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Leveraging Systems Thinking Insights to Enhance Process Management

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Abstract

All work gets done through processes. The processes are the building blocks of organizations. With advances in quality management and reengineering, the processes are key focal points for management. For quality management award programs process management has been the dominant theme. Given this, if systems thinking were to have any impact, the tools and insight generated should ultimately be aimed at policy elements of process management or processes governed by the existing policies. The paper uses two applications to demonstrate how systems thinking enhanced process management.

Keywords: Systems Thinking, Process Management, Business Applications

INTRODUCTION

Drawing from experience, this paper presents two cases describing how the systems thinking tools were leveraged to improve process management. The processes such as product development, production, marketing, and distribution are the building blocks of today's enterprises. Process management receives great deal of attention in ISO9000 certification and Malcolm Baldrige award systems. The organizational processes are created and operated through iterations of definition/redefinition, control, and improvement efforts and are applicable at any level of detail in order to provide a systematic and thorough effort that would yield higher quality and productivity as judged by internal and external stakeholders in terms of the benefits they receive and the cost or burden they bear. We gain knowledge about process through orderly and logical analysis. During past decade, many organizations all over the world have invested heavily in change programs such as total quality management (TQM) (Deming, 1986, Juran and Gryana, 1988), total productive maintenance (TPM) (Nakajima, 1989) and process reengineering (Hammer and Champy, 1993). Quality tools among many are used to study processes and identify opportunities for improvements. At the heart of this improvement process is PDSA (Plan-Do-Study-Action) cycle and fact based analysis. Many have found that resulting changes are either short-lived, fail to measure up to expectation, or made problems worse or create new problems. Some have abandoned the change efforts before any positive results were produced at all.

Kim [1990] proposes that quality tools are adequate at the operational level but offer limited help in the way of advancing management thinking at the conceptual level. He proposed that synergy between conceptual learning and operational learning, which are equivalent to single loop learning and double learning [Argyris, 1993] or adaptive learning and generative learning [Senge, 1990], is critical to enhance organizational learning. Conceptual learning is a needed skill for effective decision making and learning in today's accelerating change. It requires us to become systems thinkers.

The field of Systems thinking [Richmond, 1993; Sterman, 2000] offers tools to understand how the structure of the system creates their behavior and thus expand and/or change one's mental models about how the world works. Systems thinking promotes the very existence of current conditions due to combination of causes mutually influencing each other. The tools offer a methodology for thinking about the ways in which existing belief system may restrict gaining deeper insights into the complexity of systems, finding high leverage points in the system and testing one's assumptions about various policy choices. Furthermore the tools can handle fuzzy variables such as effect of time pressure on productivity, effect of delivery delay on incoming orders that are only available at the intuitive level. However, if systems thinking to have any lasting effect, the insights generated from systems thinking must be leveraged through prevailing processes, because all work gets done through processes. At the operational level, the influence of systems thinking should be reflected through policies that guide decisions or improved processes guided by existing policies.

A thought-ware template in Figure 1 represents the thinking processes employed during problem identification, problem solving, and solution development. The loops B1, B2 and B3 interpreted in the context of an application facilitate observation, listening, reflection, dialogue and consultation processes. A key objective of systems thinking tools is to make the systemic and hidden problems visible.

If for some pragmatic reasons (lack of resources or interest), complete system dynamic study is not possible, dynamic thinking, operational thinking and closed loop thinking skills still can be integrated into any process management undertakings. Furthermore the wisdom available through the writings of others can be utilized as appropriate. The thrust of the rest of the paper is to describe couple of applications to demonstrate how systems thinking enhanced process management.

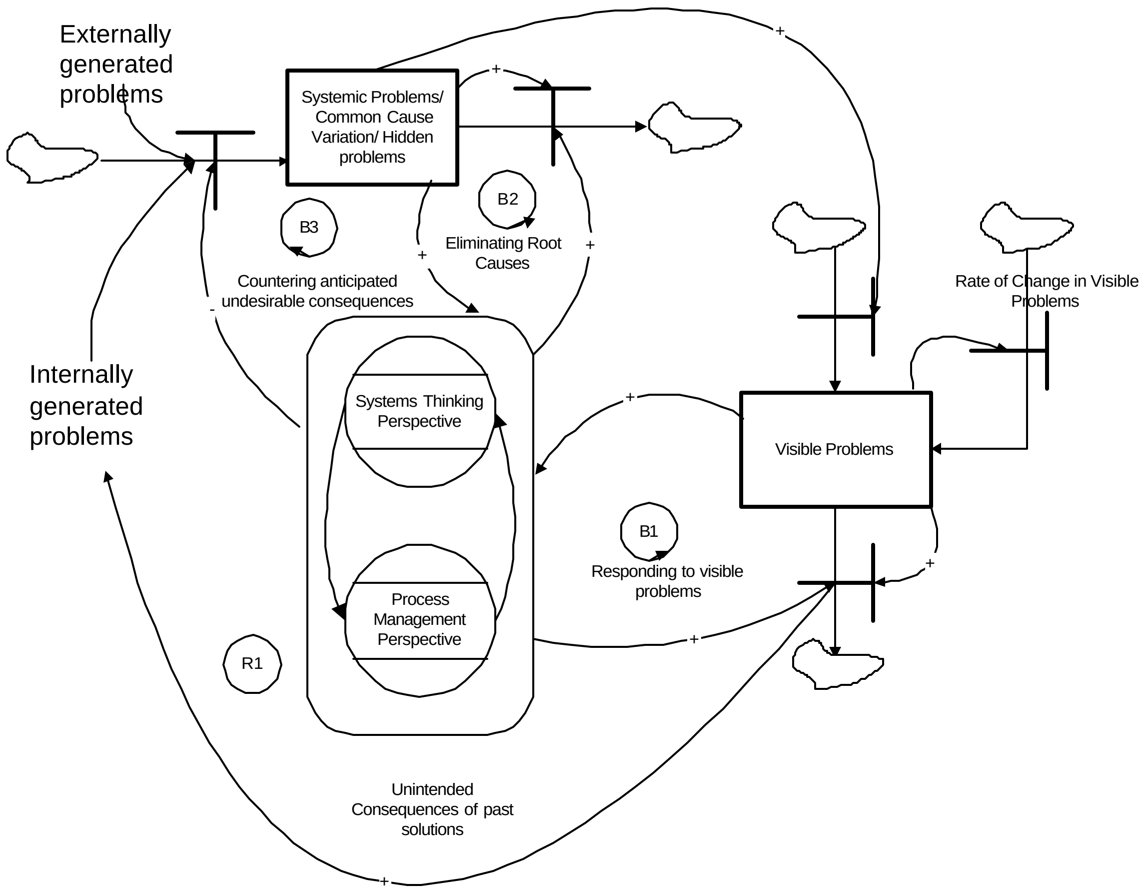

Figure 1 : A Thoughtware Template

APPLICATIONS

The names of the firms used here are fictitious, though the problems are drawn from real situations. Each case begins with brief description of the problem and dilemma, followed by applications of systems thinking tools. Then a process-based solution is briefly presented.

Case 1

Problem Background: XYZ manufactures of durable items, which are in the mature phase of the product life cycle. One of the divisions of XYZ manufactures a product line has dozens of models, many, of which are modified annually. It competes on the basis of incremental innovations, quality, and price. The following paragraphs extract and reconstruct the relevant systems related information from Jambekar and Nelson [1999].

At the time the corporate-wide quality management initiatives were in full swing, the division was experiencing two problems: 1) an unacceptable number of errors in Bills of Material (BOM) such as wrong parts, wrong number of parts, or missing parts, and 2) response time for completion of any product engineering project was getting longer. It was particularly embarrassing to the manager because of top corporate wide thrust on reducing cycle time for all activities.

Once a BOM was entered into the corporate Manufacturing Requirement System (MRS), it would be accessed by other functional units such as Manufacturing and Purchasing to generate materials requirements, the Master Production Schedule (MPS), and to initiate communication with suppliers through purchase orders. The BOM drives the activities of these functions by specifying the parts and components to order, purchase, schedule, transport, etc. Once the BOM had been released into the MRS, it was not until two to four months later that errors, if any, would be detected, generally during pre-production activities by Manufacturing. When an error in a BOM was discovered, manufacturing personnel issued an Emergency Work Order, and the Product Design Department was required to suspend all other engineering work in order to complete the Emergency Work Order quickly. The issuance of an Emergency Work Order was generally automatic; no special approval was required to initiate an Emergency Work Order. The engineer who had developed the faulty BOM is automatically assigned the job. . As the number of Emergency Work Orders increased, progress on the normal engineering work declined. These assignments did not reduce the other responsibilities that the engineer had for other assigned work. The normal work involved support for marketing sales releases and making engineering changes reflecting customer needs and feedback from after sales service engineers. Complaints from people who originated the change orders began to rise. The Product Design Department manager considered the total workload on the department only in terms of normal engineering work.

During a review of expenditures, it was noted that the direct labor incurred by the Product Design Department for processing Emergency Work Orders to correct BOMs exceeded $200,000, which was alarming. The lost work and productivity due to these were unknowable. Normal lead-time to correct errors once an Emergency Work Order was issued was one to four weeks. The real cost of the disruptions, both to Product Design Department and to production, was never estimated, but was clearly quite large. A Business Process Improvement Team was formed and given a charge to improve the responsiveness of the Product Design Department in correcting BOM errors.

As the Process Improvement Team set about to deal with the responsiveness problem, it took the time to hold a brain storming session, to reflect on the root causes and make use the quality tools. The team members were able to agree that the BOM errors could be attributed to two possible causes: incorrect original design (e.g.: the poor manufacturability the of some design configurations or the use of immature technology), or incorrect entry into the MRS. An undesirable side effect of the quality problem solving efforts was that the engineers directly responsible for the BOM errors were clearly uncomfortable, because there was no obvious explanation for their errors. An implicit assumption for the team's work was that each BOM error was unpredictable, although it was attributable. In normal quality management work, one should try to find the root causes of any non-random error. In this situation, because of the significant passage of time (two to four months) between the making of the BOM error and its detection, root cause identification would be nearly impossible.

Application of Systems Thinking Tools: As the team thought through these ideas, it gradually came to a consensus that a reactive system of correcting errors was not acceptable, although in the short-term it was expedient. The intention was, in essence, to tinker with the existing project priority system and develop a better scheduling method. The changed problem solving focus was built around the following three questions: (1) What would be the fastest way to react to the detected BOM errors and can the errors be detected earlier? (2) Was there a recurring pattern of events? (3) What systemic structures were in place and might those be responsible for commitment of errors?

In order to view the problem from a systems perspective, the BOM errors were considered as evidence left behind by the systemic structures in place at the time the errors were allegedly made. There was complete agreement that the problem was the existence of BOM errors discovered during the pre-production phase of manufacturing, and that the problem must be eliminated. At the core of the systemic structure is a straightforward view that recognizes the error correction cycle as a part of engineering work accomplishment as shown in the Figure 2. This portrayal corresponded quite closely with the existing design engineering interactions with MRS. MRS maintains two key database folders: Work Folder and Live Folder. The Work Folder maintains and tracks all necessary engineering information and is accessible only to the product engineers who are working on normal engineering work during design phase. After the design is completed, reviewed and accepted, the Work Folder becomes a Live Folder, which is then accessed by Manufacturing, Purchasing, and all other relevant groups for further processing.

The projects are classified by size and assigned to available engineers based on capacity and experience. Although the Product Design Department manager was aware of the existence of Known Rework due to discovery of BOM errors, the Known Rework did not play any role in calculation of available Engineering Capacity and scheduling of projects. The Cycle Time Reduction Goal was the influencing factor in scheduling new projects.

Backlog, Known Rework, and Engineering Capacity, a time series of data on normal workload and rework incidence was needed. Because data based on the historical records would have taken too much time to develop, and many felt that would have been a waste of time, team engineers were simply asked to sketch behavior over time. Figure 3 shows the approximate relationship. The discussion which ensued suggested that whenever the total workload exceeded available capacity, engineers were more prone to making errors for two reasons: (1) because of the schedule pressure, the engineers hurried through seemingly routine tasks; and, (2) morale fell because engineers were clearly embarrassed and were required to perform both

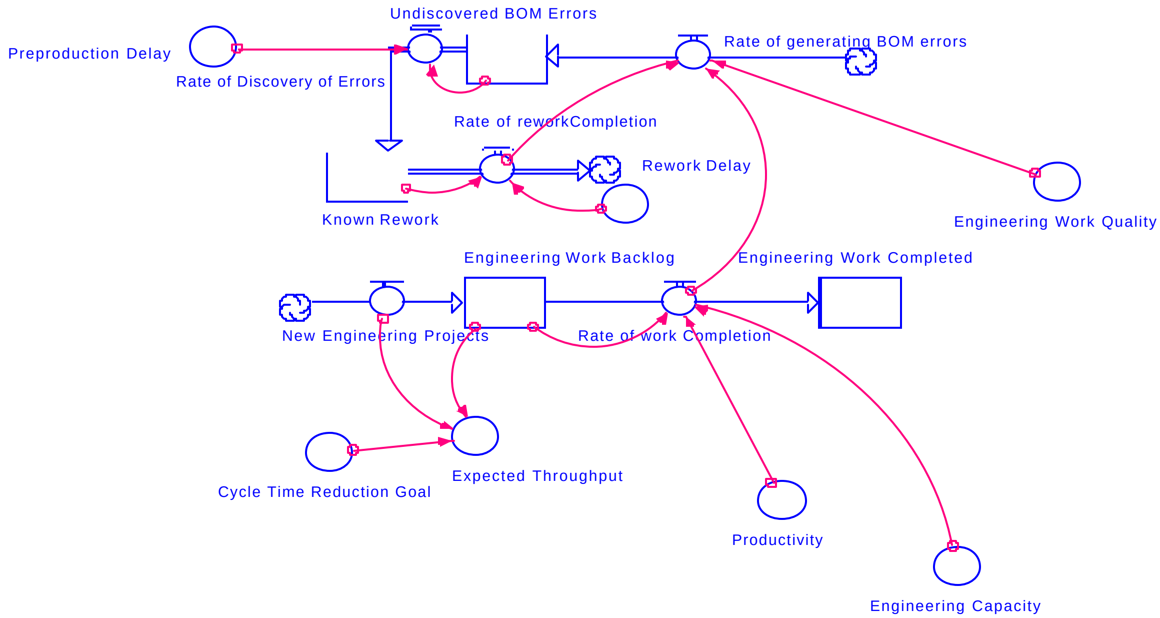

Figure 2: Basic Structure Showing How the work is Generated and Gets Done

Reference Mode: In order to understand the relationship between Engineering Work the rework and their primary duties, often leading to uncompensated overtime.

The next step was to explore the systemic structure that would combine all relevant information from Figures 2 and 3, and the discussions, to see if additional insights can be developed from the circular interdependency among interacting variables and factors.

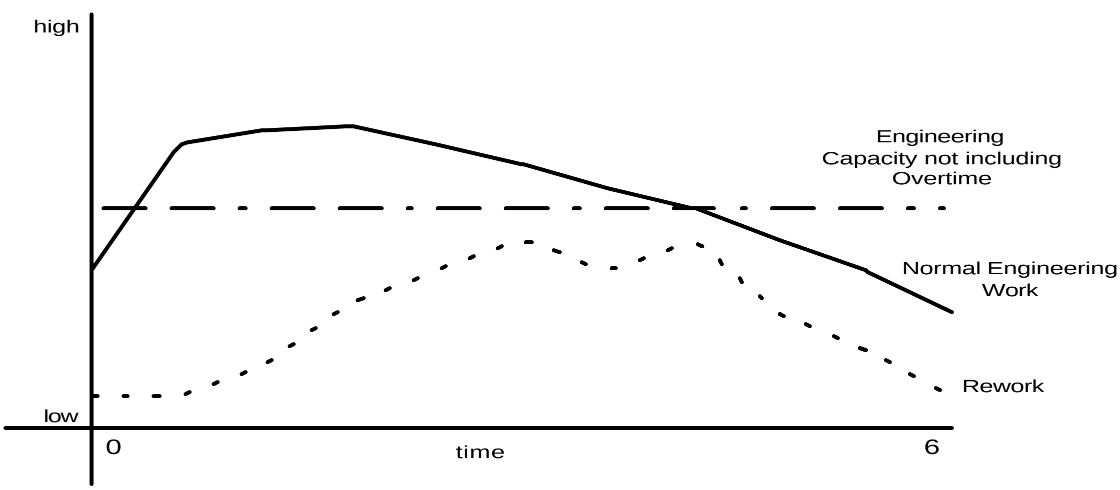

Figure 3: Relation Between Normal Engineering Work and Rework

Closing Loops: The structure shown in Figure1 was the starting point. Faced with an incoming stream of New Engineering Projects to support the Cycle Time Reduction

Goal, the first order concern is to increase the Rate of Engineering Work Completion. Operationally, there are two ways the OEM can achieve this: (1) by increasing engineering Productivity, which can be accomplished by creating schedule pressure leading to increased Intensity of Work by using all the spare time they can muster, and (2) by increasing Engineering Capacity through working overtime and /or increasing the number of engineers. Throughput Pressure is the key variable that caused engineers to pick up the pace of work and work overtime. From the product engineer's perspective, the Throughput Pressure increases from two sources: newly discovered BOM errors reduces Perceived Net Throughput, and Known Rework increases Planned Throughput well above the Expected Throughput. Figure 4 shows how productivity and quality of work loops were closed.

This first order process of regulating productivity in response to Throughput Pressure is represented by the feedback loops "B1" and "B2." Less than perfect Engineering Work Quality would generate BOM errors in some proportion to the Rate of Engineering Work Completion. The errors would be discovered during the Pre-Production Activity and accumulate into Known Rework to be taken care of immediately. Under steady and increasing inflow of New Engineering Projects, the Rate of Discovery of Errors and Known Rework will increase Throughput Pressure to further increase the Rate of Engineering Work Completion, which, in turn, increases the Rate of Generating BOM Errors. The loops "R1" and "R2" are reinforcing vicious cycles, which would become stronger and stronger during the peak periods of new project activities. These are the unintended consequences of throughput pressure.

It was pointed out that during the slack times, throughput Pressure was low, and BOM errors were attributed to design flaws or poor manufacturability. However, all Product Design Department engineers along with professionals from other functional units had gone through significant training in such topics as design for manufacturability, cross-functional team management, quality function deployment, Taguchi design of experiments, etc., and a disciplined approach to "Concept to Market" was in place.

When over a three to four month period, about fifty percent of the BOMs were returned as engineering change orders the managers were naturally alarmed. During the same period, more and more normal engineering projects were delayed. One consequence was that the reputation of Product Design Department was tarnished.

Solution Development: The team discussions also dwelled on the fact that design work consisted of creative, challenging, and interesting tasks. Once the design engineering is complete, the responsible engineers were required to update the MRS database so downstream functional units could begin their work. The updating was tedious and mundane, was the last step performed, and consumed a very small proportion of total time allocated to a typical design project. Because during slack times, this production work was not considered to be the root cause BOM errors and because adequate training for cross-functional management was in place, it was hypothesized the engineers must commit that errors inadvertently during the MRS updating phase.

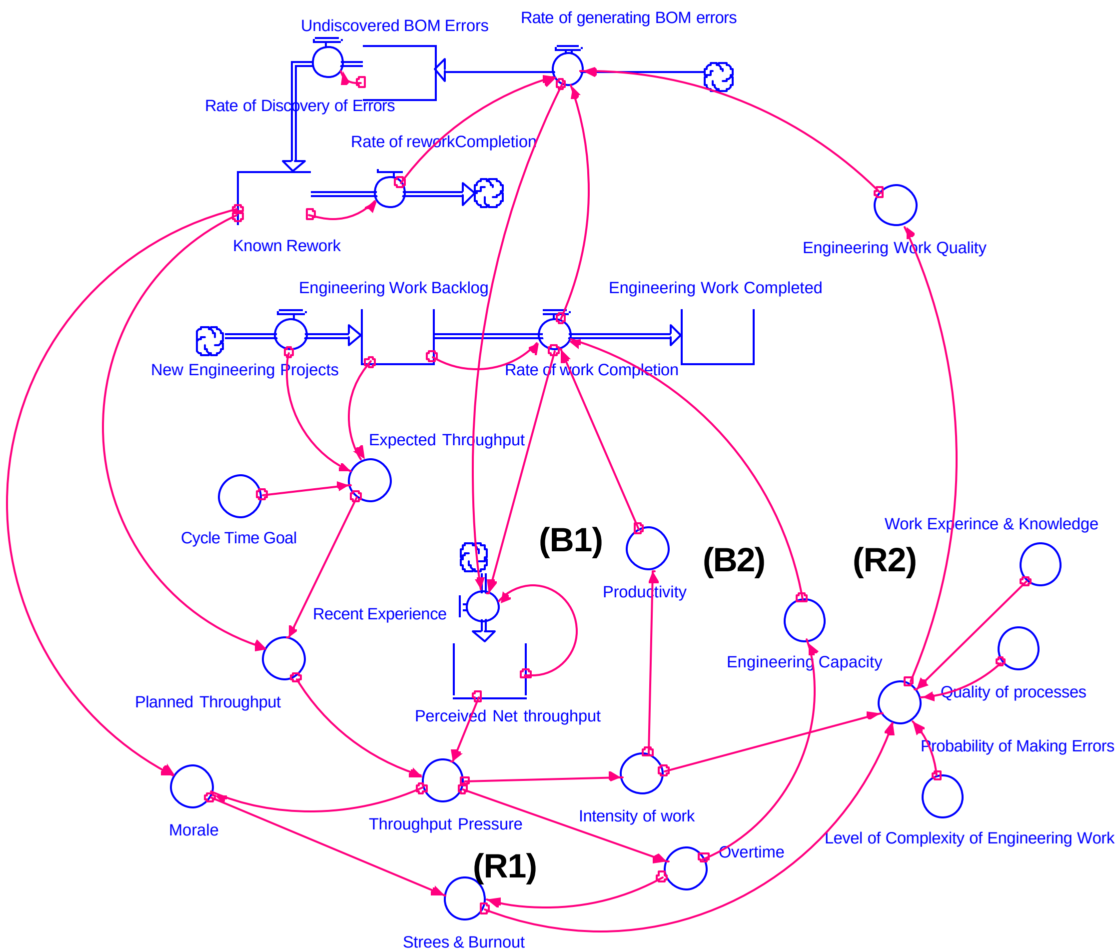

Figure 4: Closing Loops- Productivity and Quality of Engineering Work

The team now focused on finding a technological solution that might help foolproof the BOM updating process. At this point, the process of entering changes into MRS was flowcharted. Further investigation revealed that engineers had to sit in the front of a computer screen and locate all the necessary parts for the BOM from the data base; this time consuming, mundane, unexciting work was the final step that signaled the completion of a work order.

The solution focus was on modification of the organization of the BOM itself. The new BOM organization included three changes: consistency between BOMs; ease of locating parts; and reduction in the time needed to locate related parts and assemblies. This re-structuring of the BOMs increased the interface capability of Product Design Department and reduced the time necessary to create BOM. This also increased productivity. Furthermore, with increased capability, Product Design Department would face less Time Pressure, and hence less Stress and Burnout, which would decrease the likelihood of Undiscovered Rework. The proposed BOM organization in the database was targeted at ultimately eliminating BOM errors. A goal of 0.05 errors per BOM was set.

The effect of implementing the changes in database reorganization and modular BOM format resulted in less than 15% of the BOMs containing errors for the initial models hitting production in the following model year, compared to over 50% before. This number was subsequently reduced to less than 5% of all BOM when the complete product line reached production.

Case 2

Problem Background: ABC manufacturing company had been implementing some variations of TQM and TPM. They experienced very spotty successes. Even though the organization has labor unions and organized around functions, all key decision-makers in general acknowledged the importance of preventive maintenance systems and preventive measures. TQM initiatives were already underway. Training programs were widely available to all employees. In the nutshell the basic problem was a progressive battle to achieve adequate throughput, with processes that are always imperfect and with equipment that are less than reliable and people who take actions in response to variety of performance pressures.

A team was formed to look at all issues and after a while they concluded that as long as meeting customer deadlines is a high priority, they would just have to live with the situation until they could add more capacity.

Application of Systems Thinking Tools: First step was to develop a big picture using causal loops [Richmond, 1993; Wolstenholme, 1990] and try to understand various pressures in the system. Figure 5 shows the basic systemic structure, which is derived from the structure presented by Jambekar [2000]. The balancing loop B1 represents how the shipment schedule is met. A process represented by reinforcing loop R1 plays out over time. In brief, increase in planned gross throughput increases equipment utilization and over time equipment reliability goes down, which in turn increases process variation. Increased process variation manifests itself in the form of unacceptable throughput and that requires upward adjustment in the planned gross throughput.

Decreased reliability also increases frequency of breakdowns and the closed loop B2 shows restoration of equipment reliability using breakdown maintenance. The unplanned consequence is need to even further increase in planned gross throughput per period (loop R2).

Recently introduced total preventive maintenance (TPM) initiatives are shown by the loop B3. These initiatives required daily visual checks, inspection and cleaning to uncover any latent problems with the equipment and schedule preventive maintenance to address any problems. However, the operating norm dictated that as long as the equipment requiring maintenance is capable of producing, meeting shipment schedule had high priority. Over time the TPM began to wither out.

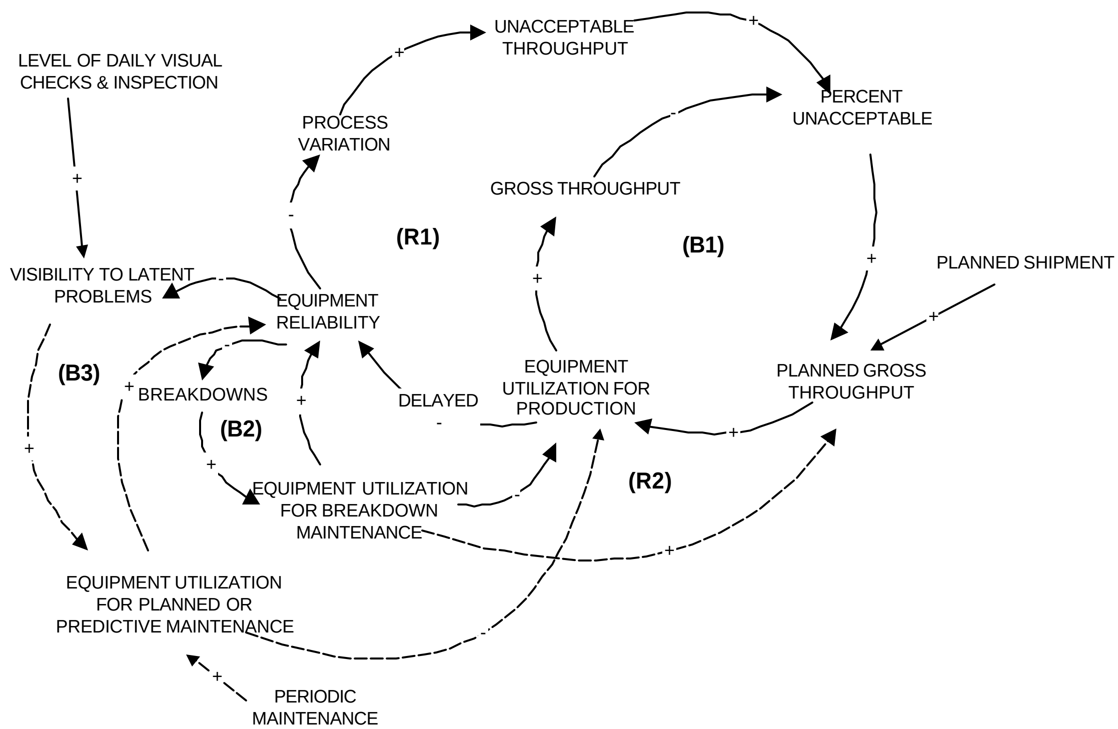

Figure 5: The Systemic Structure of The Existing Situation

Solution Development: Plant manager was there for less than two years and TPM/TQM initiatives were introduced under his watch. He wanted to see the initiatives succeed, but also realized that being customer responsive is also critical for the business. After careful deliberation, it was learned that performance of the plant was evaluated based on its ability to meet master schedule, which has been the shipping schedule. Through experience most came to realization that meeting customer-shipping schedules has higher priority than preventive maintenance. After some reflection couple of interventions were adopted. The causal structure is as shown in the figure 6.

First, by monitoring process variation using statistical process control (SPC), more visibility to latent equipment problems was created (B4) in addition to daily check, inspection and cleaning. Rules for recognizing assignable causes and their relationship to latent equipment problems were developed.

Second in order to make sure predictive and planned maintenance has high priority, Master Production Schedule (MPS), which was used to schedule customer shipments, was adjusted to reflect the maintenance-needs. Now the master schedule plans both shipments and predictive maintenance.

The MPS had time fences: demand time fence, followed by planning time fence. To allow flexibility to schedule preventive maintenance as implied by latent problems, the demand fence was increased to reflect capability to accommodate any predictive maintenance requirements. That added structure is represented by the closed loop B5, which links need for preventive maintenance to planned gross throughput. The scheme was phased in over next sixteen weeks on trial basis. Initial experience was positive. In brief, the intervention institutionalized some portion of equipment capacity for preventive maintenance.

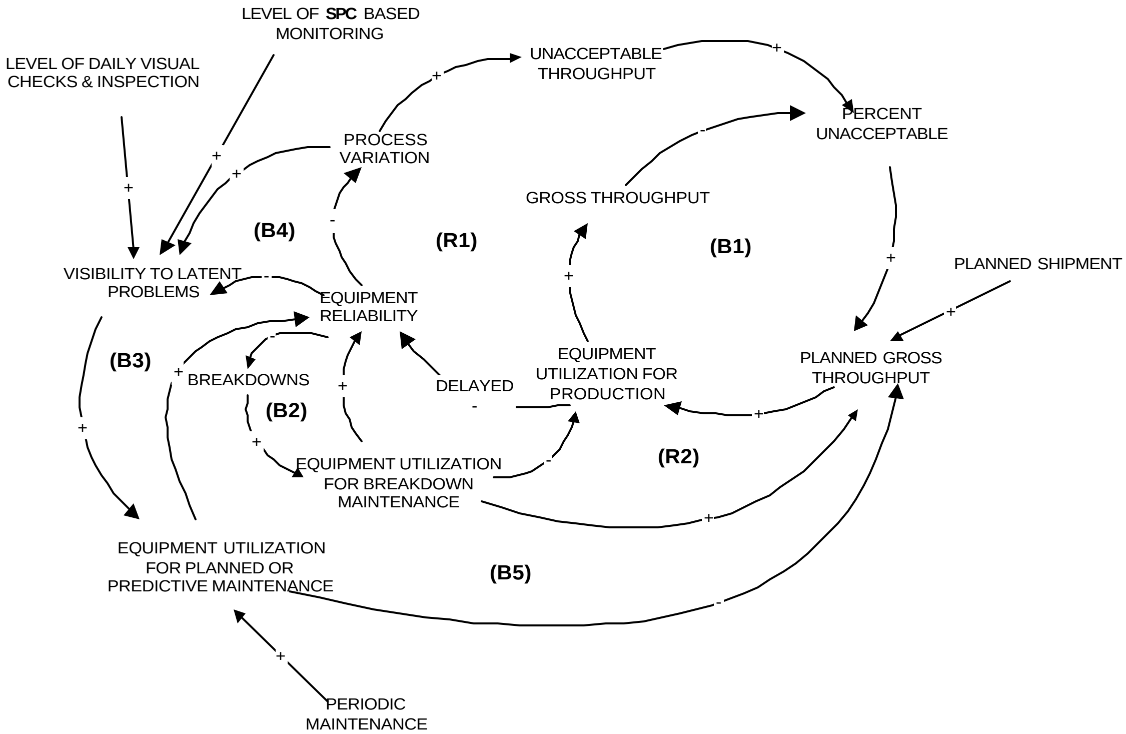

Figure 6: The Modified Systemic Structure

CONCLUSIONS

Key message of this paper is to emphasize that all work in organizations is done through processes and hence, for systems thinking tools, concepts and insights to have any influence, the process perspective must simultaneously be followed. The message is neither new nor original, but it is being re-emphasized. Systems thinking by its very nature require us to pull away in time and space to build models or interdependencies among key variables. The tools help us make the hidden problems visible. Once appropriate set of tools is applied and insights developed and communicated, it is critical that we get up close to the problems and suggest any context specific interventions.

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