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IMPLEMENTING LOGISTICAL CONTROL RULES USING SIMULATION GAMING

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ABSTRACT

The uses of simulation today are as much about the derivation and verification of control logic as they are about sizing of manufacturing processes. This paper will examine the use of simulation in the design of control logic, the uses in agreeing the control logic and in disseminating the principles and benefits of the control logic to the total workforce. The use of simulation to derive control logic for a manufacturing facility is an integral part of most simulation projects, but can give an optimistic view of its performance as full information about the system state is available to the simulation modeller but not always to the decision makers in the real world. This paper will examine how restricted information affects the decision process and how simulation can be used to improve decision makers vision in these situations.A major food producer wished to change their method of operation from a traditional batch manufacturing to a method more responsive to their customer needs. The proposed method of manufacture was well documented and there was no need to simulate it , but there was a problem in communicating the new method to the total workforce and getting them to follow the new method. A simulation game was built that illustrated both the old and the new methods and then the game was made freely available to the workforce via the companies PC network. No training was given in simulation to the game players, but after playing the game the players not only understood the new logistical methods but also had an awareness of the problem solving capabilities of simulation.

1 INTRODUCTION

The majority of simulation projects start with a concern over the physical characteristics of the domain being modelled, but end with some recommendations concerning the control characteristics of the domain. In some situations changes to the control procedures of the domain may be all that is required to achieve the objective set of the project. Simulation is a very powerful tool in determining control logic but can lead to recommendations that are difficult to implement. Different forms of simulation model can be used to resolve these problems. This paper reviews, by means of case studies, why control logic should always be considered a variable in simulation projects, the problems associated with some control assumptions and some novel ways in which to aid implementation of control logic by means of simulation models.

2 WHY CONTROL LOGIC SHOULD ALWAYS BE CONSIDERED VARIABLE

A range of electronic assemblies was to be built on an assembly line. The components for each assembly were to be held in an AS/RS, a team of 5 people would call the relevant components out of the AS/RS and make up the relevant kits ready for assembly. The designers of the facility were worried about the capacity of the conveyor system linking the AS/RS to the kitting operation and about the amount of storage available at each kitting station. A model was constructed of the process, see fig 1. and very quickly the capacity and the bottlenecks of the system were identified. The model showed the conveyor system to have sufficient capacity, but it also showed that there was a potential problem with the kitting stations. This problem could arise when the buffer storage at the kitting stations becomes full and trays have to be recirculated before entering the kitting storage area.

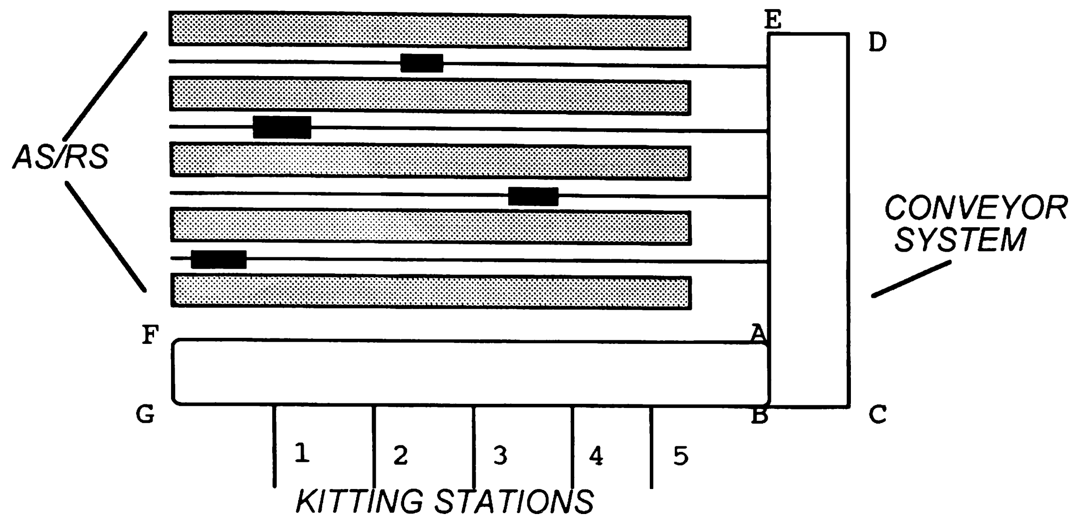

FIGURE 1 KITTING STATION SIMULATION

Trays of parts would be sent out of the AS/RS around the conveyor system (in the direction of E - A - F - G - Kitting Station), the trays would then be returned along the conveyor system (Kitting Station - B - C - D - E - AS/RS). If the kitting station was already full, the tray would circulate around the conveyor (A - F - G - B - A) until a space was available at the relevant kitting station. This situation occurred on about 5 % of kits and had a significant impact on the capacity of the conveyor system. What had more impact was the situation when any given kitting station had to kit two consecutive assemblies that both contained a large number of parts. In these cases it was possible for parts for the second assembly to clog up a kitting station before all parts for the first assembly had been made up into kits, the resultant effect was for parts from both assemblies to circulate, ad infinitum, on the conveyor system.

One solution to this problem was to increase the size of the kitting stations, thereby allowing more parts to be stored . A much better solution was to modify the control logic such that an assembly with a small number of parts always followed an assembly with a large number of parts. Both alternatives gave feasible solutions, but the control logic was much cheaper to implement and was more robust in terms of production throughput. This solution was found because one member of the project team asked the what- if question, much as you would do if you were playing a game. By treating a model as a game, albeit a serious game, the modeller will free their thinking from the constraints that could be assumed from the original phrasing of the objective. Then, just as in games, the modeller can use lateral thinking to find a way to exploit the rules to enable them a better chance of winning.

3 THE PRE PAINT CAR-BODY STORE

The domain of this project was a conveyor (A) feeding a six lane storage area that was used to sort car bodies into paint batches for paint shop (B), ref fig 2. The problem is to sort a random stream of car bodies such that the paint batch size can be maximised. Paint batches are created from an order bank of car body styles that are to be painted on a specific day. If the number of storage lanes exceeds the number of types of car body the complexity of the sorting algorithm is much reduced. If the problem is reversed and the number of car body types exceeds the number of storage lanes then sorting becomes a much more difficult problem. In this example there were 9 car body types and only 6 storage lanes.

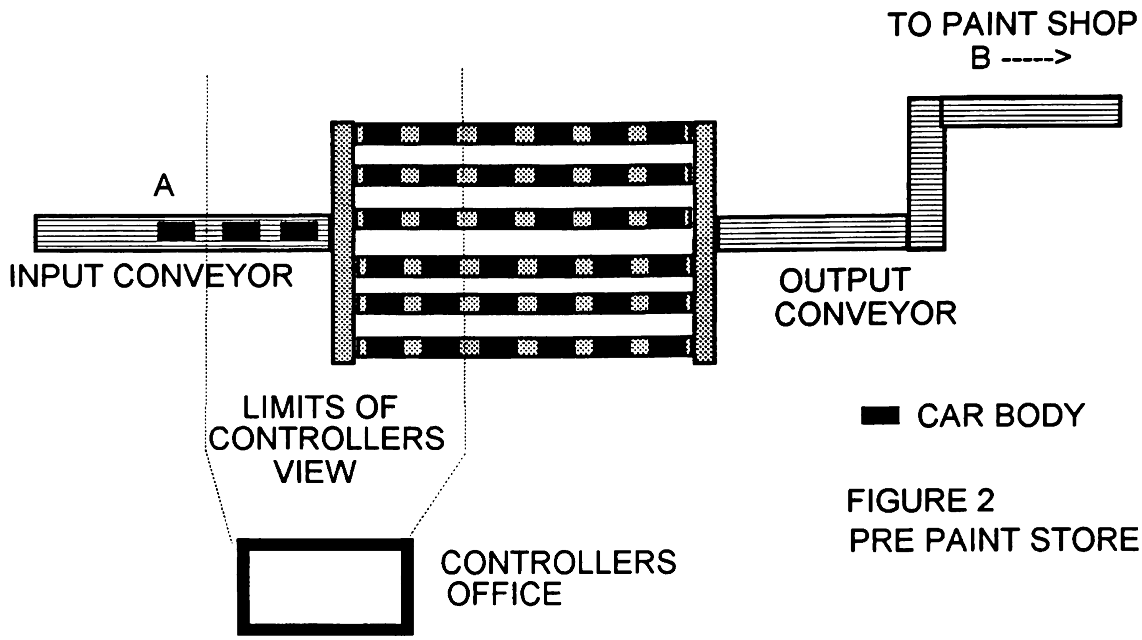

FIGURE 2
PRE PAINT STORE

The initial objective of this project was to determine how to increase the size of paint batches in a car plant. (Increasing the average paint batch size decreases the cost of the painting operation in two ways, firstly it reduces the waste in paint changeovers and secondly it reduces the paint rejects) . The method of paint batching adopted was to try and build up paint batches on input . In this method the store input logic is of the form can this car body be part of the current paint batch , if so go to lane 1 , if not go to lane 6 . The paint batch size can be increased if you consider as many as possible of the cars on the input conveyor, in this way you can judge when there are no further cars that can be added to the current batch. This improved logic was accepted by the management of the car plant and was duly implemented. However the average size of the paint batches did not increase. In fact it decreased, and the management of the factory called into question the validity of the simulation model.

It was at this point that the store controller pointed out that he had a restricted view from his office and could only see the first two car bodies on the input conveyor and the last two car bodies in each of the store lanes. This is a case when the modeller had bent the rules of the game too far and had used data not available in practice. The simulation model was then modified such that the control logic only took into account what the controller could see. The model then gave very similar results to what was being achieved in practice. At this point the validity of the simulation model was no longer in question and the project became one of to enable the store controller the scope of data that had been used in the model to achieve the larger paint batches.

The project then moved into a new phase in that the objective became that of justifying the investment needed to give the controller the visibility of the facility he needed to implement the logic that had been shown to give the much improved paint batching. This, given the size of the improvement, was a trivial task to achieve.

In this case study the modeller had used lateral thinking , as in playing a game to win, to find a solution but had failed to check the feasibility of implementation. It is obvious, in hindsight, how the problem occurred and also how the problem should have been avoided but perhaps a different view of the animation would have made the problem more apparent. The traditional simulation schematic animation did not identify the implementation problem, would a virtual reality display shown the problem?

4. THE GAME

The case study described below is a rare example of where simulation has been used solely for communication. It also shows a method of implementing control logic that could have been derived from a simulation model. The details of the case study simulation can not be given as they would reveal details of the logistics method that a company believes gives it a competitive edge. Therefore a separate model will be used as an example of this method.

A company had decided to update its method of manufacture from a method that had been used for the last 10 years , or more, to a new method that would improve their responsiveness to customers but changed practically every persons way of working. The problem was how to sell the new method to all employees. Part of the solution was to use a computer game, available to all employees, that would illustrate the benefits of the new logistics method. Discrete event simulation games have been used to teach students simulation or to teach students a specific method but I am not aware, until this case, of any simulation model being used in a completely unsupervised way to sell the benefits of a logistics method.

A Witness model was built of the company's production process. The process included the placing of orders for raw material, a production line and both raw material and finished goods stocks and deliveries to customers. The model was a much simplified version of the real situation, covering 3 products and one production line (effectively one machine), but even this situation was not as simple to control as the model users initially thought. To use the model, the users had first to decide what kind of production cycle to use; produce every product every day or produce in a weekly cycle. Once they have decided on the cycle, it must then be adhered to for the following month. At this stage, the customer demand would be revealed for the following month and the users then have to decide the frequency and quantity of raw material deliveries. Again, once decided this was fixed for the following month which is a fair approximation of real life. The model is then run showing a simple animation of the production facility, timeseries of raw material stocks and finished goods stock and statistics indicating customer service level and an overall performance score. The performance score was calculated from the customer service level and the stock levels of both raw material and finished goods.

The users objective is to maximise this overall performance score. By running different production cycles, some using the old production method and some using the new method, the users can see the benefits of the new approach and begin to understand what it means to them in their jobs.

The system was set up so that all scores were recorded and, in the true computer game style, an honours board of the top ten scores was maintained. After one month the users of the game were questioned to see if they understood the new logistics method . All game players displayed a considerable understanding of the method. The game was therefore declared a success, however there was one slight snag. The game had been designed for a single player, but was played mostly by groups of people. This made the recording of the best scores a little more difficult to interpret but helped considerably in achieving the games purpose.

We often quote communication as a major benefit for simulation. Perhaps this case study demonstrates one way of accessing that benefit. An example of this approach is detailed below using a fictional problem as the basis for the model.

5. CONCLUSIONS

Simulation models provide a model user with an abstraction of the real world. Creating a game out of finding a solution can separate the model from the real world. As there is no cost to losing a computer game, (you can always try again), the user is more adventurous in their strategy. This can uncover some innovative solutions to real world problems, especially in the realm of control logic and can help communicate those solutions.

This method of problem solving is nothing new, psychologists tell us that this one of the ways we have always used to solve problems.

AUTHOR BIOGRAPHY

Roger Beadle holds an honours degree in Engineering Mathematics and a Masters degree in Operational Research. Roger was one of the pioneers in applying visual interactive simulation in 1978 since then he has over 14 years experience in the application of, and subsequently the development of, visual interactive simulation. This experience has been gained in the U.K., Europe, U.S.A. and Japan in a wide variety of industries. He is currently directing the advancement of simulation technology in AT & T Istel's products (WITNESS , PROVISA and PYRAMID)