

Computer Simulation Modeling of Clinical Laboratories

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Abstract

In the manufacturing sector, computer simulation has for many years been used to support complex decisions such as automation of processes or planning new factories. Clinical laboratories and diagnostic manufacturers are too faced with the challenges of automation and process re-design that will fundamentally change the way work is performed and the net economic impact of those changes. The question arises 'how can the risks be minimized, the options be explored and the right decisions made?'. In this report, we present an overview of how simulation modelling can assist with laboratory decision making.

Introduction

In late 1997, Chiron Diagnostics-Australia, now Bayer Diagnostics began a development project on whether computer simulation systems could be used to assist in the re-engineering of pathology laboratories. Our aim was to develop a tool that demonstrated how a laboratory could cope with growth, automation and improvement to service and quality while providing sustainable reductions in cost. Our team, comprised of three persons, was already conducting workflow/site reviews and preparing manual models of current state and future state options. The team found this laborious and time consuming. Many times our clients asked us to make changes, that were small in their minds, but took hours of re-work to demonstrate the outcomes. We were looking for a way to quickly and easily visualize for our clients what their laboratory looked like today and what alterations and outcomes were possible in the future? With the assistance of industrial engineers and operations research techniques, our first step was to understand what simulation modelling encompassed.

What is simulation?

Simulation is a concept that involves building a model, which mimics reality. Visual interactive simulation software creates a dynamic, computer-based model representing a physical system, its structure and resources, and the activities and processes taking place. Discrete Event Simulation involves the modelling of a system as it progresses through time. It gives the ability to model random events based on standard or non-standard distributions and to predict the complex interactions between those events. The process of designing a mathematical-logical model of a real system and experimenting with that model using a computer is the basis of computer simulation.

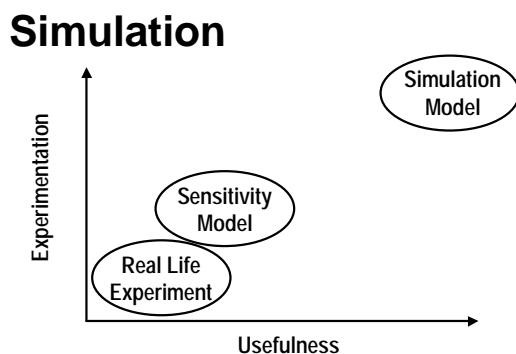


Figure 1: Simulation alternatives

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Many organizations speak about 'simulation alternatives'. Sometimes they refer to real life pilot studies, which are conducted within a 'near perfect' environment, using a pre-determined set of criteria and normally using a small set of data. This scenario is risky, costly and time consuming, nor is it readily repeatable. Another option is a sensitivity model, which is 2 dimensional, and does not factor in 'real life processes nor people' but can effectively model fixed data points under a variety of pre-determined conditions. This scenario is rather inflexible, as it requires a complete rebuild to test various options. Simulation however, can model multiple facets of processes, scheduling, people and equipment in real time. Comparing these options against factors such as usefulness and degree of experimentation leaves simulation modelling as a clear winner. Figure 1.

What does simulation do?

Simulation can bring to life working processes within the confines of a desktop and can be infinitely examined, adjusted and re-tested. The animated, interactive graphic user interface enables anyone to relate to the model and quickly understand the issues of discussion. The models are built and validated in stages to secure their foundations in reality.

Simulation can account for the volatility of real life through the incorporation of statistical variations ranging from arrival times and growth data (deemed to be simplistic) to process re-design attributes (may be complex). Workload variations, test densities, operational throughputs or breakdown and repairs can be readily and easily defined. Organization data such as courier delivery, shift patterns, hands-on labor and equipment schedules can be incorporated into models. Even the physical layout and proximity's of equipment, people, stores and space can be modeled and combined to ensure all factors are being accurately represented.

What simulation software do we use?

The software used to develop the models in this study is the Lanner Group's product WITNESS®. A comprehensive range of graphical images designed specifically to reflect the modern industrial environment is used by the modeler. There is also the provision to incorporate custom images, high quality graphics and photographic imagery to make the visual representation as realistic as possible. Video clips can be imported to aid comprehension. This makes WITNESS® simulation a powerful training tool. Other software like CAD/CAM and process mapping tools can be utilized in conjunction with WITNESS® to add movements to layouts.

Why simulate?

Competitive organizations worldwide have proven they can reduce the risks associated with business change by applying a practice of process simulation and analysis. Decisions supported by simulation testing can be made with greater confidence and with a higher level of organizational buy-in before crucial capital investment. The effects of a potential scenario are startling, demonstrable and realistic. Simulation can help with:

- Security in decision
- Accuracy in predicting outcomes
- Model outcomes of consolidation opportunities and study the effects
- Understand the cause and effect of various issues
- Identify opportunities in spare capacity
- Quantify service delivery and analytical utilization
- Build confidence in experimenting with options prior to installation and usage
- Test different scenarios in a risk-free environment
- Validate proposed processes prior to capital investment and enabling project justification process to be accepted
- Optimize existing processes and configurations

Methodology

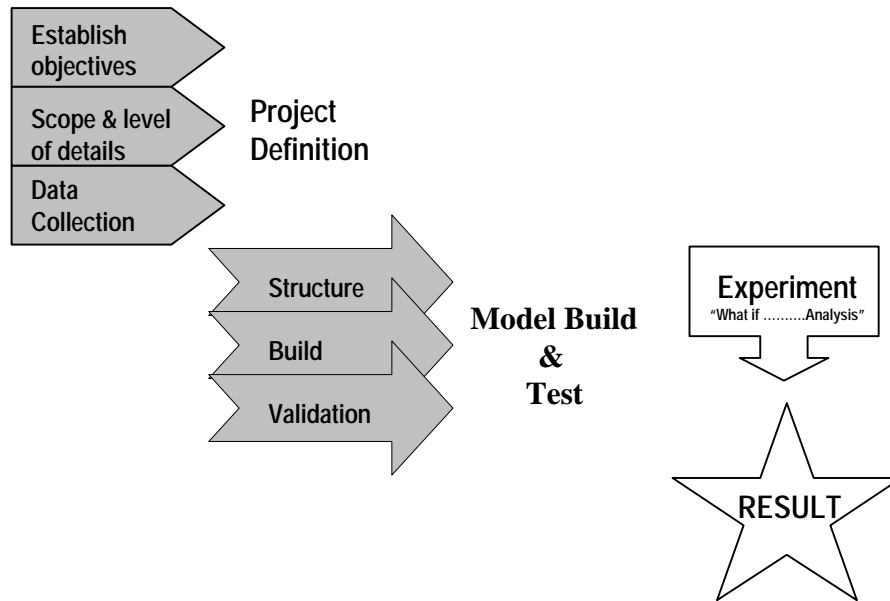


Figure 2: Steps to Simulation

Application in the Clinical Laboratory

Each clinical laboratory is unique in its modes of operation, whilst many similarities do exist between laboratories it is this uniqueness that allows simulation to be differentiated from other types of workflow analysis tools. The ability to mimic the functions of an individual laboratory and then perform experiments, changing the input parameters and using the model to predict the likely outcome is an extremely powerful capability. It is from this form of experimentation, “what if analysis”, that simulation acquires its greatest usefulness. It is also important to recognize that simulation is primarily a decision support tool and does not directly seek optimum solutions^[1].

Modelling a laboratory requires the collection and analysis of data. Data such as, laboratory design, specimen arrival times, request patterns, analyser attributes, staffing. Listed in Figure 2 are the basic steps involved in completing a successful simulation project.

Our models then allow visualization of outputs such as:

- Turnaround times
- Sample queue lengths
- Instrument utilization
- Productivity impact of new automation
- Labour reduction
- Identification of workflow bottlenecks
- Impact and capacity for growth
- Utilization of laboratory space

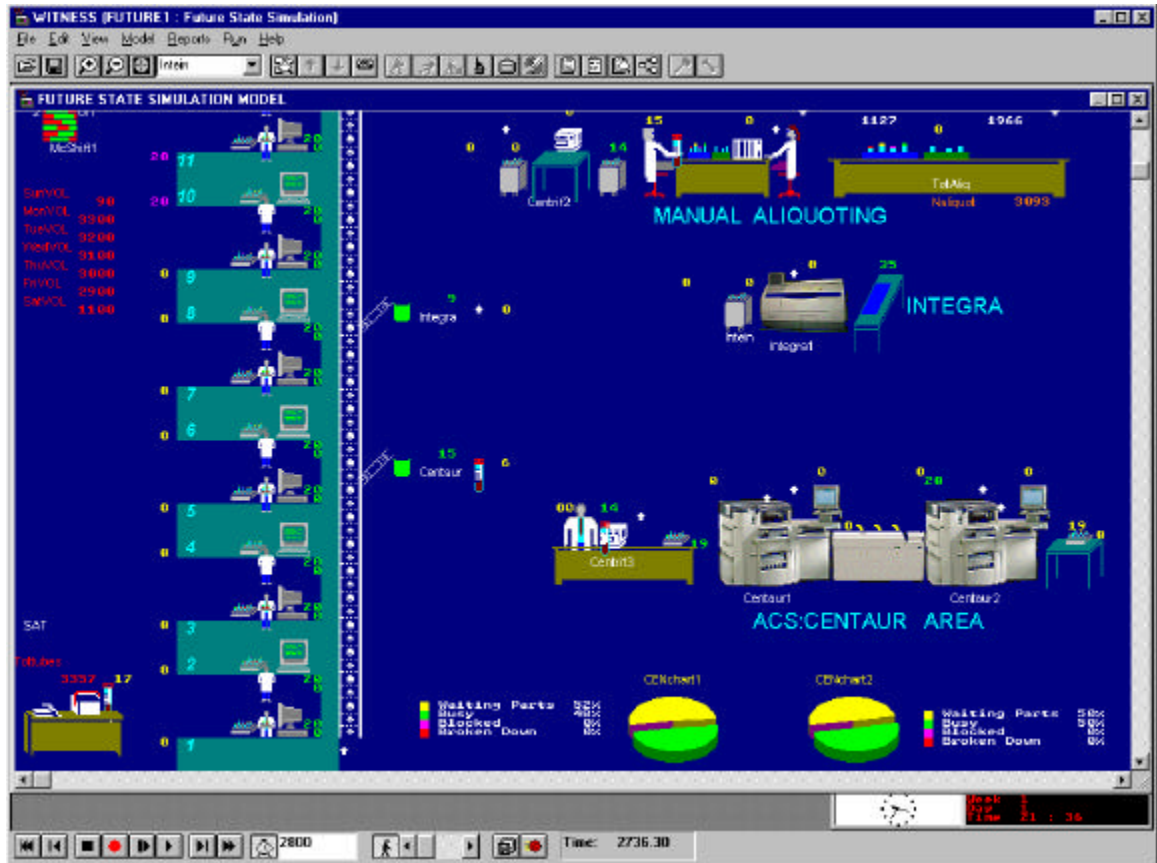


Figure 3 : Screen Display of a Typical Model

Benefits of Simulation

In clinical laboratories, there is an ever-increasing focus on delivering higher standards of service and quality within tight resource constraints. As a result, today's pathology organizations are constantly changing and evolving; on the one hand striving to find ways of streamlining operations, on the other, the dynamic nature of the business requires exploration of new ideas and the success of innovative solutions.

Risk must be removed. Using simulation software provides one with a highly predictive outcome that reduces risk and ensures confidence.

The highly visual nature of WITNESS® encourages team based problem solving and the inclusion of ideas from different areas so that organizational buy-in of the change process occurs. When a team of people are involved in the planning process, the validation stage and the experimentation, a broad base of agreement is reached prior to decision and implementation. The team will gain a greater understanding of the system in question. Understandably, improved communications regarding issues and implications ensues during the building, validation and experimentation phases. The time to install and implement is reduced and the quality of success rises.

Other business benefits include:

- Improved resource allocation
- Reduction in operating costs
- Improved planning and justification procedures
- Reduction in time to decision
- Improvement in accuracy particularly when analyzing the impact of automation, the implementation of new technology, varying capacity or growth or test patterns, altering courier routes, redesigning work practices
- Improvement in productivity by proactive operational optimization

Business operation analyst, David Brooks said, 'it is easier to see a picture than to work with figures, when re-engineering a process....simulation has allowed us to focus away from

guesswork and towards areas where accuracy of resource planning avoids teething problems and under utilized resources'. Figure 3 shows a screen display of a typical model.

Conclusion

Today's decisions will have an impact for many years and it is for this reason that decisions involving complicated processes be dealt with using a sound decision support tool rather than subjective feelings. Simulation modelling reduces this element of risk that is present in all decision making processes as management is now better able to weigh the impact of complex factors in complex environments.

References

- [1] S. Robinson, *"Successful Simulation : Practical Approach to Simulation Projects"*, McGraw-Hill, Berkshire UK (1994)

Acknowledgements

The authors thank Jenny Morwood and Lambros Zigouras for their operations research assistance and members of the Lanner Group.