

USING SIMPLE++ FOR IMPROVED MODELING EFFICIENCIES AND EXTENDING MODEL LIFE CYCLES

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ABSTRACT

SiMPLE++ is an object-oriented simulation environment for modeling all types of manufacturing, logistics and service systems. AESOP's SiMPLE++ is a fully object-oriented implementation and uses a unique simulation modeling paradigm that increases the value of modeling through reusability and connectivity while leveraging object-oriented concepts for modeling efficiencies.

SiMPLE++ has been linked with a wide variety of other decision support software. In addition, a number of simulation application libraries are available. Together, these create a highly efficient, highly flexible tool for simulation and support of a number of simulation-based manufacturing, scheduling, logistics, staffing and maintenance support applications.

1 INTRODUCTION

The trend for most simulation software has been to provide "front-ends" to existing simulation languages or to provide a domain restricted modeling environment that is pre-programmed to visually build models using convenient modeling paradigms such as flow charts or constrained simulators. The motivation of this trend has been ease of use, usually at the expense of model flexibility and accuracy.

SiMPLE++ is a new generation object-oriented simulation environment for modeling manufacturing, logistics and service systems that can be defined in terms of discrete events. Released commercially in 1992 by AESOP GmbH, it has become the popular choice for simulation and simulation-based IT solutions for hundreds of organizations worldwide. With SiMPLE++, AESOP has taken a different approach to modeling than previous simulation software. Using object-orientation to implement a

modeler's logical process, SiMPLE++ has been able to achieve the ease of use of more specialized packages while at the same time eliminating limitations found in narrowly defined application programs (Geuder, 1995a) (Geuder 1995b). SiMPLE++'s object-oriented paradigm was designed to facilitate the modeling processes as most engineers and analysts approach problems: incrementally with several aspects and details being considered simultaneously.

This object-oriented paradigm, when combined with the drag and drop graphical user interface (GUI), offers the modeler rapid modeling, convenient data and logic hierarchy, power and flexibility of reusable user-created objects while at the same time removing the overhead and restrictions of language-based modeling. Chen et al. (1997) found that the SiMPLE++ user was able to take full advantage of object-orientation through its convenient graphical user interface, dramatically cutting modeling time compared to generalized object-oriented languages such as C++. Likewise, Chen and Cochran (1995) found that not only did SiMPLE++ score the highest when compared to C++ (a general purpose object-oriented language), but also scored the highest when compared to SIMAN (a non object-oriented simulation language).

In addition to the modeling efficiencies created by object-orientation, SiMPLE++'s open architecture allows it to be linked with other software, either by embedding it within other packages, or by linking them through interfaces. SiMPLE++ has been embedded within software for layout optimization, Business Process Re-engineering (BPR), and workstation design. This brings discrete-event simulation to otherwise static analysis tools. In these specialized areas of application, SiMPLE++ is employed as the simulation engine (client) running automatically generated models from the analysis software (server).

SiMPLE++ can also be linked to other packages using interfaces. Here, instead of running in the background transparent to the user, SiMPLE++ can be controlled by the user directly. Some examples of this are in the areas of expert systems, scheduling, real-time monitoring and control systems, optimization, work measurement, and virtual reality. In these applications, SiMPLE++ is coupled through custom or industry standard connections (DDE, CORBA, etc.) to provide dynamic systems analysis.

SiMPLE++ provides the capability for users to construct and reuse application objects. An application object can be as simple as a name and graphic change to a basic object or as complex as to include an entire simulation model. Application objects capture modeling expertise, provide customized user interfaces and facilitates “plug and play” modeling and “what-if” analysis. This allows users to build customized application templates unique to their company, application and industry needs. Chen et al. (1997) offer examples of the usefulness of object-orientation simulation through the use of application objects in SiMPLE++. AESOP and others have created commercial or research Application Object Templates (AOTs) for specific applications such as process industries, automated guided vehicles, conveyor systems, job shop scheduling, personnel deployment, and complex material flow.

2 SiMPLE++ MODELING PARADIGM

Figure 1 shows an example of an object library used in SiMPLE++. This library contains two types of objects, *Basic* and *Application*. SiMPLE++ includes 33 *Basic objects* as shown in the top five rows of the library in Figure 1. From these basic objects, *Application objects* are created by the user for specific models. In fact, even the models themselves will be application objects in the library. In this example, the application objects were used to construct a model of the aircraft engine maintenance system shown in Figure 2.

The system shown in Figure 2 consisted of three Air Force bases and one repair depot. Each base and depot is an application object at the highest level in the model. One of these bases is located at the point marked by (1). At (2), this base is opened with a double mouse click, revealing several functional areas of the base such as maintenance, painting, repair, etc. At (3), one of these objects - a repair shop located in the base - is opened to show the tasks performed in the repair shop. This *hierarchy* of model structure can

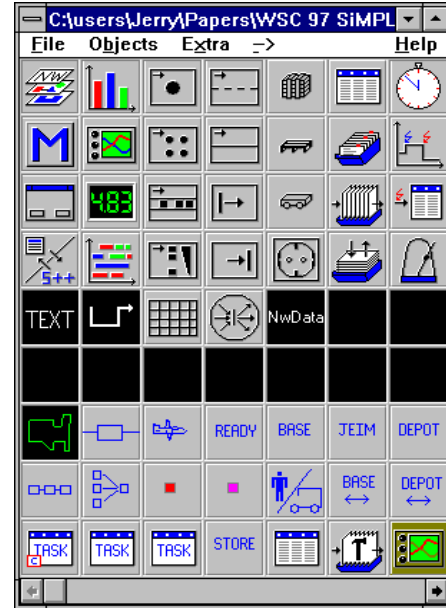


Figure 1: A SiMPLE++ Object Library

continue to any number of levels the user desires. The use of hierarchy in SiMPLE++ allows top-down and bottom-up modeling approaches as well as easy model maintenance in an intuitive model structure.

In SiMPLE++, the modeler constructs objects, stores them in a library and then inserts them into models by simply clicking them in. In this example, the user only needed to make one *parent* object for an Air Force base in the library. All three bases in the model (the *children*) will *inherit* all characteristics they need to operate from the parent in the library, with individual customization of each base possible. Inheritance allows that any changes made in the parent objects can be immediately and automatically updated to the children in the model. Likewise, the multitude of tasks networks at the lowest level of the hierarchy are easily maintained with the latest data and logic edits immediately transferred within the model. Also, additional bases can be clicked-in and out for evaluating logistics and efficiency scenarios.

Modularity, or the ability of objects to be self-contained with their own data, structure, interfaces and logic, allows that each base will be fully functional when clicked into the model. This means that the logic and part routings within each base is defined, data is included within the base, and output presentation will be collected and graphically presented for each new base without further modification once clicked into the

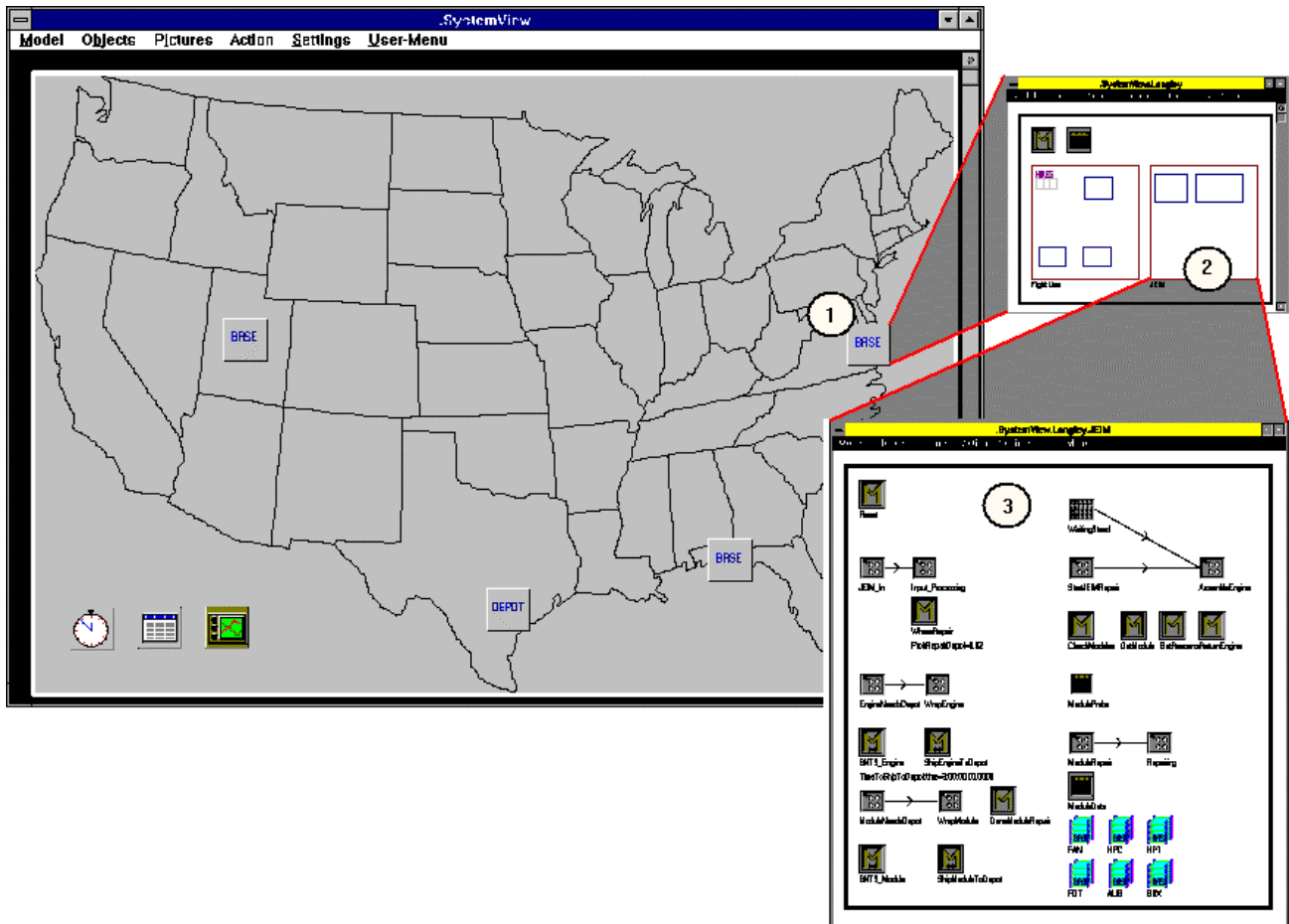


Figure 2: A SiMPLE++ Model With Three Levels of Hierarchy

model. Of course, customization of individual bases is possible by the user.

One advantage of this approach is that it is very natural way for modelers and engineers to think about the problem. Now, instead of worrying about every detail of the model at first glance, the modeler can construct a hierarchical structure to the overall problem, then focus on the details within specific objects when more appropriate. Later, because of inheritance, if the modeler decided to make a change, only the application object in the library would need to be changed and not all of the inserted objects in the model. Finally, because of modularity, the modeler only needs to construct the parent object a single time in the library -- the structure, input data, and output data collection will be automatically included with the base whenever a new base is inserted into the model. Some detailed examples of the modeling techniques used are described by Kalasky and Akbay (1997) and Levasseur (1996) (1997).

3 SiMPLE++ EMBEDDED IN OTHER APPLICATIONS

The previous section examined how SiMPLE++ used as an off-line simulation planning tool can improve modeling efficiency. This section identifies other industrial and facilities engineering software which automatically generate SiMPLE++ models. These are not GUIs for SiMPLE++ but each adds analysis and diagnostic capabilities in their own areas of application.

3.1 Layout Planning

MALAGA is a layout planning tool used to plan, implement and control factory floor and office environments. MALAGA is an add-on package for most popular CAD packages. The model shown in Figure 3 is a CAD layout with departments optimally placed by MALAGA. The arrows show relative flow intensity between functional areas. Using data already

entered or read by MALAGA, plus data relating to the simulation run length and production requirements, an entire SiMPLE++ model is generated. This approach uses SiMPLE++'s "Auto Build" feature where a complete simulation model can be constructed and run using only data tables and a class object library. In this case, it merely uses data already in MALAGA to build the layout, thus eliminating redundant data entry. The model then can be run and a trace file used to animate the MALAGA drawing. Thus, a layout planner can see the proposed layout operate over time, instead of only in the aggregate.

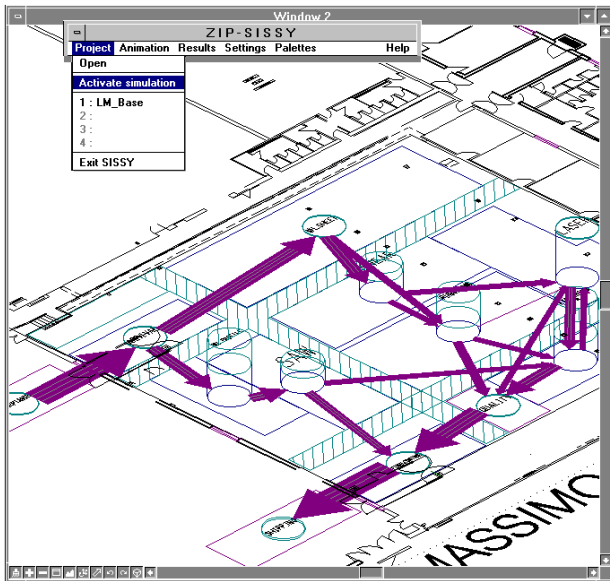


Figure 3: A MALAGA Layout with an Automatically Generated Simulation Model.

3.2 Business Process Re-engineering (BPR)

SiMPLE++ has been integrated with ARIS, a business modeling and SAP R/3 implementation tool. ARIS allows companies to capture and integrate business information in the form of graphical models, which can then be analyzed and improved. The ARIS Toolset has many applications including process improvement, business driven implementation of standard software packages, capture of business knowledge, and training of employees. Figure 4 shows an ARIS model with an integrated SiMPLE++ model that is automatically generated in a manner transparent to the user. The net result is a dynamic simulation for improvement of any business process.

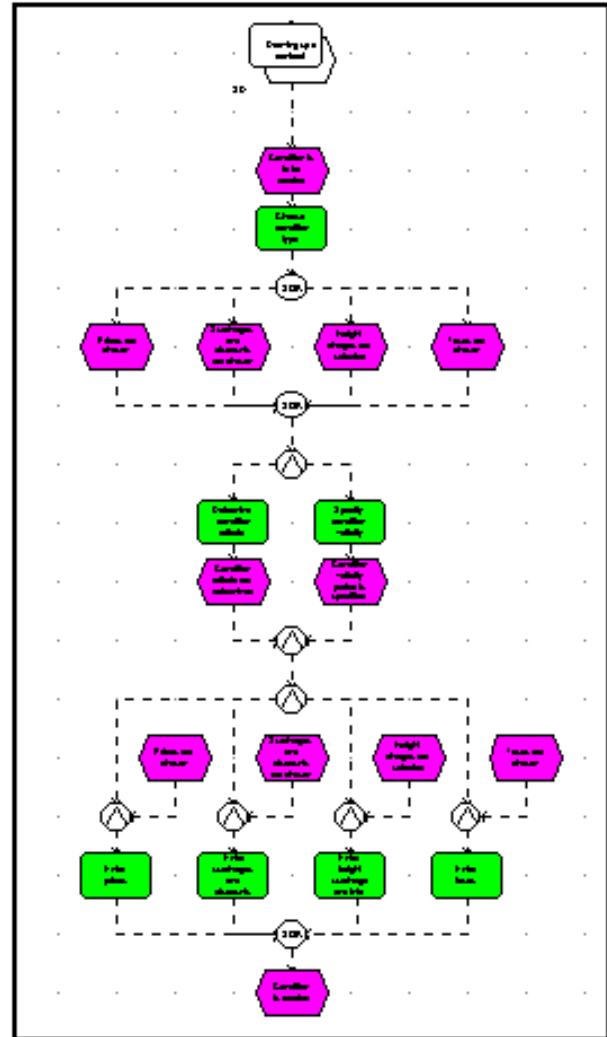


Figure 4: An ARIS BPR Model with an Embedded SiMPLE++ Simulation Model

3.3 Workstation Design

ERGOMAS (*ERG*onomic Layout and *Optimization of Manufacturing Systems*) is a computer aided planning system used for the ergonomic design of work stations and cells. Once a layout of one or more work stations is completed, MTM cycle times from data bases can be automatically calculated. Then, using the embedded SiMPLE++ simulation engine, a functional discrete-event simulation can be automatically generated from the software to predict the dynamic performance of the entire system. No modeling in SiMPLE++ is required to construct the simulation model because the data and model structure is obtained totally from the *ERGOMAS* model. While this is true for all the applications described, the SiMPLE++ models can be further

extended in SiMPLE++ and used for real-time and on-line monitoring and control.

4 SiMPLE++ CONNECTED TO OTHER SOFTWARE APPLICATIONS

In addition to being embedded with other types of software packages where SiMPLE++ runs behind the scenes, SiMPLE++ is often linked to other packages extending the benefits and life-cycle of the simulation models. The use of SiMPLE++ in this section is in connected applications where both packages can be seen and controlled directly by the user. These links may use standard interfaces such as DDE, socket connections, UNIX mailboxes or they may be custom built. Here are some examples.

4.1 Expert Systems

SiMPLE++ has been linked to expert systems such as Neuron Data's Intelligent Rules Element (IRE). This link occurs in real-time via Dynamic Data Exchange (DDE) communication. from the expert system The following example demonstrates the ability to link object-oriented simulation models with other applications such as expert systems with real-time data collection and shop floor control. The model shown Figure 5 represents a processing line with a conveyor feeding a high speed processing machine. In a typical simulation, the model would include processing rates, feeds, speeds and downtime information. Given this example, the engineer could evaluate throughput, conveyor speeds and capacity, and operator utilization with the simulation model output.

In this example, the model has been extended to communicate with the expert system. Instead of just simulating the machine downtime as a mean time between failure (MTBF) and mean time to repair (MTR), the model can communicate with the operator, expert system and shop floor control devices. This is achieved by switching the simulation to real time where 1 second of simulated time is performed in 1 second of clock time and launching the expert system for problem resolution and assist the operator in repairing the machine.

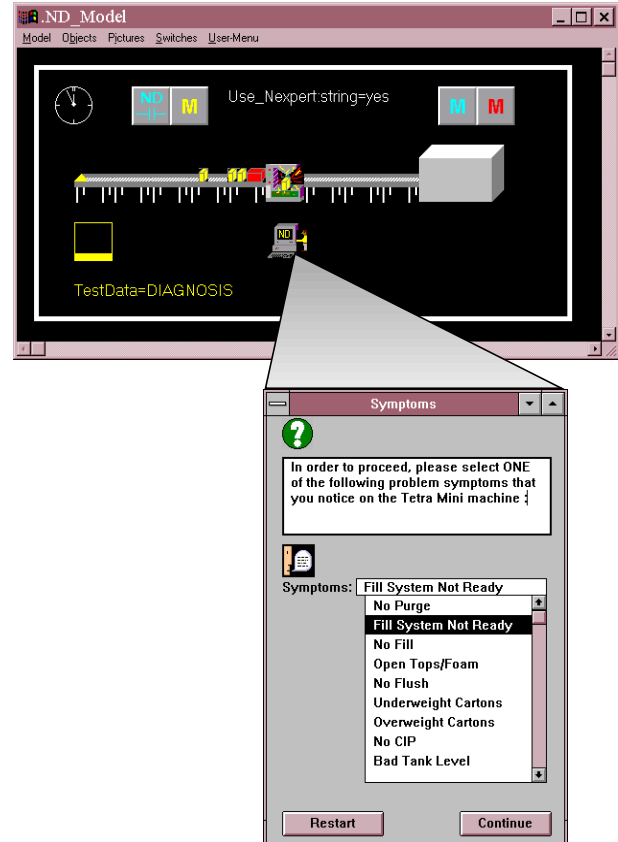


Figure 5: Connection of Model to the Expert System and Real-Time Control.

4.2 Daily Operations

In order to use simulation for “what if” scenarios and daily order planning and scheduling, Wacker Siltronic Corporation, a silicon wafer manufacturer in Portland, OR, used SiMPLE++’s SQL interfaces to tie the simulation model into their production data base (OR/MS Today 1996b). As a result, they are able to perform “what if” scenarios using the latest and most accurate data. In addition, they now use SiMPLE++ has part of daily capacity planning and scheduling. They run the simulation model every night, and the next day they are able to reschedule the factory based on shop performance, WIP and any new orders.

SiMPLE++ has been linked with shop floor control systems to support Just-in-Time (JIT) manufacturing at T&D Automotive in the UK (OR/MS Today 1996a). Using a SiMPLE++ model, they were able to conduct traditional “what if” simulation studies as well as use SiMPLE++ to see the impact of real-time changes to production schedules on a continuing basis.

4.3 Simulation-based Optimization

Harvard University's Discrete Event Dynamic Systems Group has integrated an optimization analysis tool, the Soft Optimization Shell (SOS), into a SiMPLE++ object template. Here, the link to SOS is not an external one – SOS was built right into the SiMPLE++ Object Library. Using the object-oriented paradigm, models are simply objects in the library, and can be optimized. This allows optimization to take place for different types of systems, as well as similar systems that are parametrically different. This is described in detail at: <http://hrl.harvard.edu:80/people/faculty/ho>

AESOP also offers a genetic algorithm to search the solution space of a given SiMPLE++ model and optimize parameter settings such as the number of workers, WIP buffer sizes, process rates, production scheduling and sequencing.

4.4 Standards and Methods Measurement

SiMPLE++ has been used with the MTM Association's 4M System of work measurement. In a simulation model of a bakery, Levasseur (1997) showed how standard times generated as output by the 4M System could be used as direct input for a simulation model. Recipes, along with the standard times for each task in the recipe, were read into the model upon model initialization using an ASCII interface.

4.5 Virtual Reality

To take advantage of the visualization capabilities of Virtual Reality (VR), SiMPLE++ has been interfaced to VR software. In this connected application, SiMPLE++ is used to trigger and account for all discrete events while passing object information to the VR package for real-time VR animation and interaction. SiMPLE++ is used to launch VR animations and control two-way communications when used with immersive VR environments.

Figure 6 shows an example of one application where SiMPLE++ was linked to a virtual reality model using DDE. In this example, the objects in both systems are mapped to each other at initialization to establish communications channels. As the model runs, entity activity, such as movement and change of state, along with resource activities and parameters are passed from SiMPLE++ to the VR environment. The number of objects and their relative locations in SiMPLE++ are

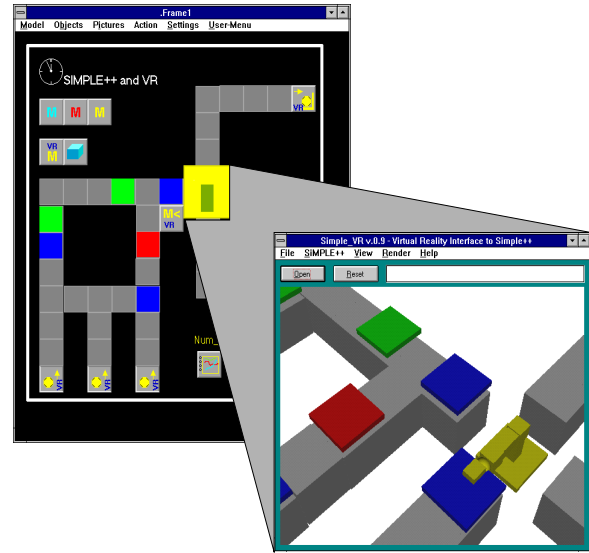


Figure 6: A VR Model Linked to a SiMPLE++ Model

also passed to the VR model. Therefore, any SiMPLE++ model changes are automatically updated in the VR database. AESOP is able to employ standard object interfaces such as CORBA or can create customized interfaces as required.

5 APPLICATION OBJECT TEMPLATES

A number of Application Object Templates (AOTs), or libraries for specific industries or application areas, have been developed for SiMPLE++. Below are some examples of AOTs:

5.1 SiMPLE++_process

SiMPLE++_process is used by some of the largest chemical and process industry companies. This template allows very complex process plants to be modeled with no programming or coding by the user. This template includes application objects which can model, collect statistics and analyze any process industry application. All facilities, resources, and recipes can be clicked into the model and data entered via tables and pop-up windows. See Guenther and Levasseur (1997) for further detail and a complete description of the operation of SiMPLE++_process.

5.2 SiMPLE++_AGV, SiMPLE++_conveyor, and SiMPLE++_HBW

These are templates for specific material handling applications. These templates capture application expertise to conveniently model complex material handling systems which include AGVs, conveyors and

high-bay warehouses. The objects in these templates include logic commonly used in material handling and storage applications such as pre-programmed rules, routing and branching. Users can click-in and connect the application objects representing their process and respond to user dialogue boxes. Figure 7 shows an example of a model created using these templates.

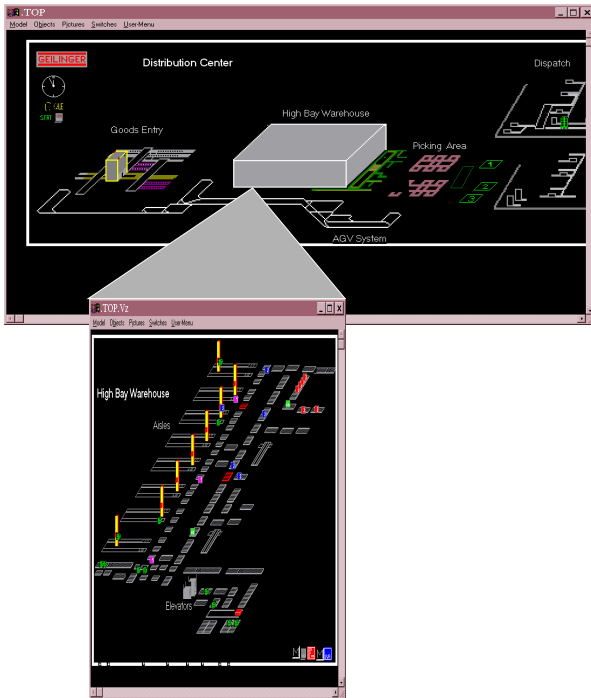


Figure 7: SiMPLE++ Model Developed with Material Handling AOTs

6 SUMMARY

SiMPLE++, using an object-oriented approach to modeling, is able to offer the user a highly flexible simulation tool in a user-friendly environment. Such a tool allows the user to efficiently create their own application libraries, or use pre-made Application Object Templates for specialized applications. Finally, because of its open architecture, SiMPLE++ can be linked to other software packages to solve a wide range of applications which can benefit from simulation.

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SIMAN is a registered trademark of Systems Modeling Corporation. MALAGA is a registered trademark of ZIP GmbH. ARIS is a registered trademark of IDS-Scheer GmbH. ERGOMAS is a registered trademark of DELTA Industrie Informatik GmbH. MTM is a registered trademark of the MTM Association.

Intelligent Rules Element (IRE) is a registered trademark of Neuron Data, Inc.

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