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TRIPLE DIAGONAL MODELING: A MECHANISM TO FOCUS PRODUCTIVITY IMPROVEMENT FOR BUSINESS SUCCESS

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TRIPLE DIAGONAL MODELING: A MECHANISM TO FOCUS PRODUCTIVITY IMPROVEMENT FOR BUSINESS SUCCESS

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ABSTRACT

Triple Diagonal (TD) modeling is a technique to help quickly diagnose an organization's existing production system and to identify significant improvement opportunities in executing, controlling, and planning operations. TD modeling is derived from ICAM Definition Language (IDEF 0)--also known as Structured Analysis and Design Technique. It has been used successfully at several Department of Defense remanufacturing facilities trying to accomplish significant production system modernization.

TD has several advantages over other modeling techniques. First, it quickly does "As-Is" analysis and then moves on to identify improvements. Second, creating one large diagram makes it easier to share the TD model throughout an organization, rather than the many linked 8 1/2 x 11" drawings used in traditional decomposition approaches. Third, it acts as a communication mechanism to share understanding about improvement opportunities that may cross existing functional/organizational boundaries. Finally, TD acts as a vehicle to build a consensus on a prioritized list of improvement efforts that "hangs together" as an agenda for systemic changes in the production system and the improved integration of support functions.

INTRODUCTION

Most explanations of efforts to make major, productivity improvements throughout an organization (e.g., TQM and JIT) emphasize top management commitment as a prerequisite for successful organizational change. While necessary, such commitment is frequently insufficient. By itself, top management commitment to a major change in operations can result in enormous investments in training and extensive, uncoordinated efforts by many teams and tasks forces.[1] If these activities are not focused to achieve significant business objectives, results may be disappointing.

Management must be committed to change and to employee empowerment. But they must also understand and articulate how key business objectives are linked to an operational concept. Management must understand and share a vision of how the new production system will work. This operational concept must define how the present production system functions and what systemic changes must occur to significantly improve performance. Triple Diagonal (TD) modeling is a technique to help quickly diagnose the present production system and to identify significant improvement opportunities in the execution, control, and planning of operations.

IDEF 0 AND TRIPLE DIAGONAL MODELING

Triple Diagonal modeling is derived from ICAM Definition Language (IDEF 0) -- also known as Structured Analysis and Design Technique.[2][3] IDEF 0 has been used recently by the Department of Defense (DoD) Corporate Information Management (CIM) initiative to support analysis of proposed standardization of information systems.[4] TD modeling was originally developed to assist manufacturers move toward computer integrated manufacturing.

Unlike most functional decomposition approaches, TD starts by modeling the flow of material among major functional operations to produce the product or service (i.e., starts at the bottom rather than the top). Above this execution level, the model is expanded to incorporate information flows among functions that act to modify or control the execution functions. Above the control level, a third level of planning functions is added to describe how production is scheduled and how the execution and control functions receive the physical and information resources needed to meet that schedule.

FUNCTIONAL DECOMPOSITION, TD MODELING AND IMPROVEMENT

Functional decomposition as a tool to describe and analyze large systems has been used in information systems for about two decades. Its proponents claim it is a useful way to document complex functional relationship and information flows in understandable chunks through a series of hierarchically linked diagrams.[5] Unfortunately, these diagramming efforts often result in very large static documents containing numerous individual diagrams. The volumes of information makes it difficult for anyone, other than those who created the diagrams, to understand, update, and elaborate on what the diagrams are describing as a whole.

There are three fundamental problems with functional decomposition as a tool to aid business improvement. First, the large number of linked drawings, and their difficult to understand linkages, limit their use as a vehicle for broad based communication within an organization. Second, in practice functional decomposition efforts frequently take a long time and much effort. Third, the functional, top-down, decomposition does not always show how tasks are sequenced. All these limitations interfere with effective problem analysis and identifying solutions.

TD has several advantages over other modeling techniques. First, it quickly does "As-Is" analysis and then moves on to identify improvements. Analysis efforts can be tailored to the requirements of the organization by scoping the model to cover the few key activities or products that are critical to success. Second, creating one large diagram makes it easier to share the TD model throughout an organization, rather than the many linked 8 1/2 x 11" drawings used in traditional decomposition approaches. The TD is also a static model. However, its one page diagram allows for modification to readily be inserted and understood as on-going organizational or functional changes take place. Third, it acts as a communication mechanism to share understanding about improvement opportunities that may cross existing functional/organizational boundaries. Finally, TD acts as a vehicle to build a consensus on a prioritized list of improvement efforts that "hangs together" as an agenda for systemic changes in the production system and the improved integration of support functions.

TRIPLE DIAGONAL MODELING – THE 8 STEP PROCESS

TD modeling is an eight step process. These are described below.

Step 1: Determine the Basic Flow of the Product

Before beginning, the purpose and scope of the modeling effort should be clear to ensure the project can be completed within time and budget constraints and the results are of value to the organization. This can often be achieved by selecting a key product family or critical production process as the focus. Part of determining the scope is deciding on the boundaries of the system to be modeled (i.e., the first and last activities that transform the product). When these questions are resolved, then the process is broken into the activities that are the basis of the production process. Often it is useful to note where material handling equipment is required to separate different execution level functions.

Step 2: Determine the Material Flow

Inputs and outputs of each execution level function are identified. These can include purchased and fabricated parts, and scrap. A good check to ensure the functions are defined properly is to examine whether the input of a function appears to have been transformed at the output. Outputs of one execution function that are used as inputs for another such function are also marked on the drawing.

Step 3: Add Control Feedforward

The modeling effort now moves up to the control level. First, control functions are identified. Next, outputs from control functions that are used as controls to execution level functions are noted. Control inputs trigger or influence the transformation process of an execution function (job order packet). Finally, outputs are from one control function that serve as inputs to another control function are identified (e.g., job order scheduling feeding the development of a work center dispatch list).

Step 4: Add Control Feedback

Information outputs from the execution level serve as inputs to control functions (e.g. production and scrap reporting). This as identified and noted. In some cases, the output of some control functions may serve as an input to another control function (e.g., an evaluation of the requirements to rework an item can feed the rescheduling of a job order).

Step 5: Add Planning Feedforward

The modeling effort now moves up to the planning level. Planing functions are identified. Next outputs from one planning function that are used as inputs to another planning function are noted. These data flows usually represent relatively stable data, like Bills of Materials and Routing, that feed the generation of a Master Production Schedule. Outputs of planning functions can also serve as control inputs to control functions. These outputs are typically schedules and revisions to previous schedules, and authorizations to adjust near-term capacity (e.g., approval of overtime).

Step 6: Add Planning Feedback

The output of some planning functions can serve as a control feedback to another planning function. A typical example is doing rough-cut capacity planning which determines a proposed Master Production Schedule is infeasible. This causes the MPS to be modified to fit within capacity constraints. Often planning functions require feedback from lower levels to replan when operations cannot achieve original goals and schedules. While every effort should be made to get back on plan, this is not always possible. This feedback may be from either control functions or execution functions.

Step 7: Quantify the Material Flow

Once the basic model is defined, it is selectively annotated with important quantitative measures of resource consumption and performance. This effort usually requires some analysis of records and/or questioning knowledgeable staff. The level of resource consumption (e.g., manhours or machine hours) and cycle time is determined for each execution function. Finally, quality of key inputs and/or outputs is noted.

Step 8: Quantify the Information Flow

Finally, the processing of information is quantified. This involves quantifying the resources consumed in each control and planning function, determining cycle times for information processing and decision-making, and evaluating the quality (accuracy) of the information flows.

TD MODELING AT CORPUS CHRISTI ARMY DEPOT

Triple Diagonal modeling was successfully applied at Corpus Christi Army Depot (CCAD). CCAD is the Army's aviation repair depot. It repairs, overhauls, and modifies a range of helicopters and their components. CCAD formed a cross-functional team of shop floor employees, industrial engineers, and production and material controllers. This team was trained by staff at Pacific Northwest Laboratory in the TD methodology. The team then spent five weeks developing a TD model of critical processes that are associated with a strategically significant workload of the depot.

To be effective, the TD model needed to address immediate concerns of both upper management and shop floor personnel. Upper management was supportive of the focus of the effort since the workload selected represented a potentially growing market segment. The shop floor personnel were supportive because they understood that improvements that helped achieve this growth would not threaten jobs. Both sides knew that the increased work was dependent on significant improvement gains.

The team developed and quantified the model. Cycle times and scrap rates at the execution level were quantified. Control and planning feed forward and feed back loops were evaluated for their contribution to effectively managing the production system.

Brainstorming sessions were held to identify problem areas. Individual project identification sheets were written and submitted for team review. Valid projects were then grouped into three areas based on recurring themes. The first group of projects all dealt with the lack of process flow design to support efficient remanufacture. The second group of projects dealt with the lack of program level control for the work load. No one person or functional organization truly managed the work load from start to finish. The third group of projects dealt with the level of information used to plan. Specifically, the lack of structured, accurate data and the lack of integration of interdependent planning functions was negatively affecting the remanufacture of products on time, at cost, and with proper quality.

Given that the analysis of the diagram and the potential solutions all dealt with significant organizational issues, the means and manner to share the results and develop organizational ownership was not a trivial exercise. To debrief the findings and present the potential improvements several questions were addressed.

1. Who needed to be involved? The team felt each Directorate needed to be represented, but specifically the production Director, Division, Branch, and Shop Foreman needed to be involved. Another key ingredient to ensure the ears of the audience were truly in tune that day, was to have the Chief Executive Assistant in attendance.

2. What should be the format of this debriefing? A one day off site participative workshop was selected.

3. Where did this project fit into the managers' (audience) agenda? The project team felt the strongest common ground between the project findings and the managers' interests was cycle time reduction. Therefore this topic would be related to each issue the team presented.

4. What were the specific objectives of the workshop? The team had spent roughly three months in modeling, validating, analyzing, and deciding on specific shop floor projects, redefining organizational control responsibilities, and identifying current information structure limitations for company wide planning and control. How much could honestly be expected to be debriefed in a day? The group brainstormed and concluded that the number one objective of the workshop was understanding three simple concepts. First, the process flow of parts, sub-components, modules and the end item must be designed for short cycle time. Second, controlling the material flow required the focus and responsibility of a clearly identifiable person with the accountability and authority to manage the cycle time of an end item. Third, the data structure, data integrity, data collection, and interrelated planning

functions must provide the information to focus corporate resources and attention on reducing the end item cycle time.

5. How to structure the workshop? Given the objective of the workshop the one day session was designed to include multiple learning opportunities for the participants. These included brief macro and micro needs statements from senior and mid level managers, a physical (game) simulation of an assembly process based on the one analyzed by the team, followed by three lessons illustrating the three concepts mentioned above. The lessons consisted of a presentation describing a specific problem, a break out working session for the participants to answer questions pertaining to the problem, and a summary discussion of the various break out groups.

Based on the analysis of the model, and the workshop, several important outcomes were achieved. First, shop floor improvements to reduce cycle time were identified and prioritized. Second, a high priority information systems project was identified to fill a critical gap in shop floor control. Finally, the model identified a gap in the overall data structure and information systems architecture, that limits the organization's ability to effectively focus its corporate resources in a timely manner. Resolving the identified issues will require changes in both organizational responsibilities and new systems, but primarily it will require leadership. Although the triple diagonal is a tool built from the bottom up, it can best be used from the top down.

CONCLUSION

Large scale performance improvement requires an overarching vision of the organization as a system that plans, controls, and produces the goods or services that meet the needs of its customers. Organizations trying to achieve this type of improvement need tools that help them to quickly:

- identify areas that need improvement;
- prioritize these changes;
- develop a common vocabulary/model to communicate this new vision throughout the organization.

When supported, understood, and valued by the organization's leadership, Triple Diagonal modeling can be that tool.

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BIOGRAPHICAL SKETCH

Lawrence O. Levine joined Pacific Northwest Laboratory (PNL), a national laboratory of the U.S. Department of Energy, in 1983. His professional experience has included management systems assessment, application software design and development, technology assessment, and R&D planning and assessment. At PNL, his recent focus has been on ways to improve management effectiveness, especially as it relates to reducing cycle time in administrative processes, and implementing pull remanufacturing. Mr. Levine has a B.S. in Engineering from the University of Michigan and an M.S. in Industrial Administration from Carnegie Mellon University.

Luis D. Villareal, P.E., is a Senior Industrial Engineer with the Corpus Christi Army Depot. He has been at the CCAD since 1989. His professional experience includes shop floor manufacturing methods analysis, managing a shop floor production crew for a private industry aerospace manufacturer, and proposal management in the Industrial Modernization Incentives Program (IMIP). At CCAD, his current duties are directed at modernizing the depot's use of labor, process planning, equipment, facility layout, and data acquisition to reduce product cycle times. Mr. Villareal is a Professional Engineer in the state of Texas, has a B.S. in Industrial Engineering from the University of Texas - El Paso and an M.B.A. from Pepperdine University.

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