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EFFECTIVE USES OF BUSINESS PROCESS SIMULATION

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ABSTRACT

This paper evaluates a number of tools for the redesign of processes through the use of two case studies based in the UK Police Service. There is a particular emphasis on the use of Business Process Simulation in conjunction with Activity Based Costing and Activity Based Budgeting within the context of a Business Process Reengineering approach. The use of a balanced scorecard and marking guide can be used to identify suitable processes for redesign. A process map enables a study of the relationship between the activities that form the process. The process map relates to the conceptual map in a simulation study. A Business Process Simulation based on the logic contained in a process map is demonstrated to enable a dynamic analysis of current process performance and proposed process design. To ensure that the results of the study are implemented the balanced scorecard can be used to set operational targets for performance measures. The current political and cultural context of the organisation should also be taken into account to ensure successful implementation.

1 INTRODUCTION

This paper evaluates the use of a number of tools for the redesign of processes through the use of two case studies based in the UK Police Service. The case study details are as follows:

1.1 Case 1: Redesign of the 'Sickness and Absence' Process

The issue of absence from work due to ill health in the UK Police Service has recently attracted publicity (Sheehan 2000). A UK Police Service recently undertook a reengineering study to assess if the sickness and absence procedure could be improved through the use of a process-based perspective.

1.2 Case 2: Analysing Arrest Costs and Predicting Resource Requirements in a Police Custody Suite

The objective of this study was to identify and reduce costs within the Police custody process. At present the custody suite is considered as an essentially fixed cost with an annual budget and there has been no attempt to correlate demand on the facility with costs. It was also envisaged that the effect on resource allocation of changes in demand on the process could be assessed through a study of the proposed changes in the law regarding drinking hours in the UK. The custody process under investigation includes the arrest process, from actual apprehension of a suspect, to processing through a custody suite, to possible interview and court appearance.

2 PROCESS METHODOLOGY

The redesign programme will be described within the following four-step model:

1. Identify and Map Processes
2. Measure and Analyse Process Performance
3. Develop Future Process Design
4. Implement Future Process Design.

Analysis methods will be outlined for each of these steps with particular reference to the use of Business Process Simulation (BPS) for steps 2 and 3 where it has most relevance (Aguilar et. al. 1999).

2.1 Step 1: Identify and Map Processes

This step entails identifying those process elements that require redesign in order to meet the strategic objectives of the business unit. The balanced scorecard (Kaplan and Norton 1996) incorporates a 'balanced' set of performance indicators from the perspectives of financial, learning, customer and internal (business process). A balanced score-card can be constructed at the organisational, SBU or depart-mental level at which a focused strategy can be adopted. 'A

department should have a balanced scorecard if that organisational unit has (or should have) a mission, a strategy, customers (internal or external) and internal processes that enable it to accomplish its mission and strategy' (Kaplan and Norton 1996). Once a suitable level has been found it is necessary to identify the critical success factors (CSF) across the four perspectives which identify 'what needs doing well' in order to meet the unit's strategic objectives.

The next stage is to identify the internal business processes which impact on these CSF's, which can then be mapped and redesigned. The identification of the relevant business processes can be undertaken using a scoring system such as the performance/importance matrix (Martilla and James 1977) on which processes can be plotted in terms of how well the organisation performs them and how important they are. The operational performance of the business processes should be linked back to strategic measures to ensure changes are linked to strategic objectives.

Once the relevant business processes have been identified the current design can be analysed using the technique of process mapping which involves a study of how activities link together to form a process. The technique involves interviewing personnel and observation of the relevant process that provides information that is used to draw a process map. The analysis shows the interrelationships between activities and identifies the elements and roles involved in process execution. In BPS projects this diagram is often referred to as the simulation conceptual model.

2.1.1 Case 1: Using the Balanced Scorecard and a Marking Guide to Identify Processes for Improvement

The first step of the process investigation was to conduct a strategic review of the Human Resources Division of the Police Service. The divisional strategy was expressed as a series of critical success factors (CSF) which provide a guide to determine 'what needs doing well' in order to implement the strategic objectives (Davenport 1993). The critical success factors are derived in the context of the four perspectives (internal business process, innovation and learning, customer and financial) of the balanced scorecard. This allows the strategic direction of the business unit to take into consideration the needs of its different stakeholder groups. The critical success factors were based on the strategic plan developed at a divisional level with the involvement of the heads of the various departments within the Human Resource division (e.g. head of personnel, head of training).

The next step involves the use of a marking guide to identify processes from which an increase in performance at an operational level will improve performance in relation to the critical success factors identified.

The marking guide marks each process on a scale of 0 to 5 against two measures: impact and innovation. Impact is the extent to which the achievement of the CSF depends on the process. Innovation is the extent of the change required to the process in order to meet the CSF.

The marking guides for each measure are shown below.

Table 1: IMPACT Scope Marking Guide

Mark	IMPACT Scope Marking Guide
0	This individual process has minimal or no effect on the individual CSF
1	This individual process is dependant on another process, in order for it have an effect on this CSF
2	This individual process has a marked influence on this CSF
3	The individual process has substantial impact on whether another process can maximise its beneficial effects on this CSF
4	The individual process has substantial influence on this CSF
5	The individual process is a critical part of being able to achieve the individual CSF

Table 2: INNOVATION Scope Marking Guide

Mark	INNOVATION Scope Marking Guide
0	This process cannot be improved either by process or automation for this CSF
1	This process achieves its objective but could be improved even further.
2	This process achieves its objective but could be improved by review of both automation and process improvement in the areas of time/complexity/location/resourcing.
3	This process does not effectively achieve all its objectives and could be improved by review of both automation and process improvement in the areas of time/complexity/location/resourcing.
4	The process exists and functions but needs substantial alteration to meet its objectives.
5	The process either does not exist or only partially exists and fails to meet any objectives.

The IMPACT measure relates to the achievement of the CSF from the stakeholder and financial (external) perspectives of the balanced scorecard. The INNOVATION measure relates to the amount of change required from the learning and business process (internal) perspectives. A simple spreadsheet sort by composite score identifies a priority list of processes for improvement.

2.2 Step 2: Measure and Analyse Process Performance

The techniques of Business Process Simulation and Activity Based Costing will be discussed in the context of the measurement and analysis of process performance.

2.2.1 Business Process Simulation

Business Process Simulation (also referred to as discrete-event simulation) is a tool that has it roots in the analysis of manufacturing systems, but is now being utilised to assist in the management of change in a variety of manufacturing and service settings. Pidd (1996) characterises systems best suited to simulation as dynamic, interactive and complex. These characteristics relate to the ability of simulation to analyse the variability of individual process durations and the interdependence of process elements in determining overall process performance. For assessment of current process performance the following features of the 'as-is' simulation model can be outlined.

The 'As-Is' Model

- Provides a visual representation of the whole process
- Incorporates variability and interdependence factors in analysis
- Identifies critical processes

2.2.2 Activity Based Costing

Turney (1996) outlines an Activity Based Costing (ABC) model that has two main views. The cost assignment view of ABC allocates costs to activities by identifying *resource drivers* which determine the cost of resources and *activity drivers* which determine the use of these resources. The process view of ABC provides information about the effort needed to undertake the activity termed the *cost driver*.

The cost assignment view can be used to reduce cost by either re-configuring the resources needed for an activity (resource driver) for example by using different personnel, or reducing the amount of resource required (activity driver) for example by reducing the number of times the process occurs. The process view can be used to reduce cost by reducing the resources needed to perform an activity (cost driver) for example by incorporating information technology in the design. Thus an investigation of a combination of resource drivers, activity drivers and cost drivers for an activity can improve process performance by identifying why cost has been incurred from these three perspectives.

2.2.2.1 Case 2: Using Business Process Simulation and Activity Based Costing in a Polie Custody Suite

A Business Process Simulation was constructed using the ARENA system (Pegden 1995). The model requires data collection to construct probability distributions for decision points and activity durations. The model was validated in two stages. Firstly the model was built incorporating directly the historical data for the timing of arrests over a 12-month period. By driving the model with these fixed times it was possible to test performance against historical data. Because custody costs were not known, performance measures such as custody cell utilisation, interview room utilisation, arrest process duration and number of court appearances were used for validation purposes. The model was then run incorporating the probability distributions for each arrest type and performance was compared to the historical model.

By attaching cost rates to resources (i.e. staff pay rates) the model can indicate costs by multiplying the cost rate by the duration of activated processes. It can then provide an estimate of the costs incurred in the custody process from the perspective of arrest type, staff type and activity. The output measure of a business process model is stochastic and so multiple replications are used to provide an average (mean) value of this variation. Thus the simulation was run for 10 replications and the average cost value calculated.

Table 3: Costs by Arrest Type (Activity Driver)

Arrest Type	Average Number	Average Cost (£)	% of costs	% of arrests
BREACH OF BAIL	49	2695	5%	5%
BURGLARY	85	7172	13%	9%
DAMAGE	91	5522	10%	9%
DRUGS	43	3522	6%	4%
FRAUD	19	972	2%	2%
PUBLIC ORDER	63	3083	5%	7%
ROBBERY	12	822	1%	1%
SEX	15	1362	2%	2%
THEFT	266	18600	33%	28%
TRAFFIC	20	983	2%	2%
VIOLENCE	104	6755	12%	11%
WARRANT	189	5349	9%	20%
	958	**56837**		

Table 4: Cost by Process (Cost Driver)

Process	Average Cost (£)
SEARCH (LOCATION)	5770
TRANSPORT	4192
BOOKIN STAGE 1	5690
BOOKIN STAGE 2	5036
SEARCH (PERSONAL)	3180
DNA	4351
INTERVIEW	11826
DETENTION	0
ADMIN. IF RELEASED	3409
ADMIN. IF CHARGED	13384
COURT	0
	56837

Table 5: Cost by Staffing Grade (Resource Driver)

	Average Cost (£)	% of total cost
COSTPC	45171	79.5%
COSTJAILER	8564	15.1%
COSTCOF	3102	5.5%
	56838	

2.3 Step 3: Develop Future Process Design

The role of Business Process Simulation and Activity Based Budgeting will be described in the context of the development of future process design.

2.3.1 Business Process Simulation

BPS is an ideal tool with which to conduct scenarios of different process designs and observe performance. The following advantages of this method can be summarised.

The 'To-Be' Model

- *Reduces Risk*
  The use of scenarios and sensitivity analysis reduce the risk of the unknown.
- *Proves Concept*
  The model of the proposed process can help sell that design and 'unfreeze' current ways of doing. The use of animation can help understanding and the use of data collection of performance measurement can help management by 'facts'.
- *Identifies Change Strategies*
  The simulation can assess process change from the perspectives of a change in demand on the process, a change in resource availability on the process and a change in the design of the process.

2.3.2 Activity Based Budgeting

Once the ABC model has been constructed and costs estimated the flow of information can be reversed to form an Activity Based Budgeting (ABB) system (Kaplan and Cooper 1998). This allows resource needs and cost estimates to be made under a number of 'what-if' scenarios regarding changing demand and process efficiency.

2.3.2.1 Case 2: Using Business Process Simulation and Activity Based Budgeting for Resource Allocation within a Custody Process

The objective of this stage of the custody process study was to estimate the effect of a change in demand on resource usage in terms of Police Constable (PC) hours. This scenario took the form of a proposed change in the drinking law, extending public house opening hours from 11pm to 12am, leading to a proposed increase in certain arrest types. In order to estimate changes in resource allocation for the 'late drinking' scenario, estimates of the increase in demand for each relevant arrest type are required. In order to assess the effect on resources of the 'late drinking' scenario the number of PC hours was estimated from the simulation over a period of 50 days. The simulation was run 5 times and the mean of the PC hours estimated for each shift.

Table 6 shows the effect on the mean number of PC hours required of the policy to extend drinking hours from 23.00 to midnight. A one-sided two-sample t test (Oakshott 1997) shows there is a statistically significant difference (i.e. we can be 95% sure that the change in mean PC hours is not due to random variation alone) in PC hours for shift 1 and shift 3 only. The results show that although the increase in arrests occurs in shift 3 (22.00 until 6.00) most of the additional resources required in response to the predicted increase in arrests will occur in shift 1 (6.00 until 14.00). This is because of delayed activities such as interviews and administration required for court appearances.

Table 6: Mean Number of PC Hours

	PC Hours	Shift1 6–14	Shift2 14–22	Shift3 22–6
Existing drinking hours	Mean	557.0	859.4	962.0
	Std. Dev.	24.3	43.7	36.3
'Late Drinking' scenario	Mean	628.0	851.0	975.6
	Std. Dev.	23.2	41.8	35.7
t value		23.05*	1.22	2.17*

The critical t value for the significance test at 5% level is $t_{8, 0.05} = 1.86$
*Significant at 5% level

2.4 Step 4: Implement Future Process Design

Whatever tools are used the organisational context of the change must be considered in order that the results of the study are implemented. In terms of a business process reengineering project Buchanan (1997) states the approach has three main characteristics in relation to organisational change.

- *Process Orientation legitimates cross-functional perspective*
  The process orientation of BPR provides a legitimating force in the analysis of processes from a cross-functional as opposed to a departmental perspective. This is important because powerful political forces may need to be overcome in ensuring departmental power does not prevent change from a process perspective.
- *Method of introducing work practices from other settings (e.g. manufacturing)*
  Approaches including the creation of cross-functional teams, multiskilling, the establishment of 'customer-care teams' and clarification of

'process ownership' are examples of relatively common manufacturing management techniques applied in a hospital setting in the context of the BPR framework.

- *Method of participation through the use of process mapping methods*
  The use of a visual process map is seen as essential in providing personnel with an overall view of the process, in contrast to the particular aspects of the process they are involved with. 'The use of a process map can deepen appreciation of the extent to which problems are shared, the extent to which activities may be unnecessarily duplicated, and also how problems can be unwittingly passed on from one stage on the trial to another.' (Buchanan 1997).

Another tool that can be used at this stage is the Balanced Scorecard which can form the basis of a management control system, by setting performance measures and targets at the operational level which are in alignment with the strategic objectives identified.

2.4.1 Case 1: Using the Balanced Scorecard for the 'Sickness and Absence' Process Improvement

The study focused on one particular CSF identified in the balanced scorecard initiative, that of increasing individual performance. At a strategic level the measure of staff productivity was chosen with a target to increase availability of police officers by 5%. In order to meet this strategic target, measures and targets are needed at an operational level. These are derived both from the strategic measure and an understanding of the relevant business process. The measure chosen for the sickness and absence process was 'average days lost per year'. The target for this measure was to be 11.9 days lost per year per employee for sickness and absence. This benchmark was derived from the national average performance. The current performance is at 14.1 days lost per year per employee (figure 1).

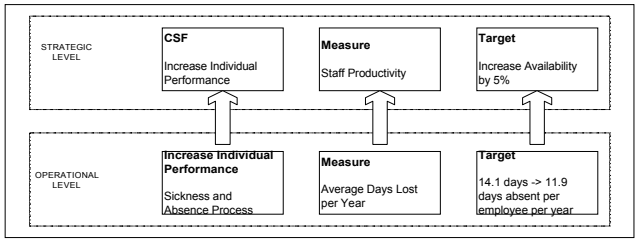

Figure 1: Deriving Operational Measures from Strategic Objectives

3 DISCUSSION

Case 1, involving the redesign of the sickness and absence process, shows the use of the balanced scorecard and marking guide to identify processes for improvement. The balanced scorecard can be used during the implementation stage to provide targets for a performance measurement system.

Case 2, the Police Custody case, provides an example of the potential gains for organisations using the BPS tool where it was used to incorporate the effects of process dynamics on system performance. ABC is traditionally used to provide accurate product cost information and to determine which products or customer are profitable or unprofitable. However it can also be used to identify where cost is being generated. The case uses ABC in conjunction with BPS to determine cost by arrest type, staff type and activity. Activity Based Budgeting is used to estimate resource needs under a scenario of a change in the law regarding late drinking.

In manufacturing, Business Process Simulation has been used for many years and this is still its main application area (Hlupic 1999). However its application in process design is becoming more widespread (Profozich 1998). Authors have differing opinions of the usefulness of BPS or simulation software in this context. Peppard (1995) is wary of the use of simulation analysis and simulation packages in the redesign stage due to the potential time and cost involved in building the model. Petrozzo (1994) outlines how BPS helps understanding of the process dynamics. In other words the process map gives an indication of the relationship between process activities but does not give any indication of process duration over time. This will depend on the probabilities at decision points and probability distributions defining activity durations. With this information the Business Process Simulation can predict process performance along a number of measures such as lead-time, resource utilisation and cost.

The characteristics of change within a BPR project outlined by Buchanan could also be applied to the BPS method and thus implies that the use of BPS could be widened by its use in the context of a BPR change methodology. However although BPS can help process change, potential problems with a process approach such as BPR need to be considered. BPR is a non-context sensitive approach to change in that it does not take into consideration the current political and cultural context of the organisation. Thus it may be better to see the approach within an organisational development change programme (Buchanan 1997).

Process change also needs to take account of the strategic direction of the organisation. One approach to ensuring change is in alignment with strategy is to use the balanced scorecard to link measures at an operational level with strategic measures and targets. Simulation can help to

do this by providing information on process metrics and their relationship to higher level performance.

4 CONCLUSION

Decision makers need to know what tools can do for them and the context in which they can be used. This paper has shown two case studies using a selection of different tools to assist in the analysis of business processes. BPS is entering the mainstream of process improvement tools, in part on the back of the BPR movement. It is generally accepted that the process perspective can deliver benefits and BPS can provide a powerful tool to help ensure success by providing a means for quantitative analysis. However, as with BPR, the organisational context of the use of BPS should be considered, otherwise the results of the analyses may not be implemented.

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