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SIMULATION OF THE REMOTE UNIT ASSEMBLY AND TEST: A CASE STUDY

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ABSTRACT

This paper will present a case study on the use of simulation to develop and implement an assembly line for the assembly and test of customer located telephony equipment. The simulation model was used as a tool to assist in development and integration of the assembly and test processes with a focus on capacity, material flow optimization, and equipment layout. The authors will discuss how the model affected the facilities layout, equipment specifications, and material flow.

1 INTRODUCTION

This is a case study of a simulation model used to develop an assembly line to build a new product utilizing fixed wireless technology to provide local phone service and high speed data.

The product, assembly methods, and test procedures were not developed when the simulation effort was started. The expectation was that the production ramp would be steep once the product was introduced to the market due to inherent product advantages. With so many unknowns, it was necessary to find a method to experiment with multiple possible product flows, assembly times, and test processes. It was concluded that simulation would provide a tool that could be used to optimize the material flow, methods, capacity and layout of the assembly line.

This tactic proved to be very effective in helping to develop the final processes in use today. As the model was being developed, there were separate teams working on product design, test procedures, process development, facilities layout, and material flow. The model required data input from all of these functions. It provided an inexpensive method of doing "what-if" analysis of the various possibilities. One of the primary outputs of the model was the realization that the assembly line had to be very flexible. The resulting assembly line is capable, with minor modification, of assembly and test of any small electronic product.

This paper will provide details on (1) why simulation was used (2) what inputs were determined to be significant and why (3) the outputs of the model and (4) the results.

2 WHY SIMULATION WAS USED

When simulation activity started, there was very little information on the product to be produced in terms of product design, assembly processes, test processes and actual requirements. It was known that the product would consist of a small indoor electronics box and an outdoor electronics box each about the size of a VCR. Given the expectation of a steep production ramp, lead time to purchase production line equipment and limited information, the use of simulation proved to be essential to the success of manufacturing the product.

The overall objective was to develop and integrate a robust manufacturing process to meet a projected line capacity of 500 indoor units and 500 outdoor units per shift. It was decided that simulation was the best method available to determine the feasibility of a given process to meet the capacity requirements.

The building blocks of the simulation model required many assumptions. Actual pick, assembly, test, quality, pack, and ship strategies had to be defined before simulation development. This involved such assumptions as:

1. Removal of part packaging materials prior to transfer to the assembly area.
2. The use of a pull system with limited WIP.
3. The automation of material handling through the pick cycle and WIP.
4. In-line test process.
5. In-line pack stations.
6. The assembly line would be very flexible in terms of product design changes.
7. The line also had to be scaleable so that the capacity could be easily increased.

The simulation provided a visual aid that helped to assure that all of the required processes were taken into account. The model provided a graphical representation of the flow of material, indicated WIP levels, and identified blockages. These are features that are easily identifiable through the use of simulation. It also clearly identified linkages between functional organizations. This information was instrumental in obtaining cross department support the assembly line strategies. Therefore, there were very few surprises when the line was installed and operational.

As the product design firmed and more data was available, the model was updated. It was then possible to use the model for "what-if" analysis. It provided dynamic fast response answers to such questions as:

1. Can the test stations keep up with assembly?
2. Can picking provide for the assembly requirements?
3. Will the conveyor be blocked with product at any location?
4. Capacity per shift?
5. How should rework be handled?
6. Plus numerous other issues.

To summarize, the simulation model:

1. Provided a better understanding of the overall manufacturing process.
2. Provided validation of the capabilities of proposed processes thus reducing risk.
3. Aided in the facilities layout development.
4. Drove some of the equipment cycle time specifications.
5. Provided a visual tool that can be used to justify the equipment expense to management.
6. Provided staffing requirements in terms of both hours required and skill set requirements.

3 SIMULATION INPUTS

Due to the lack of relevant information such as product bills of material (BOMs), assembly times, test times, etc., assumptions were made for all of the information needed to create the model. As more data became available, the model was revised. Over a period of approximately six months the model was complete to the point that manufacturing equipment was specified and put on order.

Key model inputs were:

1. The set of process strategy assumptions previously mentioned.
2. The facilities limitations.
3. Equipment parameters.
4. Bills of Material.
5. Test parameters.
6. Process and labor standard times.

Since the WITNESS (The Lanner Group 1998) modeling software that was used provided graphical animation, it was concluded that the model should represent the layout of the manufacturing process. This had the added benefit of showing physical as well as calculated blockages and utilization of different pieces of equipment. It also allowed the model to be used to validate the manufacturing process layout as well as the process.

The proposed manufacturing equipment parameters were loaded into the model to verify that the overall equipment cycle time would sufficiently support the required capacity.

When the product bills of material became available, they were used in conjunction with method based time standards (Zandin 1990) to develop process cycle times for picking, assembly, and packaging.

Test parameters and cycle times were estimated by test engineering.

4 MODEL OUTPUTS

The process of obtaining all of the information needed to develop the simulation model helped to recognize and centralize the requirements for the development of the manufacturing process. This included the overall flow chart, various department responsibilities, targeted capacity, and equipment requirements.

The use of the model as a "what if" tool provided a decision making method to determine the optimum material flow, build and test process methods, projected capacity, and the equipment layout (figure 1).

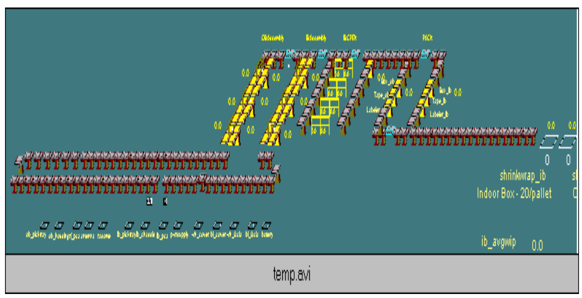


Figure 1: Equipment Layout in WITNESS Model

The model was kept simple to provide clear and quick data analysis. Equipment downtime, maintenance, and other line delays were not characterized individually. These factors were incorporated into the cycle times at each operation and modeled with the triangle distribution.

Since the model is relatively simple, the simulation reaches steady state in 2 hours (of simulation time) for the outdoor unit and in 1 hour for the indoor unit. The time to achieve steady state was included in the simulation results that were used to evaluate the various line configurations. The various configurations of the simulation were run for 2 shifts to provide simulation results. Each shift is 384 minutes in length assuming an 80% utilization factor.

When random numbers are utilized, the WITNESS program defaults to a series of pseudo random number streams that are reused each time the model is run. "Since the streams of random numbers are reproduced faithfully each time the model is run, the conditions of the investigation are also reproduced. This insures that you are comparing like with like between runs of the models." (The Lanner Group 1998) This default feature of WITNESS was used to perform the evaluations of the various facility layouts.

As previously indicated, numerous assumptions were made at the beginning of the model development and over the period of approximately 6 months the model data were continuously updated and refined.

5 RESULTS

One of the important results of the overall model development was the specification of the material handling, pick, assembly, test, and pack processes. The model acted as a repository for all of the process information. The resulting process flows as shown in Figure 2. The initial model was constructed based on line layout as shown in Figure 3.

It was decided to experiment with the picking area using the model. The original picking area required that both the indoor and the outdoor units be picked on the same line and then sorted out onto two separate lines to feed the assembly lines. The conveyor being used is automated; therefore, this would add expensive logic to the system. This scheme also required three additional gates that would impede the mobility of support personnel.

The picking area was changed as shown in Figure 4. With this layout the picking line would flow from the middle outward in both directions. This eliminated the three gates and the logic necessary to separate the indoor and outdoor products. The simulation indicated a higher picking and delivery capacity with this method.

Another what-if exercise involved how to handle rework on the assembly lines. Figure 5 shows a version where the rework stations were located in line with each assembly line on the opposite side of the take away conveyor.

The simulation of this proposed process resulted in blockages of the take away conveyor due to units going both across the conveyor and being taken away to test and pack at the same time. Therefore, it was concluded that rework would take place on the actual assembly lines if necessary. The conclusion was to make spare parts available on the lines. Rework will be conducted on the assembly lines as required.

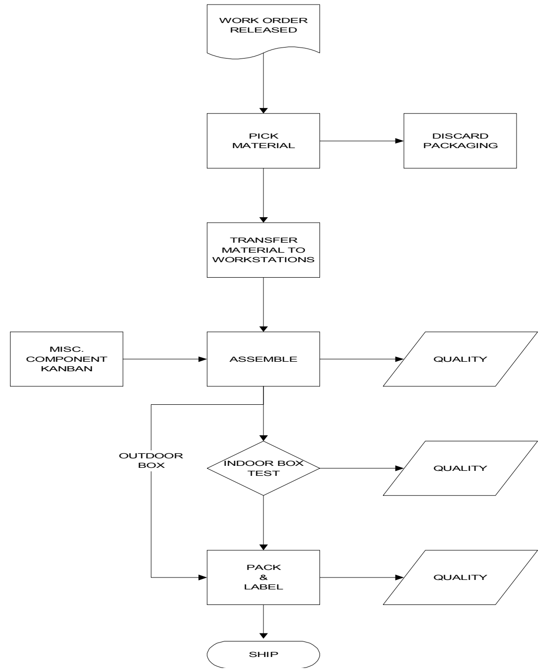
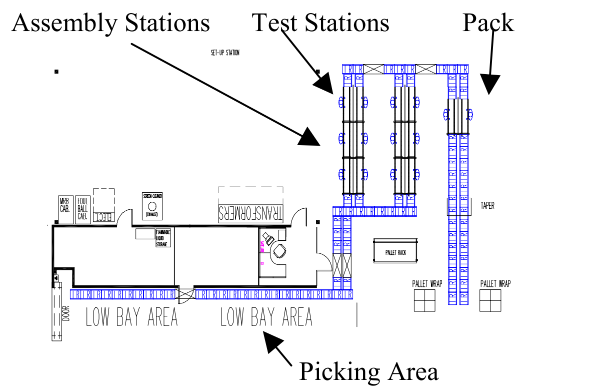


Figure 2: Remote Unit Process Flows



Output = 280 indoor units/shift and 630 outdoor units/shift

Figure 3: Original Equipment Layout Alternative

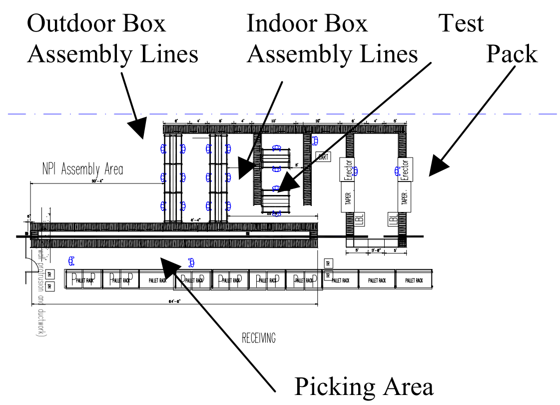
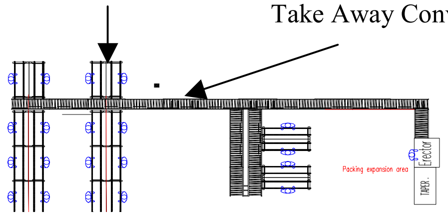


Figure 4: The Final Layout

Proposed Rework Station Location

Take Away Conveyor



Output = 310 indoor units/shift and 405 outdoor units/shift

Figure 5: Layout with Rework Stations

Another what-if layout issue concerned where to locate the test stations. The original plan (Figure 3) was to have the test stations located in line with the assembly operations. Due to very vague information from test engineering concerning the number of stations and the cycle time for each test, the simulation indicated that this location would cause blockage and poor utilization of the assembly stations. Therefore it was concluded that the test area needed to be separated from assembly as shown in Figure 4.

The assembly line was designed with expansion in mind. Assembly and test capacities can be doubled without redesigning the overall layout. The picking queues are oversized for flexibility and fast response to output demand. Additional lines are added in parallel to existing lines. Response time is constrained only by equipment purchase and staffing recruitment lead times.

Toward the end of the model building process, the model was used to show the results of proposed line balancing scenarios. The model provided detailed data concerning equipment utilization, capacity, flow time, WIP, and staffing.

The resulting model display of the capacity for the line is shown in Figure 6. This figure shows the state of the production process after simulation of a 2-shift run time. As can be seen, the model indicates that the line is capable of producing 1360 indoor units and 1170 outdoor units in two shifts. This meets the original goal of 500 units per shift (500 indoor and 500 outdoor sets).

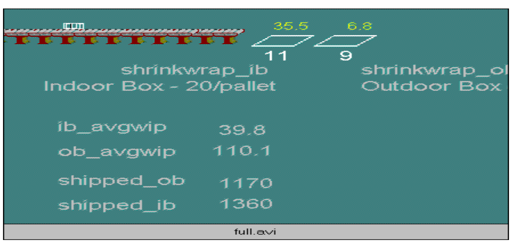


Figure 6: Two Shift Simulation Results

The final iteration of the model incorporated very detailed information concerning the picking operation, assembly methods, test methods, and packing methods. Therefore, it validated that utilizing these methods will achieve the capacity goal. It also provides the information needed to see if each individual operation is producing as planned. If an operation does not perform as expected, it will be reviewed for differences between the estimated cycle times and the actual cycle times with the expectation of implementation of corrective action.

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