The Application of System Dynamics to the Re-Engineering of Value Processes

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Abstracts

Value Processes are those high level processes which are critical to achieving an organisation's objectives. This paper describes the authors' work in re-engineering a value process which was not working efficiently and causing serious problems to an important new business operation. Conventional process engineering tools were initially used and after these had failed to deliver significant improvement. The authors readdressed the problem using System Dynamics and the i-THINK modelling tool.

The authors' experience of using System Dynamics are reported in detail, together with the results achieved. The models produced are described as is how System Dynamics forced the authors to explore the processes beyond the boundaries identified by the conventional approach. It was in these new areas that the key to the problem lay and its solution lay. The problem was a case of process invasion by the customer into the suppliers value process and the solution identified by simulating the i-THINK model lay in obliteration of the elements of the process. Finally, the authors comment on the relative merits of System Dynamics with conventional process engineering and describe their plans to continue investigation into other areas of the value process.

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1. INTRODUCTION

Manufacturers and vendors of computers and software have, over the last few years, been forced to fundamentally change the way they do business. At the smaller end of the market, PC's and hardware running UNIX based applications have become ubiquitous, consequently hardware profit margins have been seriously eroded as manufacturers have been forced to compete on price for sales of hardware and basic software. Whilst applications software and related services provide opportunities to improve profit margins; it has still been necessary for many vendors to address the issue of margins in other ways. One solution was to create a low cost selling operation dedicated to the sale of PC's and UNIX computers, to large customers wishing to buy these products in volume. To facilitate such a low cost operation, production and distribution to customers of a catalogue of the products was essential. Customers could then order directly against items in the catalogue thereby in theory reducing significantly the operational costs.

Such an operation was developed for ICL's Government and Major Corporations Division in response to demand from major accounts. Although it was successful in winning catalogue sales contracts, the organisation, however, failed to meet its profit targets. Examination of the problem identified that the "costs of the operation" were much higher than expected. It was decided therefore to re-engineer the business processes with the aim of reducing the cost of selling to a level at which the organisation would meet its targets. Initial attempts to do this using a conventional process re-engineering methodologies met with limited success. A more radical approach was required and a deeper understanding of the problems needed. To achieve this it was necessary to do two things:-

(1) Identify the Value Processes, i.e. those high level sets of processes which were absolutely critical to achieving the operations' objectives.

(2) Understand how the value processes interlinked and fed back inter-dependencies. This appeared to be particularly important where the value processes interfaced to the customer.

Recognition that there was feed-back and interdependence in the system; indicated that an approach based on System Dynamics could be appropriate. Consequently it was decided to adopt the modelling approach based on i-THINK software and attempts were made to model the system. It was agreed that if a model of the system could be developed using i-THINK, then simulation of the model would enable the team to identify the high cost areas in the processes of the system. This achieved, it would then be feasible to re-engineer these processes and simulate them using i-THINK prior to their implementation.

2. APPROACHES

2.1 Conventional Process Analysis

2.1.1. The Application

One of the sales teams who had won a catalogue sales contract in the beginning of 1993 sought help to address their issues in the order processing process. The team were experiencing the symptoms of a set of problems but they were unable to describe exactly where the problems lay.

At the time, Soft System Analysis was decided as the appropriate technique to use in identifying the

problem areas. The analysis work was carried out in three phases.

Phase 1: The management team was asked to meet and give their views of the perceived problems. This enabled the management team to define precisely their scope of interests and their understanding of the order processing process. Their descriptions of the process was documented using basic data flow diagramming techniques (DFD) as adopted in Structured System Design And Methodology v4 (SSADM v4). This laid the foundation for further in-depth analysis. [Ref 1]

Phase 2: A random sample of team members were interviewed on an individual basis. The sample was chosen in such a way that each job role was represented by at least two team members currently working in that role at the time. The purpose of the exercise was to gain an in-depth understanding of the activities within a sub-process and how one sub-process interacted with its neighbouring sub-processes. The results of each interview were documented in the format of Role Activity Diagrams (RADS).

Phase 3: Having established a good understanding of the sub-processes under the scope of the order processing process, a workshop was conducted where the team was asked to conceptualise on the process under the facilitation of an analyst. The process and its sub-processes were described by the activities and the Inputs, Outputs, Controls and Mechanisms (ICOM) of those activities. The process and its decompositions were documented using the ICOM Definition Method (IDEF0), a technique which is very similar to the Structured Analysis and Design Techniques (SADT) [Ref 2].

2.1.2. Results and Observations

The process analysis was completed with limited success giving the team a good understanding of their processes. The problem areas were described and located in relation to the sub-processes. As an outcome of using various conventional process analysis tools and techniques, the team had compiled a list of problems and requirements. The team had also achieved a common understanding of the order processing process.

A number of observations were made:

(1) Although the problems were described more fully than before, the size of the problem was not quantified. The team were unable to establish a baseline for their process in question from the existing information and operational data which they had got.

(2) The techniques which were used during the analysis did not force the team to define the area of interests in very rigid terms. As a result, it had become very difficult for the team to decide what measurables they required in order to enable them to gauge the efficiency and effectiveness of their process.

(3) The team had a very strong and established culture. Although the team were facilitated to conceptualise on what the system required and to identify areas of change whilst making the comparison of the ideal world and the real world, it had been very difficult to mobilise the team to break out from their current frames of minds to perform lateral thinking and creative problem solving. Conducting the analysis in the conventional way by describing the flow of the sub-processes encouraged the team to think along the daily work flow. As Information Systems had been a key mechanisms to the work flow, the team were deeply embedded in the thinking that the sub-processes were driven by Information Technology rather than vice versa.

The authors were keen on the concept that change ought to come from the team and should not be prescribed by any outsiders but felt extremely difficult to make any further progress. Consequently, whilst progress had been made by the use of conventional process modelling techniques, it had been

realised that these techniques had not produced a solution to the problem and that another approach should be sought.

2.2. System Dynamics and i-THINK Modelling Techniques

2.2.1. The Application

The System Dynamics approach [Ref 3] which was first introduced to the authors through the i-THINK modelling tool was believed to be an alternative approach to the conventional methods.

It had been decided that the approach should be tested for its suitability under a laboratory environment before it could be introduced to the team. With the assistance of Brunel University, it was agreed that the authors would re-describe the process and its related problems using the i-THINK modelling tool at the University.

The exercise was divided into two stages.

Stage 1: By applying the concepts of system thinking, the authors attempted to identify and define an overall model of the catalogue sales process and in particular focus on the feedback loops within its boundary of the model.

Stage 2: Having identified the feedback loops, the process activities of each loop were described and simulated using the i-THINK modelling tool in an attempt to identify the activities which were acting as inhibitors to the cost effectiveness of the process.

3. THE RESULTS

3.1 Value Processes

The initial investigation had focused on a single process, called Order Processing, concerned with the receipt validation and fulfilment of an order. The System Dynamics approach, however, forced the team to look beyond this single process by examining its boundaries. A second value process was thus identified. This was concerned with sales activities prior to receipt of the order. It was discovered that, whilst customer could order directly from the catalogue, they still preferred to work through an enquiry and proposal system before placing the order. In this they were encouraged to a degree by the sales teams, who recognised that, by being involved at the pre-order stage, they could eliminate work in validating orders once received.

Therefore a second value process was discovered. Further investigation of this value process called Proposal Response identified that it had two interlinked chains. The first chain was the arrival and response to proposals and the second chain was the sales activity which alternated between selling and writing. It was the identification of two discrete chains within the Proposal Response value process which provided a key to the overall problem. The initial investigation using System Dynamics identified a much more complex picture than linear process modelling techniques had revealed. The system had a second value process, Proposal Response, which itself contained two chains. This model can be seen in Diagram 1.

3.2 Process Linkages

Having identified the main chains and documented them in i-THINK, attention turned to analysing the linkages and in particular the feedback loops. This was where the approach fundamentally differed from the conventional process modelling method used at the beginning of the project. Discussions with the sales teams and the support staff identified the following dependencies in the processes:-

differed from the conventional process modelling method used at the beginning of the project. Discussions with the sales teams and the support staff identified the following dependencies in the processes:-

1. Between sales staff selling and writing proposals.

2. Between a proposal being submitted and an order being received.

3. Between an order being completed and a proposal being turned into an order.

4. Between an order being completed and a proposal being received.

5. Between staff selling and a proposal being received.

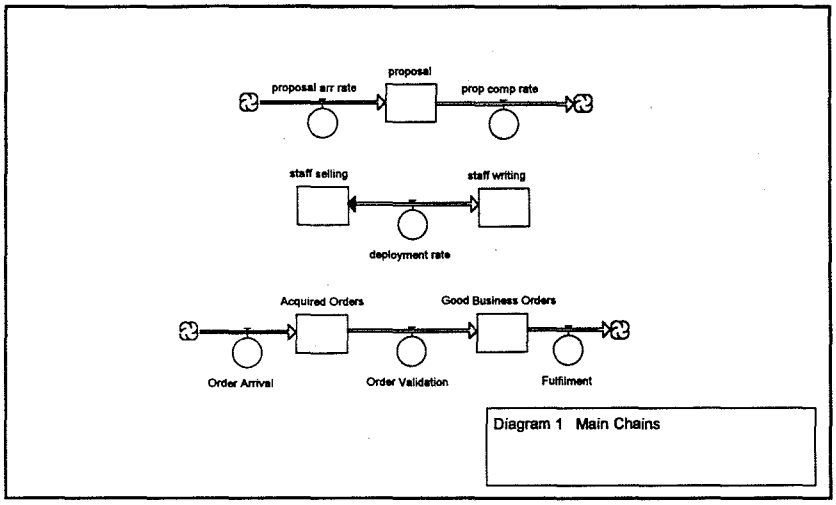

Diagram 1 Main Chains

These linkages are shown in Diagram 2 :-

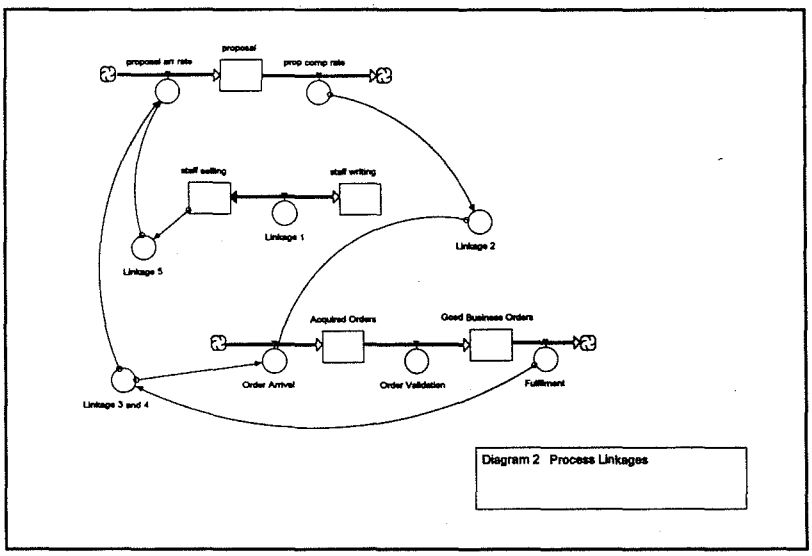

Diagram 2 Process Linkages

The linkages as identified provided the necessary reinforcing and balancing loops in the model. The investigation helped to determine the following principles which underlay the Catalogue Sales Process.

1. Staff could be either selling or writing proposals. With finite staff available, effort spent in writing proposals limited future sales. (Linkages 1 and 5)

2. Even though the customer had a contract with ICL which allowed him to use the Catalogue system, having requested a proposal there was no requirement that this be turned into an order (Linkage 2).

3. The performance of ICL in completing an acquired order, by delivering on time and with the correct products, had an impact after a delay on the rate at which proposals arrived and the conversion of proposals into orders (Linkage 3 & 4).

3.3 Completing the Model

The detailed modelling based on investigation of the main chains and linkages produced the final version of the Catalogue System Model. This is shown in Diagram 3 below:-

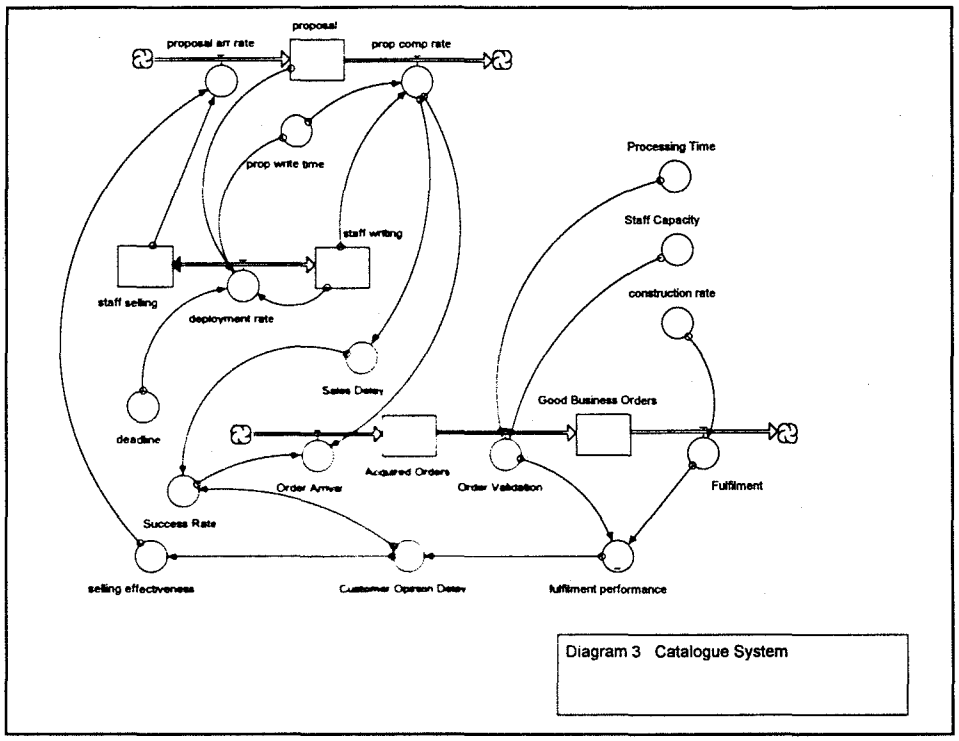

Diagram 3 Catalogue System

The elements of the model which represented the key issues in the process were discovered to be:

1. Fulfilment Performance

2. Proposal Write Time

Fulfilment Performance was an indicator of how well orders were completed. A relationship was

modelled where, as the rate of order-validation and orders-fulfilled (Fulfilment) increased, the fulfilment-performance decreased. This represented the situation which occurred in reality which was that errors crept into the system as the load on order processing increased. The impact of a decline in fulfilment-performance was to create an adverse customer opinion (Customer-Opinion-Delay). This was modelled with a delay factor of 10 weeks. In turn customer-opinion-delay impacted the selling-effectiveness thereby making it necessary to put more selling effort into winning proposals. Customer-opinion-delay also impacted the success-rate which was the factor determining the proportion of proposals which became orders. Introducing these feedback loops created a dynamic model which interworked the three processes.

Of more critical importance was the proposal-write-time. This was an essential element in the model for 2 reasons:-

1. It input into the deployment-rate flow which decided whether staff were selling or writing.

2. It provided a necessary link between the two main claims which represented the proposal value process.

The model had been created to represent selling and writing as an either/or activity for a sales team of finite size. The purpose of the team being to win proposals and turn them into orders through a response process. The number of proposals received related directly to the number of staff selling and their selling effectiveness. As proposals had to be responded to by a deadline, writing had to have priority over selling and the effort to produce a proposal was a very significant factor.

Creation of these feedbacks and relationships created a model which seemed to be totally logical and consistent at a qualitative level. Quantitative data was then applied which was extracted from the performance of the sales and order processing team to provide input for simulation of the model.

3.4 Pre-Simulation Results

Whilst the model was being constructed it was sensible to carry out some simulations to check out ideas and validate relationships in the model. Additionally, as the i-THINK software and System Dynamics principles were new to the authors, time was spent in investigating the theory and practice which involved running the model at every opportunity. However, before simulation commenced in earnest, examination of the model in its qualitative form through inspection enabled a major weakness in the process to be identified. The weakness was in the staff value chain. Examination of the model raised two questions:

1. Why were staff spending time writing proposals?

2. What were they writing in these proposals that required so much effort?

Catalogue Sales was targeted to be a low cost selling operation where a customer could order products described in a catalogue. In principle, therefore, the selling activity should be sufficient to produce orders. In reality ICL staff were providing customers with free advice and guidance to technically configure and size their required computer systems. That was done a legacy from the past when support activity of this type was given for the configuration and sizing of bespoke mainframe systems. This situation clearly was against the principles of catalogue business operation. It was further compounded by the fact that the staff who were doing it were highly paid IT professionals.

Consideration of the situation revealed by the System Dynamics approach drew the following

conclusions:

1. That systems configuration in the catalogue selling operation was not a task which should be done by the vendor.

2. That its happening was a clear case of invasion of the value process [Ref 4] by the client.

3. Removing the activity from the value process would achieve two results:

   a) reduce the cost of the operation by removing a manpower expensive activity.

   b) free up staff to focus on selling and thereby increase the orders received.

3.5 Simulation Results

The model was run over a 104 week cycle. This was chosen because the sales campaigns and order cycles took about 10-15 weeks and it was necessary to study the behaviour over a number of cycles. The key indicator describing the models behaviour was selected to be the stock Acquired-Orders, primarily because it reflected the overall objective of the system.

The model after simulation was found to display classic system dynamics behaviour of overshoot and compensate [Ref 5]. The actual curve corresponding to a second order damping. With the two delays built into the system such behaviour was to be expected. The result is shown below in Diagram 4:

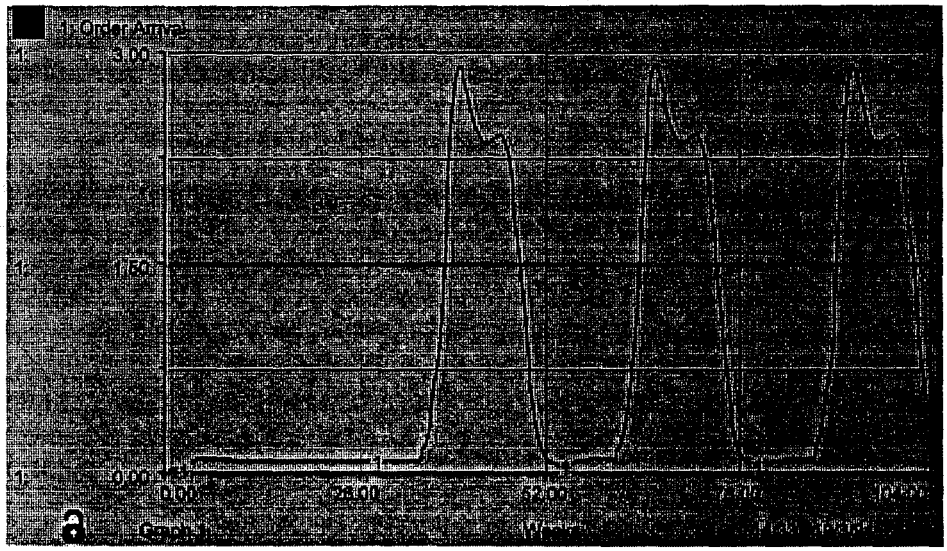

Diagram 4

Having derived a model which had a self balancing structure, equilibrium was found to be reached after 180 weeks, attention was turned to establishment of the sensitivity variables in the model.

Examination of the staff selling/staff writing issue to prove the point about removing the staff writing activity from the process, was tackled by progressively reducing the proposal-write-time converter from its initial value of two weeks down to 0.5 days. This had the desired effect in that the model then displayed the result of staff deployed on selling always above 90% of total resource. It also increased the acquired order by some 60% as is shown in Diagram 4.

The second area to receive investigation was the feedback loops, particularly those concerned with fulfilment performance impact back into selling effectiveness and the success rate of turning proposals into orders. Initial results indicate that this area is highly sensitive in that changes in the profile of the fulfilment performance graph have an impact of over 100% on the number of orders acquired and of over 70% on the staff selling/writing ratio. There is further research to be done in this area to establish the exact detail of the relationships. That the model is sensitive to feedback is nevertheless a significant result on its own since it provides a second area where the system can be re-engineered to improve its effectiveness.

4. LESSONS LEARNT

The problem was examined via two very different approaches which gave complimentary benefits to the understanding of the problem. The experience had shown that whilst the System Dynamics Approach has its strengths over more conventional methods, it also has some limitations.

4.1 Strengths of the System Dynamics Approach

(1) By applying the system thinking discipline using the System Dynamics Approach and with the aid of the i-THINK modelling tool, not only the processes are being examined but the company's policies around the processes are also subjected to scrutiny. This is a key strength over the Soft System Approach.

(2) The System Dynamics Approach provokes serious system thinking. Taking the Approach in modelling will help one to focus on the business boundary where the problem lies rather than the process boundary where the problem manifests itself most. This brings out the key differentiator of Business Process Re-engineering against the traditional Organisation & Methodologies (O&M) or Total Quality Management (TQM). [Ref 6]

(3) One of the key success criterion in Business Process Re-engineering is the capability to establish business metrics and measurables for better business control. Using the System Dynamics Approach in conjunction with the i-think modelling tool, one is led to think more deeply about how to control and monitor processes in quantifiable terms. This has been found very difficult to achieve using the Soft System Analysis approach due to its resemblance with the common mind set in workflow analysis.

4.2 Limitations of the System Dynamics Approach

(1) The System Dynamics Approach is encompassed by a strong engineering discipline. In soft areas where the users have difficulties in expressing the problems in the first place, this approach may not be as effective as Soft System Analysis. [Ref 7].

(2) The System Dynamics Approach can work best at the strategic level of the overall business. It can become over complex and difficult to apply when it operates at a detailed level of processes flow and work activities analysis. However, it is suspected that System Dynamics may also have applicability at the micro process level where the process is highly complex.

(3) System Dynamics in conjunction with i-THINK enabled the problems and limitations of the process to be defined and solutions derived. However, it will need to be complemented by a process re-design tool in order to construct and enact the new processes.

4.3 Conclusions

2 very different approaches were taken to resolve the process problems of the Catalogue Sales Operation. The first approach using conventional system analysis and process modelling techniques enabled the team to develop an understanding of the activities inside the process. However, it did not enable the underlying problem to be identified and resolved. System Dynamics, however, forced the authors to think about the process and examine the process boundaries. As a result, the other processes were identified and as a result the underlying problems were identified. It is significant also that the thinking and analysis steps were sufficient to identify the problem without the need to build and simulate a rigorous model in i-THINK.

The authors conclude that System Dynamics coupled with a modelling tool such as i-THINK provides a powerful method to understand and re-engineer business processes at the macro-level. However, to then proceed and enact these processes through re-design and definition still requires the use of process modelling tools which will integrate with system building tools.

5. PLANNED FURTHER WORK

There is no doubts in the authors' beliefs that the System Dynamics Approach can be applied as a very powerful consultancy tool at a strategic level of the business paradigm.

As a result of the work of the authors, System Dynamics is being introduced to ICL's consultancy group as an additional skill and toolset.

As regards to the Catalogue Sales Operation, the authors' findings to date have been accepted by management and planning is underway to implement them. The authors have also identified specific areas within the model which require additional investigations: These are in the Order Fulfilment and Fulfilment Performance processes. These sub-processes cross organisation boundaries within ICL and are not operating at the required levels of effectiveness. It is the authors' intention to extend their existing i-THINK models in these areas in an attempt to understand the dynamics of these sub-processes especially as they cross the organisational boundaries.

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