Simulation in Bus Manufacture

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***Abstract*—Globalisation and competitive pressure force many SME organizations' to radically change business processes. Although this approach can provide significant benefits such as reducing costs or improving efficiency, there are substantial risks associated with it. Using simulation for modelling and analysis of business processes can reduce that risk and increase the chance for success. This paper exploits the potential of simulation to be used for modelling business processes and supports the case for a wider use of simulation techniques by the business community.**

Following a discussion on business process modelling methods and tools, the usability of simulation modelling for evaluating alternative business process strategies is explored by way of case study in the bus manufacturing domain.

***Index Terms*—Business Process Simulation, Process Modelling, Simulation,**

I. Introduction

In the last two decades, competition in the global consumer-based markets has greatly intensified. For organisations to survive and maintain profit margins, business operations must constantly be improved [1]. The challenge for commercial enterprises is the achievement of agility and lean operations [2]. Within this theme, it has long been recognised that cost-effectiveness and profitability of a business organisation is critical for its existence in globalised and local markets [3]. Often in industry one asks "How can I best run the organisation to achieve my business objectives yet at the same time, meet customer demands?" [4]. Manufacturers are continually being asked to increase production volumes in less time with less people and for less money. Trying new ideas out in the organisation are all very well, but they can take time, be disruptive, very costly, and you may not get it right first time [5]. In a highly competitive environment managers cannot afford to take risks when implementing change.

Experimenting with new ideas on a computer model before you make changes for real is simple common sense. It takes the risk out of change. This is where Business Process Simulation (BPS) has gained a competitive edge, an advantage that results in bottom-line benefits to their business [6].

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II. What is BPS?

The BPS technique is a method of exploring at a detailed level just what happens between the customer making a request and the customer going away satisfied with the goods or services that have been provided [7]. Within that flow, we need to understand where defects and/or unnecessary delays are introduced so that we can adjust the process to remove their cause. Central to the exploration is a dynamic model of the process.

Working in a simulated environment gives the opportunity to make key decisions quickly in response to business needs as they arise promoting agility in enterprises. It also is the key link for driving business performance in terms of improvement of product and processes potentially leading to reduction in waste and an increase in valued output. Furthermore, World-class organisations utilising this technology, have reported to achieved significant benefits including:

- Better utilization of resources through the identification of bottlenecks and spare capacity
- Validation of new processes prior to launch
- Improved customer service levels

III. How does BPS work?

A simulation is a model that mimics reality; well-known examples are flight simulators and business games. Computer-based simulations have been used to tackle a range of problems in most business sectors leading to improvements in efficiency, reduced costs and increased profitability. Modern simulation tools now include dynamic animation that allows managers to better understand the flow of their operations (business) and how it performs [8]. These tools ultimately allow managers to make the correct decisions based on the state of their business and being aware of those activities in the business process that could be improved.

Simulation is an enabling technology which allows models of real world systems to be built and understood. The simulation model representing the operations of the current system can be easily modified to allow operational improvements to be made without incurring the risks. These improvements often focus on Key Performance Indicators (KPIs) usually in terms of profits, performance, and service levels, etc. The simulation package is a management decision-making tool which is particularly useful for modelling any system (or business) that has flow of entities, activities, queues, resources and constraints. Simulation has been applied within a wide range of industrial and service sectors including manufacturing, health care, building & construction, logistics & distribution, and financial institutions.

A major facet of simulation based on discrete events is its ability to model random events and to predict the complex interactions between these events [9]. Consider the knock-on effects on adjacent queues when a cashier moves away from a check-out counter.

Having built a simulation model (on a computer), experiments are then performed changing the input parameters and predicting the response. Experimentation is normally carried out by asking 'what-if' questions and using the model to predict the likely outcome, for example, what if a breakdown occurs at a specific time. It is important to recognise that simulation is primarily a decision support tool and aids the manager to predict the likely effects of a particular action thus enabling correct and optimum decisions to be made.

One of the greatest advantages of a simulation model is that it can compress or expand time. Compression of time refers to the ability of these models to simulate several years of activities within minutes or even a few seconds. Simulation models can also be used to observe phenomenon that cannot be observed in real time by expanding time and taking observation at very small intervals of time. This allows an in-depth understanding on how the business operates in a dynamic manner.

Most commercial simulation software is dynamic and visually interactive allowing you to:

- Model processes to define, document, and communicate.
- Simulate the future performance of a business to understand complex relationships and identify opportunities for improvement.
- Visualize operations with dynamic animation graphics.
- Analyze how a system will perform in its “as-is” configuration and under a myriad of possible “to-be” alternatives so that you can confidently choose the best way to organise the operations and run a business responsively.

All of these benefits ensure that a positive move towards creating an agile organisation that is responsive to the needs of its customers.

IV. CASE STUDY – BUS MANUFACTURE

A leading bus manufacturer in the UK was experiencing efficiency problems and wanted to explore alterations on their working practices and its affects on their business. The objective of the study was to improve lead times without incurring risks. The bus manufacturer had a variety of factories around the UK. At the height of their operations the bus manufacturer produced a range of bus and coach chassis and bodies as well as fire engines and waste collection vehicles. However this project focused on the manufacture and assembly of the body of a double decker bus.
Initially a study was undertaken to review the overall situation resulting in a number of change options suggested to be explored that would enable the manufacturing operations to

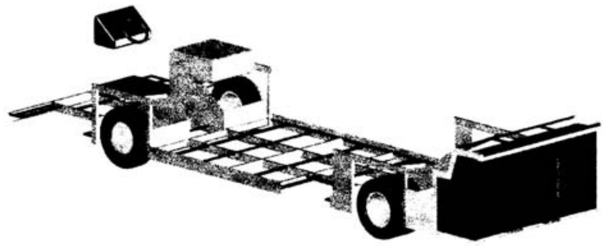

Fig 1: Chassis preparation

be maintained whilst not creating legacy or effecting competitiveness.

An analysis of the manufacturing operations was conducted seeking to establish sequence of operations and resources. The key stages of manufacture comprised of five flow line manufacturing cells:

Cell 1: Chassis preparation as depicted in figure 1
Cell 2: N/S side frame, O/S side frame, intermediate roof, back frame (figure 2)
Cell 3: Wheel arch tins & GRP boxes, floorboards, roof, front frame, staircase (figure 3)
Cell 4: Cab/staircase partitions, back seat
Cell 5: floorboard/panels sealed, door ramps

In addition to the above in-line cells other cells also existed primarily to produce the side frames and roof structure.

Based on observations and historical records data was collected and compiled to form process plans. An example of a typical process plan is shown in Table 1.

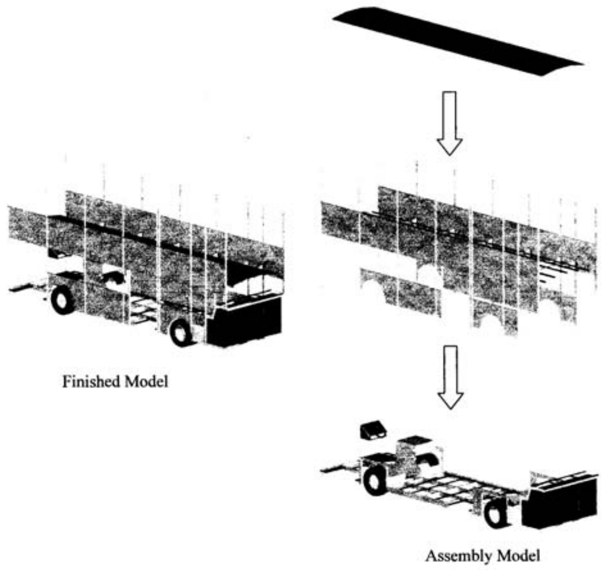

Fig 2: Frame assembly

From the information obtained and its analysis, a base model was built which involved the following stages

- Understanding the dynamics of the cell based workload and staffing.
- Witness simulation software was used [10]. Witness is user-friendly graphical software that allows complex modelling by using predefined and

programmable elements to be joined together to reflect workflows.

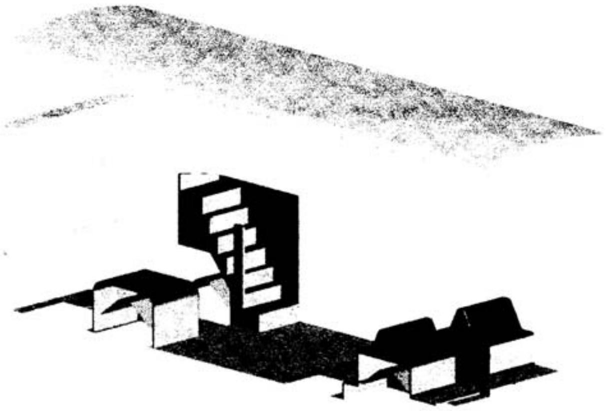

Fig 3: Internal assembly

- A simulation "base" model was developed as shown in figure 4. The model constructed comprised of 81 activities, 30 workers, and 58 entities that flowed through the model.

Table 1: Process plan

ID	Task Name	Duration	Predecess
1	CHASSIS ENTERS CELL	25 mins	
2	SWEEP FLOARBOARDS	15 mins	1
3	SAND FLOOR BOARDS	120 mins	2
4	SWEEP SAWSUDT CLEAR	15 mins	3
5	FILLER FLOARBOARDS	90 mins	4
6	FILLER DRIES	60 mins	5
7	SAND FILLER SMOOTH	90 mins	6
8	SWEEP ALL FLOARBOARDS U/S L/S	30 mins	7

- The model was calibrated against historical data for current operating conditions, ensuring that it reacted to system changes in the same direction and magnitude as would be observed in real life. The base model was able to mimic the bus manufacturing operations with acceptable results. A section of the base model showing cells 1 & 2 is depicted in figure 5.

The issues that had been highlighted was

- Line balancing problems in the different cells
- Worker utilisation
- Crane availability

Subsequently various change options that were within remit of the project were considered and applied to the base model to address the highlighted problems. These changes reflected a number of different scenarios:

Scenario 1

- Cell 1: Alterations to the arriving chassis and arrival of parts from suppliers
- Cell 2: Fitting of roof boards to the intermediate roof
- Cell 3: Alterations to the GRP boxes to eliminate trimming activity
- Workers mobility

Scenario 2

- Outsourcing cell 1 – chassis preparation

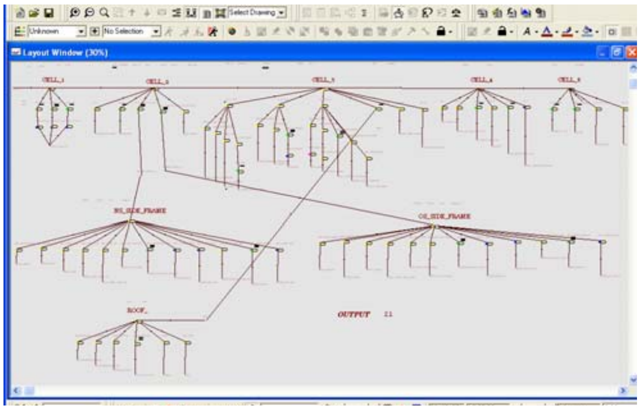

Fig 4: Witness model

Scenario 3

- Splitting cell 3 into two cells

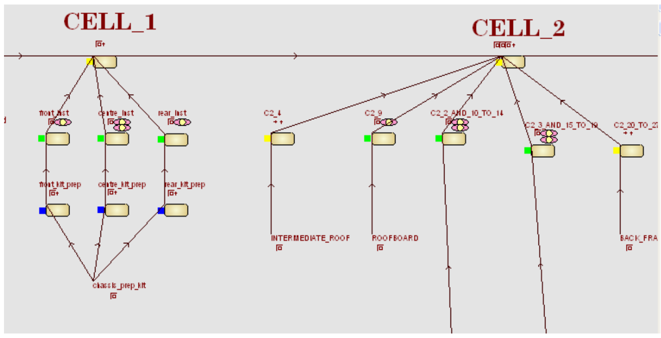

Fig 5: Cell 1 and 2

All of these scenarios were simulated and evaluated against the project objectives. The outcomes of these simulations produced results showing

- Workloads more evenly spread
- Increase in production
- Reduction in manufacturing lead time

However, scenario 2 offered further potential but was difficult to offset against the cost of the work outsourced.

Many operational changes were easily applied and simulated quickly, producing large amounts of measures and outputs. These were all analysed and compared to determine the "best" operating scenario and understand the sensitivity to changes. The simulation study enabled the bus manufacturer to better understand complex operational aspects and the causes of delays and inefficiencies.

The resulting simulation models and its interpretation of results gave an idea of what impact the planned changes to the operating regime in the manufacturing plant will have, providing estimates of the resulting effects on production and resourcing requirements before rolling them out.

V. SUMMARY AND CONCLUSIONS

The paper has presented an introduction to BPS and its scope to provide operational agility for organisations that wish to implement successful improvements. It is clear that computer simulation models are a safe testing ground for new operating rules and systems and are an effective business-planning tool. The ability to mimic real life system behaviours before implementing them leads to cost savings in optimising the change and avoiding problems.

REFERENCES

[1] Trkman, P "Process approach to supply chain integration", Supply Chain Management: An International Journal 12(12), 2007, pp116-128

[2] Latif, M. "Simulation – the key to agile enterprises", Keynote speech at Doctoral symposium on research in computer science, UCP, Lahore, Aug 2008, pp 9-12

[3] Mankins, M.C. "Stop Wasting Valuable Time", Harvard Business Review, 82(9), 2004, pp 58-65

[4] Stickel, E. "Uncertainty reduction in a competitive environment", Journal of Business Research, 51(3), 2001, pp 169-177

[5] Kumar, S and Phrommathed, "Improving a manufacturing process by mapping and simulating critical conditions" ,Journal of Manufacturing Technology Management, 17(1), 2006, pp 104-132

[6] Greasley, A. "Using business-process simulation within a business-process reengineering approach", Business Process Management Journal, 9(4),2003,pp 408-420

[7] Kleijnen, J. "Supply chain simulation tools and techniques", International Journal of Simulation and Process Modelling, 1(2), 2005, pp 82-89

[8] Kelton, W.D., Sadowski, R.P., and Sturrock, D.T., Simulation with Arena, 4th Ed, McGraw-Hill, New York, 2007

[9] Goldsmith, D. "Introduction to simulation", proceedings of the 2007 Winter Simulation Conference,IEEE,2007,pp 26-37

[10] Lanner Group PLC, Witness Simulation Software,2007, www.lanner.com