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USING A SIMULATION MODEL TO EVALUATE THE CONFIGURATION OF A SORTATION FACILITY

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ABSTRACT

At a parcel delivery company, the items being shipped must be sorted by destination. However, the company typically serves more destinations than there are distinct positions for sorting within their sortation. Therefore, several destinations may be assigned to some of the sort positions. It is also possible to assign a single destination to multiple sort positions, if the destination has an extremely high volume.

At one major parcel delivery company, sort position assignments were previously made by examining how well a configuration had performed and where imbalances were observed. Then, based on this experience and the expected package volume, destinations were assigned to sort positions in the facility.

To provide its engineers with more information for making this decision, a model of their sortation facility was developed for this company. The simulation model allows testing of multiple configurations before they are implemented in the system. The model also allows different conditions, such as conveyor breakdowns, to be specified so that alternate plans can be tested.

1 INTRODUCTION

Sort time is extremely important to a package delivery company. If the packages are to be delivered in a timely manner, there is little margin for delay or wasted time. There is no opportunity for trying untested ideas on the floor of the sortation facility.

2 BACKGROUND

The objective of this project was to develop a tool that could be used by engineers with little or no simulation experience. The purpose of the tool was to allow engineers to simulate the sortation of all items during one shift so that different configurations of the facility could be tested.

2.1 System Description

Figure 1 provides a schematic representation of the sortation facility that was modeled. In the facility, items arrive and are sent to one of three areas to be unloaded, depending on how they arrived: on a semi-truck, in a container (which holds approximately 300 items) from a domestic airplane, or in a container from an international airplane. Due to the different requirements for unloading each of these (including customs restrictions), each is taken to a different area to be unloaded. Within each area are a certain number of locations at which unloading can be performed (input stations). After being unloaded, items are transported by conveyor from the input station to one of six main input conveyors

Each item that arrives to the facility is sorted to one of approximately 110 locations (output stations), depending on the item's ultimate destination. The items are classified into different categories depending on their handling needs. The main focus of this model is conveyable packages; these packages make up the largest portion of the items that are handled

The efficiency of the system is largely dependent on how well the destinations (i.e., cities) are assigned to the available output stations. With only 110 output stations to accommodate more than 1400 destinations, multiple destinations must be assigned to an output station. These output stations are located on one of nine output conveyors and these conveyors can become overloaded if too many of the high volume destinations are assigned to output stations located on the same output conveyor. Also, sending a large number of items to the same output station at the same time can cause the output station to become overloaded.

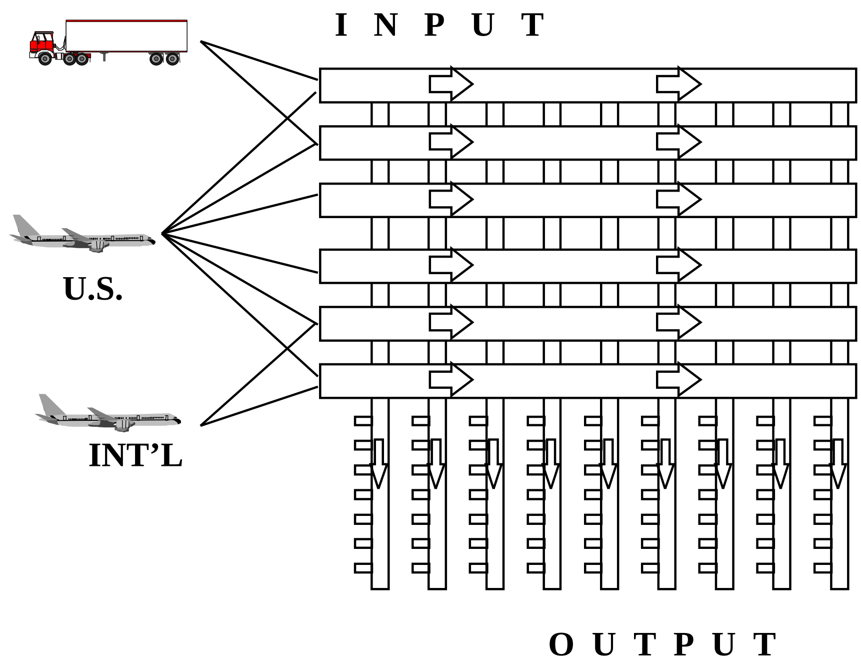

Figure 1: Representation of Simulation Model Layout

3 MODEL DESCRIPTION

The simulation model of the facility was developed using the AutoMod simulation software running on a Pentium PC. Since it was not necessary to recompile the model before each run, the run-time version of the software (which allows the model to be executed, but not edited) was installed for use at the sortation facility.

The physical layout was generated from CAD drawings of the sortation facility. Details about the sortation logic of the system were provided by the designers of the system and the engineers within the sortation facility.

3.1 Operating Modes

The model can be operated in two different modes: review and forecast. Other than different ways of determining the packages that are to be sorted and their characteristics, the operation of the model is the same in both modes.

Review mode uses the actual arrival time and input station that were scanned from the package during sorting. This information is used to determine when and where the item is introduced into the system. The city destination that was collected from the item is also used in conjunction with an output station assignment list to determine the output station to which the item should be sent. This list is a mapping of cities to output locations and is also used during the actual sorting process in the facility.

The purpose of review mode is to test data that was already processed by the system. By modifying the output station assignment list and rerunning the model, users can learn how the performance of the system could have been improved.

Forecast mode uses a schedule of aircraft arrivals and truck arrivals along with the number of packages on each vehicle. The schedule also includes the origin of the vehicle and the time at which it is expected to arrive. However, each item does not have a predetermined destination. The destination is assigned to the item when it is unloaded, based on the historic percentage of items that go to each destination from the specified origin.

Forecast mode allows the users to have more flexibility in the situations that are tested. In addition to modifying the output station assignment list, the package volume and the vehicle arrival times can be adjusted to examine the effects of these changes on the performance of the system.

In both operating modes, once the items have entered the system, the logic of the model is identical. An item enters the system via the appropriate input conveyor and is diverted to one of the output conveyors. The appropriate output conveyor is determined using the output station assignment list.

The item travels along this output conveyor until reaching the correct output station. It is diverted at its output station and then is destroyed. The accumulation and containerizing of packages for outbound shipment is beyond the scope of this model, but the model could be enhanced in the future to include these areas if desired.

3.2 Input Data

The model utilizes several data files that can be modified by the user without requiring the user to edit and recompile the model. These files specify the items that are to be sorted, the output station assignment list, and the operating status of the system. The operating status is defined by parameters which include the unloading rates in each area and the number of input stations that connect to each of the input conveyors.

By modifying the input files, the user has extensive flexibility in defining how the system will be set up for the simulation. For many of the parameters, it is possible to define them with a probability distribution instead of just a constant value.

The items that are to be sorted are specified in different ways depending on the operating mode. To operate in review mode, the file generated during the actual sorting shift is used for input. From this file, the time of arrival, the input station, the dimensions, and the destination city are collected.

In forecast mode, the schedule of aircraft arrivals and the schedule of truck arrivals are each specified in a separate file. Included in each schedule are the time of arrival, the city of origin, and the number of packages on each vehicle. A third file is used to generate the destination of each package based on its origin. This file contains the percentage of items from each origin that should be sent to each destination. In forecast mode, the package dimensions are generated randomly.

3.3 Additional Features

In addition to operating the system as described above, features were added to extend the flexibility of the model. For example, the model allows the user to examine the effects of conveyor failure and also balances the arrival rate of packages arriving between each of the three input areas.

If one of the output conveyors fails during a sortation shift, the results can be catastrophic. All of the items that are traveling to output locations along that conveyor must be rerouted to another output conveyor. Backup plans can be tested with the simulation model before they are needed so that they can be implemented if the need arises.

Another feature that was added to the model is automatic balancing between the different input areas. Items being unloaded from international aircraft containers and from trucks merge with the items coming from the domestic aircraft containers. To prevent congestion on the input conveyors, the number of input stations available in the domestic container area is reduced whenever unloading is being done in either of the other two areas. When this unloading is done, the capacity of the domestic area is returned to its normal level.

The number of input stations idled in the domestic container areas is based on the unloading rates in each of the areas. Enough stations are idled so that the total flow on that input conveyor does not exceed the capacity of that conveyor when the items from the other area (international or truck) begin to arrive.

3.4 Output

During execution of the model, data on package flow is collected in two-minute intervals. This information includes the rate of package arrivals at each of the input conveyors, each of the output conveyors, and each of the output stations.

As the program is running, AutoMod graphs are generated that show the value for each time interval and a moving average. This information is also written to a data file so that it can be referred to later for graphs or other uses.

By monitoring the flow of items at each of these areas, locations where overloading is occurring can be determined. The number of input stations, the output station assignments, and the arrival scheduling can all be varied to determine the configuration that minimizes the time to complete sorting without overloading any areas of the system.

4 MODEL PERFORMANCE

Validation of the model is ongoing. It is being accomplished by comparing actual results from the system with the results produced by the simulation, but difficulties were encountered in collecting some of the data from the real system for comparison. Results compared include total sortation time and the flow (number of items per hour) along the conveyors and to each of the output stations.

The time to simulate a full shift of packages (typically 40,000 items) depends upon the capabilities of the computer being used and the graphics mode that is being used.

Running the model using AutoMod 8.1 on a dual Pentium Pro 200 PC in Windows NT 4.0, an entire sortation shift was simulated in approximately four minutes when the model was run in windowless mode. The running time is significantly longer, approximately one hour, when model is run in normal (non-windowless) mode, even if the animation has been turned off.

Although the simulation model does not provide instant information about the system's performance under the specified conditions, the short running time permits the user to quickly test several different configurations and evaluate the effectiveness of each.

5 SUMMARY

With this simulation model, users can evaluate different configurations of the system to examine the resulting package flows and sortation times. The model can also be used to develop backup plans in the event of late-arriving vehicles or conveyor failures. The model can also be used to predict the staffing levels needed in the facility by examining the number of packages to each of the output stations.

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KEYWORDS

Manufacturing Applications, Sortation, Logistics, Facility Layout, Facility Staffing, Scheduling