THE OPTIMISATION OF A STRATEGIC BUSINESS PROCESS

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ABSTRACT

The optimisation of a Tendering Process for Warship Refit Contracts is presented. The Pre Contract Award process (PCA) involves all the activities needed to successfully win a Refit Contract, e.g. estimating, planning, tendering and negotiation. Process activities and information flows have been modelled using Integrated computer aided manufacturing DEFinition methodology (IDEF0) and a Design Structure Matrix (DSM) with optimisation performed via a Genetic Algorithm (DSM-GA) search technique [1]. The aim of the DSM-GA is to provide the user with an enhanced sequence of performing process activities.

A new process was extracted from the optimised solution, showing an improved sequence with reduced iteration and planned activity concurrency based on carefully considered information requirements. This is of practical benefit to enhance understanding and to provide a guide to implementation. The approach suggests an enhanced sequence of process activities, based on information requirements, and can lead to improved business practice. This Paper discusses the potential benefits and limitations of this approach in a practical setting.

KEYWORDS: Optimisation, IDEF0, DSM

1. INTRODUCTION

The application of a Dependency Structure Matrix based Genetic Algorithm (DSM-GA) to a manufacturing tendering process is presented. Babcock Engineering Services is a major UK defence contractor and has embarked on a major process improvement programme. To achieve this, a collaboration with the University of Strathclyde in Glasgow has been formed in which experience and expertise flows both ways. In particular the DSM-GA, developed by Whitfield et al [1], is being utilised to optimise strategic business processes. The DSM-GA can be applied to any process and will re-sequence the activities, based on relevant information, to provide a new process sequence that exhibits less iteration and greater planned concurrency, ultimately leading to a reduction in process lead time. The tendering process, also known as the Pre Contract Award (PCA) process, was identified by an internal study as a key process for optimisation and is presented here as a case study. As Babcock Engineering Services move from the non-competitive market to fully competitive, the tendering process needs to be as efficient as possible, otherwise potential opportunities and market share may be lost. This paper discusses the practicalities of undertaking a process modelling and optimisation project on a large, complex and information intensive business process. The merits and limitations of the various tools used are reviewed.

2. CASE STUDY - PRE CONTRACT AWARD PROCESS (PCA)

Make/Engineer-to-Order companies spend a significant amount of time and effort in putting together tenders [2]. In Babcock Engineering Services this is known as the PCA process and involves all the work activities required to obtain a refit contract. This includes converting the customer requirements into a product specification and executing the design work, through to estimating (material & labour requirements), tendering and contract negotiation. The process can vary in duration and work scope depending on customer requirements. In addition, the quantity of bid opportunities may vary, due to market conditions, leading to peaks and troughs in process loading. Ultimately the PCA process is a means for winning contracts and in order for Babcock Engineering Services to maintain its market position, as a leading defence industry contractor, it needs to be highly efficient.

3. MODELLING OF THE PCA PROCESS

The objective of modelling is to obtain knowledge of the existing process and to serve as a model for the future implementation, Svensson [3]. This project utilised Integrated computer aided manufacturing DEFinition Language (IDEF0) in order to initially capture and understand the key characteristics of the PCA process i.e. information transfers between various internal departments and the customer. IDEF0 is a commonly used modelling tool for capturing the decisions, actions and activities of a manufacturing company. It was selected due to its strength in rigorously detailing and logically decomposing a process [4]. The process was modelled to an operational level where there are 86 work activities and 460 information links. The construction of an IDEF0 model was only the first step of the PCA process modelling stage. This was due to a common IDEF0 constraint i.e. the difficulty in understanding information flow between decomposed diagrams. Also, when using IDEF0 the user had difficulty in identifying sources of inputs/controls and destinations of outputs. This important feature of process focussed improvement could be lost if IDEF0 was used in isolation. This study focussed on optimising the information flows at operational level, five or six levels down in the hierarchy, consequently the IDEF0 goals, constraints and mechanisms, which were captured at the top levels were not cascaded down to this level of detail. The high level IDEF0 models are being used to communicate understanding of the process to senior managers during strategic meetings where radical, longer term, re-engineering decisions are being made.

The next step in modelling the PCA process was then to link the information, captured in the low-level models, to the relevant activities and represent this in a single diagram. As a result, the Dependency Structure Matrix (DSM) process modelling tool was selected as it captures work activities and information requirements in a compact and visually effective manner. Developed by Stewart [5], the DSM was primarily used to formalise complex information flows and iterative cycles, a process characteristic often overlooked when modelling processes [6]. Fleming et al [7] gives a full description of the DSM and PCA modelling.

The DSM is essentially a square matrix with a series of activities each containing a row and column. A row with a dependency represents information that is required by a recipient activity and a column indicates the feeder activity. Having captured the information dependencies the next step was to establish the information criticality with respect to the recipient activity and give them reflective weightings i.e. 1.0 being most critical and 0.1 least critical. This is essential so that the DSM-GA is able to prioritise the movement of the more critical information dependencies below the diagonal, during optimisation (see section 4).

For this case study two different dependency weightings were adopted, represented by coloured crosses within the matrix. These determine when an activity starts and when it will conclude, in respect to the other process activities. The darker crosses represent the most critical information and as such have been assigned a weighting of 1.0. This is due to it being most disruptive if supplied in anything other than it final form. In this case performing the activities concurrently is not recommended due to the recipient activity's sensitivity to changes [8] and the subsequent time and effort required to perform the iterations. The lighter crosses have a weighting of 0.5 and represent information that can be used by the recipient activity in a preliminary form, permitting overlaps to exist that will prove advantageous to the process' performance [8].

Figure 1a, shows a finish to start information dependency, which is represented by a darker cross below the leading diagonal on the matrix. Conditional concurrency can exist between two activities, shown in Figure 1b as a lighter cross below the leading diagonal. Figure 1c represents two activities that are independent of each other, as there is no information passed between them. If critical information were unavailable it appears as darker cross above the leading diagonal, as shown in Figure 1d. This is undesirable as the downstream activity will have to estimate a value for the information. Even slight inaccuracies in this estimate, from the final value, can lead to a dramatic increase in process duration [8], as future iterations will require major rework. There can also be times when less critical information is unavailable. In these cases a lighter cross appears above the leading diagonal, as shown in Figure 1e. Although potentially disruptive, the process duration will not be affected as significantly, as smaller and faster iterations can be performed. Finally there could be coupled or interdependent tasks where a cross exists above and below the diagonal, see Figure 1f.

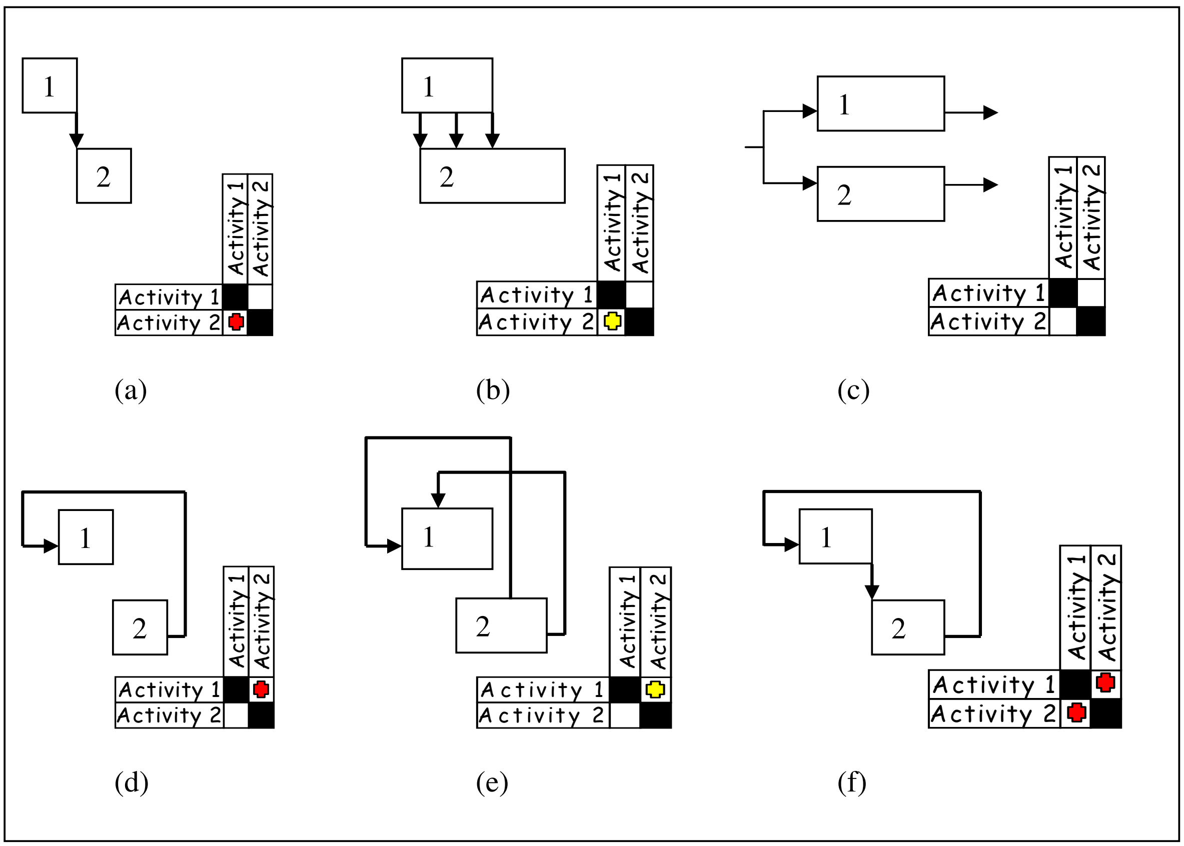

Figure 1 Information Dependency Rules

The final step in modelling the current process was to hold a quality review between the senior customer (process owner), their team (process operators) and the producers (process analysts). This was done during two workshops to confirm and verify the 'As-Is' PCA process's activities, information links and their specific weightings. These workshops, each lasting three hours in duration, allowed key process operators within the process to verify that the DSM matrix reflected their current process. Each row in the matrix had to be reviewed and its dependencies considered. In a large process, such as the PCA, it is a major task to check every activity and every dependent link e.g. PCA matrix is 86x86 in size. The end of the quality review was signified by the process owner "signing off" the matrix. This indicated that in their opinion the matrix provided a true representation of the PCA process' activities and information dependencies and was of a suitable quality to begin the optimisation stage.

4. OPTIMISATION OF PCA PROCESS

Whitfield et al [1] built on the strengths of the DSM modelling technique with the introduction of a Genetic Algorithm (GA) search technique (DSM-GA). A full description of the GA and its structure can be found in [1]. The DSM-GA is a powerful tool in that it can automatically search through the n! potential combinations of process sequence, where n is the number of activities in the process. In the PCA process there were 2.42×10^{132} possible combinations. Of these, 9×10^6 possible solutions were searched beyond which the degree of improvement was deemed negligible, Whitfield et al [1]. This search took three days to run on a standard laptop and was considered to be a more than adequate run time. As a result of this optimisation the PCA process was re-sequenced and a 51% reduction in a criterion indicating rework was achieved. This sequence was then presented to the process operators at a workshop to assess its practical value. This was a valuable step in getting the process operators 'Buy-In' in that they had an opportunity to re-design the process' sequence. In the new sequence there would be occasions where process operators would have to estimate information that was previously firm. The operators assessed these occurrences to ensure that reasonable estimates could be made. If a reasonable estimate could not be made then the operators selected a new position in the matrix for the activity to occur. The operators decided that 54 changes were required to make the optimised sequence practicable and ensure more sensitive information is available when required i.e. below the leading diagonal. Interestingly, in making these changes a further improvement of 6% was obtained. The final reduction in a criterion indicating rework was now 57%. The operators had further optimised the process and ensured they were confident with its sequence. The procedure of this workshop is discussed more fully in Fleming et al [7].

Having obtained an optimised sequence, fully validated by the process operators, the next step was to 'extract' a meaningful process, from the optimised DSM sequence, that clearly showed the new process sequence with reduced unplanned iteration.

5. EXTRACTION OF AN OPTIMISED PROCESS

In order that the process operators could obtain maximum value from the optimised process sequence it needed to be presented in a more 'user-friendly' format. This was defined as 'extracting' a new process. Other authors such as Cho and Eppinger [9] have extracted processes from a DSM process model using simulated Gantt charts. This approach differs in that it demonstrates more of the potential activity overlaps. The extraction is performed by firstly grouping matrix activities of a similar function, so as to gain a high level model of the process. This is of benefit to process operators, as it illustrates in simple terms the general working of the process. The next stage is to move through the matrix, and identify the dependencies and their respective weightings. By applying these rules the process was extracted from the matrix into a format that shows the process sequence, planned concurrency (overlaps) and the multi-thread feedback loops that can cause iteration. The process owners preferred the extracted format to that of the optimised DSM matrix as it clearly depicted the execution of their process. For the first time they could clearly see the enhanced process with opportunities for concurrent working and reduced rework. Importantly, some activities could now be performed earlier than before, this could mean that an activity would have to use initially guessed information where previously it had firm information. However the guess would be made within a reasonable tolerance, based on process operator's expertise and experience.

6. IMPLEMENTATION OF THE EXTRACTED PROCESS

The bid manager will champion the implementation of the new PCA process, during the next tender submission, using the extracted process with the continuing support of the process analysts. The extracted process is in the form of a project plan that demonstrates to the bid manager what sequence the tasks should be performed in, the potential concurrency (overlaps) and activities where iteration will occur. The amount of conditional concurrency and low level detail will be established and agreed with the team managers and is reliant on the amount of time and resource available to the project manager and the quality constraints on the products being created during the PCA process.

The bid team has been organised into co-located teams so that iterative activities within the PCA process are more efficient and effective. This was the only change made that required director level backing to implement.

7. DISCUSSION

The DSM-GA performed a quantitative optimisation on the PCA process that reduced a criterion indicating rework by 51%. In practical terms this means that there is potentially 51% less rework of the process activities. The criterion was further reduced by 6% during the validation stage. The DSM-GA was a powerful tool in terms of being able to automatically search through potential process sequences. This coupled with the process owner's expertise allowed a further improvement of the solution. This was possible due to the dynamic nature of the DSM-GA tool and allowed the process operators to participate in the optimisation of their process. This was extremely valuable in terms of gaining their support and the creation of a practically viable solution. Significant benefits can ultimately be derived from this optimisation, such as reduced process lead-time and planned concurrency based on the information requirements. Factors that may result in changes being made to the optimised sequence include, no specific process heuristics, a limitation in the applicability of the GA, an insufficient search space and/or incorrect dependencies in the matrix. In practical terms it takes a significant amount of time to capture the current process at the level of detail required to optimise the process. It should be noted that a few erroneous dependencies were identified despite the process owner having checked and signed off the 'As-Is' process for accuracy.

Initially there was a degree of scepticism regarding some process operators having to estimate information that they previously possessed as their activities would now have a greater probability of more frequent iteration. However, reassurance was given that the 'global' solution had been improved. This is an important point for process operators as there will be winners and losers from re-sequencing, however the overall result will be an improvement.

The extracted process was extremely valuable as it clearly represented the tasks start and finish positions in relation to the rest of the process, the potential concurrency and the feedback loops. The process optimisation technique seeks to reduce unintentional rework caused, in part, by information being unavailable due to poorly sequenced activities. The redesigned process should demonstrate the earliest time an activity can start and finish (i.e. the sequence), maximum potential concurrency and reduced rework cycles. The translation also needs to be in a format meaningful enough that the process operators can quickly understand and relate to the new process. This will increase the likelihood of success in the implementation phase.

A clear advantage of this approach is that the Project Manager can implement the process himself as part of his duties. This represents a more incremental level of improvement. If a more radical reengineering approach had been taken then senior management would have been required to drive the improvement. The only higher level support required to implement the new PCA process was that for co-location of the bid team.

8. CONCLUSION

The optimisation of a strategic business process has been presented. The ‘As-Is’ process has been optimised and a 57% reduction in a criterion indicating rework has been obtained. By re-sequencing there are winners and losers amongst the process operators in terms of information availability. However the global solution is significantly improved. In order to gain full value of this improvement a new process has been extracted that clearly shows the sequence and planned concurrency of activities. The new process can be tailored and implemented by a project manager.

9. ACKNOWLEDGEMENT

The authors would like to acknowledge the support provided by the Senior Management and Bid team of Babcock Engineering Services.

10. REFERENCES

[1] R.I Whitfield, A.H.B Duffy, G. Coates, W. Hills. “Efficient process optimisation”, accepted by the Journal of Concurrent Engineering Research and Applications (2002).

[2] I. Henderson “Why is making to order so different”? Control, December–January (2001).

[3] D. Svensson, J Mamstrom, P Pikosz, J Malmqvist “A framework for modelling and analysis of engineering information management systems”, Proceedings of the ASME Design Engineering Technical Conferences (1999).

[4] K. Soung and J. Ki-Jin, “Designing performance analysis and IDEF0 for enterprise modelling in BPR”, International Journal of Production Economics, V76 p121-133, (2002).

[5] D.V. Stewart, “The design structure system: a method for managing the design of complex systems”, IEEE Transactions on Engineering Management, V28, No.3, August (1981).

[6] J.L. Rogers, “Reducing design cycle time and cost through process re-sequencing”, International Conference on Engineering Design ICED Tampere, August 19 – 21, (1997).

[7] D.A. Fleming, G.A. Forbes, L.E. Hayfron, A.H.B. Duffy and P.D. Ball, “The optimisation of a tendering process in warship refit – a case study”, Proceedings of Computer Aided Production Engineering (2003).

[8] K. Viswanathan, S. Eppinger and D.E. Whitney, “A model based framework to overlap product development activities”, Management Science, V43, No. 4 April (1997).

[9] S. Cho and S.D. Eppinger, “Product development process modelling using advanced simulation”, Proceedings of DETC'01 ASME 2001 Design Engineering Technical Conferences and Computers and Information in Engineering Conference (2001).