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A STUDY OF CONTINUOUS MODELLING USING SIMULATION SOFTWARE FOR BUSINESS PROCESSES

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ABSTRACT

In this paper, two business process simulation (BPS) software tools have been evaluated and compared in terms of the user experience. BPS is a technique, which assists companies in mimicking their everyday operations to find ways in which to improve and develop them to achieve either productivity, financial or risk-free gains. There are many computer packages available on the market, and it is important to have an idea of the type of software that can promote these benefits further. The two software packages investigated in this study are Witness (the Lanner Group) and Simul8 (Simul8 Corporation). These packages are used by organisations as management tools to optimise their internal operations. A practical evaluation of both packages has been undertaken from the experience gained during the model building of a refinery case study. Comparisons were made with a number of conclusions and recommendations, and the advantages and disadvantages of each package are provided. This study is different from other investigations as it focuses on evaluating the user experience rather than a traditional comparison of the statistical output of the reference models and it also focuses on a continuous-time simulation.

Keywords: Business Process Simulation, Continuous Simulation, Witness, Simul8, Modelling Software, Simulation Software

INTRODUCTION

Business Process Simulation (BPS) software tools has been used throughout industry in numerous formats to support change by using dynamic animation to give managers and decision makers a better understanding of the flow of their business and how it operates [1]. By creating a virtual replica of the system under consideration, using computers and specifically designed software, problems are examined in detail and various policy options are formatted to solve areas of concern within the simulated system [2].

BPS is, in our opinion, one of the most interesting techniques available. The process model to be simulated must take into account the resources used and the characteristics of the activities that make up the process itself. By specifying the system's workload, the analyst can evaluate the performance of the business process along a number of indicators such as lead-time, use of resources and costs [3]. Once built, the process model allows the analysis of many potential new scenarios with little extra effort, commonly known as 'what-if' analysis [4].

BPS, whether applied in the service or manufacturing industries, supplies organisations with a technique for investigating and testing its own working practices, and the results provide many benefits, such as reduced risks/costs, faster implementation of change, and improved operational efficiency [5]. All of these factors combine to show how BPS can be a beneficial process for any company or organisation.

BPS has evolved and utilised the best features inherent in computer software [6]. The development of these software packages allows an analyst to watch the dynamics of a model unfold in the form of a semi-pictorial silent film [7], users can stop the running of a model and interact with it [8]. BPS has introduced effective decision-making to a new generation of management.

This paper reports on the practical experience gained from evaluating two BPS tools available on the market rather than on a comparison of the output statistics from the manufacturing models [9]. Due to the wide variety of software packages available, the evaluation and comparison has been limited to the two main packages available and utilised for teaching and research at Manchester Metropolitan University in the UK.

Witness is the first of the two commercial packages to be discussed, developed by the Lanner Group [10], and promoted for its easy to use and flexible properties. It is utilised by world-class organisations in many different industry sectors, aerospace, automotive, food & beverage, criminal justice, defence and oil companies, and organisations such as the BAE systems, Nissan, Ford motors, the UK Ministry of Defence, Shell and Mars confectionary have benefitted from the Witness package. The second package to be considered is Simul8, which is described as a “Empowering rapid, confident decision-making for 25 years” [11], and has been applied in manufacturing, healthcare, automotive, call centres, pharmaceutical industries and used by the NHS, Coca Cola, Intel, Bosh and the British Nuclear Group, for its planning capabilities.

In order to compare and evaluate the two software packages, a scenario have been modelled and simulated, using continuous simulation elements. The diversity of simulations supports the main objectives of this study, which are:

- (i) To test the ease of handling of both Witness and Simul8; advantages or disadvantages of each package
- (ii) To evaluate specifications and scope of each simulation program; to be investigated by developing models using Witness and Simul8 for the same case study.

In addition to the above, this paper provides research into the following.

- The help facilities available - can each package provide the same assistance required by either experts or novices
- Does the type of process being simulated have contributing factors as to which system should be used

BPS METHODOLOGY

A common strategy for implementing BPS contains a number of steps from the initial plan of considering simulation, through to the results produced by this technique. If these steps are followed, the simulation will develop in a logical sequence [12].

1. Decide the purpose of the investigation

In general terms, this will be the reason why the organisation feels the need to simulate part or all of its current systems. A type of improvement is the obvious target, but this could be either examining the logistics of change or developing methods of control for queuing.

2. Analyse the system structure

Parts, customers, workers and machine activity need to be tracked through the system to ensure the simulation mimics the original. This phase produces flowcharts/activity cycle diagrams that capture the operational flow.

3. Identify stochastic processes

All simulations have randomness within the system; a customer’s inter arrival time at a bank would be described as a random phenomenon, and this assists in setting the statistical distributions which are required as part of the simulation input.

4. Code the simulation

At this stage of the procedure, the simulation package is used to convert all the information gathered into a system simulation.

5. Preliminary runs and validation

The simulation is trialled until it is certain that it is imitating the system. This has three stages:

- Verify that all internal logic is correct. Activity cycle diagrams and statistical distributions are working correctly.

- Validate that all system outputs are similar to the real system.
- Analyse the stability of the system; this will show whether queues are causing bottlenecks or not.

DESIGN EXPERIMENTATION

The importance of the simulation runs that are created in phase seven of the simulation is realised in this step by designing specific runs. Another advantage for developing the experiments at this point of the process is that the results can be compiled quicker.

MAIN RUNS

This stage generates the data which is relied upon to generate the final results.

ANALYSE RESULTS

Conclusions are now made from all the data and information gathered in each step.

With the basics of BPS methodology clarified, the paper will now continue to build on this information, with the evaluation and comparison of two widely used simulation packages.

COMPARISON AND FINDINGS

A series of simulation case studies were collated from Manchester Metropolitan University. The example in question have been taken from the School of Engineering's Operational Management based courses taught at postgraduate level.

Both software packages use graphical user interfaces (GUI's) to create Visually Interactive Models (VIMs) that represent operational logic and flow using modelling elements displayed as icons. VIMs are user-friendly and support rapid model building onscreen. Models are constructed by selecting icons that represent features of the system being simulated and these are linked together onscreen and parameterized using property sheets. The case study has been selected to give a diverse spectrum of utilisation for both software packages. The case study is modelled and simulated in both Witness and Simul8, with findings presented below.

CASE STUDY: THE REFINERY

The refinery consists of an oil company that has delivery of crude oil from a dock by ships; the oil then requires transferring through a pipeline to the refinery. Once the oil is refined, the oil needs to be transferred back to the docks through the pipeline; this will then be taken for distribution via ships. There is only one pipeline, which carries crude oil from the storage tanks at the refinery and there is a delay when it is switched from pumping in one direction to pumping in the other direction.

The purpose of the simulation is to investigate the effect of different rules on using the pipeline. The highest priority objective is to keep the refinery working for as much of the time as possible, but there is also a cost of keeping a tanker waiting for the finished product at the dock. This means that there is a major cost if the storage tanks at the head of the refinery run empty and a smaller, but still significant cost if the final product tanks at the dock run empty.

Operational data for the case study is detailed in Table 1.

Table 1: The Refinery: Simulation Specific Information

Type	Detail of Type	Distribution or Additional Notes
Temporary Entity	Crude Oil	Arrives by Ship, transferred at 30 units per minute
Temporary Entity	Refined Oil	Transferred to Ship at 30 units per minute.
Permanent Entity	Work Centre/Activity – All Tanks: Refinery Head Tanks Refinery Product Tanks Dock Crude Tanks Dock Product Tanks	All Tanks have capacity of 5000 units. Dock Crude pipes to Refinery Head Refinery Product pipes to Dock Product All transferred by one pipeline at 30 units per minute
Permanent Entity	Pipeline	Flow Rate at 30 units per minute (Oil) Flush of Pipeline – Fixed (20)
Resource/Labor	Dock Resource Refinery Resource Pipeline Resource	Available at all times.

Assumptions:	Pipeline must be flushed before a different fluid is passed through
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System state and activity diagrams of the Refinery are given in Figures 1 and 2 respectively. The Refinery Model is simply set up in both software by setting:

- Entities or Parts – for the Crude Oil, Refined Oil and Ships
- Queue’s, Stores or Buffer’s - for the Storage facilities of the Refinery and Dock Areas
- Activities or Work Center’s - for the Refinery Plant, Docks and Pipeline
- Resource or Labour to assist with the rules on the pipeline
- Only Crude or Refined oil can be pumped at any one time through the pipeline.
- Pipeline requires flushing if the type of entity is different than the last one.

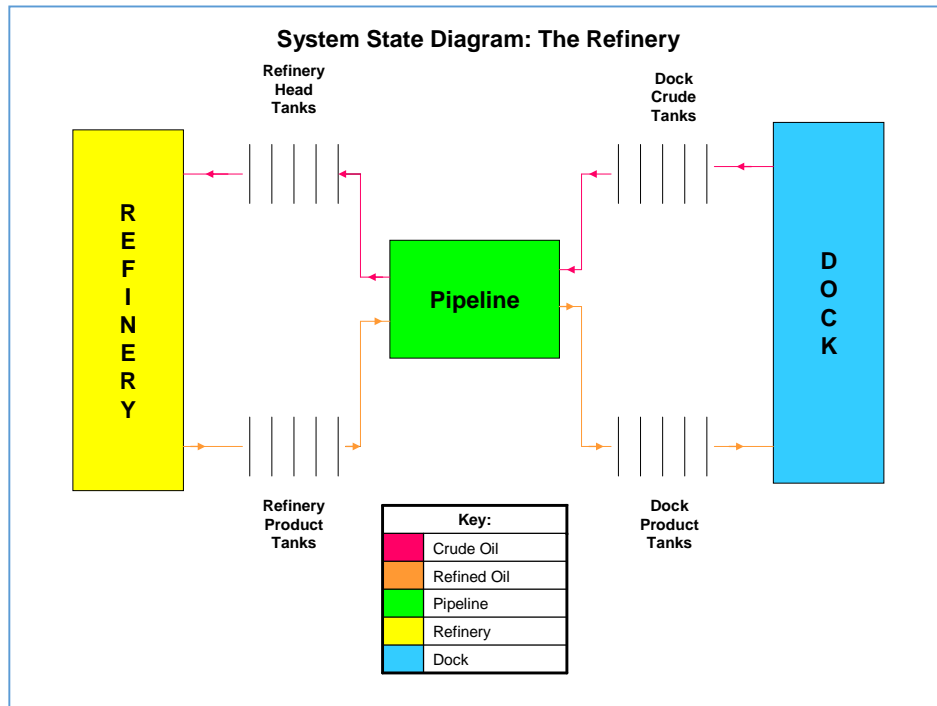


Figure 1. System state diagram of the Refinery

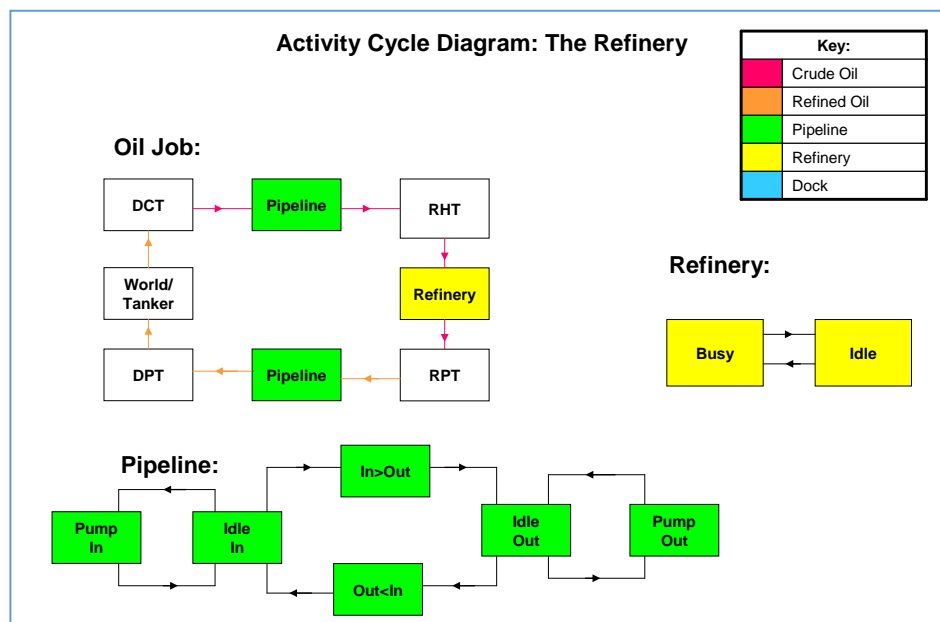


Figure 2. Activity Cycle Diagram of the Refinery

SIMULATION MODEL OF THE REFINERY

The refinery consists of an oil company that has delivery of crude oil from a dock by ships; the oil then requires transferring through a pipeline to the refinery. Once the oil is refined, the oil needs to be transferred back to the docks through the pipeline; this will then be taken for distribution via ships.

There is only one pipeline, which carries crude oil from the storage tanks at the refinery and there is a delay when it is switched from pumping in one direction to pumping in the other direction.

1. Witness Simulation Model for the Refinery

Data from the Refinery case study were implemented in the Witness simulation software. The completed model in Witness is illustrated in Figure 3.

It includes some amazing visual effects, as well as accurately depicting the system required:

- Crude Oil arrives in the form of black liquid
- It flows into the Docks Crude Oil Tank
- The Pipeline is set from Docks to Refinery at this point
- The Refinery's Head Tanks will fill from the Pipeline
- The Pipeline will be flushed
- A Ship will arrive for Refined Oil and be filled from the Dock's Product Tanks
- This will prompt the Pipeline to transfer the Refined Oil through the Pipeline from the Refinery Product tanks to the Dock's Product Tanks
- The Pipeline can now be flushed awaiting a further delivery of Crude Oil

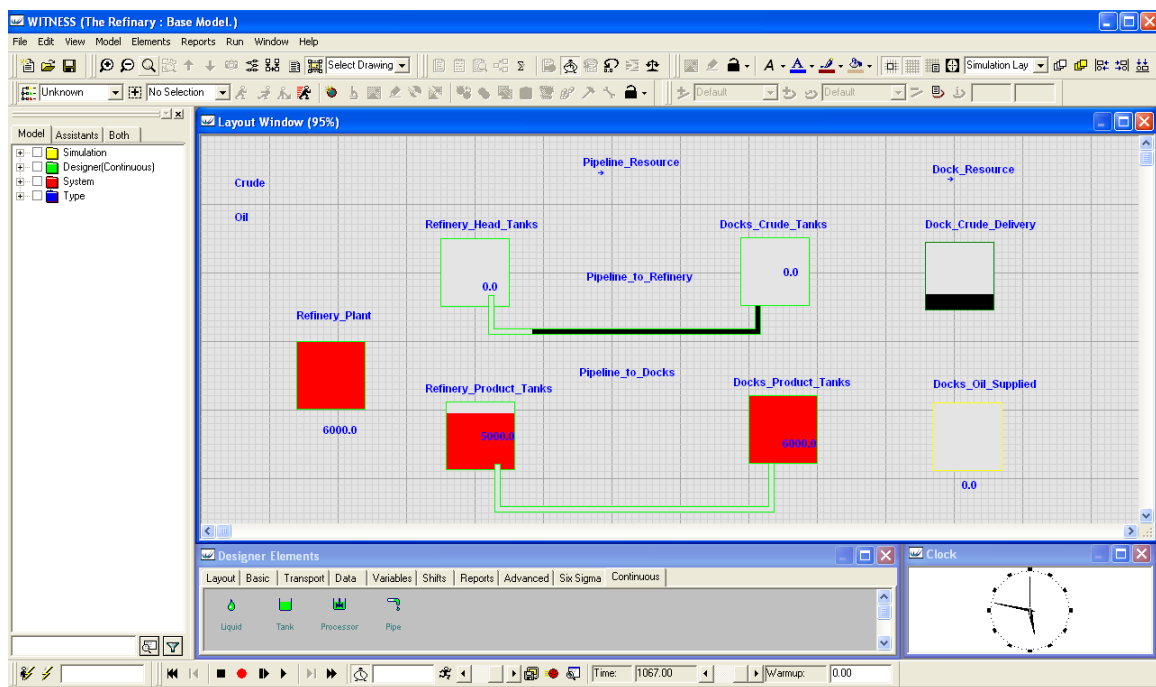


Figure 3. The Refinery – Witness Model

The model was developed by utilising the designer modelling elements found under the Continuous library as shown in Figure 4. The properties of each continuous element are logical and intuitive as shown in Figure 5.

In comparison to a discrete element the Input, Duration and Output rules are replaced with Filling, Flowing and Empty rules. These act identically to the properties used in discrete event modelling, but with slightly different commands to write in for ingoing and outgoing entities.

If the “To” tab is opened in properties (Figure 5), the rule to send the liquid to the next stage in the system is as shown in Figure 6. The continuous modelling elements were totally new and was learnt by using the help command and the example models supplied with the Witness package.

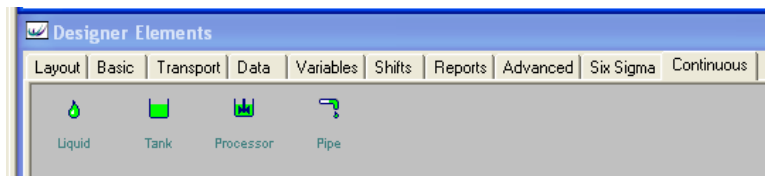


Figure 4. The continuous modelling elements in Witness

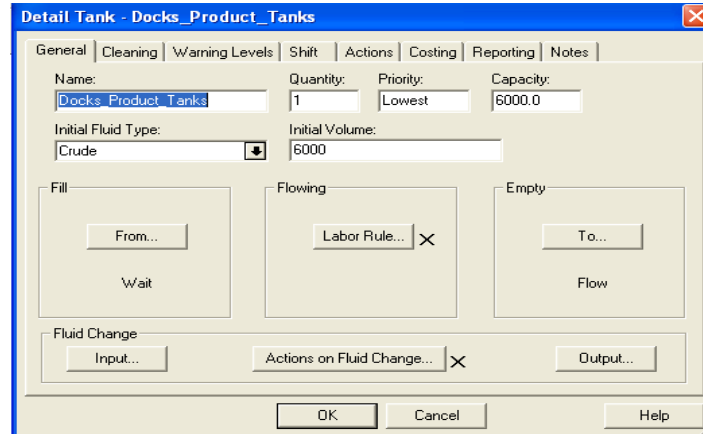


Figure 5. General detail page defining a tank element – Witness Model

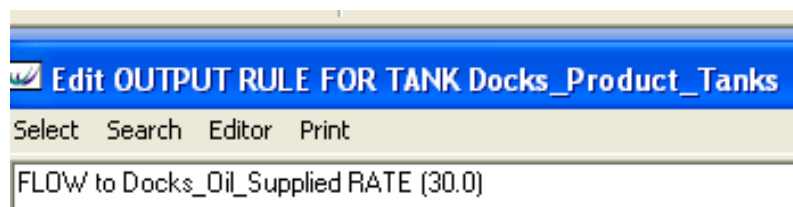


Figure 6. Output rule for tank – Witness Model

2. SIMUL8 SIMULATION MODEL FOR THE REFINERY

Regrettably Simul8's help commands have little to offer in the way of assistance when setting up Tanks and Pipelines. They do exist, however, with limited help to assist with building an accurate model as shown in Figure 7.

A working example was found with the simulation templates. However, it was also realised that the limited version copy of Simul8 does not offer Tanks and Pipes objects to be inserted into the Layout Window. After overcoming these issues, the final model has been built and illustrated in Figure 8.

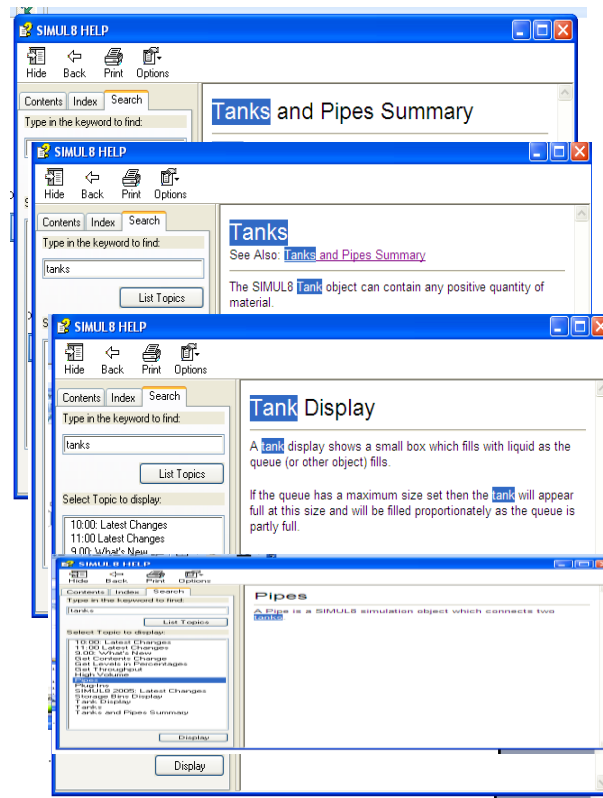


Figure 7. Help pages for Tanks and Pipelines – Simul8 Model

One concern with setting the model up this way was the question of how to control the flushing procedure on the pipeline. This has been solved using two Dummy Activities involving Resources:

- Set up a Resource, named InRes
- Set up a Resource, named OutRes
- Open Pipeline In properties and select Resource Option, Add InRes
- Open Pipeline Out properties and select Resource Option, Add Out Res
- Set Up Two Dummy Activity's consisting of a Queue and a Work Center, each routing back and forth between each other (see Figure 6). Name them:
 - Out to In
 - In to Out
- First open up properties for Out to In. Set Resource Required to OutRes, then select the detail option. This box has an option called Release Resource as, select InRes from the drop down menu. (see Figure 9)
- Repeat with the In to Out Work Center but amend Release Resource as to OutRes.

This approach ensures that only one resource is available to do the flush procedure on the pipeline, which will take twenty minutes as stated in the appendix. Crude and Refined Oil will be unable to both flow at the same time.

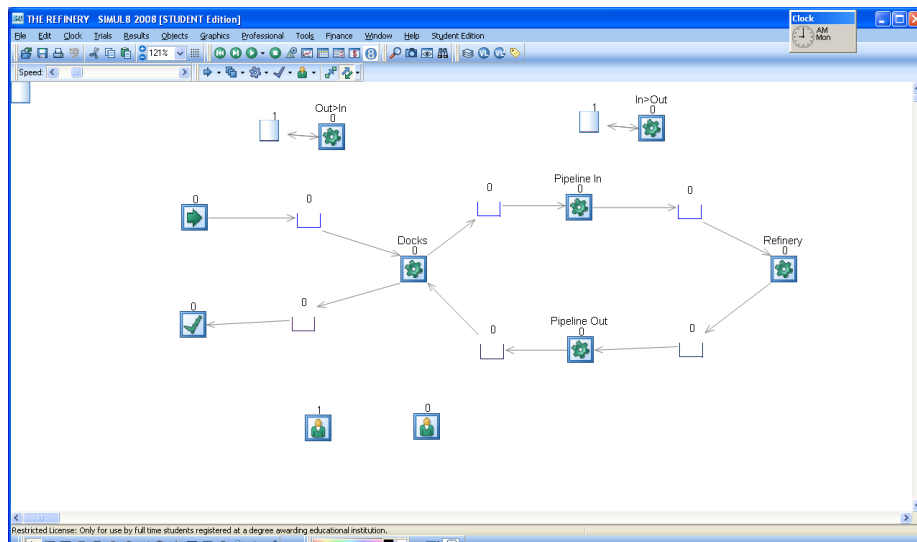


Figure 8. The Refinery model – Simul8

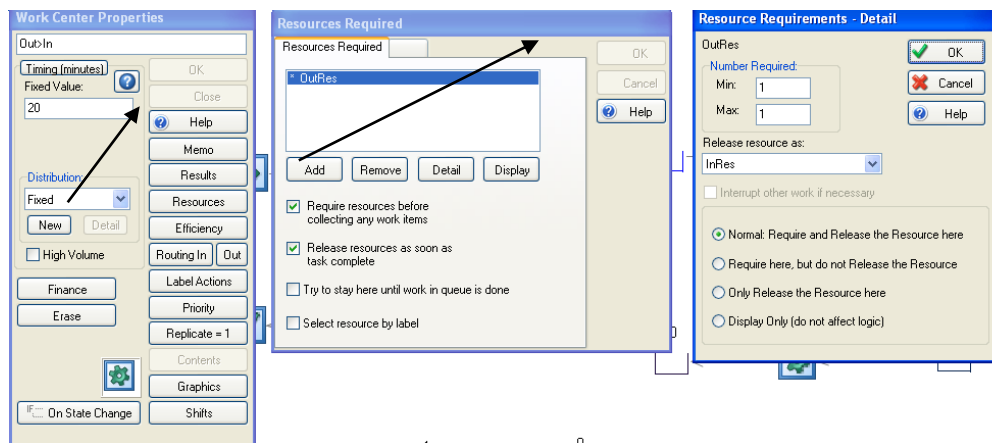


Figure 9. Resource details – Simul8 Model

REFINERY CASE STUDY SIMULATION MODELS: KEY FINDINGS

The model built within Witness has more impact visually than that of the model built within Simul8. However they are both mathematically sound and produce the research that the analyst would require to experiment with changes and improvements in order to develop the Refinery system to the optimal solution. It is noted as expected that both software produce almost the same results and outputs for the given case study. However, some differences exist which are outside of the remit of this paper that are related to how random numbers are generated.

Reports are automatically compiled in the Witness software, whilst Simul8 needs specific commands to compile the reports. Results can be examined for each object by opening the properties window and selecting the results icon. The use of tanks, pipes and flow rates ensured Witness to be the more adaptable of the two programs for this scenario. With the visual aid to assist the analyst when explaining any planned improvements or changes to the organisation and its staff. Simul8 although extremely accurate in its findings does not give the same concept of modern simulation.

At this point of the evaluation, it seems that the two packages are offering exactly the same function, which is to simulate business processes in order to encourage improvements within the system that is being modelled. However, the detail which can be included is phenomenal, and at what point is this detail too much?

DISCUSSIONS

Throughout the model building, simulation and analysis of the refinery case study, some initial findings have been made, with differences highlighted. Amalgamating the differences between the two simulation packages will be basis for the outcomes of this evaluation study. When either Witness or Simul8 is applied to a case-study there are some differences that become immediately apparent:

SIMULATION PLAN

Witness requires an initial investigation into the system to be simulated in the form of a flowchart, whereas Simul8 introduces system state and activity cycle diagrams from the beginning of the simulation process.

NAMES OF SPECIFIC ELEMENTS

Whilst Simul8 creates its own language, which distances itself from the generic language of simulation, Witness uses standard terminology, with glossaries provided if a more technical version is used. For example, the performance & service version of Witness describes the element of interest that flows through the system as an 'entity', but the manufacturing version describes this as a 'part'. Simul8 complicates matters by having its own personalized terminology, for example, an entity can be a work item or resource depending on the entities used.

EASE OF HANDLING

Immediately on opening the Simul8 package, assistance is offered, with the use of templates and examples to consider when designing and creating a personalised simulation. Examples are available with the Witness package; however these are not as obviously demonstrated as in Simul8.

Simulation packages do offer an extensive scope of areas to consider when creating a simulation, but can anyone use them immediately?

Using Witness has shown that some training is needed even for simple simulations, but this is no different from Simul8. Although Simul8 is a simple and straightforward package when dealing with a simulation with one work item, anything more in-depth needs some form of training. However, after working with both packages for many hours, it becomes a logical process that can be experimented with.

Both software packages offer help commands and searches, but continuous simulation problems require the use of tanks and pipes, and Simul8 has little explanation on how to approach these. The help section offered by Witness is comprehensive and detailed compared to the more simplistic approach of Simul8 software. This highlights that further support is required after purchasing Simul8, whereas most problems with Witness can be researched through the help application provided..

CONCLUSIONS

After reflection on the discussions, the following conclusions have been identified.

Advantages of Witness as a Simulation Package

- This program allows greater diversity for input of distributions
- First arrival times can be stated
- Cloning of elements can speed up simulation input
- Layout screen can include feedback on the simulation whilst model is running, e.g. in the dynamic model, for example financial data or timing of activities
- Machine status key allows the analyst to visualise where the blockages or delays are occurring without stopping the simulation
- The graphical content available for each industry is comprehensive
- Numerous entities can be simulated to progress through the system, making it more realistic
- Authentic elements are available, for example tanks and pipes, rather than just using parts and activities
- Help available as part of the program is extensive, and works through "how to..." scenarios in detail
- A strong format to present to employees and management, without having to explain the mathematical processes behind the system itself

Disadvantages of Witness as a Simulation Package

- This package is marketed as easy to use; however, the practicalities of getting it right, rather than experimenting with analytical tools, is not highlighted
- The limited use of pre-modelling planning may mean that the modelled system and the real system could have major differences

Advantages of Simul8 as a Simulation Package

- Examples and templates are offered immediately, with many guides to simple systems
- No further work is required to allow the work area to highlight numbers of entities served etc., as the simulation runs

- Similar terminology used as Microsoft Windows, which offers familiarity with the Simul8 program immediately. For example, ‘copy’, ‘paste’, etc.
- Additional routing options are available, making Simul8 more versatile
- Results can be trialled giving more versatility

Disadvantages of Simul8 as a Simulation Package

- Simul8 assumes information without actual input by the analyst. Timings of processes and time to travel between objects, requires amendment immediately. In addition, routing is often assumed by the software rather than allowing an analyst to program the software themselves
- Only one work item is deemed as compulsory, which brings in the factor of Labels, a function that can be confusing rather than a helpful addition

After careful consideration of the simulations, it is the conclusion of this study that, whilst the use of graphics has developed, the process, planning and investigation are still only as good as the data implemented into the model.

This study also provides interesting insights into the usability and relevance of component technology for simulation modelling. It demonstrates that a component-based approach can be usefully exploited to construct simulation environments that are able to address the compromise between ease-of-use and flexibility. On a more critical note, it dismisses the claims of scientific literature that component technology is a cure for simulation modelling. The technology alone is not enough for a successful outcome, but component-based simulation still requires careful attention to design principles. Hence, this paper contributes to the emerging discussion investigating the potential of BPS software technology for continuous simulation.

CONFLICTS OF INTEREST

The authors’ certify that there are no conflicts of interest in submitting and publishing this research article.

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