj)
        LdrRes:             LdrResObj;
        ModResPool,
        ReqRes:             ReqResRec;
        PilTrig,
        CompTrig:    TriggerObj;
        TrkRes:             ARRAY INTEGER OF ModTrkRec;
        DozRes:             ARRAY INTEGER OF ModDozRec;
        PildVol:     REAL;
        SuffPilVol: BOOLEAN;
        {TELL METHOD StartConcurSim;
        TELL METHOD StartNextSim;
        TELL METHOD StartMod;}
        TELL METHOD DoSim;
        {ASK METHOD StartSim;}
```

```
            ASK METHOD ChkResAvail: BOOLEAN;
            ASK METHOD ChngStat;
            ASK METHOD InitMod(IN DozTravPrms:PrmsTyp;
                  IN TravPrms:PrmsTyp;IN Vol:REAL;IN Nam: STRING);
            ASK METHOD AssnDep(IN Elem:ModObj; IN Str1: STRING; IN
Str2: INTEGER);
            ASK METHOD Update(IN Cap: REAL);
            ASK METHOD PilUpdate(IN InCap:REAL);
            ASK METHOD FUpdateSuff(IN InBool:BOOLEAN);
            OVERRIDE

                  {ASK METHOD InitConfig(IN FilNam: STRING);}
                  {ASK METHOD Output;}
                  {TELL METHOD Const;}
      END OBJECT;

      BlkObj =
      OBJECT(SubStrObj)

            BlkConfig:  ModLvlTyp;
            HP1,HP2,
            RP1,RP2,
            DHP1,DHP2,
            DRP1,DRP2:  REAL;
            {TELL METHOD StartConcurSim;
            TELL METHOD StartNextSim;
            TELL METHOD StartBlock;}
            ASK METHOD GenNext(IN FilNam: STRING);
            ASK METHOD Constr;
            OVERRIDE
                  {ASK METHOD GenNext;}
                  {ASK METHOD Output;}
                  {ASK METHOD InitConfig(IN FilNam: STRING);}

      END OBJECT;

      {ElemObj =
      OBJECT(SubStrObj)
            {TELL METHOD StartConcurSim;}
            {TELL METHOD StartNextSim;
            TELL METHOD Start;}
            {ASK METHOD GenNext;}
            OVERRIDE

                  ASK METHOD Output;
                  ASK METHOD InitConfig(IN FilNam: STRING);
                  {TELL METHOD Const;}
      END OBJECT;}

      SubStrObj =
      OBJECT
            SuccNum,
            ConcNum,
            Name:       STRING;
            NumNext:    INTEGER;
```

```
        TotVol,
        CurrVol:     REAL;
        LC,Conc,
        PS, SS:              ModLvlTyp;
        HavSucc,
        Comm,Comp,
        HavConc:     BOOLEAN;
        NumBlks:     INTEGER;
        ConfigR:     SubStrObj;
        StrtTime:    REAL;
        {MatSrcs:    MatSrcCollTyp;}
        ASK METHOD Init(IN Str1: STRING; IN Str2: STRING);
        {ASK METHOD InitConfig(IN FilNam: STRING);}
        {ASK METHOD GenNext(IN FilNam: STRING);}
        {ASK METHOD Output;}
        {ASK METHOD UpdateVol(IN Vol: REAL);}
        {ASK METHOD GetInfo(IN FilNam: STRING);}
        {TELL METHOD Const;}
        {TELL METHOD StartConcurSim;}
        {TELL METHOD StartNextSim;
        TELL METHOD Start;}
END OBJECT;

StructObj =
OBJECT
        StructVol:   REAL;
        VolCompl:    REAL;
        ModsPredLine:        INTEGER;
        ConfigR:     SubStrObj;
        Config:              StrConfigTyp;
        ASK METHOD InitConfig;
        ASK METHOD UpdateVol(IN Vol: REAL);
        ASK METHOD GenBlkStruct(IN FilNam: STRING);
        {ASK METHOD GenBlkDeps(IN FilNam: STRING);}
        ASK METHOD Output;
        ASK METHOD AssnDeps(IN FilNam: STRING);
        {ASK METHOD StartSim;}
        ASK METHOD Constr;
END OBJECT;

PathObj =
OBJECT
        Src:         STRING;
        Dest:        STRING;
        TrkDets:     ARRAY INTEGER OF TrkSpeedRec;
        ASK METHOD InitPathObj(IN i: INTEGER);
END OBJECT;

EnvirObj =
OBJECT
        MatSrcs:     MatSrcCollTyp;
        Roads:               ARRAY INTEGER OF PathObj;
        Structure:   StructObj;
        ASK METHOD ObjInit;
END OBJECT;
```

```
VAR
      NumMods,
      NumPaths,
      NumTrkTyps, {based eqpt cond & op eff}
      imax, jmax,
      NumMatSrcs:        INTEGER;
      {ProjResPool:      ProjResObj;}
      Cntrlr:            CntrlObj;
      Envir:             EnvirObj;
      Struct:      StructObj;
      TempQ:             QueueObj;
      BlkBrd:            BlkBrdObj;
      NumResTypArr:      NumResType;
      NumLifts:    INTEGER;
      CmpctrPPoolArr: CmpctrPoolTyp;
      TrkPPoolArr:       TrkPoolTyp;
      LdrPPoolArr:       LdrPoolTyp;
      DozPPoolArr:       DozPoolTyp;
      TrkInfo:     TrkInfoType;
      LdrInfo:     LdrInfoType;
      DozInfo:     DozInfoType;
      CmpctrInfo: CmpctrInfoType;
      Strm1,Strm2:       StreamObj;
      MatSrcInfoArr:     MatSrcInfoType;
      MatSrcObjArr:      MatSrcCollTyp;
      PathInfo:    ARRAY INTEGER OF TrkPathPropsRec;
      EqpmtDb:     EqpmtDbObj;
      Structure:   StructObj;
      SubStr:            SubStrObj;
      StrtSig:     TriggerObj;
      Strct:             StrConfigTyp;
      SubStrLvl:   SubStrLvlTyp;
      {ElemLvl:    ElemLvlTyp;
      BlkLvl:            BlkLvlTyp;
      ModLvl:            ModLvlTyp;}
      BlkSucc:     BlkObj;
      BlkConc:     BlkObj;
      Rand1:             RandomObj;
END MODULE.


IMPLEMENTATION MODULE CompMod;

FROM IOMod IMPORT StreamObj, FileUseType(Input);
FROM ProcMod IMPORT Concat, InitDozPPool, InitLdrPPool,
InitCmpctrPPool, InitTrkPPool,
GenEnvir, GenProjResPool, GetReqRes;

FROM SimMod IMPORT SimTime, TriggerObj, InterruptAll;

      OBJECT ModObj;
            TELL METHOD DoSim;
            VAR
```

```
                    i,j: INTEGER;
                    Truk: TruckObj;
                    LdrRes: LdrResObj;
                    Dozr: DozerObj;
               BEGIN
                    NEW(Rand1);
                    NEW(TrkRes,1..ReqRes.NumTrkTyp);
                    NEW(DozRes,1..ReqRes.NumDozTyp);
                    FOR i:=1 TO NumLC

                         IF (LC[i]<>NILOBJ) AND (LC[i].Comm = FALSE)
                              WAIT FOR LC[i] DoSim
                                   ASK LC[i] ChngStat;
                              END WAIT;
                         ELSIF (LC[i]<>NILOBJ) AND
                              (LC[i].Comm = TRUE) AND (LC[i].Comp =
FALSE)

                              WAIT FOR LC[i].CompTrig Fire
                              END WAIT;
                         ELSE
                              IF ChkResAvail=TRUE
                                   ASK Strm1 WriteLn;
                                   ASK Strm1 WriteString("Checking
Resource Sufficiency for ");

                                   ASK Strm1 WriteString(Name);
                                   ASK Strm1 WriteString(".....");
                                   ASK Strm1 WriteLn;
                                   OUTPUT;
                                   OUTPUT("Checking Resource
Sufficiency for ",Name,".....");

                                   OUTPUT;
                                   OUTPUT("
.......OKAY");

                                   ASK Strm1 WriteString("
.......OKAY");

                                   ASK Strm1 WriteLn;
                                   OUTPUT;
                                   OUTPUT("Proceeding with
Simulation.....");

                                   ASK Strm1 WriteString("Proceeding
with Simulation.....");

                                   ASK Strm1 WriteLn;
                                   IF DozUse=TRUE
                                   IF ReqRes.NumDozTyp>0
                                   FOR i:=1 TO ReqRes.NumDozTyp
{typ}

                                        NEW(DozRes[i]);
                                        IF ReqRes.Doz[i].Num>0

     NEW(DozRes[i].DozArr,1..ReqRes.Doz[i].Num);
                                             FOR j:=1 TO
ReqRes.Doz[i].Num {num of typ}

                                             NEW(Dozr);

     DozRes[i].DozArr[j]:=Dozr;
```

```
                                                    ASK Dozr
 Init(ReqRes.Doz[i].Typ,ReqRes.Doz[i].Cap,j);
                                                    StrtTime:=SimTime();
                                                    TELL Dozr
 Cut(DHP1,DHP2,DRP1,DRP2,SELF);
                                                    Comm:=TRUE;
                                                    END FOR;
                                               END IF;
                                          END FOR;
                                          END IF;END IF;
                                          NEW(LdrRes);
                                          ASK LdrRes Init;
                                          ASK LdrRes SetPendStats(TRUE);
                                          FOR i:=1 TO ReqRes.NumTrkTyp
 {typ}
                                               NEW(TrkRes[i]);

      NEW(TrkRes[i].TrkArr,1..ReqRes.Trk[i].Num);
                                               FOR j:=1 TO
ReqRes.Trk[i].Num {num of typ}
                                               NEW(Truk);
                                               TrkRes[i].TrkArr[j]:=Truk;
                                               ASK Truk
Init(ReqRes.Trk[i].Typ,ReqRes.Trk[i].Cap,j);
                                               StrtTime:=SimTime();
                                               TELL Truk
Load(HP1,HP2,RP1,RP2,SELF,LdrRes);
                                               Comm:=TRUE;
                                               END FOR;
                                          END FOR;

                                     {GenCmpctrs;
                                     ExecProc;}
                                     ChngStat;
                                          FOR i:=1 TO NumConc
                                               IF Conc[i]<>NILOBJ
                                                    TELL Conc[i] DoSim;
                                               END IF;
                                          END FOR;
                                     ELSE OUTPUT("Insufficient Resources in
Module: ",Name);
                                          OUTPUT("Terminating
Simulation.....");
                                          TERMINATE;
                                     END IF;
                                END IF;
                           END FOR;
                      END METHOD;

                      ASK METHOD AssnDep(IN Elem:ModObj; IN Str1: STRING; IN
Str2: INTEGER);
                      BEGIN

                           IF Str1="S"
                           NEW(PS[Str2]);
```

```
        PS[Str2]:=Elem;
        ELSIF Str1="C"
        NEW(Conc[Str2]);
        Conc[Str2]:=Elem;
        ELSE
        NEW(LC[Str2]);
        LC[Str2]:=Elem;
        END IF;
END METHOD;

ASK METHOD ChkResAvail: BOOLEAN;
VAR
i,j,k: INTEGER;
DozSat, LdrSat, TrkSat, CmpctrSat: BOOLEAN;
DMsgStr, LMsgStr, TMsgStr, CMsgStr: STRING;
DozTestArr: ARRAY INTEGER OF BOOLEAN;
LdrTestArr: ARRAY INTEGER OF BOOLEAN;
TrkTestArr: ARRAY INTEGER OF BOOLEAN;
CmpctrTestArr: ARRAY INTEGER OF BOOLEAN;
BEGIN
NEW(DozTestArr,1..ReqRes.NumDozTyp);
FOR i:= 1 TO ReqRes.NumDozTyp
       DozTestArr[i]:=FALSE;
END FOR;
NEW(LdrTestArr,1..ReqRes.NumLdrTyp);
FOR i:= 1 TO ReqRes.NumLdrTyp
       LdrTestArr[i]:=FALSE;
END FOR;
NEW(TrkTestArr,1..ReqRes.NumTrkTyp);
FOR i:= 1 TO ReqRes.NumTrkTyp
       TrkTestArr[i]:=FALSE;
END FOR;
NEW(CmpctrTestArr,1..ReqRes.NumCmpctrTyp);
FOR i:= 1 TO ReqRes.NumCmpctrTyp
       CmpctrTestArr[i]:=FALSE;
END FOR;
DozSat:=TRUE;
LdrSat:= TRUE;
TrkSat:=TRUE;
CmpctrSat:=TRUE;
DMsgStr := "Dozer Resource Insufficient: ";
LMsgStr := "Loader Resource Insufficient: ";
TMsgStr := "Truck Resource Insufficient: ";
CMsgStr := "Compactor Resource Insufficient: ";
FOR i:= 1 TO ReqRes.NumDozTyp
       FOR j := 1 TO NumResTypArr[1]
              {OUTPUT("ReqDozTyp: ", ReqRes.Doz[i].Typ);
              OUTPUT("PoolDozTyp: ", DozPPoolArr[j].Typ);
              OUTPUT("ReqDozNum: ",ReqRes.Doz[i].Num);
              OUTPUT("PoolDozNum: ",DozPPoolArr[j].Num);}
              IF ((ReqRes.Doz[i].Typ = DozPPoolArr[j].Typ)
              AND (ReqRes.Doz[i].Num < DozPPoolArr[j].Num))
              DozTestArr[i] := TRUE;
              EXIT;
              END IF;
```

```
            END FOR;
        END FOR;
        FOR k:= 1 TO ReqRes.NumDozTyp
            IF DozTestArr[k]=FALSE
                DozSat:=FALSE;
                OUTPUT(DMsgStr);
            END IF;
        END FOR;
        FOR i:= 1 TO ReqRes.NumLdrTyp
            FOR j:=1 TO NumResTypArr[2]
                {OUTPUT("ReqLdrTyp: ",ReqRes.Ldr[i].Typ);
                OUTPUT("PoolLdrTyp: ",LdrPPoolArr[j].Typ);
                OUTPUT("ReqLdrNum: ",ReqRes.Ldr[i].Num);
                OUTPUT("PoolLdrNum: ",LdrPPoolArr[j].Num);}
                IF ((ReqRes.Ldr[i].Typ = LdrPPoolArr[j].Typ)
                AND (ReqRes.Ldr[i].Num < LdrPPoolArr[j].Num))
                LdrTestArr[i] := TRUE;
                EXIT;
                END IF;
            END FOR;
        END FOR;
        FOR k:= 1 TO ReqRes.NumLdrTyp
            IF LdrTestArr[k]=FALSE
                LdrSat:=FALSE;
                OUTPUT(LMsgStr);
            END IF;
        END FOR;
        FOR i:=1 TO ReqRes.NumTrkTyp
            FOR j := 1 TO NumResTypArr[3]
                {OUTPUT("ReqTrkTyp: ",ReqRes.Trk[i].Typ);
                OUTPUT("PoolTrkTyp: ",TrkPPoolArr[j].Typ);
                OUTPUT("ReqTrkNum: ",ReqRes.Trk[i].Num);
                OUTPUT("PoolTrkNum: ",TrkPPoolArr[j].Num);}
                IF((ReqRes.Trk[i].Typ <> TrkPPoolArr[j].Typ)
                OR (ReqRes.Trk[i].Num > TrkPPoolArr[j].Num))
                TrkTestArr[i] := TRUE;
                EXIT;
                END IF;
            END FOR;
        END FOR;
        FOR k:= 1 TO ReqRes.NumTrkTyp
            IF TrkTestArr[k]=FALSE
                TrkSat:=FALSE;
                OUTPUT(TMsgStr);
            END IF;
        END FOR;
        FOR i := 1 TO ReqRes.NumCmpctrTyp
            FOR j := 1 TO NumResTypArr[4]
                {OUTPUT("ReqCmpctrTyp:
",ReqRes.Cmpctr[i].Typ);
                OUTPUT("PoolCmpctrTyp:
",CmpctrPPoolArr[j].Typ);
                OUTPUT("ReqCmpctrNum:
",ReqRes.Cmpctr[i].Num);
```

```
                        OUTPUT("PoolCmpctrNum:
",CmpctrPPoolArr[j].Num);}
                        IF((ReqRes.Cmpctr[i].Typ <>
CmpctrPPoolArr[j].Typ)
                        OR (ReqRes.Cmpctr[i].Num >
CmpctrPPoolArr[j].Num))
                        CmpctrTestArr[i] := TRUE;
                        EXIT;
                        END IF;
                  END FOR;
            END FOR;
            FOR k:= 1 TO ReqRes.NumCmpctrTyp
                  IF CmpctrTestArr[k]=FALSE
                        CmpctrSat:=FALSE;
                        OUTPUT(CMsgStr);
                  END IF;
            END FOR;
            IF NOT DozSat
                  OUTPUT(DMsgStr, Name);
            END IF;
            IF NOT LdrSat
                  OUTPUT(LMsgStr, Name);
            END IF;
            IF NOT TrkSat
                  OUTPUT(TMsgStr, Name);
            END IF;
            IF NOT CmpctrSat
                  OUTPUT(CMsgStr, Name);
            END IF;
            IF (DozSat AND LdrSat AND TrkSat AND CmpctrSat)
                  RETURN TRUE;
            ELSE
                  RETURN FALSE;
            END IF;
            END METHOD;

            ASK METHOD ChngStat;
            BEGIN
                  Comp := TRUE;
            END METHOD;

            ASK METHOD FUpdateSuff(IN InBool:BOOLEAN);
            BEGIN
                  SuffPilVol:=InBool;
            END METHOD;

            ASK METHOD Update(IN Cap: REAL);
            BEGIN
                  CurrVol:=CurrVol+Cap;
            END METHOD;

            ASK METHOD PilUpdate(IN InCap:REAL);

            BEGIN
                  PildVol:=PildVol+InCap;
```

```
            END METHOD;

            ASK METHOD InitMod(IN DozTravPrms:PrmsTyp;IN
TravPrms:PrmsTyp;IN Vol: REAL; IN Nam: STRING);
            VAR
                  i: INTEGER;
            BEGIN
                  TotVol:=Vol;
                  Name:=Nam;

                  NEW(PS, 1..NumPS);
                  NEW(SS,1..NumSS);
                  NEW(LC,1..NumLC);
                  NEW(Conc, 1..NumConc);
                  NEW(CompTrig);
                  NEW(PilTrig);
                  NEW(ReqRes);
                  GetReqRes(ReqRes);
                  ModResPool:=ReqRes;
                  HP1:=TravPrms[1];
                  HP2:=TravPrms[2];
                  RP1:=TravPrms[3];
                  RP2:=TravPrms[4];
                  DHP1:=DozTravPrms[1];
                  DHP2:=DozTravPrms[2];
                  DRP1:=DozTravPrms[3];
                  DRP2:=DozTravPrms[4];
                  {FOR i:=1 TO ReqRes.NumLdrTyp
                  NEW(ProcRes);
                  ASK ProcRes Create(ReqRes.Ldr[i].Num);
                  END FOR;}
            END METHOD;
      END OBJECT;

      OBJECT TruckObj;
            ASK METHOD Init(IN InTyp:STRING;IN InCap:REAL;IN
Ident:INTEGER);
            BEGIN
                  Typ:=InTyp;
                  Id:=Ident;
                  Cap:= InCap;
            END METHOD;

            TELL METHOD Load(IN HP1:REAL;IN HP2:REAL;
                        IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                        IN LdrRes:LdrResObj);
            VAR
                  StrtTime, EndTime,
                  Ldtime,OccTime: REAL;

            BEGIN

                  OUTPUT;
                  ASK Strm1 WriteLn;
                  OUTPUT("Current Time: ",SimTime());
```

```
OUTPUT("At Loader - ","Trk-",Typ,"-",Id);
ASK Strml WriteString("Current Time: ");
ASK Strml WriteString(REALTOSTR(SimTime()));
ASK Strml WriteLn;
ASK Strml WriteString("At Loader - ");
ASK Strml WriteString(Mod.Name);
ASK Strml WriteString("- Trk ");
ASK Strml WriteString(Typ);
ASK Strml WriteString("-");
ASK Strml WriteString(INTTOSTR(Id));
ASK Strml WriteLn;
IF DozUse = TRUE
IF Mod.PildVol <= PilThresh
ASK Mod FUpdateSuff(FALSE);
WAIT FOR Mod.PilTrig Fire
END WAIT;
ASK Mod FUpdateSuff(TRUE);
END IF;
END IF;
WAIT FOR LdrRes Give(SELF,1)
StrtTime:=SimTime();
ON INTERRUPT
      {DISPOSE(SELF);}
      TERMINATE;
END WAIT;
TELL LdrRes DecrementResourcesBy(1);
Ldtime:=ASK Randl
UniformReal(LdTimePrm1,LdTimePrm2);
OUTPUT("Acquired by ",Mod.Name,"-Trk ",Typ,"-",Id);
OUTPUT("Loading-Trk-",Typ,"-",Id);
OUTPUT(Mod.Name);
ASK Strml WriteString("Acquired by ");
ASK Strml WriteString(Mod.Name);
ASK Strml WriteString("-Trk ");
ASK Strml WriteString(Typ);
ASK Strml WriteString("-");
ASK Strml WriteString(INTTOSTR(Id));
ASK Strml WriteLn;
ASK Strml WriteString("Loading-Trk-");
ASK Strml WriteString(Typ);
ASK Strml WriteString("-");
ASK Strml WriteString(INTTOSTR(Id));
ASK Strml WriteString("-");
ASK Strml WriteString(Mod.Name);
ASK Strml WriteLn;
OUTPUT("Load Time: ",Ldtime);
ASK Strml WriteString("Load Time: ");
ASK Strml WriteString(REALTOSTR(Ldtime));
ASK Strml WriteLn;
ASK Strml WriteLn;
WAIT DURATION Ldtime
ON INTERRUPT
TERMINATE;
END WAIT;
ASK LdrRes TakeBack(SELF,1);
```

```
        EndTime:=SimTime();
        OccTime:=(EndTime - StrtTime);
        ASK LdrRes Update(OccTime);
        OUTPUT("Released by ",Mod.Name,"-Trk ",Typ,"-",Id);
        ASK Strm1 WriteString("Released by ");
        ASK Strm1 WriteString(Mod.Name);
        ASK Strm1 WriteString("-Trk ");
        ASK Strm1 WriteString(Typ);
        ASK Strm1 WriteString("-");
        ASK Strm1 WriteString(INTTOSTR(Id));
        ASK Strm1 WriteLn;
        ASK Strm1 WriteLn;
        ASK LdrRes IncrementResourcesBy(1);
        Haul(HP1, HP2, RP1, RP2,Mod,LdrRes);
END METHOD;

TELL METHOD Haul(IN HP1:REAL;IN HP2:REAL;
             IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
             IN LdrRes:LdrResObj);
VAR

        HaulTime: REAL;
BEGIN

        OUTPUT;
        OUTPUT("Current Time: ",SimTime());
        ASK Strm1 WriteString("Current Time: ");
        ASK Strm1 WriteString(REALTOSTR(SimTime()));
        ASK Strm1 WriteLn;
        OUTPUT("Hauling-Trk-",Typ,"-",Id);
        ASK Strm1 WriteString("Hauling-Trk-");
        ASK Strm1 WriteString(Mod.Name);
        ASK Strm1 WriteString("-Trk ");
        ASK Strm1 WriteString(Typ);
        ASK Strm1 WriteString("-");
        ASK Strm1 WriteString(INTTOSTR(Id));
        ASK Strm1 WriteLn;
        OUTPUT(Mod.Name);
        HaulTime:=ASK Rand1 UniformReal(HP1, HP2);
        OUTPUT("Haul Time: ",HaulTime);
        ASK Strm1 WriteString("Haul Time: ");
        ASK Strm1 WriteString(REALTOSTR(HaulTime));
        ASK Strm1 WriteLn;
        ASK Strm1 WriteLn;
        WAIT DURATION HaulTime
        ON INTERRUPT
        {DISPOSE(SELF);}
        TERMINATE;
        END WAIT;
        Dump(HP1, HP2, RP1, RP2,Mod,LdrRes);
END METHOD;

TELL METHOD Dump(IN HP1:REAL;IN HP2:REAL;
             IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
             IN LdrRes:LdrResObj);
```

```
VAR
        i,j: INTEGER;
        ThisTrk: TruckObj;
        MaxWait, MinWait: INTEGER;
        ModDur, MeanWait,Util: REAL;
BEGIN
        OUTPUT;
        OUTPUT("Current Time: ",SimTime());
        ASK Strml WriteString("Current Time: ");
        ASK Strml WriteString(REALTOSTR(SimTime()));
        ASK Strml WriteLn;
        OUTPUT("Dumping-Trk-",Typ,"-",Id);
        ASK Strml WriteString("Dumping-Trk-");
        ASK Strml WriteString(Mod.Name);
        ASK Strml WriteString("-Trk ");
        ASK Strml WriteString(Typ);
        ASK Strml WriteString("-");
        ASK Strml WriteString(INTTOSTR(Id));
        ASK Strml WriteLn;
        OUTPUT(Mod.Name);
        {OUTPUT("PS: ",Mod.PS[1].Name);}
        OUTPUT("Dump Time: ",DumpTime);
        ASK Strml WriteString("Dump Time: ");
        ASK Strml WriteString(REALTOSTR(DumpTime));
        ASK Strml WriteLn;
        ASK Strml WriteLn;
        WAIT DURATION DumpTime
        ON INTERRUPT
        {DISPOSE(SELF);}
        TERMINATE;
        END WAIT;
        ASK Mod Update(Cap);
        OUTPUT("Vol. Completed in ",Mod.Name," is
",Mod.CurrVol);
        ASK Strml WriteString("Vol. Completed in ");
        ASK Strml WriteString(Mod.Name);
        ASK Strml WriteString(" is ");
        ASK Strml WriteString(REALTOSTR(Mod.CurrVol));
        ASK Strml WriteLn;
        ASK Strml WriteLn;
        IF Mod.CurrVol >= Mod.TotVol
                {IF Mod.CompTrig.NumWaiting<>0}
                TELL Mod.CompTrig Trigger;
                {END IF;}
                FOR i:= 1 TO NumPS
                        IF Mod.PS[i] <> NILOBJ
                                OUTPUT("PS: ",Mod.PS[i].Name);
                                TELL Mod.PS[i] DoSim;
                        END IF;
                END FOR;
                OUTPUT;
                OUTPUT("Simulation of ",Mod.Name,"
complete...");
                OUTPUT;
                ASK Strml WriteString("Simulation of ");
```

```
ASK Strml WriteString(Mod.Name);
ASK Strml WriteString(" complete...");
ASK Strml WriteLn;
ASK Strml WriteLn;
ModDur:=SimTime()-Mod.StrtTime;
OUTPUT("Loader Utilization for ",Mod.Name);
        OUTPUT("-------------------------------");
        ASK Strml WriteString("Loader Utilization for ");
        ASK Strml WriteString(Mod.Name);
        ASK Strml WriteLn;
        ASK Strml WriteString("-------------------------------");
        ASK Strml WriteLn;
        MaxWait:=ASK LdrRes PendingMaximum;
        {MinWait:=ASK LdrRes PendingMinimum;}
        MeanWait:=ASK LdrRes PendingMean;
        Util:=(LdrRes.OccTime/ModDur);
        OUTPUT("Max. Number Waiting: ",MaxWait);
        ASK Strml WriteString("Max. Number Waiting: ");
        ASK Strml WriteString(INTTOSTR(MaxWait));
        ASK Strml WriteLn;
        {OUTPUT("Min. Number Waiting: ",MinWait);}
        OUTPUT("Mean Number Waiting: ", MeanWait);
        ASK Strml WriteString("Mean Number Waiting: ");
        ASK Strml WriteString(REALTOSTR(MeanWait));
        ASK Strml WriteLn;
        OUTPUT("Total Percent Utilization: ",Util*100.0);
        ASK Strml WriteString("Total Percent Utilization: ");
        ASK Strml WriteString(REALTOSTR(Util*100.0));
        ASK Strml WriteLn;
        {OUTPUT("Average Utilization: ",ASK LdrRes PendWtdMean);}
        FOR i:=1 TO Mod.ReqRes.NumTrkTyp
        FOR j := 1 TO Mod.ReqRes.Trk[i].Num
        ThisTrk:=Mod.TrkRes[i].TrkArr[j];
        WAIT DURATION 0.0
        InterruptAll(ThisTrk);
        ON INTERRUPT
        TERMINATE;
        END WAIT;
```

```
                                {DISPOSE(ThisTrk);}
                           END FOR;
                      END FOR;
                      {DISPOSE(SELF);}
                      TERMINATE;
                 END IF;
                 Rturn(HP1, HP2, RP1, RP2,Mod,LdrRes);
            END METHOD;

            TELL METHOD Rturn(IN HP1:REAL;IN HP2:REAL;
                      IN RP1:REAL;IN RP2:REAL;IN Mod:ModObj;
                      IN LdrRes:LdrResObj);
            VAR

                 RetTime: REAL;
            BEGIN

                 OUTPUT;
                 OUTPUT("Current Time: ",SimTime());
                 OUTPUT("Returning-Trk-",Typ,"-",Id);
                 OUTPUT(Mod.Name);
                 ASK Strm1 WriteString("Current Time: ");
                 ASK Strm1 WriteString(REALTOSTR(SimTime()));
                 ASK Strm1 WriteLn;
                 ASK Strm1 WriteString("Returning-Trk-");
                 ASK Strm1 WriteString(Mod.Name);
                 ASK Strm1 WriteString("-Trk ");
                 ASK Strm1 WriteString(Typ);
                 ASK Strm1 WriteString("-");
                 ASK Strm1 WriteString(INTTOSTR(Id));
                 ASK Strm1 WriteLn;
                 RetTime:= ASK Rand1 UniformReal(RP1, RP2);
                 OUTPUT("Return Time: ",RetTime);
                 ASK Strm1 WriteString("Return Time: ");
                 ASK Strm1 WriteString(REALTOSTR(RetTime));
                 ASK Strm1 WriteLn;
                 ASK Strm1 WriteLn;
                 WAIT DURATION RetTime
                 ON INTERRUPT
                 {DISPOSE(SELF);}
                 TERMINATE;
                 END WAIT;
                 Load(HP1, HP2, RP1, RP2,Mod,LdrRes);
            END METHOD;

       END OBJECT;


       OBJECT DozerObj;
            ASK METHOD Init(IN InTyp: STRING;IN InCap: REAL; IN
Ident: INTEGER);
            BEGIN
                 Typ:=InTyp;
                 Id:=Ident;
                 Cap:= InCap;
```

```
END METHOD;

TELL METHOD Cut(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
            IN DRP2:REAL;IN Mod: ModObj);
VAR
      Cuttime:REAL;

BEGIN
      OUTPUT;
      ASK Strml WriteLn;
      OUTPUT("Current Time: ",SimTime());
      OUTPUT("Cutting - ","Doz-",Typ,"-",Id);
      ASK Strml WriteString("Current Time: ");
      ASK Strml WriteString(REALTOSTR(SimTime()));
      ASK Strml WriteLn;
      ASK Strml WriteString("Cutting - ");
      ASK Strml WriteString(Mod.Name);
      ASK Strml WriteString("- Doz ");
      ASK Strml WriteString(Typ);
      ASK Strml WriteString("-");
      ASK Strml WriteString(INTTOSTR(Id));
      ASK Strml WriteLn;
      Cuttime:=ASK Rand1
UniformReal(CutTimePrm1,CutTimePrm2);
      OUTPUT("Cut Time: ",Cuttime);
      ASK Strml WriteString("Cut Time: ");
      ASK Strml WriteString(REALTOSTR(Cuttime));
      ASK Strml WriteLn;
      ASK Strml WriteLn;
      IF Mod.PildVol >= Mod.TotVol
            InterruptAll(SELF);
            TERMINATE;
      END IF;
      WAIT DURATION Cuttime
      ON INTERRUPT
      TERMINATE;
      END WAIT;
      Haul(DHP1, DHP2, DRP1, DRP2,Mod);
END METHOD;

TELL METHOD Haul(IN DHP1:REAL;IN DHP2:REAL;
            IN DRP1:REAL;IN DRP2:REAL;IN Mod:ModObj);
VAR

      HaulTime: REAL;
BEGIN

      OUTPUT;
      OUTPUT("Current Time: ",SimTime());
      ASK Strml WriteString("Current Time: ");
      ASK Strml WriteString(REALTOSTR(SimTime()));
      ASK Strml WriteLn;
      OUTPUT("Hauling-Doz-",Typ,"-",Id);
      ASK Strml WriteString("Hauling-Doz-");
      ASK Strml WriteString(Mod.Name);
```

```
        ASK Strm1 WriteString("-Doz ");
        ASK Strm1 WriteString(Typ);
        ASK Strm1 WriteString("-");
        ASK Strm1 WriteString(INTTOSTR(Id));
        ASK Strm1 WriteLn;
        OUTPUT(Mod.Name);
        HaulTime:=ASK Rand1 UniformReal(DHP1, DHP2);
        OUTPUT("Haul Time: ",HaulTime);
        ASK Strm1 WriteString("Haul Time: ");
        ASK Strm1 WriteString(REALTOSTR(HaulTime));
        ASK Strm1 WriteLn;
        ASK Strm1 WriteLn;
        IF Mod.PildVol >= Mod.TotVol
              InterruptAll(SELF);
              TERMINATE;
        END IF;
        WAIT DURATION HaulTime

        ON INTERRUPT
        {DISPOSE(SELF);}
        TERMINATE;
        END WAIT;
        Pile(DHP1, DHP2, DRP1, DRP2,Mod);
END METHOD;

TELL METHOD Pile(IN DHP1:REAL;IN DHP2:REAL;
               IN DRP1:REAL;IN DRP2:REAL;IN Mod:ModObj);
VAR
        i,j: INTEGER;


BEGIN
        OUTPUT;
        OUTPUT("Current Time: ",SimTime());
        ASK Strm1 WriteString("Current Time: ");
        ASK Strm1 WriteString(REALTOSTR(SimTime()));
        ASK Strm1 WriteLn;
        OUTPUT("Piling-Doz-",Typ,"-",Id);
        ASK Strm1 WriteString("Piling-Trk-");
        ASK Strm1 WriteString(Mod.Name);
        ASK Strm1 WriteString("-Doz ");
        ASK Strm1 WriteString(Typ);
        ASK Strm1 WriteString("-");
        ASK Strm1 WriteString(INTTOSTR(Id));
        ASK Strm1 WriteLn;
        OUTPUT(Mod.Name);
        {OUTPUT("PS: ",Mod.PS[1].Name);}
        OUTPUT("Piling Time: ",DumpTime);
        ASK Strm1 WriteString("Pile Time: ");
        ASK Strm1 WriteString(REALTOSTR(PileTime));
        ASK Strm1 WriteLn;
        ASK Strm1 WriteLn;
        IF Mod.CurrVol >= Mod.TotVol
              InterruptAll(SELF);
              TERMINATE;
```

```
                END IF;
                WAIT DURATION PileTime
                ON INTERRUPT
                {DISPOSE(SELF);}
                TERMINATE;
                END WAIT;
                ASK Mod PilUpdate(Cap);
                IF (Mod.PildVol >= PilThresh) AND
(Mod.SuffPilVol=FALSE)
                      TELL Mod.PilTrig Trigger;
                END IF;
                OUTPUT("Vol. Piled for ",Mod.Name," is
",Mod.PildVol);
                ASK Strml WriteString("Vol. Completed for ");
                ASK Strml WriteString(Mod.Name);
                ASK Strml WriteString(" is ");
                ASK Strml WriteString(REALTOSTR(Mod.PildVol));
                ASK Strml WriteLn;
                ASK Strml WriteLn;
                Rturn(DHP1, DHP2, DRP1, DRP2,Mod);
          END METHOD;

          TELL METHOD Rturn(IN DHP1:REAL;IN DHP2:REAL;IN DRP1:REAL;
                      IN DRP2:REAL;IN Mod:ModObj);
          VAR

                RetTime: REAL;
          BEGIN

                OUTPUT;
                OUTPUT("Current Time: ",SimTime());
                OUTPUT("Returning-Doz-",Typ,"-",Id);
                OUTPUT(Mod.Name);
                ASK Strml WriteString("Current Time: ");
                ASK Strml WriteString(REALTOSTR(SimTime()));
                ASK Strml WriteLn;
                ASK Strml WriteString("Returning-Doz-");
                ASK Strml WriteString(Mod.Name);
                ASK Strml WriteString("-Doz ");
                ASK Strml WriteString(Typ);
                ASK Strml WriteString("-");
                ASK Strml WriteString(INTTOSTR(Id));
                ASK Strml WriteLn;
                RetTime:= ASK Randl UniformReal(DRP1, DRP2);
                OUTPUT("Return Time: ",RetTime);
                ASK Strml WriteString("Return Time: ");
                ASK Strml WriteString(REALTOSTR(RetTime));
                ASK Strml WriteLn;
                ASK Strml WriteLn;
                IF Mod.CurrVol >= Mod.TotVol
                      InterruptAll(SELF);
                      TERMINATE;
                END IF;
                WAIT DURATION RetTime
                ON INTERRUPT
```

```
            {DISPOSE(SELF);}
            TERMINATE;
            END WAIT;
            Cut(DHP1, DHP2, DRP1, DRP2,Mod);
        END METHOD;


END OBJECT;

OBJECT LdrResObj;
        ASK METHOD Init;
        BEGIN
              Create(NoLdrs);
        END METHOD;

        ASK METHOD Update(IN WrkTime:REAL);
        BEGIN
              OccTime:=OccTime+WrkTime;
        END METHOD;
END OBJECT;

OBJECT CmpctrObj;
        ASK METHOD Init(IN InCap: REAL; IN Ident: INTEGER);
        BEGIN
              Id:=Ident;
              ProdRate:= InCap;
        END METHOD;
END OBJECT;

OBJECT BlkObj;
        ASK METHOD GenNext(IN FilNam: STRING);
        VAR
              BlkStrm: StreamObj;
              {NumLifts}i,j: INTEGER;
              Str,Str1,Str2, Str3: STRING;
              DozTravPrms,
              TravPrms: PrmsTyp;

        BEGIN
              NEW(BlkStrm);
              NEW(TravPrms,1..4);
              NEW(DozTravPrms,1..4);
              ASK BlkStrm Open(FilNam, Input);
              ASK BlkStrm ReadString(Str);
              ASK BlkStrm ReadString(Str);
              ASK BlkStrm ReadString(Str);
              NumLifts:=STRTOINT(Str);
              NEW(BlkConfig,1..NumLifts);
              FOR i:= 1 TO NumLifts
                    NEW(BlkConfig[i]);
                    ASK BlkStrm ReadString(Str);
                    IF STRLEN(Str)=5
                          ConfigR:=BlkConfig[i];
                    END IF;
                    ASK BlkStrm ReadString(Str);
```

```
                        ASK BlkStrm ReadString(Str);
                        Concat("Mod",INTTOSTR(i), Str1);
                        Concat("-",Str1,Str2);
                        Concat(Name,Str2,Str1);
                        FOR j:=1 TO 4
                              ASK BlkStrm ReadString(Str3);
                              ASK BlkStrm ReadString(Str3);
                              TravPrms[j]:=STRTOREAL(Str3);
                        END FOR;
                        FOR j:=1 TO 4
                              ASK BlkStrm ReadString(Str3);
                              ASK BlkStrm ReadString(Str3);
                              DozTravPrms[j]:=STRTOREAL(Str3);
                        END FOR;

                        ASK BlkConfig[i]
InitMod(DozTravPrms,TravPrms,STRTOREAL(Str), Str1);
                  END FOR;
                  ASK BlkStrm Close;
            END METHOD;

            ASK METHOD Constr;
            BEGIN
                  TELL ModObj(ConfigR) DoSim;
            END METHOD;
      END OBJECT;


      OBJECT SubStrObj;
            ASK METHOD Init(IN Str1: STRING; IN Str2: STRING);
            {Subs}
            BEGIN
                  Name:=Str1;
                  TotVol:=STRTOREAL(Str2);
            END METHOD;

      END OBJECT;

      OBJECT StructObj;
            ASK METHOD InitConfig;
            VAR
                  i: INTEGER;
                  Strm: StreamObj;
                  Str: STRING;

            BEGIN
                  NEW(Strm);
                  ASK Strm Open("StrInfo.txt", Input);
                  {WHILE NOT(ASK Strm eof)}
                        ASK Strm ReadString(Str);
                        ASK Strm ReadString(Str);
                        ASK Strm ReadString(Str);
                        StructVol := STRTOREAL(Str);
                        VolCompl := 0.0;
                        ASK Strm Close;
```

```
            GenBlkStruct("BlkInfo.txt");
            {GenBlkDeps("BlkDeps.txt");}
        {END WHILE;}
END METHOD;

ASK METHOD UpdateVol(IN Vol: REAL);
BEGIN
        VolCompl:= Vol;
END METHOD;

ASK METHOD GenBlkStruct(IN FilNam: STRING);
VAR
        i, j: INTEGER;
        Strm: StreamObj;
        NamStr,VolStr,Str: STRING;
BEGIN

        NEW(Strm);
        ASK Strm Open(FilNam,Input);
        ASK Strm ReadString(Str);
        ASK Strm ReadString(Str);
        ASK Strm ReadString(Str);
        imax := STRTOINT(Str);
        ASK Strm ReadString(Str);
        ASK Strm ReadString(Str);
        jmax:= STRTOINT(Str);
        NEW(Config, 1..imax, 1..jmax);
        FOR i := 1 TO imax
                FOR j := 1 TO jmax
                        NEW(Config[i,j]);
                        ASK Strm ReadString(NamStr);
                        IF STRLEN(NamStr) = 6
                                ConfigR:=Config[i,j];
                        END IF;
                        ASK Strm ReadString(Str);
                        ASK Strm ReadString(VolStr);
                        ASK Config[i][j] Init(NamStr, VolStr);
                        {ASK Config[i][j] AssnName(Str);}
                        Concat("Blk",INTTOSTR(i),Str);
                        Concat(Str,INTTOSTR(j),Str);
                        Concat(Str,"Det.txt",Str);
                        ASK Config[i,j] GenNext(Str);
                END FOR;
        END FOR;
        ASK Strm Close;
END METHOD;


ASK METHOD AssnDeps(IN FilNam: STRING);
VAR
        i,j: INTEGER;
        Strm: StreamObj;
        Str,StrCod: STRING;
        StrArr: ARRAY INTEGER OF INTEGER;
BEGIN
```

```
                NEW(Strm);
                ASK Strm Open(FilNam, Input);
                WHILE NOT (ASK Strm eof)
                ASK Strm ReadString(Str);
                IF Str="N" ASK Strm ReadString(Str);
                END IF;
                NEW(StrArr,1..8);
                FOR i:= 1 TO 8
                      IF i = 4
                      StrCod:=SUBSTR(i,i,Str);
                      StrArr[i]:=STRTOINT(SUBSTR(i,i,Str));
                      ELSE
                      StrArr[i]:=STRTOINT(SUBSTR(i,i,Str));
                      END IF;
                END FOR;
                ASK
Config[StrArr[1]][StrArr[2]].BlkConfig[StrArr[3]]

      AssnDep(Config[StrArr[5]][StrArr[6]].BlkConfig[StrArr[7]],
                      StrCod,StrArr[8]);
                END WHILE;
          END METHOD;

          ASK METHOD Constr;

          BEGIN
                ASK BlkObj(ConfigR) Constr;

          END METHOD;

          ASK METHOD Output;
          VAR
                i,j,k,l: INTEGER;
          BEGIN
                OUTPUT;
                ASK Strm2 WriteLn;
                OUTPUT("Testing Structure");
                ASK Strm2 WriteString("Testing Structure");
                ASK Strm2 WriteLn;
                OUTPUT("StructVol: ",StructVol);
                ASK Strm2 WriteString("StructVol: ");
                ASK Strm2 WriteLn;
                OUTPUT("VolCompl: ",VolCompl);
                ASK Strm2 WriteString("VolCompl: ");
                ASK Strm2 WriteString(REALTOSTR(VolCompl));
                ASK Strm2 WriteLn;
                ASK Strm2 WriteLn;
                {OUTPUT("ModsPredLine: ", ModsPredLine);}
                OUTPUT;
                OUTPUT("Testing Blocks 1 to ", imax*jmax);
                ASK Strm2 WriteString("Testing Blocks 1 to ");
                ASK Strm2 WriteString(INTTOSTR(imax*jmax));

                FOR i:=1 TO imax
                      FOR j:= 1 TO jmax
```

```
                                ASK Strm2 WriteLn;
                                OUTPUT(Config[i,j].Name);
                                ASK Strm2
WriteString(Config[i,j].Name);

                        END FOR;

                END FOR;
                OUTPUT;
                ASK Strm2 WriteLn;
                OUTPUT("Testing Structure Generation");
                ASK Strm2 WriteLn;
                ASK Strm2 WriteString("Testing Structure
Generation");
                FOR i := 1 TO imax
                FOR j:=1 TO jmax
                ASK Strm2 WriteLn;
                OUTPUT("Name: ",Structure.Config[i,j].Name);
                ASK Strm2 WriteString("Name: ");
                ASK Strm2 WriteString(Structure.Config[i,j].Name);
                ASK Strm2 WriteLn;
                OUTPUT("Vol: ",Structure.Config[i,j].TotVol);
                ASK Strm2 WriteString("Vol: ");
                ASK Strm2
WriteString(REALTOSTR(Structure.Config[i,j].TotVol));
                ASK Strm2 WriteLn;
                FOR k:=1 TO NumLifts
                        OUTPUT("Name:
",Structure.Config[i,j].BlkConfig[k].Name);
                        ASK Strm2 WriteString("Name: ");
                        ASK Strm2
WriteString(Structure.Config[i,j].BlkConfig[k].Name);
                        ASK Strm2 WriteLn;
                        OUTPUT("Vol:
",Structure.Config[i,j].BlkConfig[k].TotVol);
                        ASK Strm2 WriteString("Vol: ");
                        ASK Strm2
WriteString(REALTOSTR(Structure.Config[i,j].BlkConfig[k].TotVol));
                        ASK Strm2 WriteLn;
                        FOR l:=1 TO NumPS
                        IF NOT(Structure.Config[i,j]
                                .BlkConfig[k].PS[l]=NILOBJ)
                        OUTPUT("Successor: ", Structure.Config[i,j]
                                .BlkConfig[k].PS[l].Name);
                        ASK Strm2 WriteString("Successor: ");
                        ASK Strm2 WriteString(Structure.Config[i,j]
                                .BlkConfig[k].PS[l].Name);
                        ASK Strm2 WriteLn;
                        END IF;
                        END FOR;
                        FOR l := 1 TO NumConc
                        IF NOT(Structure.Config[i,j].
                               BlkConfig[k].Conc[l]=NILOBJ)
                        OUTPUT("Concurrent: ",
Structure.Config[i,j].BlkConfig[k].Conc[l].Name);
```

```
                    ASK Strm2 WriteString("Concurrent: ");
                    ASK Strm2
WriteString(Structure.Config[i,j].BlkConfig[k].Conc[l].Name);
                    ASK Strm2 WriteLn;
                    END IF;

                    END FOR;
                    FOR l :=1 TO NumLC
                    IF NOT(Structure.Config[i,j].
                         BlkConfig[k].LC[l]=NILOBJ)
                    OUTPUT("Cons: ",
Structure.Config[i,j].BlkConfig[k].LC[l].Name);
                    ASK Strm2 WriteString("Cons: ");
                    ASK Strm2
WriteString(Structure.Config[i,j].BlkConfig[k].LC[l].Name);
                    ASK Strm2 WriteLn;
                    END IF;
                    END FOR;
                    OUTPUT;

               END FOR;
               OUTPUT;
               ASK Strm2 WriteLn;
               END FOR;
               END FOR;
          END METHOD;

          {ASK METHOD Const;
          VAR
               i: INTEGER;
          BEGIN
               IF VolCompl = 0.0
                    FOR i := 1 TO NumMatTyps
                         ASK Config[i] Const;
                    END FOR;
               END IF;
          END METHOD;}
     END OBJECT;

     OBJECT PathObj;
          ASK METHOD InitPathObj(IN i: INTEGER);
          VAR
               j: INTEGER;
          BEGIN
               Src := PathInfo[i].Src;
               Dest := PathInfo[i].Dest;
               NEW(TrkDets, 1..NumTrkTyps);
               FOR j := 1 TO NumTrkTyps
                    NEW(TrkDets[j]);
                    TrkDets[j].SpeedLddModFac :=
PathInfo[i].TrkDets[j].SpeedLddModFac;
                    TrkDets[j].SpeedMtModFac :=
PathInfo[i].TrkDets[j].SpeedMtModFac;
               END FOR;
          END METHOD;
```

```
END OBJECT;

{OBJECT ProjResObj;
       ASK METHOD ObjInit;
       {VAR
              DozPPoolArr:        DozPoolTyp;
              LdrPPoolArr:        LdrPoolTyp;
              TrkPPoolArr:        TrkPoolTyp;
              CmpctrPPoolArr:     CmpctrPoolTyp;}

       BEGIN
              NEW(DozPPoolArr, 1..NumResTypArr[1]);
              NEW(LdrPPoolArr, 1..NumResTypArr[2]);
              NEW(TrkPPoolArr, 1..NumResTypArr[3]);
              NEW(CmpctrPPoolArr, 1..NumResTypArr[4]);
              InitDozPPool;
              InitLdrPPool;
              InitTrkPPool;
              InitCmpctrPPool;
              {Output(CmpctrPPoolArr);}
       END METHOD;
END OBJECT;}


OBJECT MatSrcObj;
ASK METHOD InitMatSrcObj(IN i: INTEGER);
VAR
       j: INTEGER;
BEGIN
       Name := MatSrcInfoArr[i].Name;
       QtyAvail := MatSrcInfoArr[i].QtyAvail;
       NEW(ModNos, 1..MatSrcInfoArr[i].NumModsSrvd);
       NumModsSrvd := MatSrcInfoArr[i].NumModsSrvd;
       FOR j := 1 TO MatSrcInfoArr[i].NumModsSrvd
              ModNos[j] := MatSrcInfoArr[i].ModNos[j];
       END FOR;
END METHOD;
END OBJECT;

OBJECT EnvirObj;
       ASK METHOD ObjInit;
       VAR
              i,j: INTEGER;
       BEGIN
              {NEW(MatSrcs, 1..NumMatSrcs);
              NEW(Roads, 1..NumPaths);}
              MatSrcs := MatSrcObjArr;
              NEW(Roads, 1..NumPaths);
              FOR i := 1 TO NumPaths
                     NEW(Roads[i]);
                     ASK Roads[i] InitPathObj(i);
              END FOR;

       END METHOD;
END OBJECT;
```

```
        OBJECT CntrlObj;
              ASK METHOD InitSystem;
              BEGIN

                    {NEW(EqpmtDb);}
                    GenEnvir;

                    NEW(Structure);
                    ASK Structure InitConfig;
                    GenProjResPool;
                    ASK Structure AssnDeps("Deps.txt");
                    ASK Structure Output;

                    OUTPUT("Total Current Time: ",SimTime());
              END METHOD;

              {ASK METHOD StartConst;
              BEGIN
                    ASK Structure Const;
              END METHOD;}

              {TELL METHOD HoldModWork;
              BEGIN
                    OUTPUT("HoldModWork");
              END METHOD;}
        END OBJECT;

        OBJECT EqpmtDbObj;
              ASK METHOD ObjInit;
              BEGIN
                    DozDb := DozInfo;
                    LdrDb := LdrInfo;
                    TrkDb := TrkInfo;
                    CmpctrDb := CmpctrInfo;
              END METHOD;
        END OBJECT;

END MODULE;




MAIN MODULE DAM;
FROM CompMod IMPORT Cntrlr,Structure, Strm1, Strm2;
FROM IOMod IMPORT FileUseType(Output),ReadKey;
FROM ProcMod IMPORT CreateHolders, {Output,} OutputInfo;
FROM SimMod IMPORT StartSimulation, SimTime;

VAR
      ch:          CHAR;

BEGIN
      CreateHolders;
      NEW(Cntrlr);
```

```
      NEW(Strm1);
      NEW(Strm2);
      ASK Strm1 Open("MyOutVal.txt",Output);
      ASK Strm2 Open("MyOutVer.txt",Output);
      ASK Strm1 WriteLn;
      ASK Strm1 WriteLn;
      ASK Strm1 WriteString("S Y S T E M      V A L I D A T I O N");
      ASK Strm1 WriteLn;
      ASK Strm1 WriteString("-----------------------------------");
      ASK Strm1 WriteLn;
      ASK Strm2 WriteLn;
      ASK Strm2 WriteLn;
      ASK Strm2 WriteString("S Y S T E M      V E R I F I C A T I O
N");
      ASK Strm2 WriteLn;
      ASK Strm2 WriteString("-------------------------------------
");
      ASK Strm2 WriteLn;
      ASK Strm2 WriteLn;
      ASK Cntrlr InitSystem;
      {Output;
      OutputInfo;}
      {ASK Cntrlr StartConst;}
      ASK Structure Constr;
      StartSimulation;
      {Output};
      {OutputInfo;}
      {PrRout;}
      OUTPUT;
      OUTPUT("Project Duration: ",SimTime());
      OUTPUT;
      ASK Strm1 WriteString("Project Duration: ");
      ASK Strm1 WriteString(REALTOSTR(SimTime()));
      {OUTPUT("Testing SimMod");}
      {OUTPUT(Structure.ConfigR.Name);
      OUTPUT(Structure.ConfigR.Succ.Name);
      OUTPUT(Structure.ConfigR.Succ.Succ.Name);}
      ASK Strm1 Close;
      ASK Strm2 Close;
      ch := ReadKey();
END MODULE.
```

IMAGE EVALUATION TEST TARGET (QA-3)

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0

150mm

6"

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