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Appendix A

First Session Documentation

Script for First Meeting – Oct 19, 2003

Meeting's Objectives:

1. Group preparation to understand the method of Systems Dynamics.
2. First definition of the problem.

0800 – Meeting begins

1. Introduction of the participants: Avi C. – CEO, Yael P. – Operations Manager, Michal A. – Quality Manager (Big firm), Tiki M. - Quality Assurance employee, Daniel S. – Food Engineer (Komida), Moshe M. – Inventory Manager, Yossi C. – Maintenance Manager, Rassan M. – Shift employee (production), Amal M. – manufacturing employee.
2. Introduction of the project goal
 - a. Short description of the theoretical part of my research
 - b. Explanations about how we will do the project and the rationale behind the method
 - c. The goals the project intends to achieve

0900 – Introducing the System Dynamics approach:

1. Systems and the importance of systems thinking
2. System Dynamics
3. Two kinds of feedback loops and the SD (System Dynamics) terminology
4. Examples of applications
5. Reflection on challenges

1000 – 1030 – Break

1030 – Problem introduction

1045 – Individual opinions – divergent elicitation

1130 – Discussion and moving to convergent definition of the problem

1200 – Introducing the tasks

1215 – Closing – conclusions

1230 – Session ends.

Tangible products:

1. Schedule for all the meetings
2. Thinking challenges
3. Tasks

Conceptual products:

1. Understanding the importance of perceiving the system as a social system
2. Understanding the project's goal and the 'how' to achieve it (why is it effective to build a model? why is it important to work in group? how is the process achieved? what does the project want to achieve?)
3. Basic understanding of the systems notion and characteristics of systems
4. Basic understanding of system thinking
5. Understanding of System Dynamics – why systems are dynamic?
6. Two feedback loops and how are they described

The Theoretical Session of the First Group Meeting

1. Presentation of the project's goal:

a. A short description of the theory in my dissertation

My working assumption is that an organization is a social system and therefore in every planning and strategy setting the emphasis has to situate the human side of the system at a high level of priority. Under this assumption issues of quality management and quality assurance are also placed at high priority. As review in the literature review the methods that are recommended by the quality management discipline are the same ones recommended for the promotion of employee's satisfaction and the lowering of stress in the working place. My conclusion is that if an organization implements total quality practices in the working place, then aside from improving quality, the by-products would be improving workers' satisfaction and the lowering of stress and strain at work, thus improving employees' health in general. The more quality methods in the organization, the higher the productivity- this is due to the direct impact of quality methods and its indirect impact on employees' satisfaction and health. When productivity rises, organizational effectiveness rises. Later on, it will be explained what constitutes success and effectiveness in an organization, so that we share a common vocabulary for better communication purposes.

It has shown in the past that many organizations efforts to improve quality by adopting quality methods recommended by the quality discipline, resulted in adverse results. Instead of growing and reaping the benefits of improvement, companies found themselves in stressful situations, where they were compelled to make difficult decisions leading to drastic changes and layoffs. Such a chain of events has been the result of the way we were taught to look at the world: We do X in order to get Y and hope that the process will end at this point, without realizing that when we get Y there is an influence on X and on other issues as well. With time unexpected, effects and issues arise and everything we thought of gets more complicated and more out of control so that we found ourselves in a situation far away from where we thought and planned to be. Our first thought is to blame the quality methods we used. Consequently we look for new methods and tools. We lack the tools to understand the dynamics of the whole system. There are many examples for this scenario; I will bring one of those here:

In 1987 (Sterman et al. 1997) Analog Devices, Inc, a leader manufacturer of integrated circuits, initiated a broad-based Total Quality Management program. In a very short time quality improved dramatically: by 1990 product defects had fallen by a factor of 10, wafer yield had nearly doubled, and manufacturing cycle time had fallen by half. Such results brought expectations that Analog will grow and blossom and profitability will grow accordingly. Yet during the same period Analog's share price fell from 18.75\$ to 6.25\$, return on equity fell from 7 percent to -4 percent and Analog was forced into its first-ever layoff. This raised the question: What had happened? This phenomenon of a successful improvement process followed by unfavorable business results is known as the "Improvement Paradox". In order to explain this unreasonable phenomenon we need to adopt a systems approach in order to account for all the variables including the "soft" variables such as workers moral, commitment, the fear of job losses, competitors reaction. The improvement process in Analog had started in the manufacturing department. In a very short while they managed to reduce their defects level, boost their yields and results were amazing. In that period, organizational resources for improvement were unlimited and workers commitment was high. With time passing, more quality teams were assigned to the reorganization and management ability to support those decreases rapidly. The idea to start an improvement process on the shop floor was tempting because results were usually quick and there were positive reactions throughout the organization. Conversely, quality programs in R&D department are slow and have a long reaction time. Since quality programs started a lot later in the R&D department, management's support and company's resources were inadequate. It is important to mention that the R&D department was manned mainly with engineers who usually were less open to improvement programs and to accepting changes. The quality improvement process in the R&D lagged a lot comparing to the manufacturing department. The improvement in the manufacturing department created excess capacity which was not used since the R&D department was slow on creating new products. On the other hand, market share did not grow as expected because of the better quality of the products, and also the competitors improved their products in order to keep their market share. The only one who benefited from the quality improvements efforts was the customer who got

better products and not the improved organization. The main consequence was the unutilized manufacturing capacity in the organization.

There was another problem: Analog used unit direct costs as a key input to the pricing decision. Because they did not have the ability to allocate indirect costs fully to each product, they marked up their direct costs by a standard percentage to yield a base price level. The traditional markup ratio was 200 percent and was historically sufficient to cover indirect costs and provide a reasonable return. Between 1985 and 1989, unit production costs fell by about 16 percent, and average selling prices fell by just over 17 percent. However, indirect costs per unit fell only slightly. These costs stemmed from more complex contributors such as R&D, marketing and administration, where improvement was a lot slower and their commitment to quality was very low. By 1989 unit indirect costs had fallen only 9 percent. Analog's traditional gross margins were no longer sufficient. Operating income per unit fell by 45 percent. As earnings dropped pressure to boost share prices by cutting costs and trimming excess capacity led to layoffs. Such events hit very strongly job security, stability and commitment to quality initiatives, until Analog's competitive position was eroded.

In summary: Quality program yielded far reaching improvements in the manufacturing level, which resulted in a real decline in production costs and had almost doubled the production capacity. These results created unexpected by-products: A gap between manufacturing and R&D concerning the improvement level. Improvement created a different ratio between direct costs and indirect costs, and since pricing policies hadn't change, profitability suffered, boosting the pressure to cut costs which ended in layoffs.

This example demonstrated why our traditional system thinking is inadequate in dealing with the dynamics of complex systems. For this reason we ought to look for solutions, using different methods and new tools.

b. Rationale

i. Why create a model?

Every system is represented in our mind by the use of a certain model: a map is a model of a geographic area; an equation is a model of relationship between two variables.

When we mention a “family”, a model of parents and children is created in our mind. For each system we have certain expectations and assumptions that create a picture in our mind of how this system looks like. These are called mental models that guide us in the way we act and show us what to expect. Similarly, each one of the participants here has a “picture” of the firm, which is actually their mental model of the firm. For some of us it might be conscious and for others it maybe partially conscious but most probably our mental models of the firm will be different. Lets us consider the following example: Parents may think they have open communication with their children and that the kids consult with them on everything and peace and quiet reign in this family. However, the kids may think their parents are bossy, have no listening skills and therefore they may share little with them and do not consult much with them, leaving them to think everything is going well, in order to eliminate arguments and fights. Similarly, our mental models about systems structures and systems relationship guide us to certain behaviors. For example: If a child has a mental model of bad rewards for his bad grades, he will probably prefer not to tell his parents about the grades. He is not able to understand the far reaching consequences, resulting from his behavior, and that he puts himself in a worse position, which will actually create the very behavior, he anticipated and so much wanted to avoid. We want to “put” these models on, paper so that we can “touch” them. As long as these models are hidden in our minds, there is no way to contradict them and change them. Only when we reveal them, can we challenge, prove, disprove, understand and change them. The main goal of this model is to create a change in our perception in order to bring about out willingness to make a change.

ii. What is the importance of working in a group?

In a group modeling team, if the participants come from different sections and levels of the organization, the potential to reveal many sorts of different mental models is huge. Diversity in the group creates opportunity to all members of the group to get to know a variety of concepts and to deal with the disagreements. If the group is homogenous, for instance, made of managers only, the output will be biased according to the perception of the managers: this might bring about unexpected results. A model, which is constructed by diverse perceptions is a more genuine representation, and may serve better the whole

group or organization. In addition, in order to make a change, all participants who will have to be part of the change process, should be involved in the model and in the process of creating it, otherwise change initiatives will drive resistance instead of cooperation.

iii. What is the process itself?

After we get acquainted with the “language” of system dynamics, we will together try to define the problem, in a dynamic presentation. This means that we will try to see how the system behaves over time. We will work together to choose the variables of the problem, those that are the corner stones of the system’s structure. We will try to understand the behavior over time of those variables, and understand the relationship between the variables themselves. The end-product of this effort will be a model presenting the problem we defined in a dynamic way. The meetings are of about four hours, every three weeks. Each meeting will have a goal, whose product is a step in the process of building the model. The whole process is supposed to be a learning process, meaning that our perceptions about the problem are changing all the time. The model is supposed to help us to arrange the information we have in our mind with more clarity.

c. The intended goals of the project

The major goal of the project is to build a model of the problem, a model that is accepted by the members of all different groups in the organization, and has the ability to express the dynamics in the organization. It is expected that the model will provide the opportunity to learn what to do and how to change in order to arrive at the desired behavior of the organization. If we choose the right problem, and work together in building the model, we may have the opportunity to “play” with the model by using the computer (simulate the model) and find out the conditions that lead to the desired behavior of the system. This is a learning environment, since the participants are constantly reinforced to challenge their perceptions and to change them accordingly.

2. Introducing the field of Systems Dynamics;

a. Systems and the importance of system thinking

We live in a world of systems. A system is an entity that exists and acts as a complete unit through mutual actions between its parts. No single part in the system has any meaning as a separate part, unless it is in relation to the entire system. An amazing characteristic of systems is that no matter the kind every system can be described by very few patterns which are identical for all systems. System thinking is therefore the ability to understand the way systems behave through the relationships between their parts and the understanding of the patterns they create. Observations that are made on separate parts will lead to misunderstandings about the system as a whole. If decisions are made on the basis of those observations, they might be leading to the wrong direction.

b. System dynamics

By “System Dynamics” we refer to a method that is used in complex systems to promote learning. This method is especially useful for social systems. It is a multidisciplinary method which draws on tools from many different disciplines like: Mechanics, social psychology, economics and more. Here is a list of some common characteristics of all systems (adapted from Sterman, 2000):

i. Efforts to solve a problem usually worsen it. Efforts to stabilize a system, usually destabilize it. Our decisions may trigger resistance from those who try to conserve the present state of the system. Examples include Ceausescu’s efforts in Romania to stimulate the birth rate, but instead caused the birth rate in the long run to fall. Another example: the prevailing use of antibiotics has stimulated the evolution of drugs-resistant pathogens, including virulent strains of TB, strep, staph, and sexually transmitted diseases. Another example: Pesticides and herbicides have stimulated the evolution of resistant pests and weeds, killed off natural predators, and accumulated up the food chain to poison fish, birds, and possibly humans. Last example: Although men surrounded themselves with lots of labor-savings appliances (washing machines, dryers, etc) people have today less leisure time than they used to have 50 years ago. We can observe the same pattern in the war against terror, the war against crime and more. This characteristic stems from the inclination of systems to conserve their stability and oppose change.

ii. A change in one part of the system causes more changes in many other parts of the system, even far away parts. These are called side effects. Side effects usually are far in time and in place from the original cause. Examples include the use of steroids for infections and autoimmune disease causing the weakening of the muscles, high levels of glucose in the blood and diabetes, respiratory problems, swinging moods and osteoporosis. The more powerful the drug, the more side effects it causes. Another example is the Adler's family therapy. Instead of dealing directly with a problematic child, he suggested to work with the whole family, and change the child's problem as a side effect of the therapy.

iii. System dynamics builds on feedback between the different parts of the system. Actions we make cause a chain reaction in the system-changes in some parts entail reactions and these reactions force us to respond. A feedback is the result of a system when it gets an input that impacts the next step. We learn through feedback. For instance, when we are thirsty; we take a drink. The drink causes the body to send a signal when we are not thirsty any more than we stop drinking. Another example of a feedback system is thermostat system.

iv. In complex systems like social systems, it is difficult to establish cause and effect as they may be distant in time and in space. We usually tend to look for the cause close to the event, but we usually concentrate on the symptoms rather than on the real causes, therefore we overlook the correct issues that need to be improved. Examples include searching for a close cause for machines' breakdowns, which might be the fault of a long maintenance policy. A certain maintenance policy might also be a result of a previous action, like layoffs. Another example is a growth in the percentage of defects. This could be blamed on the lack of training, while it might be actually the result of fear in the working place due to some bad human practices.

v. Time delays in feedback channels occur when the long-term response of a system to an intervention is often different from its short-term response. High leverage policies often cause worse-before-better behavior, while low leverage policies often generate transitory improvement before the problem grows worse. Examples: prices discounts in order to boost sales- they may boost sales in the short-term, but may also cause profitability to suffer in the long-term. Conversely, investments in quality may show a reduction in

profitability in the short run because of the high investment in improvement, but after a while, the improvement in quality will cause productivity and profitability to grow. These consequences lag after the intervention, and because of people's ignorance, the immediate conclusion is that the intervention wasn't fruitful therefore we tend almost immediately to try another one (diets).

- c. Feedback loops are essential in a system. Without feedback – there is no system. There are two kinds of feedback loops in SD (System Dynamics):
 - i. A reinforcing loop – when changes in the system reinforce the initial change. The change causes an even bigger change in the same direction. Such a loop may cause an exponential growth or an exponential decay. This is the reaction of a reward, like the loop created by interest in a banking account. The birth rate is an exponential growth. Accumulation of knowledge is a reinforcing loop. Time stress is a negative reinforcing loop – the more stress the more faults and defects. The more faults and defects, the more stress.
 - ii. A balancing loop - Nothing can grow forever. With the passage of time other forces enter the system and constrain the growth. This is called – a balancing loop. This loop counteracts change. In a balancing feedback loop, a change in one of the variables cause the rest of the system to counteract the change and limit it, so that the system will remain stable and not grow out of control. A balancing loop has the mechanism to compare the state of the system to its desired state at all times. As long as a gap exists, the change still continues, otherwise, the change will stop. Most of the biological systems are balancing systems such as in human body: the respiratory system, glucose system and more. The system will act to close the gap. The smaller the gap the less the system will act until the gap is closed. This requires a measurement system to constantly monitor the gap. It works the same way with the thermostat, and also with human relations, even though we don't have precise sensors. If we are too sensitive, we might get insulted from a simple yawning we experience in a conversation. The opposite experience is also true. In every conversation there is a goal we try to achieve. During the conversation we measure constantly the gap between the present condition and our goal. We will put more efforts as long as the gap seems to increase. Inventory systems are balancing systems. Diseases

are balancing loops: the more we are exhausted, and tired, the more we tend to get sick. “Thanks” to sickness, we get some days off, have time to recover and go back to our daily routine, after we loaded the “batteries”. Stress causes us to be more susceptible to diseases: the body signals us that we are far from our comfort zone. Our immune system is a balancing system as well. Balancing systems keep the systems from falling apart.

Another well known characteristic of the balancing loops is their ability to predict the effect: If we expect something to happen, we actually cause it to happen.

d. Examples of applications

See Sterman (2000) pp. 42: The case of CarMax and Auto Nation, and the Du Pont case, pp. 66.

e. Definitions of terms

Organizational effectiveness – The degree to which the actual outcomes from the overall potential capacity of the resources of an organization meet the expected outcomes set by the organization. It can be also defined as the extent of fit between the organization’s environment and all the internal components of the social system. The more congruity that exists between the internal social system components and the environment, the more the organization is likely to exchange favorably with its environment.

Organizational efficiency - The extent of fit between the internal components of the social system. The more congruity exists between these components the more the organization will function smoothly, with relatively little dissatisfaction on the part of the organization members

Organizational Health - The capacity of an organization to engage in ongoing self-examination aimed at identifying incongruities between social systems components and developing plans for needed change in strategy (environment), structure, process, people, culture, and the dominant coalition. Such an organization is likely to maintain organizational efficiency and effectiveness in the long term.

Quality - Meeting or exceeding customers (internal and external) expectation

f. Challenges to think of: O’Connor, Joseph, and McDermott, Ian (1997) pp.

34, 78.

3. Problem Introduction

From the many interviews with all of you I have noticed that all of you care a lot and share a feel of belonging and loyalty to this place, like it is a second home for you. But I also noticed disappointment and dissatisfaction. People are not extremely happy here. Each one of you has his own reason. Some of you had expectations that didn't realize. I would like to encourage you to share your own views: Do you agree with what I have just said? Do you have anything to add? Do you think this item is important to the organization when we deal with the issue of quality improvement, or do you have any other opinion?

Moving to divergent elicitation: Each participant will have several minutes to express his opinion. I will have to record each one and collect variables and events or facts from each one. Ask Yael to record.

Moving towards convergent thinking: I will have to summarize all the issues that were revealed and I will converge them in order to find out if we all understand what had been said and if we agree on what had been said. Then we move to the next phase.

A group process to define the problem: Each participant will get a piece of paper and will have to articulate the problem as he sees it. Then all the papers will be posted on the board and the group will have to converge to one articulation of the problem.

Explanations about the tasks to prepare for the next meeting:

What are the main issues I would like for the group to discuss?

What are the important questions I would like to answer?

How can we build a better organization? What will be our cornerstones if we build a model of the organization?

How can a model be effective and be helpful to us?

First Meeting – October 19, 2003 - Tasks for the second meeting

Required Tasks: Looking for the problem to be defined

Here are several issues you have to think about and please give written answers by Wednesday, November 26, 2003. The written answers are to be given in a closed envelope to the secretary, Dikla.

1. What are the main issues you would like us to discuss in the group?
2. What are the important questions I would like to answer?
3. How can we build a better organization? What are the main ‘cornerstones’?
4. How could a model of the organization be helpful and efficient to all of us?

Optional thinking challenges

1. Challenges concerning exponential growth
 - a. Imagine folding a piece of paper in half so it was twice the thickness. How thick do you think it would be if you were able to fold it another 40 times?
 - b. You are the owner of a pond. A small water lily starts to grow in one corner. You notice it doubles in size every day. It starts very small, but after 30 days you notice it covers half the pond. You do not want it to cover the whole pond, because it would overwhelm all the other flowers, but you are busy and decide to live it until the last possible day. When will that be?
 - c. There is a legend that the game of chess was invented thousands of years ago in the Middle East as a pastime for a king. The inventor asked for a reward from the king: one grain of rice for the first square of the chessboard, two for the second and four for the third, continuing to double the last number for each subsequent square. The chessboard has 64 squares. The king knew he had hundreds of huge buildings storing the rice harvest of the kingdom, so he agreed. Was this wise?
2. Mental model challenges

- a. Three closed boxes are labeled 'Apples', 'Oranges' and 'Apples and Oranges'. Each label is incorrect. You may examine only one fruit from each box (and no feeling around allowed!) How many fruits must you examine in order to label each box correctly?
- b. Here is a set of four cards. Each has a letter on one side and a number on the other. You can only see one side of each card. What is the least number of cards you need to turn over to test the rule that vowels always have an even number on the other side?

E G 4 9

Appendix B

Second Session's Documentation

Script for Second meeting – December 12, 2003

Meeting Objectives:

1. Agreement on the articulation of the problem
2. Choosing the main variables of the problem
3. Defining the time horizon for the problem
4. Reference modes for the main variables
5. An initial model
6. First step for better communication: distinguishing between thoughts and feelings

Time Schedule:

0800 – Gathering, summarizing the first meeting and introducing the goals for this meeting

0810 – Distributing the formulation of the problem, gathering comments and do changes if desired.

0830 – Selecting the time horizon

0845 – Selecting the main variables

0900 – Reference modes – divergent activity

1000 – 1030 – Break

1030 – Convergent discussion. Agreement on the reference modes.

1100 – Selecting the boundaries of the system: choosing the endogenous variables and exogenous variables

1115 – The initial model, conclusions and homework

1130 – Discussion on the behavior rules in the meetings

1145 – First step towards a better communication: distinguishing between thoughts and feelings

Tasks:

For each of the chosen variables, think about how to measure it and write it down.

Summary and Feedback of the First Meeting

About the first part (my introduction): I felt that it was difficult for the participants to listen for a long period of time. I assumed that it was impossible to start the sessions without clarifying the terms, the method and basic ideas, in order to have a common idea about what is going on. I will be glad to receive ideas on how to do it differently and what I should avoid or add.

About the second part (the group discussion):

- a. About the 'how': I was astonished at the level of openness, relative ease of the group and the ability to verbalize thoughts and listening skills of the group. But I also found out that we could do even better at listening and expressing ourselves, so I came back to this session with several tools to improve our way of expressions and our listening skills. This will be the next part after the feedback. As for myself, I need to improve my facilitating skills, in order to progress and not to lose focus. In addition, I need to manage time better so that I won't find myself in the position of concluding the session in the middle of an issue. The end of the session is not less important than the beginning and need to be done patiently and in order. I am ready to listen to suggestion on how to deal with these issues.
- b. Concerning the content: Our point of focus in the first meeting was: **Dissatisfaction**. Each of you had to think aloud on the reasons for dissatisfaction, your expectations that didn't realize, and what you want to change and what ideas you would have. My personal belief is that in order for an external customer to be satisfied, the internal customer needs to be satisfied. An unhappy worker can rarely utilize his full potential if he is preoccupied with his inner dialog about what bothers him. Such a dialog creates friction with the system because the worker tries all the time to close the gap between the available and the desirable. It causes unwanted stress, which lowers efficiency, and a vicious circle in which the efficiency of the organization and the satisfaction of the external customer are continually affected. Lets summarize what every one said:
- c. Daniel focused on strategy. He missed the direction and the understanding of where the organization is heading in the near and far future. This lack of understanding is bothering because it doesn't give us the energy to continue when the destination is unknown.

- d. Moshe referred mainly to the deficient planning, especially to the fact that decisions are not implemented. He also referred to relationship between different subsystems in the organization that are hurt from decisions made by one subsystem without considering the needs of the other. He also raised the question on how to minimize the overall damage for the organization. According to Moshe, the problem of bad planning creates a lot of stress in the organization and limits the ability to do quality work. Decisions that change the work methods and are unilateral without giving them time to internalize slowly in the organization (namely, there is no cooperation in the decision making. Orders are given without preparation time and with no relation to workers' ability; a fact that lowers even more the capability of workers and their willingness to cooperate).
- e. Yossi continued in the same vein as Daniel, saying that also in the firm there is no strategy. In addition, decisions are made without checking their full meaning, like the ability to follow quality standards. Things like that create a lot of stress that erodes the people's capabilities in the organization. The lack of planning drives the organization to an unbalanced state between departments like maintenance and manufacturing, and maintenance has no way to deal with the "important" issues because of the "urgent" issues. All maintenance activities are reactive and not proactive.
- f. Rasan said that besides the stress that is created by the shift manager, there is a lot of stress from lack of communication, and lack of directions from above. In addition, management is not strict with the issue of cleanliness, which causes difficulties for the manufacturing system. He concurred with Yossi's complaint that maintenance lags behind the manufacturing in relation to their work capability, and he said that in Komida the situation is even worse because of more stress from the managers, even though the work itself is easier.
- g. Michal mainly referred to the whole atmosphere of stress in the organization that drives the "urgent" over the "important". According to her, there is not enough sharing of responsibilities (work sharing is a problem). As an example she brought the case of basic maintenance actions or quality control actions that are not shared by the entire workforce. The atmosphere is of ad-hoc problem solving. Management shares most of the stress, which is transferred also to the production section, which in turn is unaware of the cause of the stress and also has no control over it. Stress is behind the faults and errors, which

causes more downtime and correction, therefore is even less time for learning and improving. Michal mentioned also that there is a lot of emotional abuses as a tool to get attention.

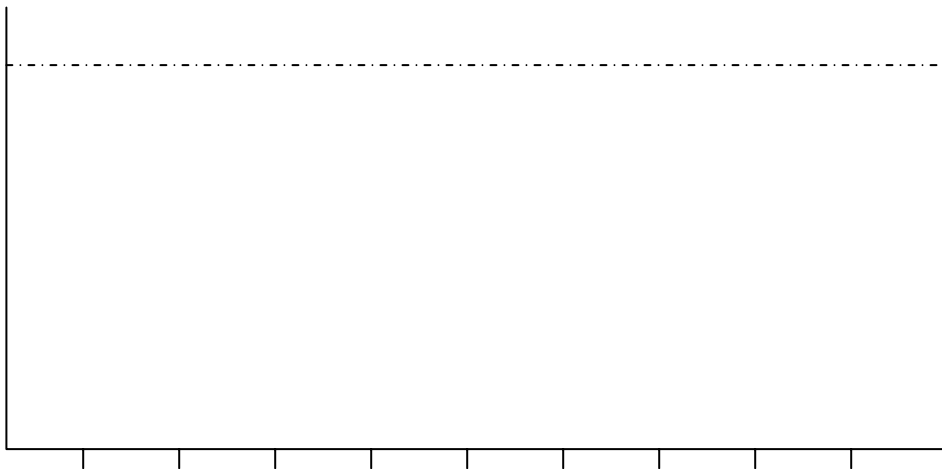
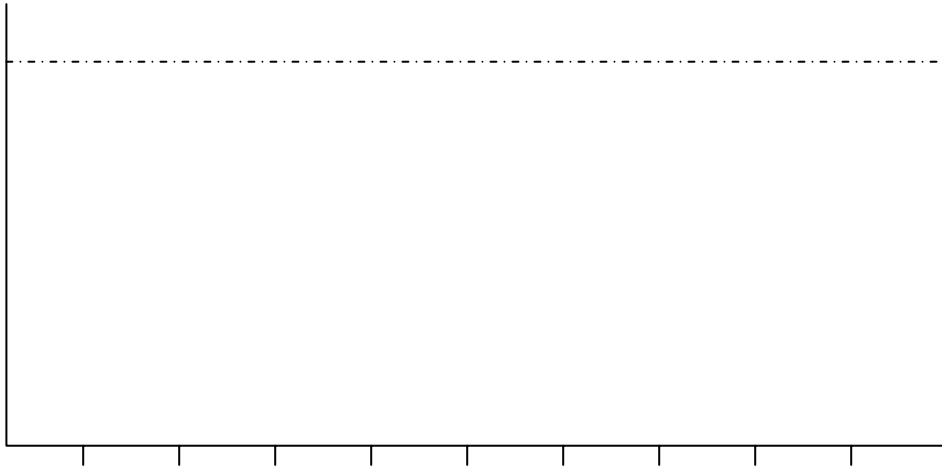
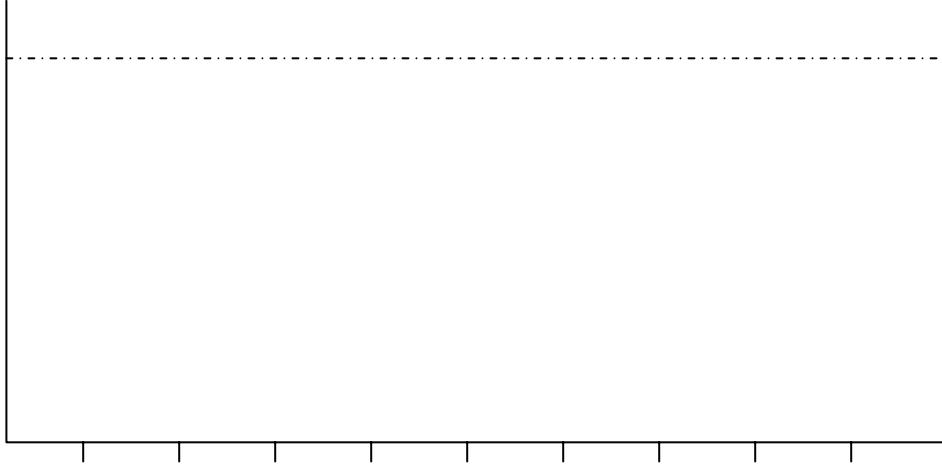
- h. Tiki expressed her hardship from the ever-growing stress at work resulting from the demanding work conditions. A lot of the stress could be relieved if management got more knowledge and more training in order to know how to share responsibilities and reduce the load. She expected that quality culture will be the heritage of everybody.
- i. Avi mentioned that much of the stress comes from within, and part of it is related to the physical structure of the organization. He concurred with the fact that they lacked in the area of management, especially regarding the sharing responsibility and avoiding repeating of tasks. Another problem: the acquisition of Komida. It created stress between different organizational cultures. There was no correlation between the rate of growth of the organization and management's capabilities. Management "chases" production. He said also that this was the most interesting place to work for. He appreciated the people he worked with for being so professional.
- j. Yael said she enjoyed the stress. Her main difficulty was the lack of balance between home and work. She did see improvement, but still the urgent tasks always come before the important ones. She believed that much of the problem lies in the way she performed her job as a manager.
- k. Amal expressed her disappointment from the way most of the production workers were doing their job. According to her, many errors occur. New workers make mistakes because of incomplete training. Senior workers make mistakes because of carelessness. Carelessness stems from problems they have at home or from dissatisfaction from the salary. In addition, turnover is very high and causes the proficiency to be very low and therefore there is a need for more training. Boredom is another problem. She is always waiting for more action and some stress so that the day will pass faster.
- l. I asked the group to list all the possible causes for dissatisfaction, and got the following list:
 - 1. Lack of personal development
 - 2. Inadequate work conditions (resources provided by management and physical environment)

3. Management's treatment
 4. Employees' moral
 5. Lack of personal responsibility
 6. Lack of good work-sharing practices
 7. Eroding work hours
 8. Boredom and routine
 9. Expectations for self actualization
 10. Excess of resources – not being efficient
- m. The session ended too fast and was not well enough organized because of time constrains. I asked everyone to write on a piece of paper what they thought of the problem and how it should be solved now. I didn't have time to gather all the responses. I gave out tasks for the second meeting. I did not have enough time to explain, and felt that I missed the end. Also, I did not have time to conclude and sum up the meeting nicely.

A Group Working Sheet – Reference Modes

Second Session – Dec 19, 2003

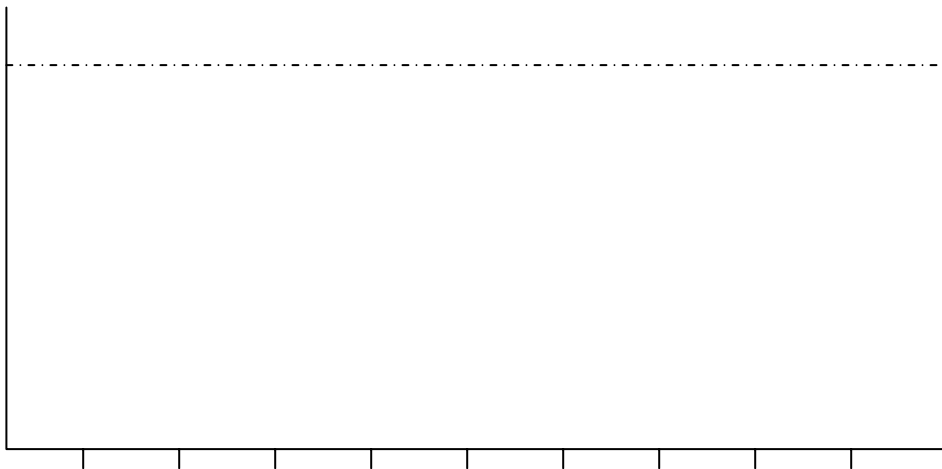
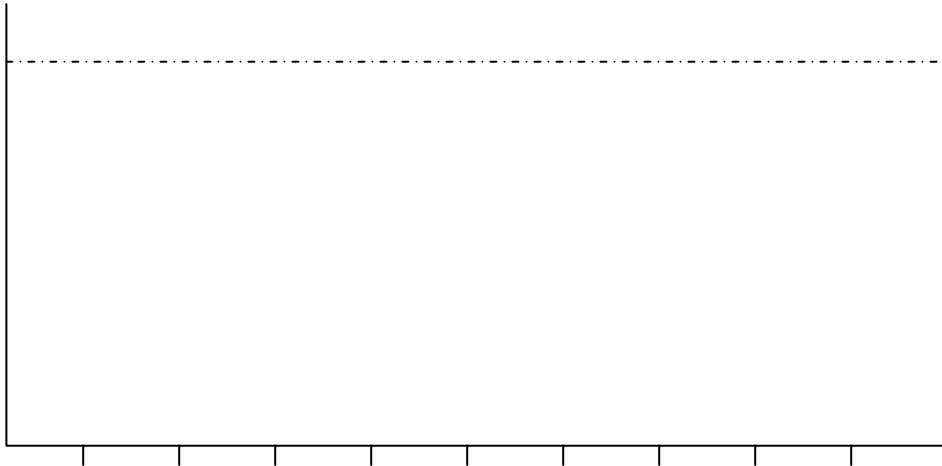
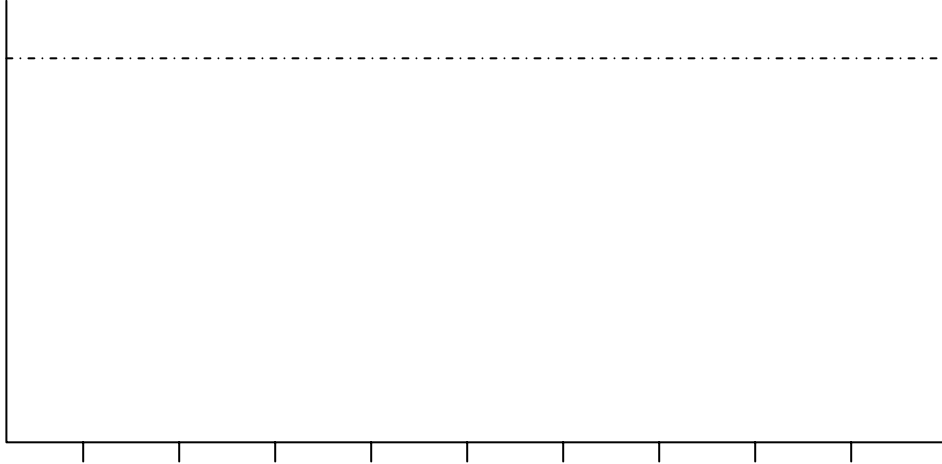
Describe the reference modes of the variables the group chose. You have to decide on the time horizon. The present time should be in the middle of the graph, so you start drawing from the past. Try to be consistent with the graphs.



A Personal Working sheet – Reference Modes

Second Session – Dec 19, 2003

Describe the reference modes of the variables the group chose. You have to decide on the time horizon. The present time should be in the middle of the graph, so you start drawing from the past. Try to be consistent with the graphs.



Definition of the Problem in the Firm

Toward the Second Meeting – Dec 10, 2003

A Working Document

The group members divided the problem definition into two levels: The organizational level and the personal level.

The Problem Definition for the Organizational Level

The problem definition at the organizational level asserts that the organization does not have a clear strategy and therefore the people working at the enterprise do not know who the customer is and what kind of service they want to offer (for example, timeliness of delivery, level of quality, etc.). Today, the organization has different customers, and the workers have no understanding about who is important and how to discriminate between the different types of customers. Therefore their managers are not capable of providing them with clear guidance with respect to work patterns: they have difficulties in developing work methods that will support organizational policies (since there are no policies or the policy is unclear). As a result, management provides short-term solutions to problems that arise over time.

When information for the workers is unclear, strain (state of nervousness that derives from mental stress) at work increases and personal stress (a physical or psychological stimulus that can produce mental tension or physiological reactions that may lead to illness) grows simultaneously. Stress causes more faults and more errors to occur, which causes more stress and more wasted time and resources. The more workers spend time with what is “urgent”, less time and resources are invested in what is “important”. Therefore less time is devoted to the development of work methods and quality improvement. This is a vicious cycle that reinforces itself.

The Problem Definition for Personal Level

The problem definition at the personal level as conceived by the group members states that for an external customer to be satisfied (for example, quality of product, quality of service), the internal customer (from the manager to the last worker) who provides the

service has to be satisfied. Only a satisfied worker will be committed to his/her work and be motivated to invest in quality and contribute to the whole quality improvement process. Management can force quality procedures only to a certain level. Quality at last, depends on the level of the worker's commitment, as long as the company provides the tools and time necessary to do the required job.

Motivation grows as long as satisfaction grows. Satisfaction increases/decreases as a result of several factors: level of interest in the work, management involvement, its relationship with workers, work conditions (personal and environmental), level of personal responsibility, level of participation, level of possible advancement or self actualization. Motivation will increase as long as the workers perceive the improvement plan as a very valuable program which can bring about very good changes. This is also contingent upon management's support of the plan which can be expressed in terms of providing adequate training and the appropriate allocation of resources. It seems also that motivation will increase when job security is guaranteed.

Conduct Codes for the Group Model Building

1. I will arrive at 8.00 AM and leave at 12.30 PM promptly.
2. I am aware of the time schedule for the meetings and I am committed to make any effort to be present in each of them. I am committed to inform the group in case of an absence.
3. During the meetings I will disconnect myself from any other activity that is not related to the model building.
4. I am committed to perform all assignments we receive on time.
5. I am committed to contribute anything I am capable of to the quality of the process. This means to internalize the content of good communication as is taught during these sessions.

Feedback Form for Session #.....Date.....

Circle your level of agreement with each of the following statements:

Content:

1. The content of the meeting today was interesting.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Totally agree Agree Indifferent Do not agree object

2. The content of the meeting today was important for the firm's needs.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Totally agree Agree Indifferent Do not agree object

Process:

3. The meeting today was efficient and informative.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Totally agree Agree Indifferent Do not agree object

4. I have moved forward in my understanding of the firm's problems and the possible solutions.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Totally agree Agree Indifferent Do not agree object

Personal:

5. I believe I can contribute to this process.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Totally agree Agree Indifferent Do not agree object

6. I believe I can learn from this process

1 _____ 2 _____ 3 _____ 4 _____ 5
Totally agree Agree Indifferent Do not agree object

7. I am happy I am part of this process.

1 _____ 2 _____ 3 _____ 4 _____ 5
Totally agree Agree Indifferent Do not agree object

8. I have enjoyed our group work today.

1 _____ 2 _____ 3 _____ 4 _____ 5
Totally agree Agree Indifferent Do not agree object

9. **If you have any comments, please express them here:**

Thanks Rina

Guidelines for Better Communication

(Adapted from Miller Sherod and Miller, A. Phyllis (1997), Core Communication, Skills and Processes, Interpersonal Communication Programs, Inc., Littleton, Co.

Every issue or subject we deal with involves three forces that influence that issue:

1. **Content** – What it concerns the main “story” of the issue? Content is a strong force. It can pull you into the situation, or it can cause you to try to move away. The more connected you are to the subject; the easier it is to lock on to content.
2. **Outcomes** – You deal with an issue to find a solution or to resolve a conflict – develop a satisfactory workable outcome.

With an issue at hand, our exchanges with others usually focus on content or end results – two forces. When we gain an agreement on the content and the outcome – we are satisfied. If not, the people involved might consider using power. It might also build resistance, pressure, and stress. Sometimes people get stuck, and their relationships are damaged.

3. **Process** – the way you deal with content and develop an outcome regarding an issue. In all exchanges, process interplay goes on, whether or not you are aware of it. Process is a third force that either supports or inhibits productive communication and satisfying issue resolution. A skilled, effective process facilitates quality content and workable outcomes that fit the situation. It pursues understanding as it works collaboratively to build agreements and consensus.

When you attend well to process – recognize its impact and put it to work for everyone involved – you can deal more effectively with complicated and difficult issues.

Some assumptions:

The 80/20 rule: About 80 percent of the time, the important content for creating satisfying outcomes to the challenging issues you face, resides inside yourself and the others involved.

It takes one person: It only takes one person to change an interaction.

Some communication styles:

1. Small and shop talks – conventional listening
2. Control, fight, and spite talk – reactive listening
3. Search talk – explorative listening
4. Straight talk – attentive listening

Straight talk – attentive listening

- Helps you discuss a difficult matter if your intentions are to connect and collaborate rather than to control and manipulate.
- Gains its real power from putting your cards/agenda on the table without playing tricks.
- Results in more helpful information and richer interchange.
- Lets you be recognized as an authority on your own experience.
- Builds trust as you share your real thoughts, feelings, and wants about issues.
- Reduces interpersonal tension, establishes rapport.
- Creates the most complete and accurate information base.
- Enhances the esteem of the players in the process.

The map of an issue

All issues, regardless of content focus, have an underlying structure. They are made up of five types of information: sensory data, thoughts, feelings, wants, and actions.

Sensory data – has two sources: external data including facial expressions, gestures, movement, posture, scent, tones and works. We use our senses to interpret these external sources. Internal data comes from inside the body: physical pain, goose bumps, fatigue, hunger, a chill, or fever. We also have intuitive sensations: these data come from our internal world of memories, associations, and dreams.

Thoughts – Thoughts are the meanings we make out of the sensory data we receive. Three basic forms of thoughts correspond generally with our past, present, and future thinking: Beliefs, interpretations, and expectations.

Words that signal thinking processes:

assumptions	guesses	judgments	opinions
benefits	reasons	metaphors	predictions
conclusions	ideas	needs	principles
evaluations	impressions	objections	values

Feelings – Our spontaneous physiological responses to our interpretation of sensory data. There are six basic emotions. Each creates a different set of physiological effects: happiness, sadness, anger, fear, disgust, and surprise. These six emotions have lots of variations:

Annoyed	anxious	ashamed	calm	cautious
Contented	comfortable	delighted	disappointed	eager
Distressed	embarrassed	elated	enthusiastic	excited
Frightened	frustrated	glad	guilty	hurt
Irritated	jealous	joyful	lonely	peaceful
Pleased	proud	relieved	satisfied	scared

Feelings come out as we make meaning of the sensory data in a situation. Because emotions reflect our interpretation of what we got through our senses, feelings are quite rational and predictable. This is why we can learn to trust our emotions as useable information. Emotions help us to judge our level of satisfaction with the process and the outcome of an issue. Since feelings are part of what is, they do not have to be justified, denied, or avoided. If we do not attend to our emotions, we miss important self information that is essential for making good decisions or resolving conflicts. Even though our emotions occur without our immediate control, once we gain awareness of them, they lose power over us. Also, as we recognize and acknowledge them, we can learn ways to manage ourselves and express them appropriately.

While using the work *feel* for think is common in our language, this use does not differentiate adequately our thoughts from our emotions. “*I feel rejected*”, “*I feel threatened*” are thoughts and not feelings. Since emotions are something that happens passively, we don’t

have any control on them. If we understand them as thoughts, we gain back the control on them and may be aware on the emotions they produce: *“I think I’m being rejected. I feel hurt and sad”*. Or *“I believe I’m being threatened. I feel scared and angry”*.

Here is a partial list of some thought words that are commonly expressed as emotions:

Abandoned	betrayed	challenged	cheated	childish
Conspicuous	deceitful	defeated	dominated	insulted
Important	persecuted	pressured	respected	rejected
Rewarded	righteous	slighted	threatened	tempted
Thwarted	unsolved	adequate/inadequate	competent/incompetent	

This list is not for use in a sequence. Any mix is right as long as it serves your communication needs.

Model Boundary Chart

Endogenous	Exogenous	Excluded
Defects and mistakes	management methods	marketing
Personal negative stress	management support	finance
Stress at work	strategy	
Satisfaction	improvement program value	
Short term solutions	job security	
Improvement results		
Effort devoted to improvement		
Commitment to improvement		
Motivation to improve		
Time devoted to development & improvement		

Appendix C

Third Session Documentation

Script for Third Meeting – January 7, 2004

Meeting's Objectives:

1. Exploring each subsystem in the organization in three categories:
 - a. The organizational structure (how things are done)
 - b. The delays: material and informational
 - c. The governing policies, decision making system and the perceptions of the system
- how they influence stresses in the subsystem
2. One more step for better communication - Wants

The desired outcomes from the meeting:

At the general level: a deeper understanding of how things are done in the organization and what causes them.

At the specific level of the model: A list of specific variables for each subsystem and the relationship between them

Time Schedule:

0800 – Gathering, summarizing the previous session, the conclusions from the feedback forms, introduction of the tasks of this meeting.

0820 – Presenting the subsystems and asking for approval.

0830 – Exploring the dynamics of the operation subsystem

0900 – Exploring the dynamics of the maintenance subsystem

0930 – Exploring the dynamics of the inventory and logistic subsystem

1000 – 1030 – Break

1030 - Exploring the dynamics of subsidiary subsystem

1100 – Exploring the dynamics of the production subsystem

1130 – Closing this part of the session – What have we learned so far

1140 – 1145 – Short break

1145 – One more step to achieve a quality process by using better communication: wants

1230 – Closing the session

Summary of the Second Meeting, December 10, 2003

After everyone read the summary of the first meeting and concurred with what was written, I gave out the problem's definition as I had formulated it from their description in the interviews. Each of the participants read the definition and following a remark on syntax, I had to read it and explain it aloud. There was a disagreement regarding the term: "Stress Strategy". Not everyone agreed with it. Moshe commented that customers want everything "instantly". Yael brought the example of the "Chicco Project" that had started one day late and the delay in supply date started to accumulate. Avi (the CEO) noted that one of firm's present strategies is to give an immediate answer to customers and to make sure that the customer is satisfied with the service. Moshe struggled with the term "satisfied". It sounded to him as lack of action, like a cat. Daniel commented that the problem formulation was too theoretical. He would like to have more specifics, less general definitions. Yael concurred with the formulation and so did Tiki and Rasan and the rest. The decision was to leave the formulation as it was.

The variables were written on the board and it was decided to accept all of them except for "strategy" on which there is no influence.

The time horizon that was chosen was 3 years. Some argued for 5 years, but gave up.

I gave out sheet of paper to graph the reference modes. The participants were divided into three groups.

Guiding Questions for the Third Meeting
Exploring the Subsystems in the Organization
(Adapted from Forrester (1961) “Industrial Dynamics”)

Introduction

Organizational ability to succeed depends on the interaction between several flows: information, orders, materials, money, personnel, and capital equipment. All these flows influence and support each other, creating changes and fluctuations that are the basis for: decisions, policies, structure, and investment alternatives.

In order to understand an industrial system we need to know three kinds of information about the system:

1. Its organizational structure
2. The delays in decisions and actions, and
3. The policies governing purchase and inventories (formal and non-formal) and how concepts about the system influence the stresses in the subsystems.

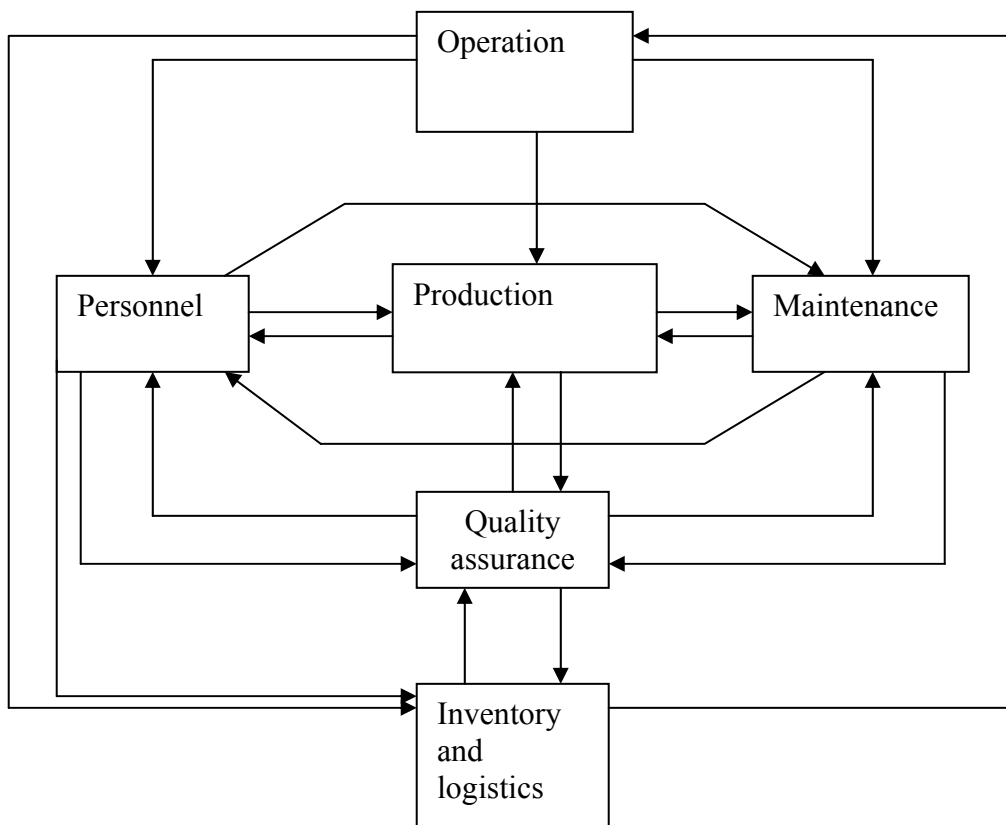
Exploring the subsystems (I have to ask these questions for each subsystem but have to modify the questions to the specific needs of each subsystem)

1. How is the physical work done in the system?
 - a. How is the information received and interpreted?
 - b. How orders are formed and how are they delivered? How does the system verify that the orders have been fulfilled? Who gets the orders and what is the operating chain?
 - c. What are the different materials the system needs for operation and how are they managed?
 - d. Is this subsystem independent concerning money flow?
 - e. Personnel – how are people hired, assigned, evaluated, advanced, laid-off, and motivated?
 - f. Equipment and machines – how are they purchased, maintained and replaced?
2. Delays:
 - a. Material delays – count all the delays the process imposes , explain them (what is planned and what is not)
 - b. Informational delays – changes in the system require processing information and it takes time to change mental models and make the desired change.

3. What are the governing policies?
 - a. What is the formal decision making system?
 - b. What is the non-formal decision making system?
 - c. What is your concept of the system?
 - d. Where are the main stresses in the system formed, how and why?

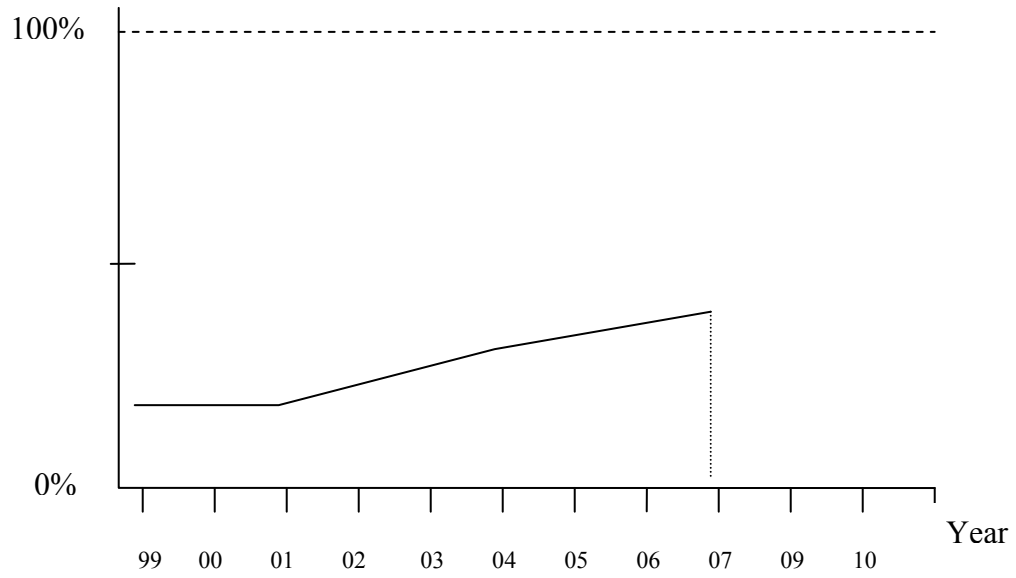
Subsystems List

An initial conceptual model of the relationships between the subsystems:

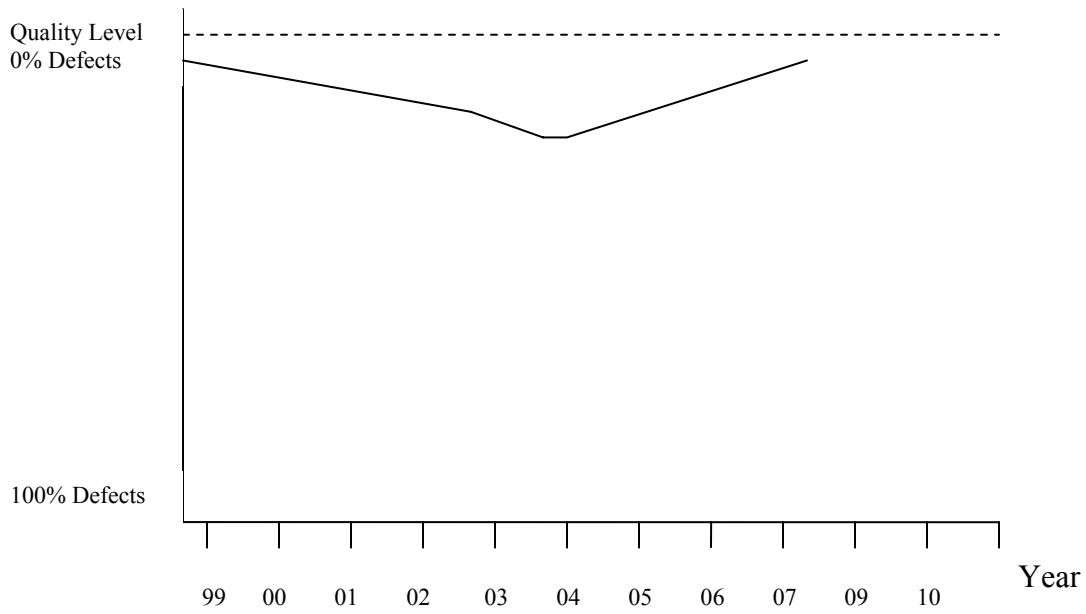


Reference Modes

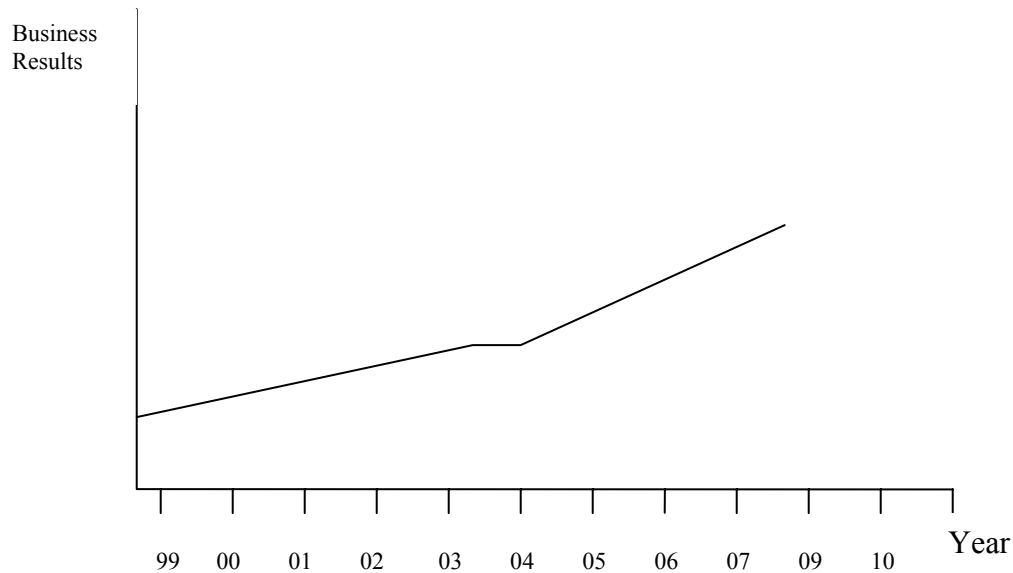
Time Devoted to Improvement



Quality Level



Profitability

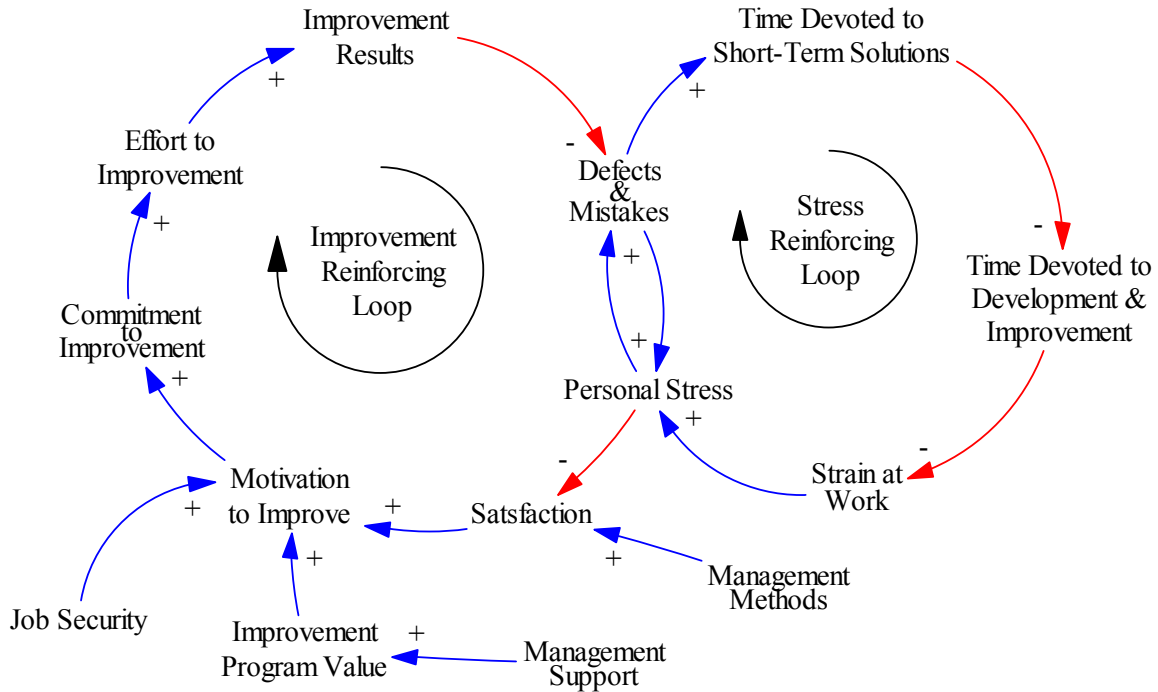


Conclusions:

Although there were differences between the reference modes, it is obvious that all demonstrate the link between investment in quality, level of quality outcomes and profitability. In addition, all participants hoped to see improvement in these three areas.

I asked all participants to graph reference modes about their individual contribution to improvement, their level of stress and their motivation level. It was impossible to aggregate these graphs. I might not have explained what I meant clearly enough, because they didn't link all the graphs as I intended them to do.

At the end of the session I showed them a causal loop diagram, linking all the variables they chose:



In the second part of the session we worked on improving communication:

I explained that in every discussion we choose a topic or subject that we are interested in, in order to arrive at some results that will satisfy everyone, through a process of communication and information transfer. The quality of the process is important if adequate results are required for the benefit of all participants.

A good communication process has several steps: collecting data through our senses, interpreting the information into thoughts, understanding the emotions that overrun us as a result from our thoughts, the awakening of desires to do something or to be something, and the actions.

I asked everyone to graph his level of awareness to his emotions, against his quality of communication. I expected that most of us would evaluate ourselves high in quality of communication and low in our awareness about our emotions. It turned out that most of us considered ourselves high in our awareness about our emotions, and less high about our quality of communication. In an exercise we did later, we found out that most of us were not at all aware of the emotions that overrun us. We anticipated a linear correlation between our level of awareness about our emotions and our quality of communication because of the

information that comes from within which we can use for our purposes. I also asked everyone to grade each of the other participants in reference to his communication abilities.

In order to sharpen the distinction between thoughts and emotions, I “threw” a sentence at each participant and ask them to write on a sheet of paper the thoughts the sentence evoked and the emotions that came after that. From the discussion afterwards we found that most of us were not aware of the emotions that overrun us, so we could not put them into use as another source of important information. Most of us do not even distinguish between thoughts and feelings, and we lack the terminology to express our emotions.

When we compared the self evaluation about quality of communication against the average grade everyone received from others, we found a real gap (only Yael and Rasan were close to what they received). The only conclusion from this exercise is that we see us in a different light than others, and that it is important to listen once in a while to what other think about us and learn from that.

Wants

Wants – there are three types of wants:

To be: healthy, honest, respected, appreciated, liked, successful

- ✓ **To do**: compete, finish a project, collaborate, get even, change jobs
- ✓ **To have**: a different car, good friends, a ticket to a concert

Wants are an inclination to act. They motivate and energize us. Sometimes wants start as a vague dream or fantasy and then turn into specific objectives. They are translated into future actions. By themselves, wants do not change things. Wants can either blend together or compete with one another. Hidden wants (perhaps because they are not acceptable to us or others) become hidden agenda. They result in confusing, misleading, or dishonest communication. Clarifying and prioritizing our wants can help focus our energy.

When we attend to wants, we often first think of self: what I desire for myself. When it comes to thinking about others, it is easy to think about what I want *from* others instead of what I want *for* others and their interest. Wants *for* others mean that I attend to and acknowledge others' interests. Wants *for* others means I want for them what they want. This demonstrates caring about others.

Caution: It is easy to want for others what we think would be good for them (what they should want). This kind of thought does not show caring, but demonstrate a superior stance – I know better what is good for him.

When we can connect with others' wants and help them achieve their objectives, we strengthen the relationship. If we don't know what others really want, we should ask them. A system that cannot or does not attend to and support each person's interests, when possible, is a system in some degree of trouble. This is diagnostic. Identifying the wants of all stakeholders in the system creates the possibility that the process we are in, will find the most desirable solution to the problem – in favor of everybody. Everybody's wants is a crucial input for the process of finding a resolution. It is therefore important to look for and clarify exactly what are the wants of the group. This is important for system thinking and for change to happen, although it is never easy.

Actions – Our verbal and nonverbal behaviors. Actions result from how we process sensory data, thoughts, and wants. Our actions are the sensory data for others. Our actions demonstrate our choices.

Basic talking skills:

1. Speak for self. This is an important rule to create attentive listening instead of ignorance and rejection. People who talk for others use words like: you, we, and everybody. This is a way to superimpose one's views on other. It generates defensiveness and resistance. People who speak for no one talk indirectly, cautiously, and in uncommitted ways. They lack authority, and others soon devalue their opinions, intentions, and feelings, too.
2. Give your observations – verbal and nonverbal.
3. Say what you think, believe, interpret and expect. Link interpretations to sensory data. This lets others know how you have drawn your conclusions.
4. Disclose your emotions directly. Try to state your emotions without using the word “feel”. That will help avoid confusing a feeling with a thought.
5. Express directly your desires for self and for others. It helps building relationship since it supports others' interests.. It makes issues more negotiable, less demanding.
6. State what you have done, or will do. When you own your own behavior, you say that you are aware, responsible and committed.

Comments on the third meeting

I finished exploring only the operation, maintenance and inventory/logistics subsystems. There were difficult discussions with a lot of blame game between the maintenance manager and the CEO and between the manager of the inventory/logistic system and the CEO. I felt I was not facilitating well and was not quite doing my job right

Later I was called to the Human Resources manager of the big firm to discuss open issues that the CEO was not satisfied with. That day I learned an important lesson. I understood that the CEO was my client and I had to serve him, no matter where my sympathy went to.

Feedback Sheet Summation
For Third meeting, January 7, 2004

Question No.	<u>Marks</u>				
	1	2	3	4	5
1	4	1	3		
2	3	3	1	1	
3	1	3	2	2	
4	2	1	2	2	1
5	2	5	1		
6	1	6	1		
7	2	5	1		
8	5	1	2		

Appendix D

Fourth Session Documentation

Script for Fourth Meeting – January 26, 2004

Meeting Objectives:

Exploring each subsystem in the organization in three categories:

- a. The organizational structure (how things are done)
- b. The delays: material and informational
- c. The governing policies, decision making system and the concepts regarding the system and how they influence stresses in the subsystem

Desired Outcomes

Agreement on the dynamics that exist in the subsystems: maintenance, inventory and logistics, and operation.

Achieving a better understanding of how things are done in the production and in the quality assurance subsystem.

Time Schedule:

0800 – Gathering, summarizing the previous session, the conclusions from the feedback forms, introduction of the tasks of this meeting.

0820 – Evaluating the model of the maintenance subsystem

0850 – Evaluating the model of the inventory and logistics subsystem

0920 – Evaluating the model of the operation subsystem

0940 – 1010 – Break

1010 - Exploring the dynamics of production subsystem

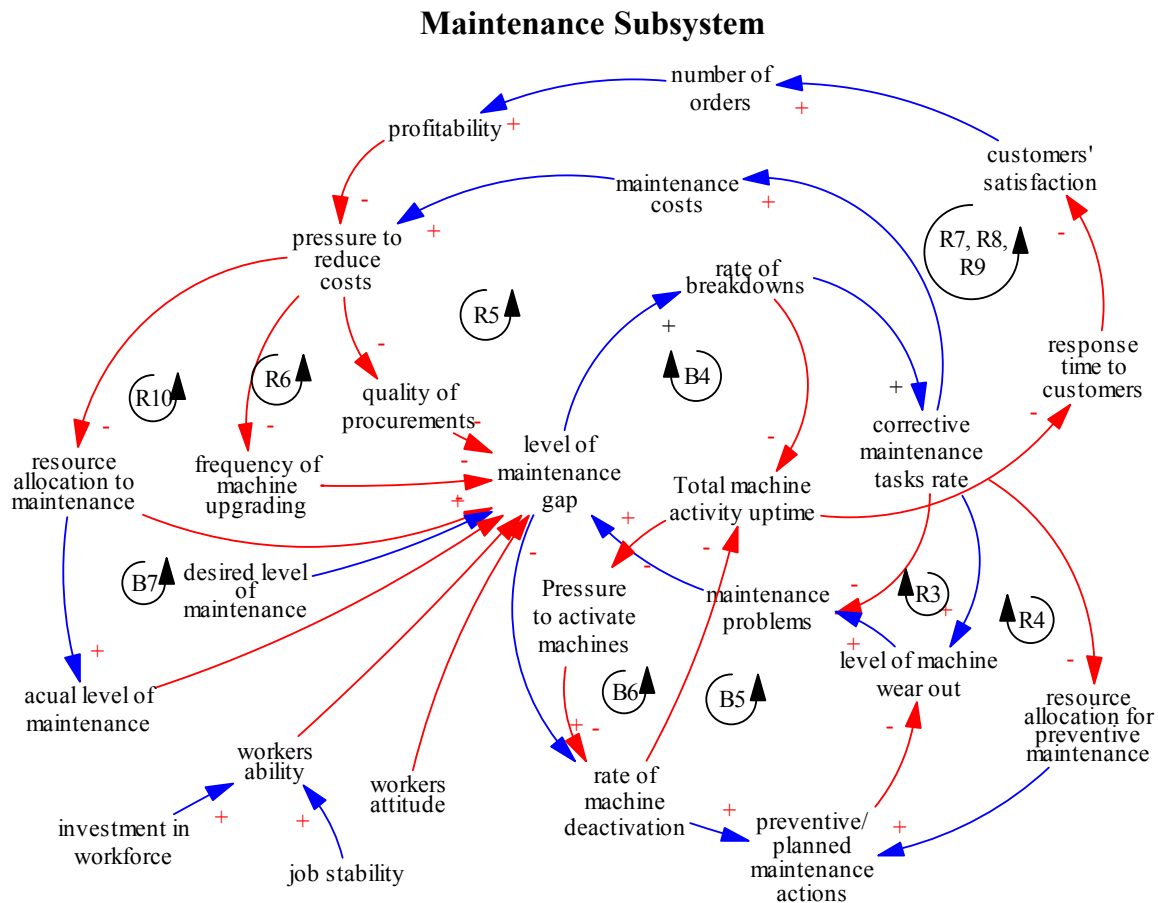
1110 – Exploring the dynamics of the quality assurance subsystem

1140 – 1145 – Short break

1145 – Summarizing what was achieved so far and what needs to be done. Hand out feedback form.

1215 – Closing the session

Dynamic Hypotheses for the Maintenance Subsystem

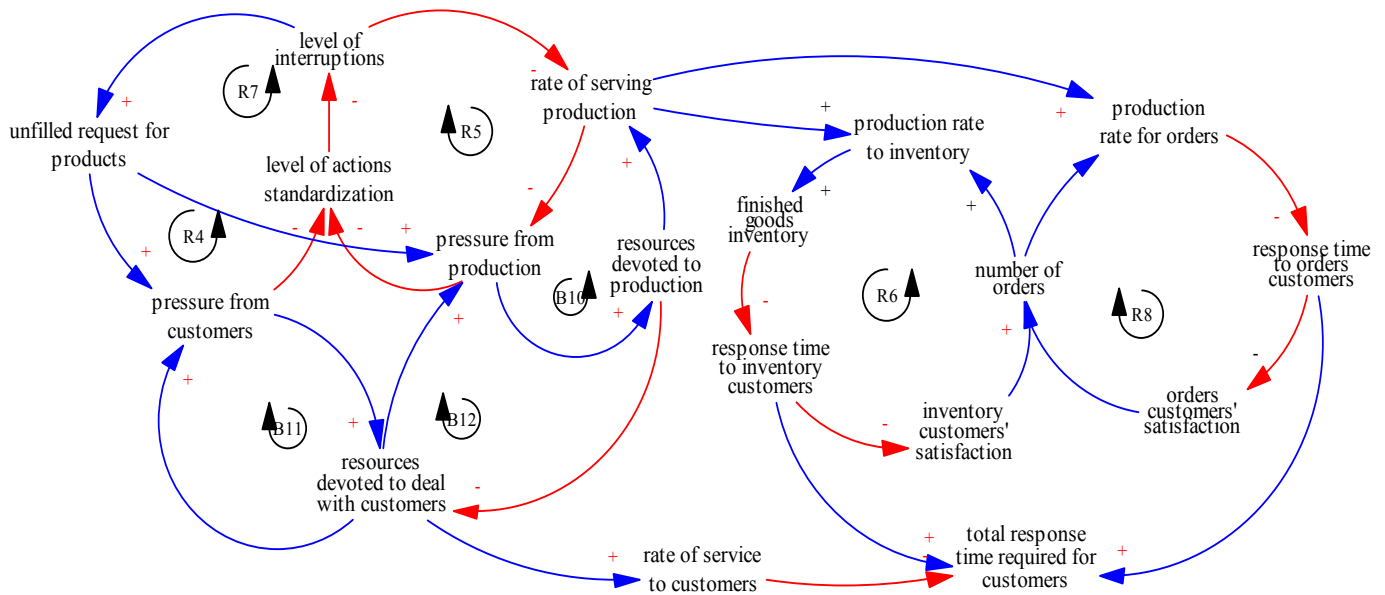


1. As the level of maintenance gap (the gap between the desired preventive maintenance and the actual preventive maintenance) increases, the rate of breakdowns increases, which causes the corrective maintenance tasks rate to increase (the urgent maintenance tasks), which lowers maintenance problems and decreases the maintenance gap (loop B4).
2. As the level of maintenance gap increases, the rate of machine deactivation increases necessitating more preventive actions. The more preventive or planned maintenance actions, the less machine wear out, less maintenance problems occur and the maintenance gap decreases (loop B5).
3. When the rate of breakdown is high, the total machine activity uptime decreases, which creates more pressure to activate the machines, which lowers the rate of machine deactivation, and the total machine activity uptime increases (loop B6).

4. When level of maintenance gap is high, there are more frequent breakdowns, more urgent maintenance actions have to be taken, and maintenance costs rise. When maintenance costs rise, there is more pressure to reduce costs. As a result, fewer resources are allocated to maintenance and the actual level of maintenance shrinks, which increases the maintenance gap (loop B7).
5. When more corrective maintenance tasks are provided, the machine wears-out faster. When the machines wear out increases, there are more maintenance problems. More maintenance problems increase the maintenance gap, and also the rate of breakdown increases, causing more corrective maintenance tasks to be needed (loop R3).
6. When more corrective maintenance tasks are provided, resource allocation for preventive maintenance shrinks, which lowers the amount of preventive/planned actions. This causes for more machines to wear out and for more maintenance problems to occur. When the amount of maintenance problems increases, it increases the maintenance gap, and also the rate of breakdown increases, causing more corrective maintenance tasks to be needed (loop R4)
7. When level of maintenance gap is high, there are more frequent breakdowns, more corrective maintenance tasks have to be taken, and maintenance costs rise. When maintenance costs rise, and there is pressure to reduce costs, the quality of procurements decreases (R5), the frequency of machine upgrade decreases (R6), and the resource allocation to maintenance is lower (R10), causing the maintenance gap to be even higher.
8. As the level of maintenance gap increases, the rate of machine breakdowns increases, causing the total machine activity uptime to decrease and the response time to customers to increase. This lowers customers' satisfaction, the number of orders and organizational profitability. Pressure to reduce costs increases. This will affect negatively (lowering) the quality of procurement (R7), frequency of machine upgrade (R8), resource allocation to maintenance (R9), all of which will increase the maintenance gap even more.

Dynamic Hypotheses for the Inventory and Logistic Subsystem

Inventory and Logistic Subsystem



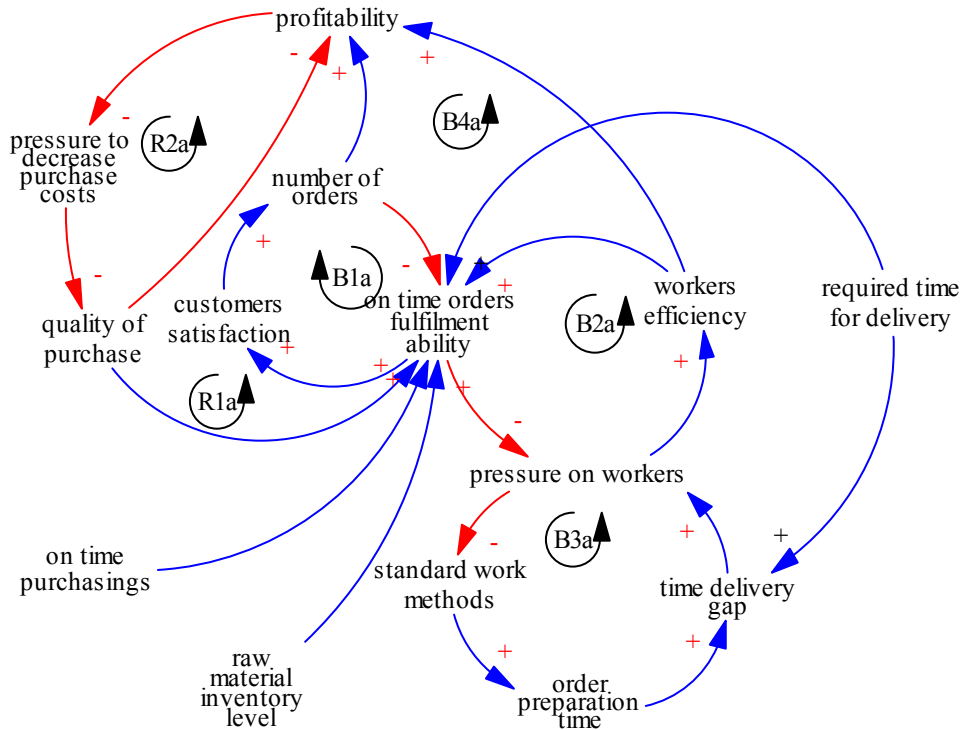
1. The more resources are allocated to production, the higher is the rate of service to production. When the rate of production is higher, there is less pressure from production to the inventory, and fewer resources are devoted to production (loop B10).
2. The more pressure from the customers the more resources are devoted to take care of them which in turn lowers the pressure from customers (loop B11).
3. The more pressure from production, the more resources are devoted to production, which decreases the resources devoted to customers, and decreases the pressure from production (loop B12).
4. When the unfilled request for products increases, it increases the pressure from customers, which causes the level of actions standardization to decrease, and therefore the level of interruptions increases, which causes the unfilled request for products to increase even more (loop R4).
5. The higher the level of actions standardization, the lower is the level of interruptions and the higher the rate of service to production, which decreases the pressure from production, causing the level of actions standardization to increase even more (loop R5).

6. The higher the rate of production for inventory the higher the amount of inventory of finished goods is. The response time to customers, who order directly from inventory is reduced, resulting in higher customer satisfaction which in turn encourages them to place orders. Consequently, a higher rate of production for inventory is required (loop R6).
7. When the unfilled request for products increases, it increases the pressure from production for inventory, which causes the level of actions standardization to decrease, and the level of interruptions to increase, which causes the unfilled request for products to increase even more (loop R7).
8. The higher the number of orders, the higher is the production rate, which lowers the response time for customers, and increases their satisfaction and increases the number of orders even more (loop R8).

Dynamic Hypotheses for the Operation Subsystem

1. When number of orders is high, the on-time orders fulfillment ability is decreased, lowering customers' satisfaction, and subsequently lowering number of orders (loop B1a).
2. When on-time orders fulfillment ability decreases, it strengthens the pressure on workers, strengthening also the workers efficiency up until a point (after that point the efficiency will decrease), strengthening the on-time orders fulfillment ability (loop B2a).
3. When standard work methods is high, it increases the order preparation time, which increases the time delivery gap (the gap between the time it was supposed to be delivered and actual delivered time), increases the pressure on workers, which results in decreasing standard work methods (loop B3a).
4. When on-time orders fulfillment ability decreases, it increases the pressure on workers, increasing also the workers efficiency (to a point), and increasing organization profitability. Subsequently, decreasing the pressure to decrease purchase costs, which increases the quality of purchase and increases on-time orders fulfillment ability (loop B4a).

Operation Subsystem



5. When on-time orders fulfillment ability decreases, it increases the pressure on workers, which results in decreasing standard work methods, lowering the order preparation time and time delivery gap. This in turn lowers also the pressure on workers, the workers efficiency, and organization profitability, thus increasing the pressure to decrease purchase costs, and decreasing quality of purchase, decreasing on time orders fulfillment ability (loop R1a).
6. When the on-time orders fulfillment ability decreases, this decreases customers' satisfaction, and subsequently decreases the number of orders, which in turn decreases organization profitability. This increases the pressure to decrease purchase costs, which decreases quality of purchase, and decreases even more the on-time orders fulfillment ability (loop R2a).

Feedback Form Summary
For the Third meeting, Jan 7, 2004

Marks

<u>Question #</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
1	4	1	3		
2	3	3	1	1	
3	1	4	1	2	
4	2	2	1	2	1
5	2	5	1		
6	1	6	1		
7	2	5	1		
8		5	1	2	

The results demonstrate the differences within the group. There were several participants who were not satisfied and came out very disappointed while others (who could express themselves) felt very good and thought it was a good meeting.

Appendix E

Fifth Session Documentation

Script for Fifth Meeting – February 16, 2004

Meeting Objectives:

1. Finish understanding production subsystem.
2. Explore the personal subsystem
3. Revisit problem definition. If required, make changes.
4. Choose the important dynamic hypotheses
5. Understand how structure influences the behavior of a system

Desired outcomes

An updated definition of the problem with a list of the major variables that are responsible for creating the problem

Schedule:

0800 – Gathering, conclusion from previous meeting, distribution of feedback summary of last meeting, and presenting today's meeting's targets.

0820 – Discussion about the production subsystem

0840 – Discussion about the personal subsystem

0900 – Displaying the structure of the quality subsystem and asking the group for a conceptual agreement

0910 - Displaying the structure of the production subsystem and asking the group for a conceptual agreement

0920 - Displaying the structure of the personal subsystem and asking the group for a conceptual agreement

0930 – Distributing the list of the dynamic hypotheses of all subsystems and the definition of the problem and examining individually the adequacy of the problem definition

0940 – Work in groups toward a new definition of the problem if necessary.

0950 – Achieving consensus about the problem definition

1000-1030 – Break

1030 – Working in groups- choosing the important variables according to the problem definition.

1050 – Achieving consensus about the important variables.

1100 – A theoretical discussion: how does the structure of a system influence its behavior

1140–1145 – A short break

1145 – Working in groups- the behavior of the main variables over time

1230 – Closing the session

Paperwork to deliver:

Schedule

Fourth meeting's feedback form summary

Feedback form for the present session

List of the dynamic hypotheses of all subsystems

Problem definition from the second meeting

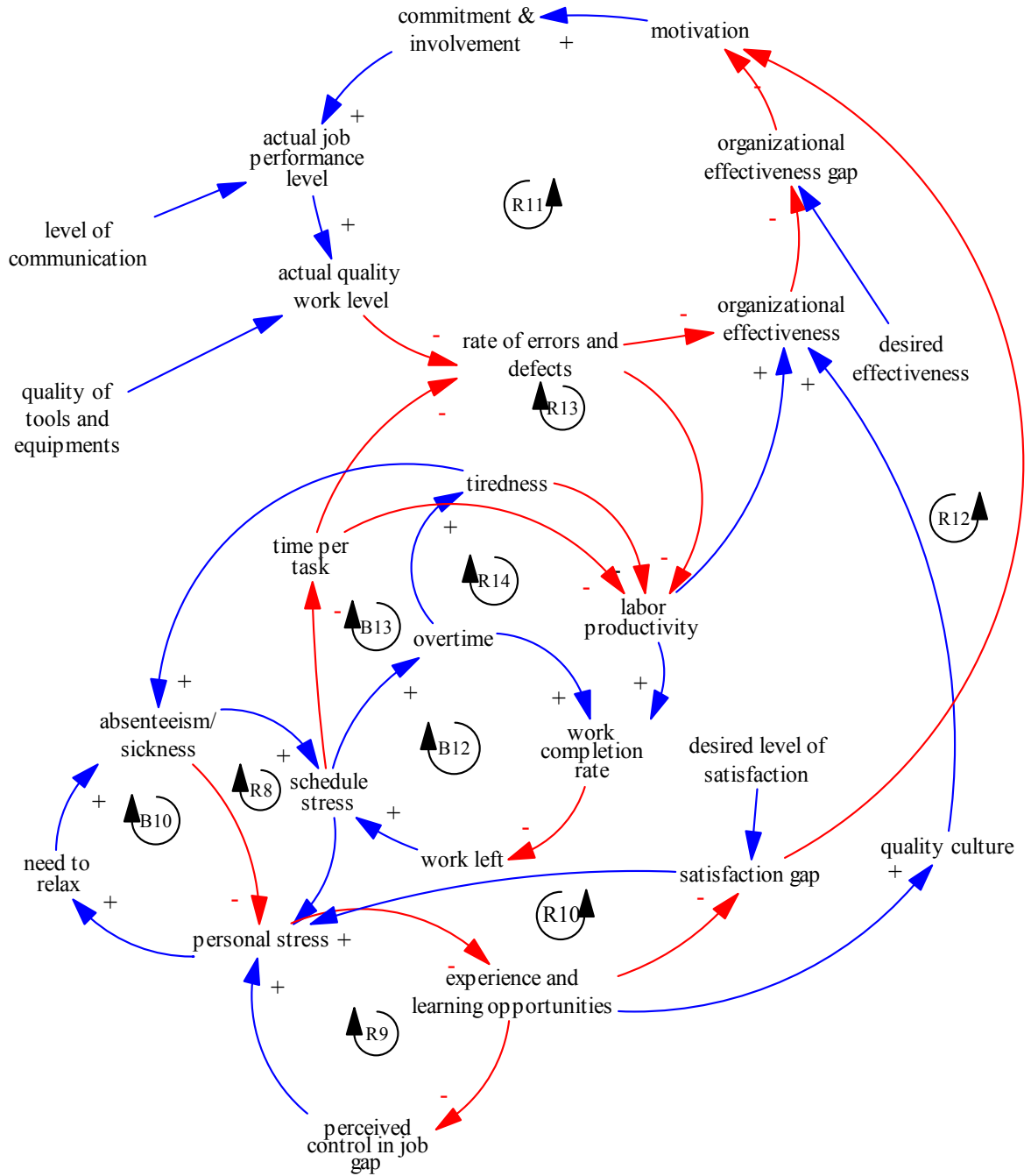
Questions about the personal subsystem:

Facilitating questions for Amal and Rasan

1. What is the linkage between employee's ability to learn and his personal stress?
2. How does his perception about his control over his work influence the stress he experiences?
3. How does personal stress influence his work satisfaction?
4. When an employee's perception about an organizational effectiveness is negative, how does it influence his motivation?
5. What kinds of things support an employee in his work so that he can do his job better?
6. What drives motivation more: warm attitude and support from management or a higher salary?
7. What drives motivation more: investment in development of the workforce or higher salary?
8. What drives motivation more: the knowledge there is place for advancement or higher salary?
9. What causes to invest more in quality: more cooperation, more teamwork, more responsibility and decision latitude, and what else?
10. How does overtime influence employees' performance?
11. What are the causes for turnover?
12. What motivates employees to stay?
13. What are the most important work conditions for employees?
14. What are some of the reasons for absenteeism and sickness?
15. What is your perception about the level of communication in the firm?
16. The condition of tools, materials, equipment: How does it influence the quality of work of the employee?

Dynamic Hypotheses for the Personal Subsystem

Personal Subsystem

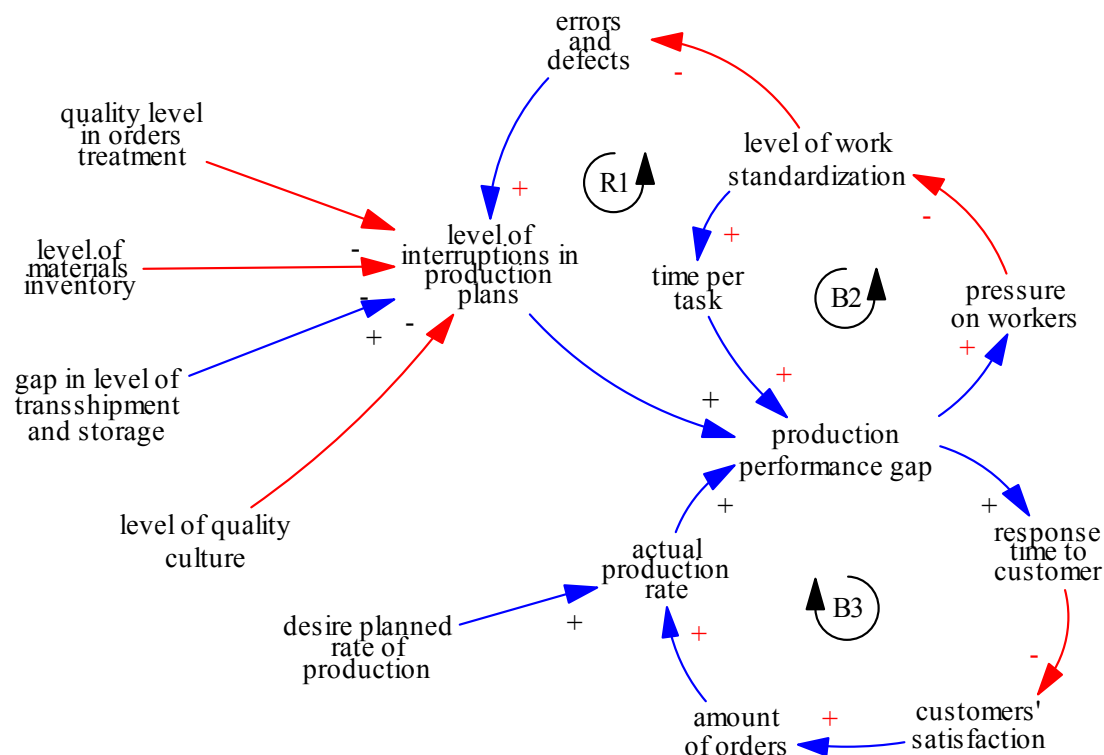


1. When personal stress increases, the need to relax increases, causing for more sickness to occur and subsequently personal stress decreases (loop B10).
2. When there is more work left undone, schedule stress increases, more overtime is needed, resulting in increased work completion rate, and subsequently decreasing work left undone (loop B12). It is important to mention that overtime in the firm is limited (no more than two to three hours are allowed). Otherwise, overtime increases work completion rate only to a degree, and thereafter more overtime decreases the work completion rate.
3. When there is more work left undone, schedule stress increases; less time per task is invested, causing labor productivity to increase, which increases work completion rate, decreasing work left undone (loop B13).
4. When personal stress increases, the need to relax increases, more sicknesses occur, schedule stress increases, increasing personal stress even more (loop R8).
5. When personal stress increases, experience and learning opportunities decrease, causing perceived control in job gap to increase, which increases personal stress even more (loop R9).
6. When personal stress is low, it enables for more experience and learning opportunities to occur, which decreases satisfaction gap, and lowers even more personal stress (loop R10).
7. When rate of errors and defects increases, organizational effectiveness decreases (the percentage between the quality products and the total number of products), causing organizational effectiveness gap to increase and motivation, commitment and involvement, actual job performance level, and also actual quality work level to decrease. This increases the rate of errors and defects even more (loop R11).
8. When more sickness occur, schedule stress increases, increasing personal stress, experience and learning opportunities decrease, increasing satisfaction gap, decreasing motivation, commitment and involvement, the actual job performance level, and actual quality work level. This increases the rate of errors and defects, lowers labor productivity and work completion rate, increasing work left undone, schedule stress, overtime and tiredness, which increases sickness even more (loop R12).

9. When there is more work left undone, schedule stress increases; less time per task is invested. This increases the rate of errors and defects, lowers labor productivity and the work completion rate, increasing work left undone even more (loop R13).
10. When there is more work left undone, schedule stress increases, more overtime is needed. This increases tiredness, which lowers labor productivity, decreasing work completion rate, and increasing amount of work left undone even more (loop R14).

Dynamic Hypotheses for the Production Subsystem

Production Subsystem



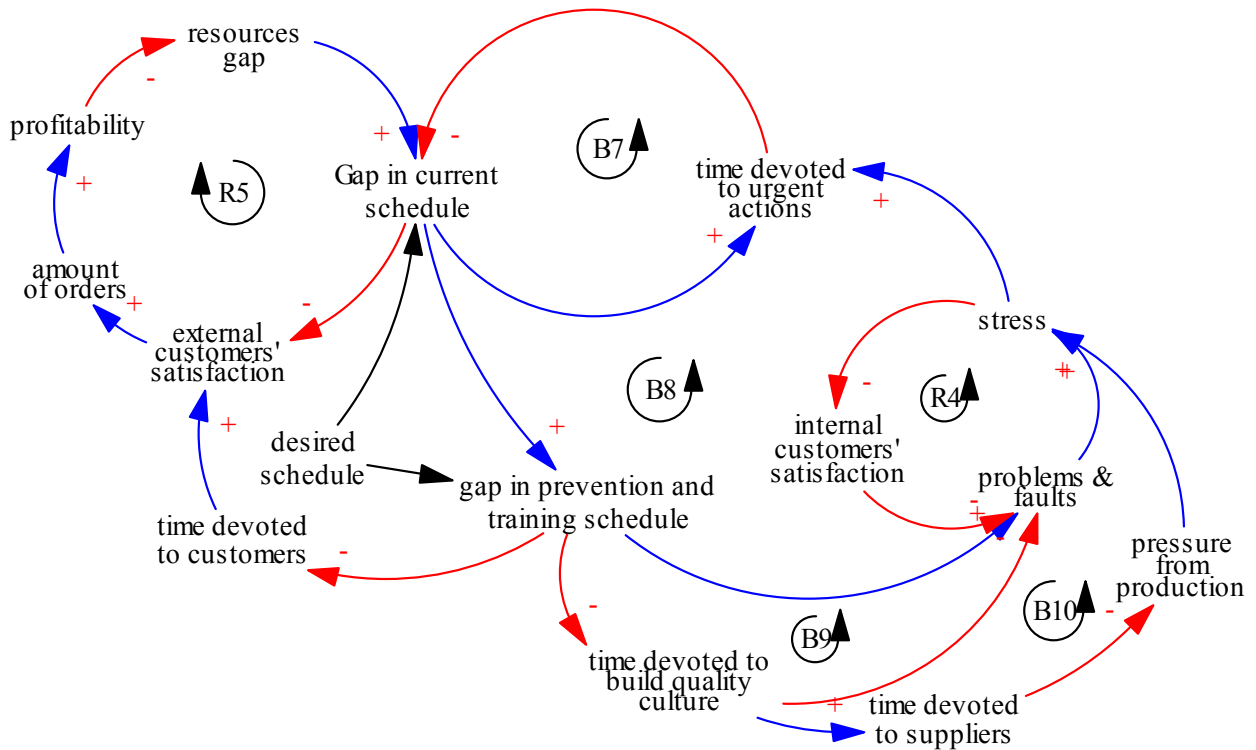
1. When the production performance gap increases, the pressure on workers increases, which decreases the level of work standardization and decreases time per task subsequently, decreases the production performance gap (loop B2).
2. When the production performance gap increases, the response time to customers increases, lowering customers' satisfaction and therefore the amount of orders lowers.

Subsequently the actual production rate decreases, decreasing the production performance gap (loop B3).

- When the production performance gap increases, the pressure on workers increases, decreasing the level of work standardization, increasing errors and defects, increasing the level of interruptions in production plan. As a result, the production performance gap increases even more (loop R2).

Dynamic Hypotheses for the Quality Assurance Subsystem

Quality Assurance Subsystem



- When the gap in current (daily) scheduled tasks (the difference between the number of completed scheduled tasks and the postponed ones) increases, the time devoted to urgent tasks increases, lowering the current schedule gap (loop B7).
- When the gap in current schedule increases, the gap in prevention and training schedule (the gap between what is done for prevention and training and what should have be done) gets bigger. This causes more problems and faults to happen, and causes more stress to

the workers subsequently influencing the time devoted to urgent actions to increase and lowering the current schedule gap (loop B8)

3. When the gap in prevention and training schedule gets bigger, time devoted to build quality culture decreases, causing more problems and faults to happen, and increasing stress to workers. This in turn increases the time devoted to urgent actions to increase and lowering the current schedule gap (loop B9).
4. When the gap in prevention and training schedule increases, time devoted to build quality culture decreases. Time devoted to suppliers decreases, increasing the pressure from production and increasing the stress to the workers, subsequently increasing the time devoted to urgent actions and lowering the current schedule gap (loop B10)
5. When stress increases, internal customers' satisfaction decreases, therefore inducing more problems and faults to happen and there is furthermore increase in stress (loop R4).
6. When the gap in current schedule is bigger, it lowers external customers' satisfaction, subsequently lowering the amount of orders and the company's profitability, resulting in the increase of the resources gap (the gap between the needed resources and the available resources) and finally the gap in current schedule increases even more (loop R5).

Dynamic Hypotheses for all Subsystems

Rank each of the following dynamic hypotheses on a scale from 5 to 1 according to the following two categories:

1. How much you agree with it (5 –very much, 1- no agreement)

2. How much is it important in reference to your firm's dynamics and our problem definition (5- very important, 1 – not important at all)

Dynamic Hypotheses for the Production Subsystem

Level of Agreement Level of Importance

B2 -When the production performance gap increases, the pressure on workers increases, which decreases the level of work standardization and decreases time per task subsequently, decreases the production performance gap.

B3 -When the production performance gap increases, the response time to customers increases, lowering customers' satisfaction and therefore the amount of orders lowers. Subsequently the actual production rate decreases, decreasing the production performance gap.

R2- When the production performance gap increases, the pressure on workers increases, decreasing the level of work standardization, increasing errors and defects, increasing the level of interruptions in production plan. As a result, the production performance gap increases even more

Dynamic Hypotheses for the Personal Subsystem

Level of Agreement Level of Importance

B10-When personal stress increases, the need to relax increases, causing for more sickness to occur, and subsequently, personal stress decreases.

B12-When there is more work left undone, schedule stress increases, more overtime is needed, resulting in increased work completion rate, and subsequently decreasing work left undone.

- B13-When there is more work left undone, schedule stress increases; less time per task is invested, causing labor productivity to increase, which increases work completion rate, decreasing work left undone.
- R8-When personal stress increases, the need to relax increases, more sicknesses occur, schedule stress increases, increasing personal stress even more.
- R9-When personal stress increases, experience and learning opportunities decrease, causing perceived control in job gap to increase, which increases personal stress even more.
- R10-When personal stress is low, it enables for more experience and learning opportunities to occur, which decreases satisfaction gap, and lowers even more personal stress.
- R11-When rate of errors and defects increases, organizational effectiveness decreases (the percentage between the quality products and the total number of products), causing organizational effectiveness gap to increase and motivation, commitment and involvement, actual job performance level, and also actual quality work level to decrease. This increases the rate of errors and defects even more.
- R12-When more sickness occur, schedule stress increases, increasing personal stress, experience and learning opportunities decrease, increasing satisfaction gap, decreasing motivation, commitment and involvement, the actual job performance level, and actual quality work level. This increases the rate of errors and defects, lowers labor productivity and work completion rate, increasing work left undone, schedule stress, overtime and tiredness, which increases sickness even more.

R13-When there is more work left undone, schedule stress increases; less time per task is invested. This increases the rate of errors and defects, lowers labor productivity and the work completion rate, increasing work left undone even more.

R14-When there is more work left undone, schedule stress increases, more overtime is needed. This increases tiredness, which lowers labor productivity, decreasing work completion rate, and increasing amount of work left undone even more.

Dynamic Hypotheses for the Quality Assurance Subsystem

Level of Agreement Level of Importance

B7-When the gap in current (daily) scheduled tasks (the difference between the number of completed scheduled tasks and the postponed ones, which the ones there are completed it that day) increases, the time devoted to urgent tasks increases, lowering the current schedule gap.

B8- When the gap in current schedule increases, the gap in prevention and training schedule (the gap between what is done for prevention and training and what should have be done) gets bigger. This causes more problems and faults to happen, and causes more stress to the workers subsequently influencing the time devoted to urgent actions to increase and lowering the current schedule gap.

B9-When the gap in prevention and training schedule gets bigger, time devoted to build quality culture decreases, causing more problems and faults to happen, and increasing stress to workers. This in turn increases the time devoted to urgent actions to increase and lowering the current schedule gap.

B10-When the gap in prevention and training schedule increases, time devoted to build quality culture decreases. Time devoted to suppliers decreases, increasing the pressure from production and increasing the stress to the workers, subsequently increasing the time devoted to urgent actions and lowering the current schedule gap.

R4-When stress increases, internal customers' satisfaction decreases, therefore inducing more problems and faults to happen and there is furthermore increase in stress.

R5-When the gap in current schedule is bigger, it lowers external customers' satisfaction, subsequently lowering the amount of orders and the company's profitability, resulting in the increase of the resources gap (the gap between the needed resources and the available resources) and finally the gap in current schedule increases even more.

Dynamic Hypotheses for the Inventory and Logistic Subsystem

Level of Agreement	Level of Importance
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B10-The more resources are allocated to production, the higher is the rate of service to production. When the rate of production is higher, there is less pressure from production to the inventory, and fewer resources are devoted to production.

B11-The more pressure from the customers, the more resources are devoted to take care of customers, which in turn lowers the pressure from customers.

B12-The more pressure from production, the more resources are devoted to production, which decreases the resources devoted to customers, and decreases the pressure from production.

R4-When the unfilled request for products increases, it increases the pressure from customers, which causes the level of actions standardization to decrease, and therefore the level of interruptions increases, which causes the unfilled request for products to increase even more.

R5-The higher the level of actions standardization, the lower is the level of interruptions and the higher the rate of service to production, which decreases the pressure from production, causing the level of actions standardization to increase even more.

R6-The higher the rate of production for inventory the higher the amount of inventory of finished goods is. The response time to customers who order directly from inventory is reduced, resulting in higher customer satisfaction which in turn encourages them to place orders. Consequently, a higher rate of production for inventory is required.

R7-When the unfilled request for products increases, it increases the pressure from production for inventory, which causes the level of actions standardization to decrease, and the level of interruptions to increase, which causes the unfilled request for products to increase even more.

R8-The higher the number of orders, the higher is the production rate, which lowers the response time for customers, and increases their satisfaction and increases the number of orders even more.

Dynamic Hypotheses for the Maintenance Subsystem

Level of Agreement **Level of Importance**

B4-As the level of maintenance gap (the gap between the desired preventive maintenance and the actual preventive maintenance) increases, the rate of breakdowns increases, which causes the corrective maintenance tasks rate to increase (the urgent maintenance tasks), which lowers maintenance problems and decreases the maintenance gap.

B5-As the level of maintenance gap increases, the rate of machine deactivation increases, necessitating more preventive actions. The more preventive or planned maintenance actions, the less machine wear out, less maintenance problems occur and the maintenance gap decreases.

B6-When the rate of breakdown is high, the total machine activity uptime decreases, which creates more pressure to activate the machines, which lowers the rate of machine deactivation, and the total machine activity uptime increases.

B7-When level of maintenance gap is high, there are more frequent breakdowns, more urgent maintenance actions have to be taken, and maintenance costs rise. When maintenance costs rise, there is more pressure to reduce costs. As a result, fewer resources are allocated to maintenance and the actual level of maintenance shrinks, which increases the maintenance gap.

R3-When more corrective maintenance tasks are provided, the machine wears out faster. When the machines wear-out increases, there are more maintenance problems. More maintenance problems increase the maintenance gap, and also the rate of breakdown increases, causing more corrective maintenance tasks to be needed.

R4-When more corrective maintenance tasks are provided, resource allocation for preventive maintenance shrinks, which lowers the amount of preventive/planned actions. This causes for more machines to wear out and for more maintenance problems to occur. When the amount of maintenance problems increases, it increases the maintenance gap, and also the rate of breakdown increases, causing more corrective maintenance tasks to be needed.

R5, R6, R10-When level of maintenance gap is high, there are more frequent breakdowns, more corrective maintenance tasks have to be taken, and maintenance costs rise. When maintenance costs rise, and there is pressure to reduce costs, the quality of procurements decreases (R5), the frequency of machine upgrade decreases (R6), and the resource allocation to maintenance is lower (R10), causing the maintenance gap to be even higher.

R7, R8, R9-As the level of maintenance gap increases, the rate of machine breakdowns increases, causing the total machine activity uptime to decrease and the response time to customers to increase. This lowers customers' satisfaction, the number of orders and organizational profitability. Pressure to reduce costs increases. This will affect negatively (lowering) the quality of procurement (R7), frequency of machine upgrade (R8), resource allocation to maintenance (R9), all of which will increase the maintenance gap even more.

Dynamic Hypotheses for Operation Subsystem

Level of Agreement Level of Importance

B1a-When number of orders is high, the on-time orders fulfillment ability is decreased, lowering customers' satisfaction, and subsequently lowering number of orders.

B2a-When on-time orders fulfillment ability decreases, it strengthens the pressure on workers, strengthening also the workers efficiency up until a point (after that point the efficiency will decrease), strengthening the on-time orders fulfillment ability.

B3a-When standard work methods is high, it increases the order preparation time, which increases the time delivery gap (the gap between the time it was supposed to be delivered and actual delivered time), increases the pressure on workers, which results in decreasing standard work methods.

B4a-When on-time orders fulfillment ability decreases, it increases the pressure on workers, increasing also the workers efficiency (to a point), and increasing organization profitability. Subsequently, decreasing the pressure to decrease purchase costs, which increases the quality of purchase, and increases on-time orders fulfillment ability.

R1a-When on-time orders fulfillment ability decreases, it increases the pressure on workers, which results in decreasing standard work methods, lowering the order preparation time and time delivery gap. This in turn lowers the pressure on workers, the workers efficiency, and organization profitability, thus increasing the pressure to decrease purchase costs, decreasing quality of purchase, and decreasing on-time orders fulfillment ability.

R2a-When the on-time orders fulfillment ability decreases, this decreases customers' satisfaction, and subsequently decreases the number of orders, which in turn decreases organization profitability. This increases the pressure to decrease purchase costs, which decreases quality of purchase, and decreases even more the on-time orders fulfillment ability.

Comments on the Fifth Meeting

The list of the dynamic hypotheses was a very efficient tool for everybody, but it was time consuming as the participants needed more time to work individually on grading the hypotheses. Also the work in two groups took a lot of time, and because of that we did not reach a consensus. But the two groups' discussions about each hypothesis were very fruitful. There were many disagreements and the debates contributed to a better understanding of the issues. This session got a very high score and participants were very satisfied.

I could observe the transition from the process "being owned" by me, to becoming more independent though this session.

We actually did not complete the scheduled tasks. We only chose the most important and relevant hypotheses and we did not have time to the rest.

Appendix F

Script for the Sixth Meeting – March 10, 2004

Meeting's Objective

1. To discuss the overall system of the organization, approve or change it.
2. To choose the main variables of the whole system. Which behavior we would like to study?
3. Understand how structure influences the behavior of a system (unfinished task from the fifth meeting)
4. Measurement issues; how to measure and which scale to use for the main variables
5. Reference modes for the main variables

Desired Outcome

Producing a list of accepted variables knowing how to measure each of them and creating a reference mode for each of them.

Schedule:

0800 – Gathering, conclusion from the previous meeting, distribution of the feedback summary of last meeting, and presenting today's meeting targets.

0820 – Discussion about the entire system comments and make changes if necessary.

0830 – Choosing the main variables (work in pairs)

0840 – Choosing the main variables in two groups

0900 – Convergent discussion – choosing the critical variables and the time horizon.

0915 – Theoretical part: explanations about reference modes and behavior of the system

1000-1030 – Break

1030 – Working in groups- choosing the measurement scales for the important variables

1100 – Reaching consensus on the measurement scales

1120 – Work in groups- designing the reference modes

1140–1145 – A short break

1145 – Reaching consensus on the reference modes

1230 – Closing the session

Paperwork to hand out

Schedule

Fifth meeting feedback form summary

Feedback form for the present session

List of the dynamic hypotheses for the entire system

Causal Loop diagram for the entire system

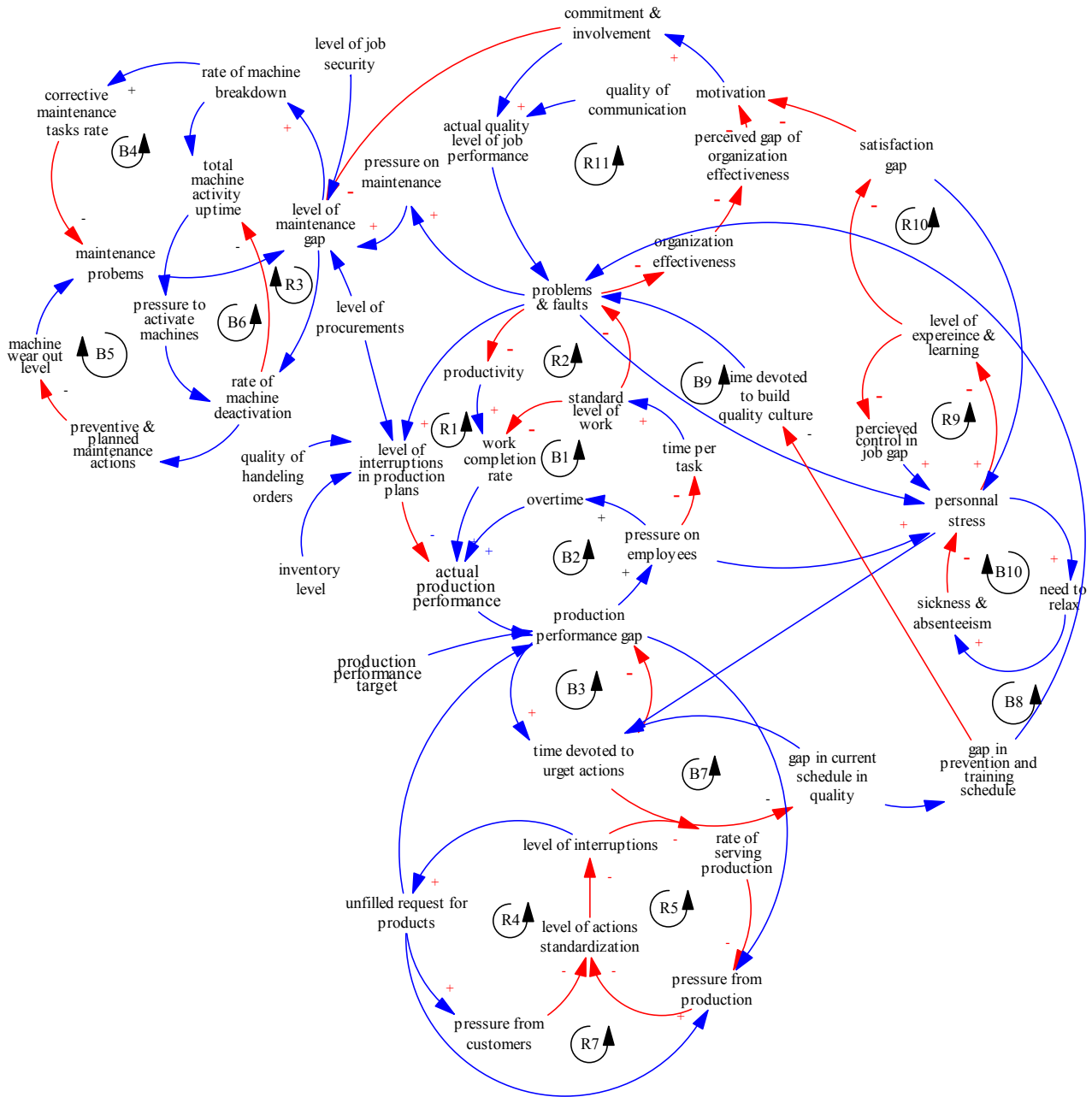
Explanatory material about reference modes and behavior of the system

Dynamic Hypotheses for the Entire System

1. When production performance gap (the gap between the production performance target and the actual production performance) increases, pressure on employees increases, decreasing time per task, decreasing also the standard level of work, which increases work completion rate, increases actual production performance and decreasing production performance gap (loop B1).
2. When production performance gap increases, pressure on employees increases, increasing overtime, increasing actual production performance and decreasing production performance gap (loop B2).
3. When production performance gap increases, it causes the time devoted to urgent actions to increase as well, which decrease production performance gap (loop B3).
4. When production performance gap increases, pressure on employees increases, decreasing time per task, decreasing also the standard level of work. This causes more problems and faults to happen, which increases the level of interruptions in production plans, decreasing actual production performance and increasing production performance gap even more (loop R1).
5. When production performance gap increases, pressure on employees increases, decreasing time per task, decreasing also the standard level of work. This causes more problems and faults to happen, which decreases productivity, which decreases work completion rate, decreases actual production performance, increasing production performance gap even more (loop R2).

6. As the level of maintenance gap (the gap between the desired preventive maintenance and the actual maintenance) increases, the rate of breakdown increases, which causes the corrective maintenance tasks rate to increase (the urgent maintenance tasks), which lowers maintenance problems and decreases the maintenance gap (loop B4).
7. As the level of maintenance gap increases, the rate of machine deactivation increases, necessitating more preventive actions. The more preventive or planned maintenance actions, the less machine wear out, less maintenance problems occur and the level of maintenance gap decreases (loop B5).
8. When the rate of breakdown is high, the total machine activity uptime decreases, which creates more pressure to activate the machines, which lowers the rate of machine deactivation, and the total machine activity uptime increases (loop B6).
9. When more corrective maintenance tasks are provided, the machine wears-out faster. When the machines wear-out increases, there are more maintenance problems. More maintenance problems increase the level of maintenance gap, and also the rate of breakdown increases, causing more corrective maintenance tasks to be needed (loop R3).
10. When the gap in current (daily) scheduled tasks (the gap between the number of completed scheduled tasks and the delayed ones) increases, the time devoted to urgent tasks increases, lowering the current schedule gap (loop B7).
11. When the gap in current schedule increases, the gap in prevention and training schedule (the gap between what is done for prevention and training and what should have be done) gets bigger. This causes more problems and faults to happen, and causes more stress to the workers subsequently influencing the time devoted to urgent actions to increase and lowering the current schedule gap (loop B8).
12. When the gap in prevention and training schedule gets bigger, time devoted to build quality culture decreases, causing more problems and faults to happen, and increasing stress to workers. This in turn increases the time devoted to urgent actions to increase and lowering the current schedule gap (loop B9).
13. When the unfilled request for products increases, it increases the pressure from customers, which causes the level of actions standardization to decrease, and therefore the level of interruptions increases, which causes the unfilled request for products to increase even more (loop R4)

The Firm's Conceptual Model



14. The higher the level of actions standardization, the lower is level of interruptions, the higher is the rate of service to production, which decreases the pressure from production, causing the level of actions standardization to increase even more (loop R5).
15. When the unfilled request for products increases, it increases the pressure from production for inventory, which causes the level of actions standardization to decrease,

and the level of interruptions to increase, which causes the unfilled request for products to increase even more (loop R7).

16. When personal stress increases, the need to relax increases, causing for more sickness to occur, thus decreasing personal stress (loop B10).
17. When personal stress increases, experience and learning opportunities decrease, causing perceived control in job gap to increase, which increases personal stress even more (loop R9).
18. When personal stress is low, more experience and learning opportunities present, thus decreasing the satisfaction gap, and lowering even more personal stress (loop R10).
19. When rate of errors and defects increases, organizational effectiveness decreases, causing an increase in organizational effectiveness gap and decreasing motivation, commitment and involvement, actual job performance level and finally there is a decrease in the actual quality work level. In turn, this increases the rate of errors and defects even more (loop R11). The organizational effectiveness gap is defined as:

$$1 - (\text{quality products} / \text{total products manufactured}).$$

Feedback Form Summary

For the Fifth meeting, Feb 16, 04

<u>Question #</u>	<u>Marks</u>			
<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1	5	4		
2	5	4		
3	2	7		
4	1	6	2	
5	4	5		
6	4	4	1	
7	4	5		
8	3	5	1	

Appendix G

Script for the Seventh Meeting – March 29, 2004

Meeting Objective:

1. Measurement issues; how to measure and which scale to use for the main variables – continue from the previous meeting
2. Reference modes for the main variables
3. Examine the Stock and Flow Diagram representation, and make changes if necessary.

Desired Outcomes

1. A list of accepted variables, how to measure them and create reference modes for each of them.
2. A corrected Stock and Flow Diagram.

Schedule:

0800 – Gathering: Conclusions from the previous meeting, distribution of the feedback summary of last meeting, and presenting today's meeting objectives.

0820 – Short explanation about Stocks and Flows diagrams, and the presentation and examination of the new model

0840 – Working on the measurement scales of the main variable – reaching consensus about the scales (continues from last session).

1000 – 1030 – Break

1030 – 1115 – Working in groups: reference modes for the main variables

1115 – Reaching consensus about the reference modes.

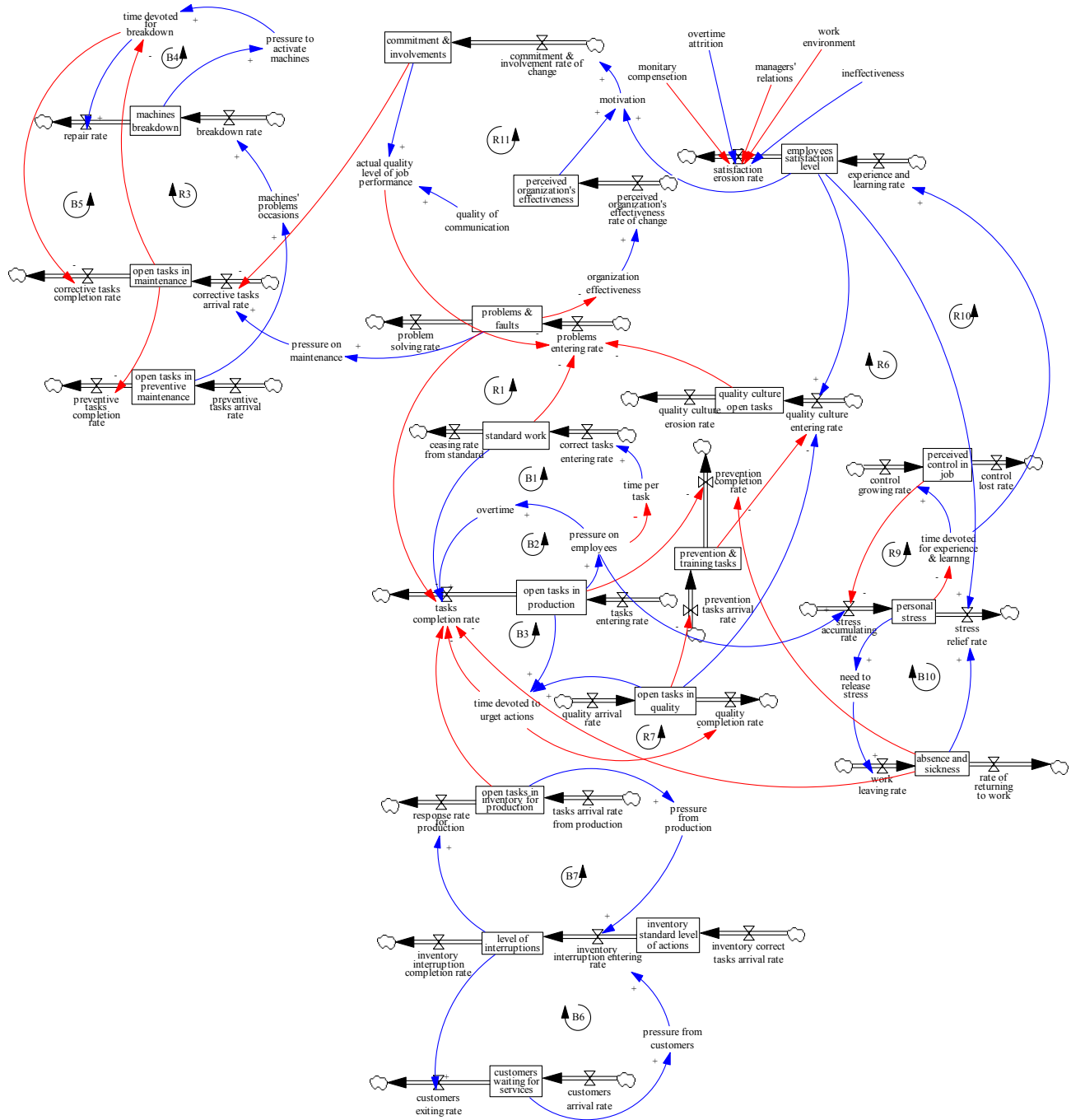
1230 – Closing the session.

Paperwork to handout:

Today's time schedule, the summary of the last (Sixth) session's feedback form, feedback forms for today's session, a copy of the Stocks and Flows Diagram.

The First Stock and Flow Diagram for the Full Model

The Firm's Stock and Flow Model



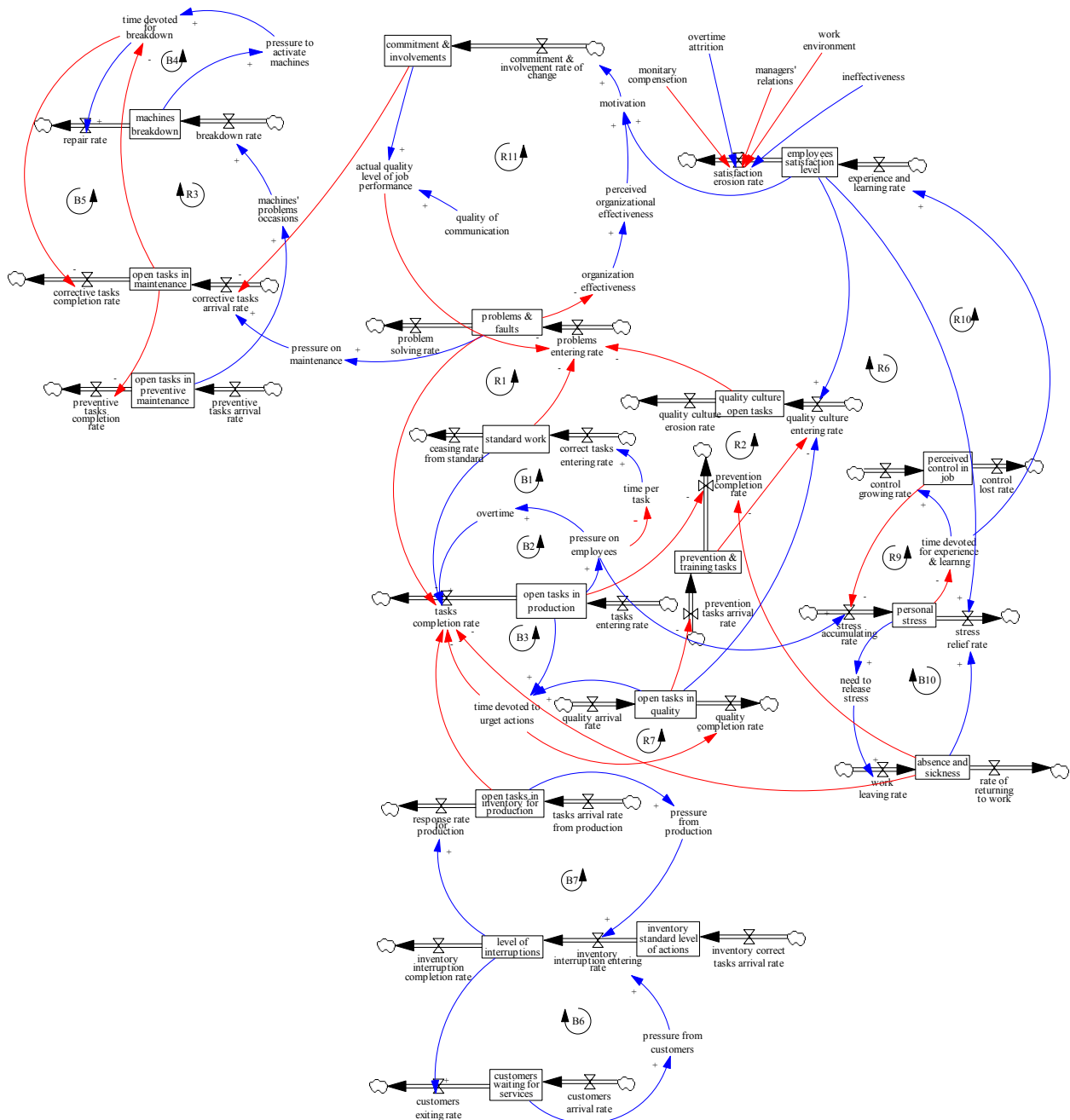
Dynamic Hypotheses for the Full model

- B1 –When *open tasks in production* (stock) increases, the *pressure on employees* increases, decreasing time for task, decreasing also the *correct tasks entering rate* and the *standard work* (stock), which increases the *tasks completion rate*, decreasing the *open tasks in production*.
- B2 -When *open tasks in production* (stock) increases, the *pressure on employees* increases, increasing *overtime* and decreases *open tasks in production*.
- B3 - When *open tasks in production* (stock) increases, it causes the *time devoted to urgent actions* to increase too, which decreases *open tasks in production*.
- R1 - When *open tasks in production* (stock) increases, pressure on employees increases, decreasing time per task, decreasing also the *correct tasks entering rate* and the *standard work* (stock). This causes *problems and faults* (stock) to increase, which decreases the *tasks completion rate*; increasing the *open tasks in production* even more (loop R1).
- B4 - When *machines breakdown* (stock) increases, the *pressure to activate machines* increases, increasing *time devoted for breakdown*. It increases the *repair rate*, which decreases *machines breakdown*.
- B5 – When *open tasks in maintenance* (stock) increases, *time devoted for breakdown* decreases, increasing the *corrective tasks completion rate*, which decreases the *open tasks in maintenance*.
- R3 – When *open tasks in preventive maintenance* (stock) increases, *machines' problems occasions* increases, causing the *breakdown rate* and *machines breakdown* to increase too. *Pressure to activate machines* increases, increasing *time devoted for breakdown*. Subsequently, the *corrective tasks completion rate* decreases, increasing *open tasks in maintenance*, which *decreases preventive tasks completion rate*, increasing *open tasks in preventive maintenance* even more.
- B6 – When *customers waiting for services* (stock) increases, *pressure from customers* increases too. *Inventory interruption entering rate* increases, causing the *level of interruptions* (stock) to increase. This impacts the *customers exiting rate* to increase, decreasing *customers waiting for services*.

- B7 – When *open tasks in inventory for production* (stock) increases, *pressure from production* increases, increasing *inventory interruption entering rate* and *level of interruptions* (stock) too. As a result, *response rate for production* increases, decreasing *open tasks in inventory for production*.
- R7 – When *open tasks in quality* (stock) increases, *time devoted to urgent actions* increases too, decreasing *quality completion rate*, causing *open tasks in quality* to increase even more.
- B10 – When *personal stress* (stock) increases the *need to release stress* increases too. It causes *work leaving rate* to increase, which increases *absence and sickness* (stock). As the result, *stress relief rate* increases decreasing *personal stress*.
- R6 – When *personal stress* (stock) increases, *time devoted for experience & learning* decreases, decreasing also the *experience and learning rate* and the *employees' satisfaction level* (stock). It causes *quality culture entering rate* to decrease, thus increasing *problems entering rate* and *problems & faults* too (stock). *Tasks completion rate* decreases, causing *open tasks in production* to increase, increasing *pressure on employees*, which increases *stress accumulating rate*, and *personal stress* increases even more.
- R9 - When *personal stress* (stock) increases, *time devoted for experience & learning* decreases, decreasing *control growing rate*, which decreases *perceived control in job* (stock), increases *stress accumulating rate*, and *personal stress* increases even more.
- R10 - When *personal stress* (stock) increases, *time devoted for experience & learning* decreases, decreasing also the *experience and learning rate* and the *employees' satisfaction level* (stock). It decreases *stress relief rate*, causing *personal stress* to increase even more.
- R11 – When *problems & faults* increase (stock), *organization effectiveness* decreases. It decreases the *perceived organization's effectiveness rate of change* and the *perceived organization's effectiveness* (stock). As a result, *motivation* decreases, and so decreases also *commitment & involvement rate of change*, which decreases the *commitment & involvement* (stock). It causes the *actual quality level of job performance* to decrease, *problems entering rate* to increase, and *problems & faults* to increase even more.

The second draft of stock and flow full model: (changes in loop R11).

The Firm's Stock and Flow Model



Feedback Form Summary
For the Sixth meeting, March 10, 04

Marks

<u>Question #</u>	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1	1	4	1		
2	2	4			
3	1	5			
4		4	2		
5	2	4			
6	2	4			
7	2	4			
8	1	5			

Most of the answers assign the grade four to the question. This means that they concur with the given declarations.

Appendix H

Script for the Eighth Meeting – April 19, 2004

Meeting's Objectives:

1. Reference modes for the main variables
2. Reviewing what we have done so far and what lies ahead in the following sessions.

Desired outcomes:

Creating a list of variables with reference modes and also setting the means of measurement for each variable.

Schedule:

0800 – Gathering

Conclusion from the previous meeting including the examination of the measures we discussed, distribution of the feedback summary, and presenting today's meeting targets.

0830 – Discussion on the time unit set for our variables, the time horizon of the project, and the time frame we want to characterize and learn.

0850 – Working on the reference modes in groups.

1000 – 1030 – Break

1030 – Reaching consensus on the reference modes.

1130 – Conclusions about the process so far and explanations about the next steps.

1215 – Closing the session.

Main Variables Measurements Methods

Decisions from the seventh session

March 29, 04

Open tasks – A table that will be filled each Sunday and Monday, by several managers and employees, representing all levels and functions of the organization. The table will distinguish between ‘urgent tasks’ and ‘projects’ (jobs that are of preventive nature, maintenance, training development, etc. actions).

Responsible: Rina

Amount of disruptions in production planning – Percentage of deviations from production plan. Decision category: any delay is considered a deviation, including a one-day delay.

Recording responsibility: Production managers.

Problems and malfunctioning – Counting machine stops above half an hour (from Quality Control records in production)

Yael will follow-upon the recordings done by production managers.

Correctness of work methods – In production: information will be gathered from ‘Rectifying Action and Non-Conforming Materials’ records. In inventory: information will be gathered by counting the number of manual shipping records.

Prevention and training open tasks in quality – Will be designed by Yael and Tiki

Employee’s personal stress, satisfaction, commitment and involvement – A questionnaire will be designed by Rina.

Feedback Form Summary
For the Seventh meeting, March 29, 04

<u>Marks</u>					
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Question #</u>
	1		5		1
			4	2	2
	1	1	3	1	3
		3	2	1	4
			5	1	5
		1	3	2	6
		1	2	3	7
		3	3		8

Relatively, this time the grading was lower than the one of the previous sessions. There was less satisfaction, participants did not feel they advanced in their understanding of the problem, and there was less enjoyment of the meeting. This was expected since the meeting was interrupted constantly. On the other hand, all participants thought the content of the meeting was important for the firm (we were dealing with measurement issues).

Appendix I

Ninth Session Meeting – April 19, 04

A Discussion about Measurements

Following our discussion in the Seventh meeting concerning measurements, some more decisions and clarifications were accepted in this meeting:

Open Tasks - The table we created will characterize a workweek. In the next two weeks the participants will do a pilot study. They will use the table in order to follow up the open tasks and after two weeks we will meet and consider changes of the form, before spread it to the rest of the company. Yael is responsible on the execution of this activity.

Amount of disruptions in the production planning – Yael will make sure that the production managers will be strict with collecting and recording the disruptions.

Problems and malfunctioning

1. Machine stoppage over half an hour – data collection will be through production managers (Quality control reports in production)
2. Number of disqualification of raw materials – data collection through quality control (Tiki's responsibility).
3. Number of disqualification of finish goods - data collection through quality control (Tiki's responsibility).
4. Unit measurement will be “number of problems per week”

Correctness of work methods

- In production: the measure will be: number of rectifying actions divided to number of actions. Responsible: Tiki.
- In inventory: the measure will be: Number of manual shipping records divided by the total number of shipping records. Responsible: Moshe

Prevention and training open tasks in quality

A training program needs to be designed, including: new recruits training, quality training, forklift training, and safety training. The design of the program is under the responsibility of Yael and Tiki until May 15, 2004.

Employee's personal stress, satisfaction, commitment and involvement – A questionnaire will be designed by Rina, until July, 2004.

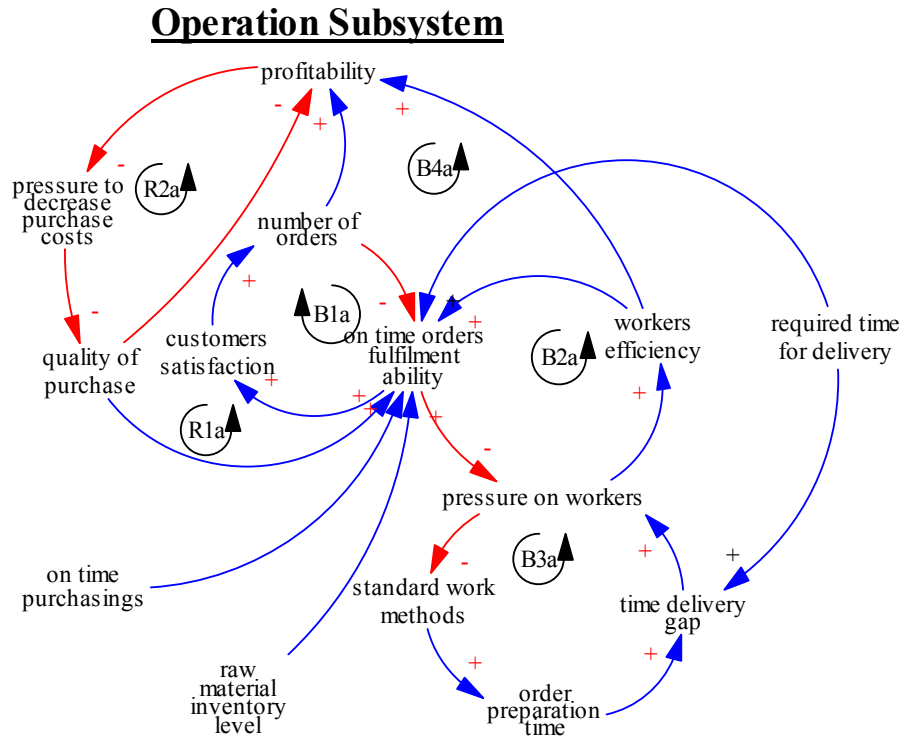
Feedback Form Summary For the Eight meeting, April 19, 04

<u>Marks</u>					<u>Question #</u>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
		2	4	1	1
			6	1	2
		4	2	1	3
	1	3	2	1	4
		1	6		5
		1	6		6
		1	4	2	7
		5	2		8

There was an atmosphere of the end. Most of the grades concentrated around 4, which means that participants are satisfied with what was done and with the efficiency of the meeting. But several grades were also below that, which indicate kind of erosion from the process that had lately been very slow in its progress.

Appendix J - In Between Subsystems' Conceptual Models

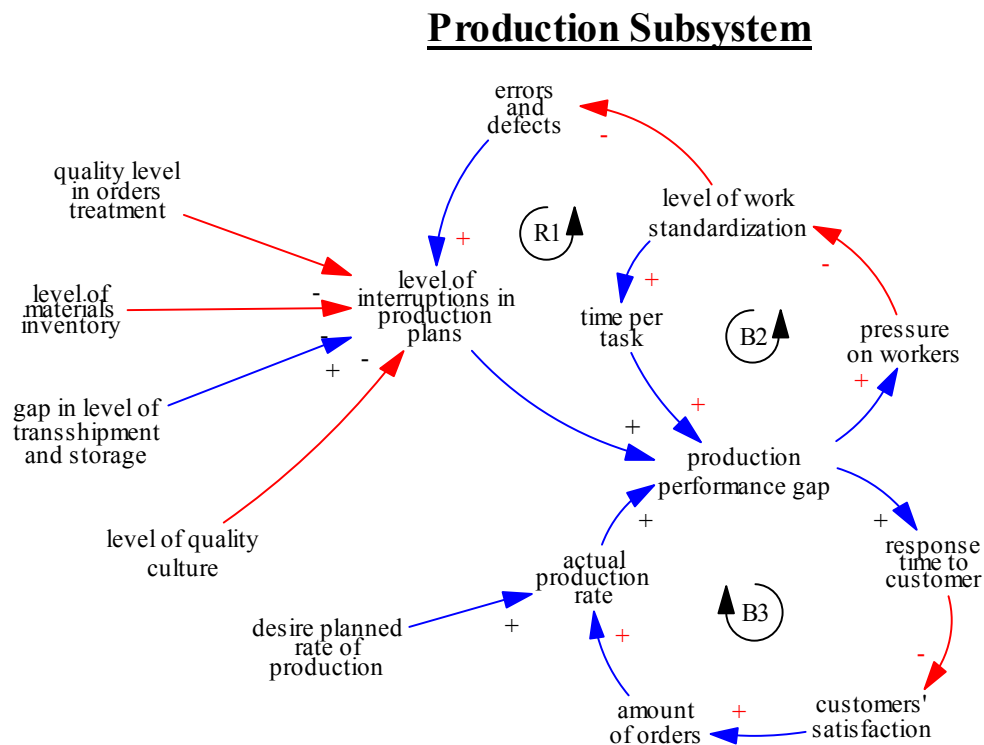
Dynamic Hypotheses for the Operation Subsystem



When number of orders is high, the on time orders fulfillment ability is decreased, lowering customers' satisfaction, lowering number of orders (loop B1a). When on time orders fulfillment ability decreases, it strengthens the pressure on workers, strengthening also the workers efficiency up until a point (after that point the efficiency will decrease), strengthening the on time orders fulfillment ability (loop B2a). When standard work methods is high, it increases the order preparation time, which increases the time delivery gap (the gap between the time it was supposed to be delivered and actual delivered time), increases the pressure on workers, which results in decreasing standard work methods (loop B3a). When on time orders fulfillment ability decreases, it increases the pressure on workers, increasing also the workers efficiency (to a point), increasing organization profitability, decreasing the pressure to decrease purchase costs, which increases the quality of purchase, increasing on time orders fulfillment ability (loop B4a). When on time orders fulfillment ability decreases, it increases the pressure on workers, which results in decreasing standard work methods,

lowering the order preparation time and time delivery gap, which lowers also the pressure on workers, lowering also the workers efficiency, lowering organization profitability, increasing the pressure to decrease purchase costs, decreasing quality of purchase, decreasing on time orders fulfillment ability (loop R1a). When the on time orders fulfillment ability decreases, this decreases customers' satisfaction, which decreases the number of orders, which decreases organization profitability, which increases the pressure to decrease purchase costs, which decreases quality of purchase, which decreases even more the on time orders fulfillment ability (loop R2a).

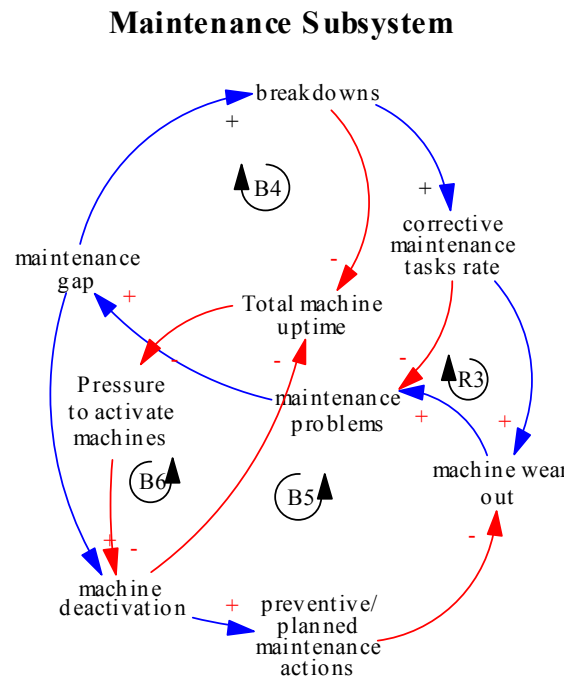
Dynamic Hypotheses for the Operation Subsystem



When the production performance gap is high, the pressure on workers is stronger, which lowers the level of work standardization, investing less time per task, which reduces the production performance gap (loop B2). The bigger the production performance gap the longer is the response time to customers, lowering customers' satisfaction, which lowers the amount of orders, which lowers the actual production rate, which lowers the production performance gap (loop B3). When the production performance gap is high, the pressure on

workers gets stronger, which lowers the level of work standardization, more errors and defects occur, increasing the level of interruptions in production plan, which increases the production performance gap even more (loop R2).

Dynamic Hypotheses for the Maintenance Subsystem



Second maintenance subsystem CLD

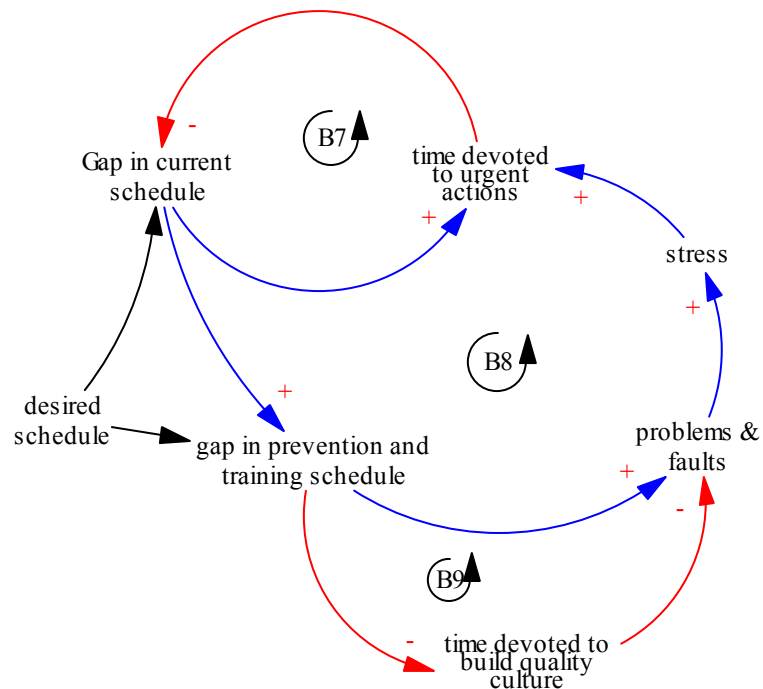
As the maintenance gap (the gap between the desired preventive maintenance and the actual preventive maintenance) increases, the breakdowns rate increases, which causes the corrective maintenance tasks rate to increase (the urgent maintenance tasks), which lowers maintenance problems and decreases the maintenance gap (loop B4). As the maintenance gap increases, the machine deactivation rate increases, forcing more preventive actions. The more preventive or planned maintenance actions, the less machine wear out, less maintenance problems occur and the maintenance gap decreases (loop B5). When the breakdown rate is high, the total machine uptime decreases, which creates more pressure to activate the machines, which lowers the machine deactivation rate, and the total machine uptime increases (loop B6). When corrective maintenance tasks increases, the machine wears out faster (less time is dedicated for preventive maintenance). When the machines wear

increases, there are more maintenance problems. When maintenance problems increase the maintenance gap increases, and the breakdown rate also increases, causing more corrective maintenance tasks to be needed (loop R3).

Dynamic Hypotheses for Quality Assurance Subsystem

When the gap in the current (daily) scheduled tasks (the gap between the number of completed scheduled tasks and the delayed ones) increases, the time devoted to urgent tasks increases, lowering the current schedule gap (loop B7). When the gap in current schedule increases, lowering the current schedule gap (loop B7). When the gap in current schedule increases, the gap in prevention and training schedule (the gap between what is done for prevention and training and what should have be done) gets bigger. This causes more problems and faults to occur, and causes more stress to the workers, subsequently increasing the time devoted to urgent actions (the urgent tasks are part of the daily schedule) and lowering the current schedule gap (loop B8). When the gap in prevention and training schedule gets bigger, time devoted to build quality culture decreases, causing more problems and faults to happen, and increasing stress to workers. This in turn increases the time devoted to urgent actions to increase and lowering the current schedule gap (loop B9).

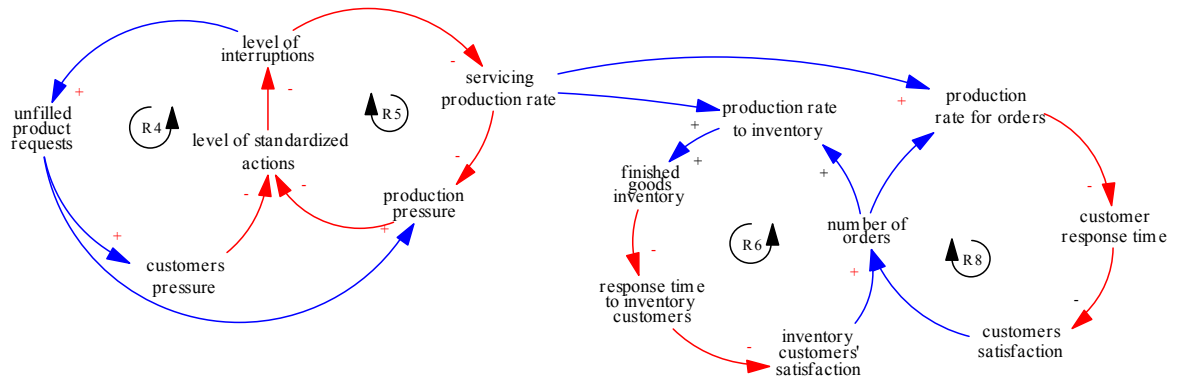
Quality Assurance Subsystem



Second quality assurance subsystem CLDs

Dynamic Hypotheses for Inventory and Logistics Subsystem

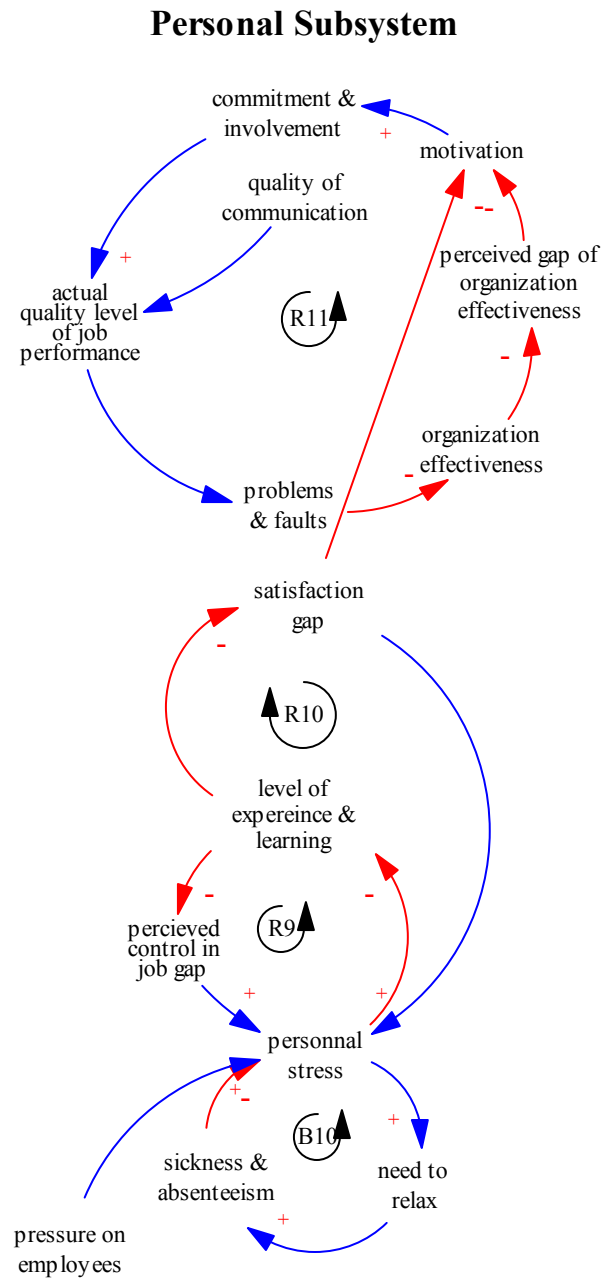
Inventory and Logistic Subsystem



Second inventory and logistics subsystem CLDs

When the unfilled request for products increases, it increases customer pressure, which causes the level of standardized actions to decrease, and therefore the level of interruptions to increase, which causes the unfilled request for products to increase even more (loop R4). When the level of standardized actions increases, the level of interruptions decreases, causing the servicing production rate to increase. This decreases the production pressure, causing the level of standardized actions to increase even more (loop R5). When the production rate for inventory (production that goes directly to inventory) increases, the amount of finished goods inventory increases too. The response time to customers that order directly from inventory is reduced, resulting in higher customer satisfaction which in turn encourages them to place orders. Consequently, a higher rate of production for inventory is required (loop R6). When the unfilled product requests increases, it increases the production pressure for products that go directly to inventory, which causes the level of standardized actions to decrease, and the level of interruptions to increase, which causes the unfilled product requests to increase even more (loop R7). The higher the number of orders, the higher is the production rate, which lowers the customer response time, and increases customer satisfaction and the number of orders even more (loop R8).

Dynamic Hypotheses for Personal Subsystem



Second personal subsystem CLD

When personal stress increases, the need to relax increases, causing for more absenteeism to occur and subsequently personal stress decreases (loop B10). When personal stress increases, experience and learning opportunities decrease, causing the perceived

control in job gap (the gap between the desired perceived control in job and the actual perceived control in job) to increase, which increases personal stress even more (loop R9). When personal stress is low, it enables for more experience and learning opportunities to occur, which decreases the worker satisfaction gap (the gap between the desired satisfaction and the actual satisfaction), and lowers personal stress even more (loop R10). When the rate of errors and defects increases, organizational effectiveness decreases (the percentage between the quality products and the total number of products), causing organizational effectiveness gap to increase and motivation, commitment and involvement, actual job performance level, and also actual quality work level to decrease. This increases the rate of errors and defects even more (loop R11).

Appendix K - Model Codes

Production Subsystem:

Correct Task Completion Rate=
Max(IF THEN ELSE (Max Completion Rate<Possible Completion Rate, Max
Completion Rate
, Possible Completion Rate), 0)
Units: Tasks/Day

Day1=
1
Units: Day

FINAL TIME = 360
Units: Day

INITIAL TIME = 0
Units: Day

Machines Gap=
Main Machines - Number of Available Machines
Units: Dimensionless

Main Machines=
7
Units: Dimensionless

Max Completion Rate=
Max (INTEGER(Production Tasks/One Day2), 0)
Units: Tasks/Day

Max Exit Rate=
Max (INTEGER(Orders/One Day), 0)
Units: Tasks/Day

Max Problem Rate=
Max (Problems and Malfunctions/Day1,0)
Units: Tasks/Day

Max Returning Tasks=
Max (Problems and Malfunctions/One Day, 0)
Units: Tasks/Day

Number of Available Machines=
INTEGER (RANDOM UNIFORM (6, 7, 5))

Units: Dimensionless

Number of Open Machines=

Max(INTEGER(Main Machines*(1 - Tasks Percent for few Day) - Machines Gap +1), 0)

Units: Dimensionless

Number of Tasks for One Day=

IF THEN ELSE (INTEGER(Production Tasks*(1 - Tasks Percent for few Day)/Tasks)< Number of Open Machines, INTEGER(Production Tasks *(1 - Tasks Percent for few Day)) , Number of Open Machines*Tasks)

Units: Tasks

One Day=

1

Units: Day

One Day for Task=

1

Units: Day

One Day2=

1

Units: Day

Order Rate=

INTEGER(RANDOM UNIFORM (3, 5 , 2))

Units: Tasks/Day

Orders= INTEG (

Order Rate -Orders Exit Rate,

1)

Units: Tasks

Orders Exit Rate=

IF THEN ELSE (Max Exit Rate<Number of Open Machines*Tasks/One Day, Max Exit Rate

, Number of Open Machines*Tasks/One Day)

Units: Tasks/Day

Out of Order Max Rate=

Max (Production Tasks/One Day2 - (Correct Task Completion Rate+ Tasks Percent for few Day

*Production Tasks/One Day2), 0)

Units: Tasks/Day

Out of Order Tasks Completion Rate=

Max (IF THEN ELSE (Out of Order Max Rate>(Machines Gap*Time for Task*Task3/(One Day2)), Machines Gap*Time for Task*Task3/(One Day2) , Out of Order Max Rate), 0)

Units: Tasks/Day

Possible Completion Rate=

IF THEN ELSE (Number of Open Machines>Number of Tasks for One Day/Tasks1, Number of Tasks for One Day/One Day for Task, Number of Open Machines*Tasks1/One Day for Task)

Units: Tasks/Day

Pressure on Employees= WITH LOOKUP (

Machines Gap,
((0,0)-(10,10)],(0,0.0877193),(0.336391,0.0877193),(0.672783,0.219298),(1.1315,0.263158),(1.43731,0.394737),(1.83486,0.526316),(2.35474,0.833333),(2.84404,1.22807),(3.5474,1.71053),(4.34251,2.80702),(4.61774,3.42105),(4.92355,4.51754),(5.04587,5.17544),(5.38226,6.71053),(5.59633,7.45614),(5.84098,8.37719),(6.26911,9.12281),(6.69725,9.47368),(7.18654,9.73684),(7.92049,9.95614),(8.47095,10.0439),(9.96942,10.0439))

Units: Dimensionless

Problem Solution Rate=

(Max Problem Rate*0.9)

Units: Tasks/Day

Problems and Malfunctions= INTEG (

Out of Order Tasks Completion Rate-Problem Solution Rate-Tasks Going Back to Production

,
0)

Units: Tasks

Production Tasks= INTEG (

Orders Exit Rate-Correct Task Completion Rate-Out of Order Tasks Completion Rate +Tasks Going Back to Production,

0)

Units: Tasks

SAVEPER = 1

Units: Day [0,?]

Task3=
1
Units: Tasks

Tasks=
1
Units: Tasks

Tasks Going Back to Production=
Max(Max Returning Tasks*0.1, 0)
Units: Tasks/Day

Tasks Percent for few Day=
RANDOM UNIFORM (0.05, 0.35, 0)
Units: Dimensionless

Tasks1=
1
Units: Tasks

Time for Task= WITH LOOKUP (
Pressure on Employees,
((0,0.5)-(10,1)],(0,1),(0.183486,0.934211),(0.397554,0.881579),(0.795107
,0.789474),(1.46789,0.703947),(2.38532,0.618421),(3.79205,0.567982),(5.1682
,0.54386),(6.81957,0.528509),(8.28746,0.517544),(9.93884,0.506579))
Units: Dimensionless

TIME STEP = 1
Units: Day [0,?]

Maintenance Subsystem:

Allowable Time for CMT per Worker=
Maximum Number of Workhours per Worker - (Training Time per Worker +
Time Spent in Meetings per Worker
+ Time Spent for MBR
+Time Required for Setup/2)
Units: day

Average Time for BMC=
RANDOM UNIFORM (0.5, 5, 0)/8.67
Units: day/Task

Average Time for MBR=
RANDOM UNIFORM (1, 8, 0)/8.67
Units: day/Task

Average time per CMT=
RANDOM UNIFORM (0.085, 0.35, 0)
Units: hours/Task

Beadle Machines Breakdown Open Tasks= INTEG (
BMB Rate-BMC Rate,
0)
Units: Task

BMB Rate=
INTEGER (RANDOM UNIFORM (1, 4, 0))*Task 9/Workweek
Units: Task/day

BMC Rate=
IF THEN ELSE(Percentage of the day for MBR/(Average Time for MBR)>MBR
Rate
, MIN((((Percentage of the day for MBR/(Average Time for MBR
) - MBR Rate)/(Average Time for BMC*Task 9/One Day 0))), Max BMC Rate) ,0)
Units: Task/day

CMT Arrival Rate=
Standard CMT Arrival Rate * RANDOM LOOKUP(Effect of Diligence on CMT
Arrival Rate
,0.6,1.6,0.75,0.4,0)
Units: Task/day

CMT Completion Rate=
Possible Completion Rate
Units: Task/day

Corrective Maintenance Tasks= INTEG (
(CMT Arrival Rate - CMT Completion Rate),
0)
Units: Task

Day Hours=
1/8.67
Units: day

Effect of Diligence on CMT Arrival Rate(
[(0.6,0)-(2,1)],(0.617125,1.00439),(0.634251,0.995614),(0.634251,1),(0.634251
,1),(0.634251,0.9912),(0.634251,1),(0.642814,0.921053),(0.659939,0.842105),
(0.715596,0.701754),(0.724129,0.679825),(0.724159,0.679825),(0.809786,0.535088
) , (0.865443,0.45614),(0.959633,0.350877),(1.05382,0.298246),(1.08807,0.276316
) , (1.14373,0.254386),(1.18654,0.236842),(1.18654,0.236842),(1.25933,0.223684
) , (1.27645,0.219298),(1.32355,0.214912),(1.40489,0.201754),(1.50336,0.21754

))

Units: Dimensionless

Effect of Machines Startup Pressure on Time for MBR per Worker= WITH LOOKUP

(
 (Machines Startup Pressure),
 ((0,0)-
(1,1)],(0,0.0131579),(0.0703364,0.219298),(0.146789,0.368421),(0.207951
,0.464912),(0.281346,0.570175),(0.345566,0.653509),(0.415902,0.745614),(0.519878
,0.850877),(0.64526,0.929825),(0.810398,1),(1,1))

Units: Dimensionless

Effect of Maintenance Problems Pressure on Overtime Required for CMT= WITH LOOKUP

(
 (Maintenance Problems Pressure),
 ((0,0)-
(10,6)],(0,0),(1.03976,0.0263158),(2.14067,0.289474),(3.36391,0.552632
) ,(4.22018,0.921053),(5.01529,1.52632),(5.59633,2.18421),(6.02446,2.89474),
(6.39144,3.55263),(6.75841,4.21053),(7.0948,5.05263),(7.40061,5.52632),(7.76758
,5.84211),(8.40979,5.97368),(9.08257,6.05263),(9.90826,6.05263))

Units: hours

FINAL TIME = 360

Units: day

Hours per Day=

8.67

Units: hours/day

INITIAL TIME = 0

Units: day

Is Manager Needed for SetUp=

IF THEN ELSE (Maximum Workers needed to Deal with CMT=2, 1, 0)

Units: Dimensionless

Machine Breakdown Open Tasks= INTEG (

 Machine Breakdown Rate-MBR Rate,

0)

Units: Task

Machine Breakdown Rate=

(RANDOM UNIFORM(0, 2 ,0) + 0.01*Corrective Maintenance Tasks)/Workweek

Units: Task/day

Machines Startup Pressure= WITH LOOKUP (

(Number of available Machines -Number of Required Machines),
 ([[(-5,0)- (7,1)],(-5,1),(-4.07951,0.973684),(-3.03058,0.868421),(-2.04587,
 0.679825),(-1.03976,0.381579),(-0.611621,0.232456),(-0.0336391,0.0219298),(
 0.0733945,0.00438596),(0.223242,0),(0.480122,0),(0.801223,0),(1.16514,0),(1.52905
 ,0),(1.89297,0),(7,0))
 Units: Dimensionless

Maintenance Problems Pressure=
 RANDOM UNIFORM (1, 5, 0)
 Units: Dimensionless

Manager's SetUp Completion Rate=
 (INTEGER (1 +(Manager's Time for CMT or SetUp*8.67/RANDOM UNIFORM (1,
 3 ,0
))))
 *Task per Day/One Day
 Units: Task/day

Manager's Time for CMT or SetUp=
 IF THEN ELSE (Maximum Number of Workhours per Worker - (Training Time per
 Worker
 + Manager's Times for Meetings +Manager's Time for Other Tasks
 + Time Spent for MBR) < 0, Maximum Number of Workhours per Worker -
 (Training Time per Worker + Manager's Times for Meetings +Manager's Time for
 Other Tasks
 + Time Spent for MBR))
 Units: day

Manager's Time for Other Tasks=
 RANDOM UNIFORM (0, 3, 0)* One Day /8.67
 Units: day

Manager's Times for Meetings=
 RANDOM UNIFORM (1, 3, 0)/8.67
 Units: day

Max BMC Rate=
 Max (Beadle Machines Breakdown Open Tasks/One Day 0 , 0)
 Units: Task/day

Max Completion Rate=
 Max (SetUp Tasks/One Day, 0)
 Units: Task/day

Max MBR Rate=
 Max(Machine Breakdown Open Tasks/One Day 0, 0)

Units: Task/day

Maximum Available Time for MBR per Worker=

Time for Other Tasks per Worker * 0.3*(1+Effect of Machines Startup Pressure on
Time for MBR per Worker
)

Units: day

Maximum Number of Workhours per Worker=

RANDOM UNIFORM (8.5 , 8.67, 0)/8.67

Units: day

Maximum Workers needed to Deal with CMT=

Max (1, INTEGER(Time Required for CMT/Allowable Time for CMT per
Worker+1)
)

Units: Dimensionless

MBR Rate=

MIN(Percentage of the day for MBR/Average Time for MBR, Max MBR Rate)

Units: Task/day

Number of available Machines=

(7 - INTEGER (1 + Machine Breakdown Open Tasks)/Tasks - IF THEN ELSE ((35
- INTEGER(1 + Beadle Machines Breakdown Open Tasks))/(3*Tasks)>(7 - INTEGER
(1 + Machine Breakdown Open Tasks/Tasks)), 0, (7 -INTEGER (1 + Machine Breakdown
Open Tasks
/Tasks) - (35 - INTEGER(1 + Beadle Machines Breakdown Open Tasks/Tasks
))/3))

Units: Dimensionless

Number of Maintenance Workers=

INTEGER (RANDOM UNIFORM (1, 3, 0))

Units: Dimensionless

Number of Required Machines=

INTEGER (RANDOM UNIFORM (4, 8, 0))

Units: Dimensionless

Number of Workers for MBR=

INTEGER (RANDOM UNIFORM(1, 3 , 0))

Units: Dimensionless

One Day=

1

Units: day

One Day 0=
1

Units: day

One Hour per Day=
1

Units: 1/day

Overtime Required for CMT=

IF THEN ELSE (Time Required for CMT>Total Possible Time for CMT,
MIN(Effect of Maintenance Problems Pressure on Overtime Required for CMT
/Hours per Day, (Time Required for CMT-Total Possible Time for CMT))
, 0)

Units: day

Percentage of the day for MBR=

Total Hours Available for MBR/One Day 0
Units: Dimensionless

Possible Completion Rate=

IF THEN ELSE (Total Possible Time for CMT>Time Required for CMT, Time
Required for CMT
*Hours per Day*One Hour per Day/Average time per CMT, (Total Possible Time for CMT
+ Overtime Required for CMT)*Hours per Day*One Hour per Day/Average time per
CMT
)

Units: Task/day

SAVEPER =
TIME STEP
Units: day [0,?]

SetUp Arrival Rate=

INTEGER (RANDOM UNIFORM (0, 5, 0))
Units: Task/day

SetUp Completion Rate=

MIN(IF THEN ELSE (Is Manager Needed for SetUp=0, Max Completion Rate,
Manager's SetUp Completion Rate
) , Max Completion Rate)

Units: Task/day

SetUp Tasks= INTEG (
SetUp Arrival Rate-SetUp Completion Rate,
0)

Units: Task

Standard CMT Arrival Rate=
RANDOM UNIFORM (20, 32, 0)

Units: Task/day

Task 9=

1

Units: Task

Task per Day=

1

Units: Task/day

Tasks=

1

Units: Task

Time for Other Tasks per Worker=

RANDOM UNIFORM (1, 6, 0)*Day Hours

Units: day

Time Required for CMT=

IF THEN ELSE (Corrective Maintenance Tasks>0, Corrective Maintenance Tasks
* Average time per CMT/Hours per Day, 0)

Units: day

Time Required for SetUp=

IF THEN ELSE (SetUp Tasks>0, RANDOM UNIFORM (1/8.67, 3/8.67, 0), 0)

Units: day

Time Spent for MBR=

Effect of Machines Startup Pressure on Time for MBR per Worker*One Day/8.67

Units: day

Time Spent in Meetings per Worker=

RANDOM UNIFORM (0 , 0.35, 0)/8.67

Units: day

TIME STEP = 1

Units: day [0,?]

Total Hours Available for MBR=

Number of Workers for MBR*Maximum Available Time for MBR per Worker

Units: day

Total Possible Time for CMT=

IF THEN ELSE (Maximum Workers needed to Deal with CMT > 3, (Allowable Time for CMT per Worker

*Number of Maintenance Workers

+IF THEN ELSE (Is Manager Needed for SetUp =0, Manager's Time for CMT or SetUp

, 0)), Number of Maintenance Workers*Allowable Time for CMT per Worker)

Units: day

Training Time per Worker=

RANDOM UNIFORM (0 , 2, 0)/8.67

Units: day

Workweek=

5

Units: day

Quality Assurance Subsystem:

Day=

1

Units: Day

Day 7=

1

Units: Day

Day1=

1

Units: Day

FINAL TIME = 360

Units: Day

Hours per Day=

8.67

Units: Hours

INITIAL TIME = 0

Units: Day

Max Quality Urgent Tasks Exit Rate=

Max (Urgent Quality Tasks/ Day 7, 0)

Units: Tasks/Day

Open Quality Tasks= INTEG (

Quality Arrival Rate-Quality Task Completion Rate,
0)

Units: Tasks

Problems and Malfunctions=

INTEGER (RANDOM UNIFORM(0, 6, 0))

Units: Tasks

Production Arrival Rate=

INTEGER (RANDOM UNIFORM (1, 7, 0))

Units: Tasks/Day

Quality Arrival Rate=

Task00*RANDOM UNIFORM (2, 10, 0)/Day

Units: Tasks/Day

Quality max Completion Rate=

Max(Open Quality Tasks/Day, 0)

Units: Tasks/Day

Quality Task Completion Rate=

IF THEN ELSE (((Time Devoted for Quality Tasks/Hours per Day)*Task00/Day)/
RANDOM UNIFORM(2, 4, 0)<Quality max Completion Rate, Quality max Completion
Rate

, ((Time Devoted for Quality Tasks/Hours per Day)/RANDOM UNIFORM (2, 4, 0)
)*(Task00/Day))

Units: Tasks/Day

SAVEPER = 1

Units: Day [0,?]

Task00=

1

Units: Tasks

Task7=

1

Units: Tasks

Tasks1=

1

Units: Tasks

Time Devoted for Quality Tasks=

(Hours per Day - Time Devoted for Urgent Quality Tasks*Hours per Day/Day 7

)

Units: Hours

Time Devoted for Urgent Quality Tasks=
IF THEN ELSE(((Production Arrival Rate*Day1/Tasks1)* RANDOM
UNIFORM(0.1,
0.4, 0) + Urgent Quality Tasks/Tasks1)*Time per Urgent Task
> Hours per Day, Day1,(((Production Arrival Rate*Day1/Tasks1)* RANDOM
UNIFORM
(0.1, 0.4, 0) + Urgent Quality Tasks/Tasks1
) *Time per Urgent Task)*Day1/Hours per Day)

Units: Day

Time per Urgent Task=
RANDOM UNIFORM (0.25, 1, 0)

Units: Hours

TIME STEP = 1

Units: Day [0,?]

Training=
IF THEN ELSE (Open Quality Tasks< 2, RANDOM UNIFORM (0.2, 0.4, 0.2),
RANDOM UNIFORM
(0, 0.1, 0))

Units: Dimensionless

Urgent Quality Tasks= INTEG (
Urgent Quality Tasks Arrival Rate-Urgent Quality Tasks Exit Rate,
0)

Units: Tasks

Urgent Quality Tasks Arrival Rate=
IF THEN ELSE (Training<0.2, ((Problems and Malfunctions/Task7 * (RANDOM
UNIFORM
(0.2, 0.4, 0)) + IF THEN ELSE
(Open Quality Tasks > 7, EXP (Open Quality Tasks
/(Task7*10)), 0))*Task7/Day), ((Problems and Malfunctions/Task7 * (RANDOM
UNIFORM
(0.2, 0.4, 0)) + IF THEN ELSE (Open Quality Tasks
> 7, EXP (Open Quality Tasks
/(Task7*10)), 0))*Task7/Day)*(1 - Training))

Units: Tasks/Day

Urgent Quality Tasks Exit Rate=
IF THEN ELSE ((Max Quality Urgent Tasks Exit Rate*Day 7/Task7)*Time per
Urgent Task
>Hours per Day, (Hours per Day/Time per Urgent Task)*Task7/Day 7

, Max Quality Urgent Tasks Exit Rate
)
Units: Tasks/Day

Inventory Subsystem:

Average Time for Serving Customers=
RANDOM NORMAL (0.25, 0.5, 0.4, 0.1,0.2)
Units: Dimensionless

Average Time for Serving Production=
RANDOM NORMAL (0.15, 1.15, 0.65, 0.25, 0.15)
Units: Dimensionless

Customers=
1
Units: Customer

Customers Arrival Rate=
INTEGER(RANDOM UNIFORM (3, 8, 0))
Units: Customer/day

Customers Exit Rate=
Min(INTEGER(((1 - Level of Interruptions/2))*(Time Resources Allocated for
Customers
*8.67/Average Time for Serving Customers)*Customers/Day + 1)/Day, Max Customers
Exiting Rate
)
Units: Customer/day

Customers Pressure on Inventory for Immediate Service= WITH LOOKUP (
Customers Waiting for Service/Customers,
((0,0)-
(12,1)],(0,0),(1.43119,0.0438596),(3.11927,0.149123),(4.44037,0.27193
) ,(5.76147,0.491228),(6.97248,0.741228),(7.81651,0.899123),(8.77064,0.982456
) ,(10.055,1.00439),(10.8257,1.00877),(12,1.00439))
Units: Dimensionless

Customers Waiting for Service= INTEG (
Customers Arrival Rate-Customers Exit Rate,
0)
Units: Customer

Day=
1
Units: day

FINAL TIME = 360

Units: day

INITIAL TIME = 0

Units: day

Level of Interruptions=

(Customers Pressure on Inventory for Immediate Service + Production Worker
Pressure on Inventory for Immediate Service
) / 2

Units: Dimensionless

Manager Time=

RANDOM UNIFORM (1.5, 2.5, 0) / 8.67

Units: day

Max Customers Exiting Rate=

Max(Customers Waiting for Service/Day, 0)

Units: Customer/day

Max Response Rate=

Max (Open Inventory Tasks for Production/Day , 0)

Units: Task/day

Open Inventory Tasks for Production= INTEG (

(Production Tasks Arrival Rate - Production Response Rate),
0)

Units: Task

Production Response Rate=

Min(Max Response Rate, ((1 - Level of Interruptions / 2)) * (Production Time Resources
* 8.67 / Average Time for Serving Production) * Task / (Day * Day))

Units: Task/day

Production Tasks Arrival Rate=

RANDOM UNIFORM(2 , 12 , 0)

Units: Task/day

Production Time Resources=

IF THEN ELSE (Production Worker Pressure on Inventory for Immediate Service
> 0.5, (Total Time Resources * Production Worker Pressure on Inventory for Immediate
Service
)

, (RANDOM UNIFORM (1.67/8.67, 4.67/8.67, 0)))

Units: day

Production Worker Pressure on Inventory for Immediate Service= WITH LOOKUP (

 Open Inventory Tasks for Production/Task,
 ((0,0)-
(30,1)],(0,0),(2.28746,0.0175439),(4.0367,0.0394737),(6.05505,0.0701754
) ,(7.98165,0.0964912),(10.5505,0.140351),(12.9358,0.197368),(15.1376,0.254386
) ,(16.8807,0.320175),(18.4404,0.381579),(20.1835,0.451754),(22.1101,0.548246
) ,(23.578,0.649123),(24.8624,0.745614),(25.7798,0.828947),(26.8807,0.899123
) ,(28.2569,0.964912),(29.9083,1.00439))
Units: Dimensionless

SAVEPER =
 TIME STEP
Units: day [0,?]

Task=
 1
Units: Task

Time Resources Allocated for Customers=
 IF THEN ELSE (Customers Pressure on Inventory for Immediate Service>0.6, (Total Time Resources * Customers Pressure on Inventory for Immediate Service), (RANDOM UNIFORM (2/8.67, 4/8.67, 0)))
Units: day

TIME STEP = 1
Units: day [0,?]

Total Time Resources=
 Manager Time +Workers Time
Units: day

Workers Time=
 RANDOM UNIFORM (1, 1.05, 0)
Units: day

Personal Subsystem:

Actual Quality Performance Level= WITH LOOKUP (Organization Commitment/Commitment,
 ((0,0)-
(6,1)],(0,0.0131579),(0.293578,0.0175439),(0.605505,0.0263158),(
 1.22936,0.0482456),(1.76147,0.0570175),(2.33028,0.0921053),(2.99083,0.171053
),(3.3578,0.241228),(3.65138,0.324561),(3.92661,0.416667),(4.20183,0.495614
),(4.47706,0.587719),(4.69725,0.671053),(4.91743,0.77193),(5.10092,0.850877

),(5.26606,0.921053),(5.57798,0.97807),(5.94495,1.01316))
Units: Dimensionless

Commitment=
1

Units: Commitment

Commitment Level=
RANDOM UNIFORM (1, 2.5, 0)

Units: Dimensionless

Commitment Loss Rate=
MIN (IF THEN ELSE (Commitment Level > 2.5:AND:Influence on Commitment
1>2.5
,
0, IF THEN ELSE
(Commitment Level<2.5, Commitment Level*Commitment/(5*Day8), 0) + IF THEN
ELSE
(Influence on Commitment 1 < 2.5, Influence on Commitment 1/5, 0)*Commitment
/Day8), Max Commitment Loss Rate)
Units: Commitment/Day

Commitment Rate=
IF THEN ELSE (Perceived Organizational Effectiveness> 0.1, (Perceived
Organizational Effectiveness
*Commitment/Day8 +IF THEN ELSE
(Commitment Level>2.5, Commitment Level*Commitment/(5*Day8), 0) + IF THEN
ELSE
(Influence on Commitment 1 > 2.5, Influence on Commitment 1/5, 0)*Commitment
/Day8), 0)
Units: Commitment/Day

Daily Tasks=
RANDOM UNIFORM (1, 7, 1)

Units: Tasks

Day1=
1
Units: Day

Day4=
1
Units: Day

Day5=
1

Units: Day

Day8=

1

Units: Day

Employees Satisfaction Level= INTEG (
Experience and Learning Rate-Satisfaction Erosion Rate,
0)

Units: satisfaction

Experience and Learning Rate=

(0.55*Work Satisfaction + 0.25 *Social Environment +IF THEN ELSE (Perceived
Control in Job
>4, 0.2 *Perceived Control in Job, 0))*Satisfaction/Day5

Units: satisfaction/Day

FINAL TIME = 360

Units: Day

Influence on Commitment 1=

Employees Satisfaction Level/Satisfaction

Units: Dimensionless

INITIAL TIME = 0

Units: Day

Managers Relations=

(RANDOM UNIFORM (1.8, 2, 1.5) + RANDOM UNIFORM (1.77, 2.7, 1))/2

Units: Dimensionless

Max Commitment Loss Rate=

Max (Organization Commitment/Day8, 0)

Units: Commitment/Day

Max Stress Out Rate=

Max(Personal Stress/Day4, 0)

Units: stress/Day

Monetary Compensation=

RANDOM UNIFORM (2.8, 3.7, 2.5)

Units: Dimensionless

One Day=

1

Units: Day

Opportunity for Promotion=
(RANDOM UNIFORM (2.22, 2.67, 2) + RANDOM UNIFORM(1.5, 2.4, 1))/2
Units: Dimensionless

Organization Commitment= INTEG (
Commitment Rate -Commitment Loss Rate,
0)
Units: Commitment

Organization Effectiveness=
IF THEN ELSE (Daily Tasks<Problems and Malfunctions, 0, (Daily Tasks -
Problems and Malfunctions
) /Daily Tasks)
Units: Dimensionless

Out of Order Tasks Completion Rate=
((RANDOM UNIFORM (1, 4, 0)) *(Task3/One Day)- (Actual Quality Performance
Level
/10)*(Task3/One Day))
Units: Tasks/Day

Overtime Attrition=
IF THEN ELSE (Production Tasks< 7, Overtime Required for CMT, ((Production
Tasks
- 7)/10 +Overtime Required for CMT))
Units: Dimensionless

Overtime Required for CMT=
RANDOM UNIFORM (0.2, 0.8, 0)
Units: Dimensionless

Perceived Control in Job=
RANDOM UNIFORM(2, 2.83, 1) +Training
Units: Dimensionless

Perceived Organizational Effectiveness= WITH LOOKUP (
Organization Effectiveness,
((0,0)-
(1,1)],(0,0),(0.17737,0.0175439),(0.345566,0.0526316),(0.529052,0.135965
) ,(0.639144,0.223684),(0.749235,0.355263),(0.844037,0.513158),(0.920489,0.675439
) ,(0.966361,0.820175),(1,0.991228),(1.01223,1)))
Units: Dimensionless

Personal Stress= INTEG (
Stress Accumulation Rate-Stress Relief Rate,

0)

Units: stress

Problem Solution Rate=

Max(Problems and Malfunctions*0.9/Day1, 0)

Units: Tasks/Day

Problems and Malfunctions= INTEG (

Out of Order Tasks Completion Rate-Problem Solution Rate,
0)

Units: Tasks

Production Tasks=

RANDOM UNIFORM (4, 20, 2)

Units: Dimensionless

Satisfaction=

1

Units: satisfaction

Satisfaction Erosion Rate=

MIN ((0.05*Overtime Attrition +0.2*Opportunity for Promotion +0.5*Monetary
Compensation
+0.05*Managers Relations +EXP(
0.1*Personal Stress/(Stress)) +IF THEN ELSE (Perceived Control in Job<4, 0.2
*Perceived Control in Job, 0)
)*Satisfaction
/Day5, Employees Satisfaction Level/Day5)

Units: satisfaction/Day

SAVEPER =

TIME STEP

Units: Day [0,?]

Sickness=

IF THEN ELSE (Personal Stress< 100, 0, Personal Stress/(100*Stress1)/Day4)

Units: 1/Day

Social Environment=

RANDOM UNIFORM (3, 3.5, 2.9)

Units: Dimensionless

Stress=

1

Units: stress

Stress Accumulation Rate=
 $((0.25 * \text{Managers Relations} + 0.7 * \text{Stress Level})) * \text{Stress/Day4} + \text{IF THEN ELSE}$
 $(\text{Perceived Control in Job} < 4, (1/\text{Perceived Control in Job}) * \text{Stress/Day4}$
 $, 0)$

Units: stress/Day

Stress Level=
 RANDOM UNIFORM (2, 2.8, 1)

Units: Dimensionless

Stress Relief Rate=
 MIN(IF THEN ELSE(Perceived Control in Job > 4, RANDOM UNIFORM(0.1, 0.3,

0))*
 $\text{Perceived Control in Job} * \text{Stress/Day4} + 0.2 * \text{Stress}$
 $* \text{Sickness} + (\text{IF THEN ELSE} (\text{Employees Satisfaction Level} > 2.5, 0.7 * \text{Employees}$
 $\text{Satisfaction Level}$
 $/ \text{Satisfaction},$

0))*Stress/Day4, 0.5*Stress*Sickness+(IF THEN ELSE (Employees Satisfaction
 Level
 >2.5, 0.7*Employees Satisfaction Level
 /Satisfaction, 0))*Stress/Day4), Max Stress Out Rate)

Units: stress/Day

Stress1=
 1

Units: stress

Task3=
 1

Units: Tasks

TIME STEP = 1

Units: Day [0,?]

Training=
 RANDOM UNIFORM (0, 0.1, 0)

Units: Dimensionless

Work Satisfaction=
 RANDOM UNIFORM (2.5, 3, 2.5)

Units: Dimensionless

Full Model Equations:

Actual Quality Performance Level= WITH LOOKUP (Organization Commitment/Commitment, ((0,0)-(6,1)],(0,0),(0.605505,0.00877193),(1.22936,0.0263158),(1.76147,0.0570175),(2.33028,0.0921053),(2.99083,0.171053),(3.3578,0.241228),(3.65138,0.324561),(3.9633,0.407895),(4.20183,0.495614),(4.47706,0.587719),(4.69725,0.671053),(4.91743,0.77193),(5.10092,0.850877),(5.26606,0.921053),(5.57798,0.97807),(5.94495,1.01316))
 Units: Dimensionless

all machines breakdown:TEST INPUT:
 Machine Breakdown Rate=7
 all machines breakdown
 Units: Task

Allowable Time for CMT per Worker=
 Maximum Number of Workhours per Worker - (Training Time per Worker + Time Spent in Meetings per Worker + Time Spent for MBR +Time Required for SetUp/2)
 Units: Day

Average Time for BMC=
 RANDOM UNIFORM (0.5, 5, 0)/8.67
 Units: Day/Task

Average Time for MBR=
 RANDOM UNIFORM (1, 8, 0)/8.67
 Units: Day/Task

Average Time for Serving Customers=
 RANDOM NORMAL (0.25, 0.5, 0.4, 0.1,0.2)
 Units: Dimensionless

Average Time for Serving Production=
 RANDOM NORMAL (0.15, 1.15, 0.65, 0.25, 0.15)
 Units: Dimensionless

Average time per CMT=
 RANDOM UNIFORM (0.085, 0.35, 0)
 Units: hours/Task

Balance between Production and Social Activities=
 RANDOM UNIFORM (0.2, 0.3, 0.1)
 Units: Dimensionless

Beadle Machines=
35
Units: Dimensionless

Beadle Machines Breakdown Open Tasks= INTEG (
BMB Rate-BMC Rate,
0)
Units: Task

BMB Rate=
(RANDOM UNIFORM (1, 4, 0))*Task 9/Workweek
Units: Task/Day

BMC Rate=
IF THEN ELSE(Percentage of the day for MBR/(Average Time for MBR)>MBR
Rate
, MIN((((Percentage of the day for MBR/(Average Time for MBR
) - MBR Rate)/(Average Time for BMC*Task 9/One Day 0 0))), Max BMC Rate) ,
0)
Units: Task/Day

CMT Arrival Rate=
(Standard CMT Arrival Rate * RANDOM LOOKUP(Effect of Diligence on CMT
Arrival Rate
,0.6,1.6,0.75,0.4,0))*(1-Quality Culture Level*Day1/Task3)
Units: Task/Day

CMT Completion Rate=
Possible Completion Rate 0
Units: Task/Day

Collaboration=
0.8
Units: Dimensionless

Commitment=
1
Units: Commitment

commitment is high:THE CONDITION:
no more problems and malfunctions:IMPLIES:Commitment Rate>= RC STEP
CHECK
(10, Commitment Rate, 1)
Units: **undefined**

Commitment Level=

RANDOM UNIFORM (1, 2.5, 0)
Units: Dimensionless

Commitment Loss Rate=
MIN (IF THEN ELSE (Commitment Level > 2.5:AND:Employees Satisfaction 2>2.5
,
0, IF THEN ELSE
(Commitment Level<2.5, Commitment Level*Commitment/(5*Day8), 0) + IF THEN
ELSE
(Employees Satisfaction 2 < 2.5, Employees Satisfaction 2/5, 0)*Commitment
/Day8), Max Commitment Loss Rate)
Units: Commitment/Day

Commitment Rate=
IF THEN ELSE (Perceived Organizational Effectiveness> 0.1, (Perceived
Organizational Effectiveness
*Commitment/Day8 +IF THEN ELSE
(Commitment Level>2.5, Commitment Level*Commitment/(5*Day8), 0) + IF THEN
ELSE
(Employees Satisfaction 2 > 2.5, Employees Satisfaction 2/5, 0)*Commitment
/Day8), 0)
Units: Commitment/Day

Correct Task Completion Rate=
Max(IF THEN ELSE (Max Completion Rate<Possible Completion Rate, Max
Completion Rate
, Possible Completion Rate*Day7*(1+0.2
*Quality Culture Level
*Day7/Tasks
Sickness1/100)), 0)
Units: Tasks/Day

Corrective Maintenance Tasks= INTEG (
(CMT Arrival Rate - CMT Completion Rate),
0)
Units: Task

Customers=
1
Units: Customer

Customers Arrival Rate=
INTEGER(RANDOM UNIFORM (3, 8, 0))
Units: Customer/Day

Customers Exit Rate=
 $\text{MIN}(\text{INTEGER}(((1 - \text{Level of Interruptions}/2)) * (\text{Time Resources Allocated for Customers} * 8.67 / \text{Average Time for Serving Customers}) * \text{Customers}/\text{Day work} + 1) / \text{Day work}, \text{Max Customers Exiting Rate})$
 Units: Customer/Day

Customers Pressure on Inventory for Immediate Service= WITH LOOKUP (Customers Waiting for Service/Customers, ((0,0)-(12,1)],(0,0),(1.43119,0.0438596),(3.11927,0.149123),(4.44037,0.27193),(5.76147,0.491228),(6.97248,0.741228),(7.81651,0.899123),(8.77064,0.982456),(10.055,1.00439),(10.8257,1.00877),(12,1.00439))
 Units: Dimensionless

Customers Waiting for Service= INTEG (Customers Arrival Rate-Customers Exit Rate, 0)
 Units: Customer

Day=
 1
 Units: Day

Day 0=
 1
 Units: Day

Day 7=
 1
 Units: Day

Day Hours=
 1/8.67
 Units: Day

Day work=
 1
 Units: Day

Day1=
 1
 Units: Day

Day15=
 1

Units: Day

Day4=

1

Units: Day

Day5=

1

Units: Day

Day6=

1

Units: Day

Day7=

1

Units: Day

Day8=

1

Units: Day

Degree of Shared Control=

0.6

Units: Dimensionless

Effect of Diligence on CMT Arrival Rate(

[(0.6,0)-(2,1)],(0.617125,1.00439),(0.634251,0.995614),(0.634251,1),(0.634251,1),(0.634251,0.9912),(0.634251,1),(0.642814,0.921053),(0.659939,0.842105),(0.715596,0.701754),(0.724129,0.679825),(0.724159,0.679825),(0.809786,0.535088),(0.865443,0.45614),(0.959633,0.350877),(1.05382,0.298246),(1.08807,0.276316),(1.14373,0.254386),(1.18654,0.236842),(1.18654,0.236842),(1.25933,0.223684),(1.27645,0.219298),(1.32355,0.214912),(1.40489,0.201754),(1.50336,0.21754))

Units: Dimensionless

Effect of Machines Startup Pressure on Time for MBR per Worker= WITH LOOKUP

((Machines Startup Pressure),[(0,0)-(1,1)],(0,0.0131579),(0.0703364,0.219298),(0.146789,0.368421),(0.207951,0.464912),(0.281346,0.570175),(0.345566,0.653509),(0.415902,0.745614),(0.519878,0.850877),(0.64526,0.929825),(0.810398,1),(1,1))

Units: Dimensionless

Effect of Maintenance Problems Pressure on Overtime Required for CMT= WITH LOOKUP

(
 (Maintenance Problems Pressure),
 ((0,0)-
 (10,6)],(0,0),(1.03976,0.0263158),(2.14067,0.289474),(3.36391,0.552632
),(4.22018,0.921053),(5.01529,1.52632),(5.59633,2.18421),(6.02446,2.89474),
 (6.39144,3.55263),(6.75841,4.21053),(7.0948,5.05263),(7.40061,5.52632),(7.76758
 ,5.84211),(8.40979,5.97368),(9.08257,6.05263),(9.90826,6.05263))
 Units: hours

effectiveness is better:THE CONDITION:
 no more problems and malfunctions:IMPLIES:Organization Effectiveness>= RC
 GROW CHECK
 (10, Organization Effectiveness, 12)
 Units: **undefined**

Employees Satisfaction 1=
 Employees Satisfaction Level/Satisfaction
 Units: Dimensionless

Employees Satisfaction 2=
 Employees Satisfaction 1
 Units: Dimensionless

Employees Satisfaction Level= INTEG (
 Experience and Learning Rate-Satisfaction Erosion Rate,
 0)
 Units: satisfaction

Experience and Learning Rate=
 (0.55*Work Satisfaction + 0.25 *Social Environment +IF THEN ELSE (Perceived
 Job Control
 >4, 0.2 *Perceived Job Control, 0))*Satisfaction/Day5
 Units: satisfaction/Day

FINAL TIME = 360
 Units: Day

high quality culture:TEST INPUT:
 Quality Culture Level=1
 high quality culture
 Units: **undefined**

Hours per Day=
 8.67
 Units: hours/Day

Hours per Day 0=
8.67

Units: hours

INITIAL TIME = 0

Units: Day

Investment in Quality Culture=

(Balance between Production and Social Activities +Collaboration +Degree of Shared Control

+Learning and Continuous Improvement

+Management by Fact +Relationship with Environment +Time Horizon +What Motivated Humans

)*Task15/(8*Day15)

Units: Tasks/Day

Is Manager Needed for SetUp=

IF THEN ELSE (Maximum Workers needed to Deal with CMT=2, 1, 0)

Units: Dimensionless

Learning and Continuous Improvement=

0.2

Units: Dimensionless

Level of Interruptions=

((Customers Pressure on Inventory for Immediate Service + Production Worker Pressure on Inventory for Immediate Service

)/2) *(1 - 0.5*Quality Culture Level*One Day for Task/Task)

Units: Dimensionless

lot of prevention:TEST INPUT:

Training>0.8

Units: **undefined**

Machine Breakdown Open Tasks= INTEG (

Machine Breakdown Rate-MBR Rate,

0)

Units: Task

Machine Breakdown Rate=

(RANDOM UNIFORM(0, 2 ,0) + 0.01*Corrective Maintenance Tasks)/Workweek

Units: Task/Day

Machines Gap=

Main Machines-Number of available Machines

Units: Dimensionless

Machines Startup Pressure= WITH LOOKUP (
 (Number of available Machines -Number of Required Machines),
 ((-5,0)-(7,1)],(-5,1),(-4.07951,0.973684),(-3.03058,0.868421),(-2.04587,
 0.679825),(-1.03976,0.381579),(-0.611621,0.232456),(-0.0336391,0.0219298),(
 0.0733945,0.00438596),(0.223242,0),(0.480122,0),(0.801223,0),(1.16514,0),(1.52905
 ,0),(1.89297,0),(7,0)))
 Units: Dimensionless

Main Machines=
 7
 Units: Dimensionless

Maintenance Problems Pressure=
 Max (Problems and Malfunctions*(RANDOM UNIFORM(0.8, 1.05, 0))/Task3, 0)
 Units: Dimensionless

Major Machines=
 7
 Units: Dimensionless

Management by Fact=
 RANDOM UNIFORM (0.6, 0.7, 0)
 Units: Dimensionless

Manager Time=
 RANDOM UNIFORM (1.5, 2.5, 0)/8.67
 Units: Day

Manager's SetUp Completion Rate=
 IF THEN ELSE (Max Completion Rate 0>(INTEGER (1 +(Manager's Time for CMT
 or SetUp
 *8.67/RANDOM UNIFORM (1, 3 ,0))))
 *Task per Day/One Day 0, (INTEGER (1 +(Manager's Time for CMT or SetUp*8.67
 /RANDOM UNIFORM (1, 3 ,0))))
 *Task per Day/One Day 0, Max Completion Rate 0)
 Units: Task/Day

Manager's Time for CMT or SetUp=
 IF THEN ELSE (Maximum Number of Workhours per Worker - (Training Time per
 Worker
 + Manager's Times for Meetings +Manager's Time for Other Tasks
 + Time Spent for MBR) < 0, Maximum Number of Workhours per Worker -
 (Training Time per Worker + Manager's Times for Meetings +Manager's Time for
 Other Tasks
 + Time Spent for MBR))

Units: Day

Manager's Time for Other Tasks=

$$\text{RANDOM UNIFORM}(0, 3, 0) * \text{One Day} / 8.67$$

Units: Day

Manager's Times for Meetings=

$$\text{RANDOM UNIFORM}(1, 3, 0) / 8.67$$

Units: Day

Managers Relations=

$$(\text{RANDOM UNIFORM}(1.8, 2, 1.5) + \text{RANDOM UNIFORM}(1.77, 2.7, 1)) / 2$$

Units: Dimensionless

Max BMC Rate=

$$\text{Max}(\text{Beadle Machines Breakdown Open Tasks} / \text{One Day}, 0, 0)$$

Units: Task/Day

Max Commitment Loss Rate=

$$\text{Max}(\text{Organization Commitment} / \text{Day}, 8, 0)$$

Units: Commitment/Day

Max Completion Rate=

$$\text{Max}(\text{INTEGER}(\text{Production Tasks} / \text{One Day}^2), 0)$$

Units: Tasks/Day

Max Completion Rate 0=

$$\text{Max}(\text{SetUp Tasks} / \text{One Day}, 0, 0)$$

Units: Task/Day

Max Customers Exiting Rate=

$$\text{Max}(\text{Customers Waiting for Service} / \text{Day work}, 0)$$

Units: Customer/Day

Max Exit Rate=

$$\text{Max}(\text{INTEGER}(\text{Orders} / \text{One Day}), 0)$$

Units: Tasks/Day

Max MBR Rate=

$$\text{Max}(\text{Machine Breakdown Open Tasks} / \text{One Day}, 0, 0)$$

Units: Task/Day

Max Problem Rate=

$$\text{Max}(\text{Problems and Malfunctions} / \text{Day}, 1, 0)$$

Units: Tasks/Day

Max Quality Urgent Tasks Exit Rate=
Max (Urgent Quality Tasks/ Day 7, 0)
Units: Tasks/Day

Max Response Rate=
Max (Open Inventory Tasks for Production/Day 0, 0)
Units: Tasks/Day

Max Returning Tasks=
Max (Problems and Malfunctions* 0.1/One Day, 0)
Units: Tasks/Day

Max Stress Out Rate=
Max (Personal Stress/Day4, 0)
Units: stress/Day

Maximum Available Time for MBR per Worker=
Time for Other Tasks per Worker * 0.3*(1+Effect of Machines Startup Pressure on
Time for MBR per Worker
)
Units: Day

Maximum Number of Workhours per Worker=
RANDOM UNIFORM (8.5 , 8.67, 0)/8.67
Units: Day

Maximum Workers needed to Deal with CMT=
Max (1, INTEGER(Time Required for CMT/Allowable Time for CMT per
Worker+1)
)
Units: Dimensionless

MBR Rate=
MIN(Percentage of the day for MBR/Average Time for MBR, Max MBR Rate)
Units: Task/Day

Monetary Compensation=
RANDOM UNIFORM (2.8, 3.7, 2.5)
Units: Dimensionless

more correctness work:THE CONDITION:
no more stress:IMPLIES:Correct Task Completion Rate>= RC GROW CHECK (5,
Correct Task Completion Rate
, 10)
Units: **undefined**

more quality is less stress:THE CONDITION:

high quality culture:AND:lot of prevention:IMPLIES:Personal Stress>=RC DECAY
CHECK

(10, Personal Stress,12)

Units: **undefined**

no machines to do work:THE CONDITION:

all machines breakdown>6:IMPLIES:Correct Task Completion
Rate<=0.01:AND:Out of Order Tasks Completion Rate
<=0.01

Units: **undefined**

no more problems and malfunctions:TEST INPUT:

Problems and Malfunctions= 0

Units: **undefined**

no more stress:TEST INPUT:

Personal Stress = 0

Units: **undefined**

Number of available Machines=

(Major Machines -IF THEN ELSE (Machine Breakdown Open Tasks >0, INTEGER
(
1 + Machine Breakdown Open Tasks /Tasks 0), 0) - IF THEN ELSE
((Beadle Machines - INTEGER(1 + Beadle Machines Breakdown Open Tasks)/(3
*Tasks 0))>(Major Machines - IF THEN ELSE (Machine Breakdown Open Tasks>
0, INTEGER (1 + Machine Breakdown Open Tasks/Tasks 0), 0)), 0, (Major
Machines
-INTEGER (1 + Machine Breakdown Open Tasks/Tasks 0) -
(Beadle Machines - INTEGER((1 + Beadle Machines Breakdown Open
Tasks/Tasks 0
))) /3)))

Units: Dimensionless

Number of Maintenance Workers=

INTEGER (RANDOM UNIFORM (1, 3, 0))

Units: Dimensionless

Number of Open Machines=

Max(INTEGER(Main Machines*(1 -Tasks Percent for few Days) -Machines Gap +
1), 0)

Units: Dimensionless

Number of Required Machines=

MIN (INTEGER((Production Tasks/Task3 +1) +(Problems and Malfunctions/Task3
+ 1)) , Main Machines)

Units: Dimensionless

Number of Tasks for One Day=
IF THEN ELSE (INTEGER(Production Tasks*(1 -Tasks Percent for few
Days)/Tasks
)< Number of Open Machines, INTEGER(Production Tasks
*(1 -Tasks Percent for few Days))
, Number of Open Machines*Tasks
)

Units: Tasks

Number of Workers for MBR=
INTEGER (RANDOM UNIFORM(1, 3 , 0))

Units: Dimensionless

One Day=
1

Units: Day

One Day 0=
1

Units: Day

One Day 0 0=
1

Units: Day

One Day for Task=
1

Units: Day

One Day2=
1

Units: Day

One Hour per Day=
1

Units: 1/Day

Open Inventory Tasks for Production= INTEG (
(Production Tasks Arrival Rate-Production Response Rate),
0)

Units: Tasks

Open Quality Tasks= INTEG (
Quality Arrival Rate-Quality Task Completion Rate,

0)
Units: Tasks

Opportunity for Promotion=
(RANDOM UNIFORM (2.22, 2.67, 2) + RANDOM UNIFORM(1.5, 2.4, 1))/2
Units: Dimensionless

Order Rate=
INTEGER(RANDOM UNIFORM (3, 5 , 2))
Units: Tasks/Day

Orders= INTEG (
Order Rate-Orders Exit Rate,
0)
Units: Tasks

Orders Exit Rate=
IF THEN ELSE (Max Exit Rate <Number of Open Machines*Tasks/One Day, Max
Exit Rate
, Number of Open Machines*Tasks/One Day)
Units: Tasks/Day

Organization Commitment= INTEG (
Commitment Rate -Commitment Loss Rate,
0)
Units: Commitment

Organization Effectiveness=
Max(IF THEN ELSE (Production Tasks =0, 0 , (Production Tasks - Problems and
Malfunctions
)/(Production Tasks)), 0)
Units: Dimensionless

our culture is quality:THE CONDITION:
high quality culture:IMPLIES:Level of Interruptions<= RC STEP CHECK (5, high
quality culture
, 3)
Units: **undefined**

Out of Order Max Rate=
Max (Production Tasks/One Day2 - (Correct Task Completion Rate+Tasks Percent
for few Days
*Production Tasks/One Day2), 0)
Units: Tasks/Day

Out of Order Tasks Completion Rate=

(Max (IF THEN ELSE (Out of Order Max Rate>Machines Gap*Time for Task*Task3 /((One Day2*One Day2) +Production Tasks/One Day2- (Actual Quality Performance Level /10)*(Task3/One Day2), Machines Gap*Time for Task*Task3/(One Day2*One Day2) +Production Tasks/One Day2- (Actual Quality Performance Level /10)*(Task3/One Day2), Out of Order Max Rate), 0))
 Units: Tasks/Day

Overtime Attrition=
 Max (IF THEN ELSE (Production Tasks< 7, Overtime Required for CMT, (((Production Tasks - 7)*Day 0)/(10*Task) +Overtime Required for CMT)) , 0.2)
 Units: Day

Overtime Required for CMT=
 IF THEN ELSE (Time Required for CMT>Total Possible Time for CMT, MIN(Effect of Maintenance Problems Pressure on Overtime Required for CMT /Hours per Day, (Time Required for CMT-Total Possible Time for CMT) , 0)
 Units: Day

Perceived Job Control=
 MIN (RANDOM UNIFORM(2, 2.83, 1) * (1+0.1*Training) * (1+ 0.1*Quality Culture Level*Day6/Task), 5)
 Units: Dimensionless

Perceived Organizational Effectiveness= WITH LOOKUP (Organization Effectiveness, ((0,0)-(1,1)],(0,0),(0.17737,0.0175439),(0.345566,0.0526316),(0.529052,0.135965),(0.639144,0.223684),(0.749235,0.355263),(0.844037,0.513158),(0.920489,0.675439),(0.966361,0.820175),(1.00612,0.991228),(1.01835,0.995614),(1.02141,1.01754)))
 Units: Dimensionless

Percentage of the day for MBR=
 Total Hours Available for MBR/One Day 0 0
 Units: Dimensionless

Personal Stress= INTEG (Stress Accumulation Rate-Stress Relief Rate, 0)
 Units: stress

Possible Completion Rate=

Max (IF THEN ELSE(Training>0.1, IF THEN ELSE (Number of Open
 Machines>Number of Tasks for One Day
 /Tasks1
 , (Number of Tasks for One Day
 /One Day for Task - ((0.01*Open Inventory Tasks for Production/One Day for Task
)*(RANDOM NORMAL(0.001, 0.0012, 0.0014, 0.001, 0))))
 ,
 (Number of Open Machines*Tasks1/One Day for Task - ((0.01*Open Inventory
 Tasks for Production
 /One Day for Task)*(RANDOM NORMAL(0.001, 0.0012, 0.0014, 0.001, 0))))), IF THEN
 ELSE
 (Number of Open Machines>Number of Tasks for One Day/
 Tasks1, Number of Tasks for One Day*(1- Time Devoted for Urgent Quality Tasks
 /One Day for Task)/One Day for Task - ((0.01*
 Open Inventory Tasks for Production/One Day for Task)*(RANDOM
 NORMAL(0.001
 , 0.0012, 0.0014, 0.001, 0))),
 Number of Open Machines*Tasks1*(1 - Time Devoted for Urgent Quality Tasks
 /One Day for Task)/One Day for Task - ((0.01*Open Inventory Tasks for Production
 /One Day for Task)*(RANDOM NORMAL(0.001, 0.0012, 0.0014, 0.001, 0)))) -
 (Level of Interruptions*Tasks1/One Day for Task)*0.01, 0)
 Units: Tasks/Day

Possible Completion Rate 0=
 IF THEN ELSE (Total Possible Time for CMT>Time Required for CMT, Time
 Required for CMT
 *Hours per Day*One Hour per Day/Average time per CMT, (Total Possible Time for CMT
 + Overtime Required for CMT)*Hours per Day*One Hour per Day/Average time per
 CMT
)
 Units: Task/Day

Pressure on Employees= WITH LOOKUP (
 25*Machines Gap/Main Machines+0.25*Corrective Maintenance
 Tasks/(Task0*(RANDOM UNIFORM
 (10, 16, 10)))+2.5*Level of Interruptions,
 ((0,0)-(10,10)],(0,0.0877193),(0.336391,0.0877193),(0.672783,0.219298),(
 1.1315,0.263158),(1.43731,0.394737),(1.83486,
 0.526316),(2.35474,0.833333),(2.84404,1.22807),(3.5474,1.71053),(3.94495,
 2.23684),(4.34251,2.80702),(4.61774,3.42105),
 (4.92355
 ,4.51754),(5.04587,5.17544),(5.22936,5.92105),(5.41284,6.75439),(5.59633,
 7.45614),(5.84098,8.37719),(6.26911,9.12281),
 (6.69725
 ,9.47368),(7.18654,9.73684),(7.92049,9.95614),(8.47095,10.0439),(9.96942,
 10.0439))

Units: Dimensionless

Problem Solution Rate=
(Max Problem Rate*0.9)

Units: Tasks/Day

Problems and Malfunctions= INTEG (
Out of Order Tasks Completion Rate-Problem Solution Rate-Tasks Going Back to
Production

,
0)

Units: Tasks

Production Response Rate=
MIN(Max Response Rate, ((1- Level of Interruptions)/2)*(Production Time

Resources

*8.67/Average Time for Serving Production)*Task/(Day 0*Day 0))

Units: Tasks/Day

Production Tasks= INTEG (
Orders Exit Rate-Correct Task Completion Rate-Out of Order Tasks Completion Rate
+Tasks Going Back to Production,

0)

Units: Tasks

Production Tasks Arrival Rate=
MIN(RANDOM UNIFORM(2 , 12 ,0), RANDOM NORMAL (0.5, 0.7, 0.9, 0.1,

0)*Production Tasks

/One Day for Task)

Units: Tasks/Day

Production Time Resources=
IF THEN ELSE (Production Worker Pressure on Inventory for Immediate Service
>0.5, (Total Time Resources *Production Worker Pressure on Inventory for Immediate
Service

)
, (RANDOM UNIFORM (1.67/8.67, 4.67/8.67, 0)))

Units: Day

Production Worker Pressure on Inventory for Immediate Service= WITH LOOKUP

(
Open Inventory Tasks for Production/Task,
((0,0)-
(30,1)],(0,0),(2.28746,0.0175439),(4.0367,0.0394737),(6.05505,0.0701754
) ,(7.98165,0.0964912),(10.5505,0.140351),(12.9358,0.197368),(15.1376,0.254386
) ,(16.8807,0.320175),(18.4404,0.381579),(20.1835,0.451754),(22.1101,0.548246

),(23.578,0.649123),(24.8624,0.745614),(25.7798,0.828947),(26.8807,0.899123
) ,(28.2569,0.964912),(29.9083,1.00439))

Units: Dimensionless

Quality Arrival Rate=

Task00*RANDOM UNIFORM (2, 10, 0)/Day

Units: Tasks/Day

Quality Culture Level= INTEG (

(Investment in Quality Culture -Quality Culture Level)/Time to Build Quality Culture

,

0)

Units: Tasks/Day

Quality max Completion Rate=

Max(Open Quality Tasks/Day, 0)

Units: Tasks/Day

Quality Task Completion Rate=

IF THEN ELSE (((Time Devoted for Quality Tasks/Hours per Day 0)*Task00/Day
) /RANDOM UNIFORM(2, 4, 0)<Quality max Completion Rate, Quality max Completion
Rate

, ((Time Devoted for Quality Tasks/Hours per Day 0)/RANDOM UNIFORM (2, 4,
0))*(Task00/Day))

Units: Tasks/Day

Relationship with Environment=

RANDOM UNIFORM (0.05, 0.15,0)

Units: Dimensionless

Satisfaction=

1

Units: satisfaction

Satisfaction Erosion Rate=

MIN ((0.05*Overtime Attrition/Day5 +0.2*Opportunity for Promotion
+0.5*Monetary Compensation

+0.05*Managers Relations +EXP(

0.1*Personal Stress/(Stress)) +IF THEN ELSE (Perceived Job Control<4, 0.2*
Perceived Job Control, 0)

)*Satisfaction

/Day5, Employees Satisfaction Level/Day5)

Units: satisfaction/Day

SAVEPER = 1

Units: Day [0,?]

SetUp Arrival Rate=
INTEGER (RANDOM UNIFORM (0, 5, 0))

Units: Task/Day

SetUp Completion Rate=
MIN(IF THEN ELSE (Is Manager Needed for SetUp=0, Max Completion Rate 0,
Manager's SetUp Completion Rate
) , Max Completion Rate 0)

Units: Task/Day

SetUp Tasks= INTEG (
SetUp Arrival Rate-SetUp Completion Rate,
0)

Units: Task

Sickness=
IF THEN ELSE (Personal Stress< 100, 0, Personal Stress/(100*Stress1)/Day6)

Units: 1/Day

Sickness1=
Sickness

Units: 1/Day

Social Environment=
RANDOM UNIFORM (3, 3.5, 2.9)

Units: Dimensionless

Standard CMT Arrival Rate=
RANDOM UNIFORM (20, 32, 0)

Units: Task/Day

Stress=
1

Units: stress

Stress Accumulation Rate=
((0.25*Managers Relations + 0.7*Stress Level))*Stress/Day4 + IF THEN ELSE(
Perceived Job Control<4, (1/Perceived Job Control)*Stress/Day4, 0)

Units: stress/Day

Stress Level=
RANDOM UNIFORM (2, 2.8, 1) + (EXP(Pressure on Employees/10))

Units: Dimensionless

Stress Relief Rate=

$$\text{MIN}(\text{IF THEN ELSE}(\text{Perceived Job Control} > 4, \text{RANDOM UNIFORM}(0.1, 0.3, 0)) * \text{Perceived Job Control} \\
 * \text{Stress/Day4} + 0.2 \\
 * \text{Sickness} * \text{Stress} + (\text{IF THEN ELSE} (\text{Employees Satisfaction Level} > 2.5, \\
 0.7 * \text{Employees Satisfaction Level} \\
 / \text{Satisfaction}, \\
 0)) * \text{Stress/Day4}, 0.5 * \text{Sickness} * \text{Stress} + (\text{IF THEN ELSE} (\text{Employees Satisfaction} \\
 \text{Level} \\
 > 2.5, 0.7 * \text{Employees Satisfaction Level} \\
 / \text{Satisfaction}, 0)) * \text{Stress/Day4}), \text{Max Stress Out Rate})$$
 Units: stress/Day

Stress1=
 1
 Units: stress

Task=
 1
 Units: Tasks

Task 9=
 1
 Units: Task

Task per Day=
 1
 Units: Task/Day

Task0=
 1
 Units: Task

Task00=
 1
 Units: Tasks

Task15=
 1
 Units: Tasks

Task3=
 1
 Units: Tasks

Task7=
 1

Units: Tasks

Tasks=

1

Units: Tasks

Tasks 0=

1

Units: Task

Tasks Going Back to Production=

Max Returning Tasks*0.1

Units: Tasks/Day

Tasks Percent for few Days=

RANDOM UNIFORM (0.05, 0.35, 0)

Units: Dimensionless

Tasks1=

1

Units: Tasks

Time Devoted for Quality Tasks=

(Hours per Day 0 - Time Devoted for Urgent Quality Tasks *Hours per Day 0/

Day 7)

Units: hours

Time Devoted for Urgent Quality Tasks=

IF THEN ELSE (((Orders Exit Rate*Day 7/Tasks1)*RANDOM UNIFORM (0.1, 0.4,

0

) + Urgent Quality Tasks

/Tasks1)*Time per Urgent Task>Hours per Day 0, Day 7,(((Orders Exit Rate*Day 7

/Tasks1)*RANDOM UNIFORM

(0.1, 0.4, 0) + Urgent Quality Tasks/Tasks1)*Time per Urgent Task)*Day 7/

Hours per Day 0)

Units: Day

Time for Other Tasks per Worker=

RANDOM UNIFORM (1, 6, 0)*Day Hours

Units: Day

Time for Task=

(1 - Pressure on Employees/30)*Day1

Units: Day

Time Horizon=

RANDOM UNIFORM (0, 0.1,0)
Units: Dimensionless

Time per Urgent Task=
RANDOM UNIFORM (0.25, 1, 0)
Units: hours

Time Required for CMT=
IF THEN ELSE (Corrective Maintenance Tasks>0, Corrective Maintenance Tasks
* Average time per CMT/Hours per Day, 0)
Units: Day

Time Required for SetUp=
IF THEN ELSE (SetUp Tasks>0, RANDOM UNIFORM (1/8.67, 3/8.67, 0), 0)
Units: Day

Time Resources Allocated for Customers=
IF THEN ELSE (Customers Pressure on Inventory for Immediate Service>0.6, (
Total Time Resources * Customers Pressure on Inventory for Immediate Service
) , (RANDOM UNIFORM (2/8.67, 4/8.67, 0)))
Units: Day

Time Spent for MBR=
Effect of Machines Startup Pressure on Time for MBR per Worker*One Day 0/8.67
Units: Day

Time Spent in Meetings per Worker=
RANDOM UNIFORM (0 , 0.35, 0)/8.67
Units: Day

TIME STEP = 1
Units: Day [0,?]

Time to Build Quality Culture=
30
Units: Day

Total Hours Available for MBR=
Number of Workers for MBR*Maximum Available Time for MBR per Worker
Units: Day

Total Possible Time for CMT=
IF THEN ELSE (Maximum Workers needed to Deal with CMT > 3, (Allowable
Time for CMT per Worker
*Number of Maintenance Workers

+IF THEN ELSE (Is Manager Needed for SetUp =0, Manager's Time for CMT or
SetUp
, 0)), Number of Maintenance Workers*Allowable Time for CMT per Worker)
Units: Day

Total Time Resources=
Manager Time +Workers Time
Units: Day

Training=
IF THEN ELSE (Open Quality Tasks< 2, RANDOM UNIFORM (0.2, 0.4, 0.2),
RANDOM UNIFORM
(0, 0.1, 0))
Units: Dimensionless

Training Time per Worker=
RANDOM UNIFORM (0 , 2, 0)/8.67
Units: Day

Urgent Quality Tasks= INTEG (
Urgent Quality Tasks Arrival Rate-Urgent Tasks in Quality Exit Rate,
0)
Units: Tasks

Urgent Quality Tasks Arrival Rate=
Max ((Problems and Malfunctions/Day
* (RANDOM UNIFORM (0.2, 0.4, 0)) + IF THEN ELSE
(Open Quality Tasks > 7, EXP (Open Quality Tasks
/(Task7*10)), 0)*Task7/Day) *(1 - 0.2*Training)*(1-0.2*Quality Culture Level
) *Day/Task7, 0)
Units: Tasks/Day

Urgent Tasks in Quality Exit Rate=
IF THEN ELSE ((Max Quality Urgent Tasks Exit Rate*Day 7/Task7)*Time per
Urgent Task
>Hours per Day 0, (Hours per Day 0/Time per Urgent Task)*Task7/Day 7
, Max Quality Urgent Tasks Exit Rate
)
Units: Tasks/Day

we are controled on our jobs:THE CONDITION:
high quality culture:AND:lot of prevention:IMPLIES:Perceived Job Control>=
RC STEP CHECK (10, Perceived Job Control, 0.5)
Units: **undefined**

What Motivated Humans=

RANDOM UNIFORM (0, 0.1, 0)
Units: Dimensionless

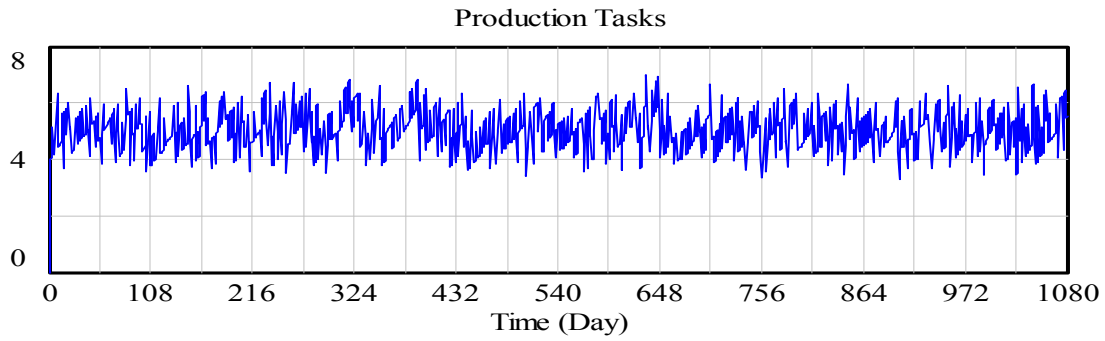
Work Satisfaction=
RANDOM UNIFORM (2.5, 3, 2.5)
Units: Dimensionless

Workers Time=
RANDOM UNIFORM (1, 1.05, 0)
Units: Day

Workweek=
5
Units: Day

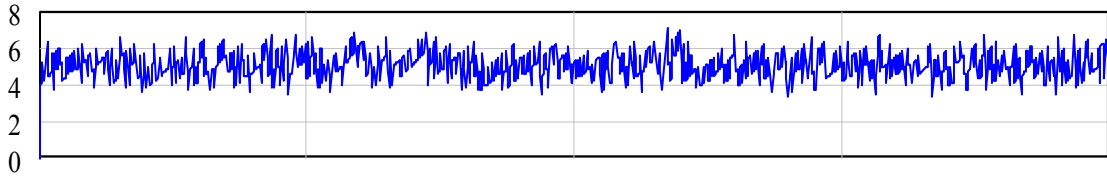
Appendix L -Three Years Behavior

Production Subsystem:

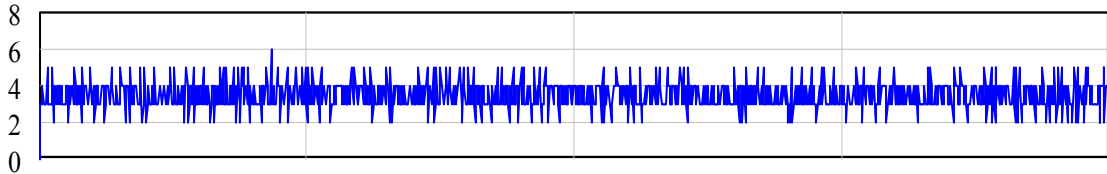


Production-three year- _____

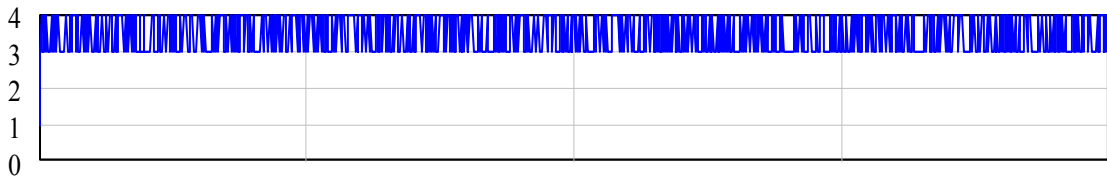
Production Tasks



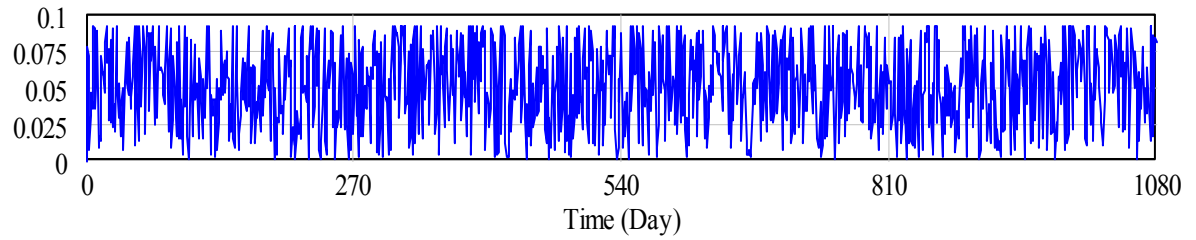
Correct Task Completion Rate



Orders Exit Rate

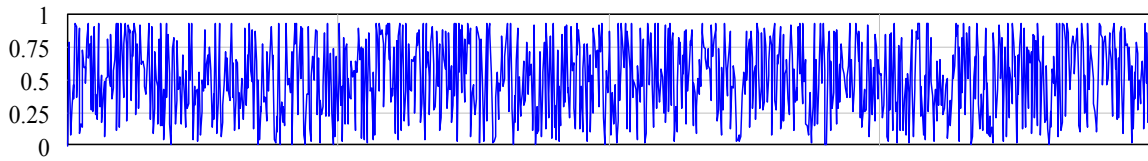


Tasks Going Back to Production

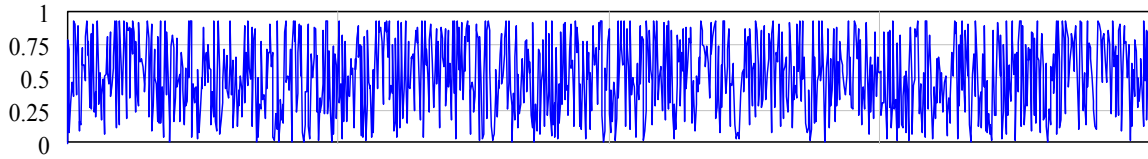


Production-three year-

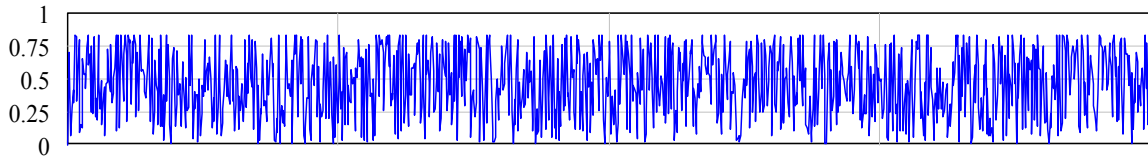
Problems and Malfunctions



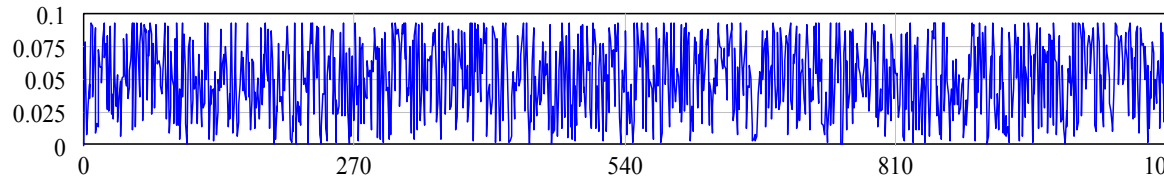
Out of Order Tasks Completion Rate



Problem Solution Rate



Tasks Going Back to Production

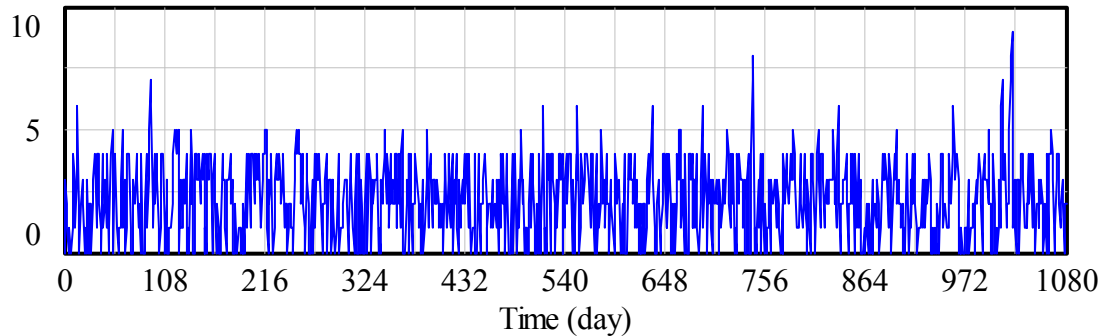


Time (Day)

Production: No changes in the behavior of three years compared with the behavior of one year.

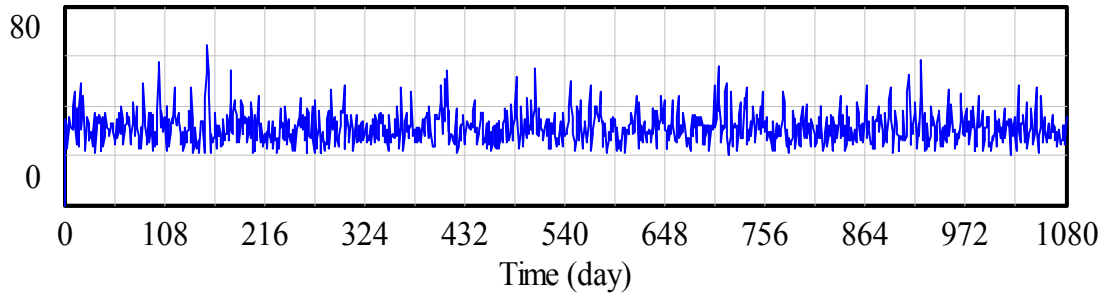
Maintenance Subsystem:

SetUp Tasks



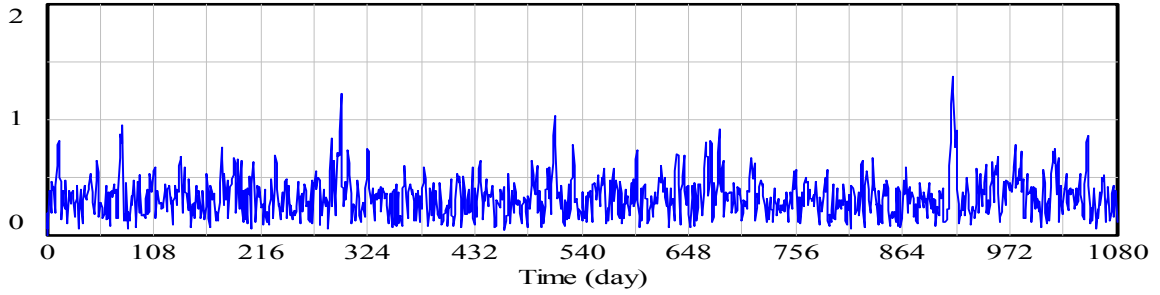
SetUp Tasks : Maintenance three years _____ Task

Corrective Maintenance Tasks



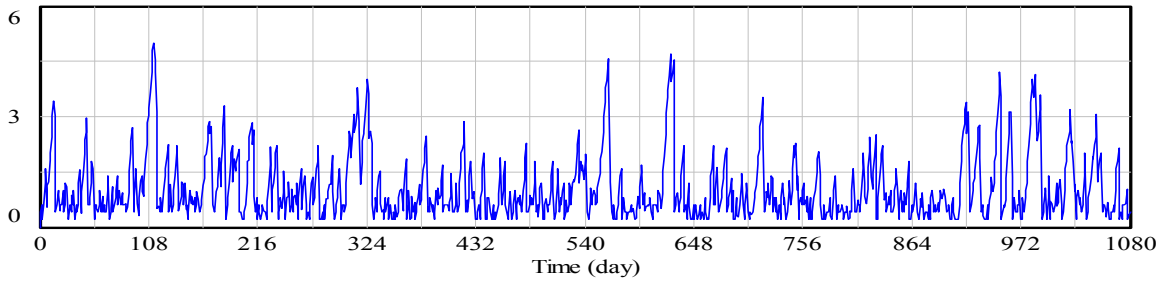
Corrective Maintenance Tasks : Maintenance three years ————— Task

Machine Breakdown Open Tasks



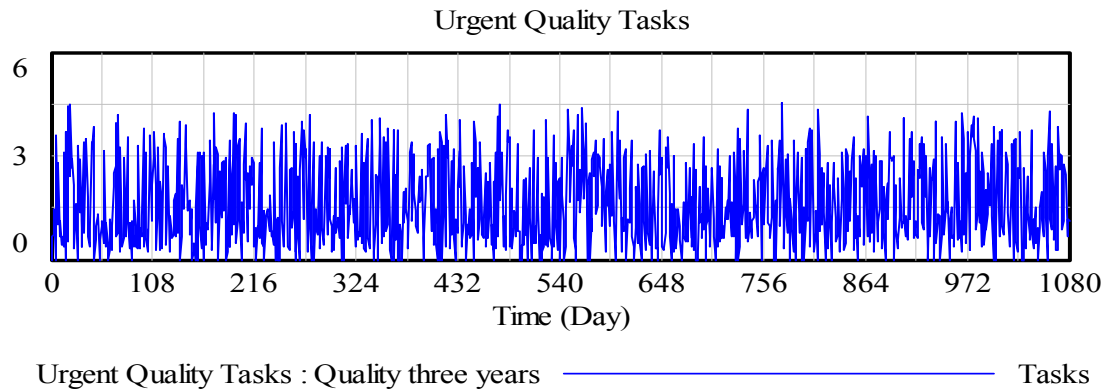
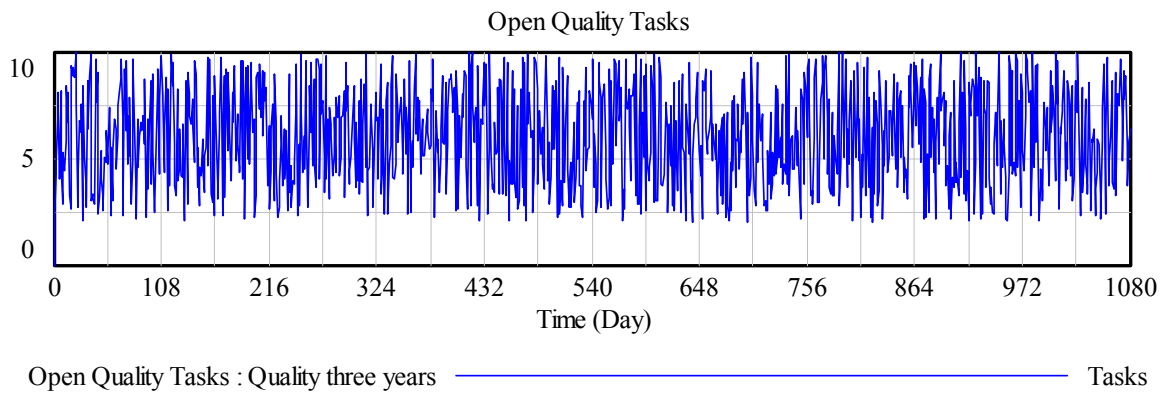
Machine Breakdown Open Tasks : Maintenance three years ————— Task

Beadle Machines Breakdown Open Tasks

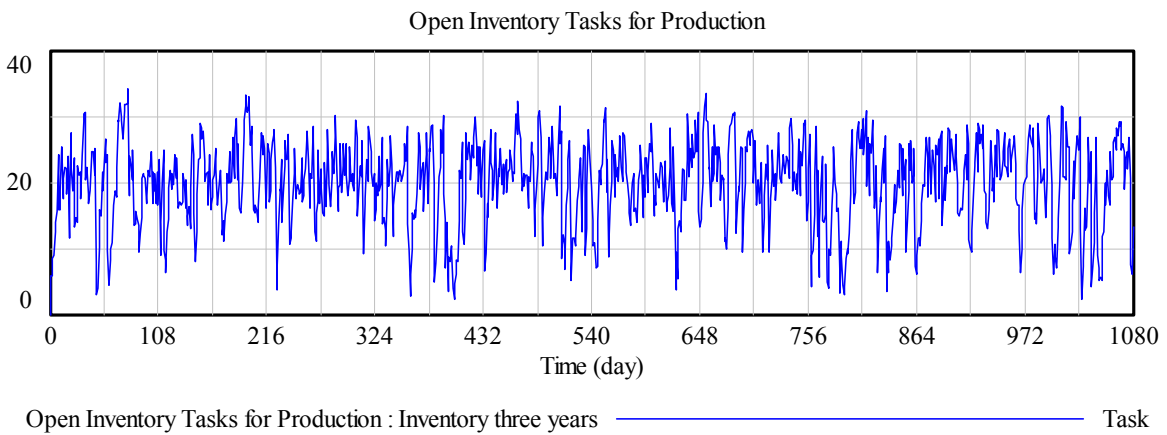


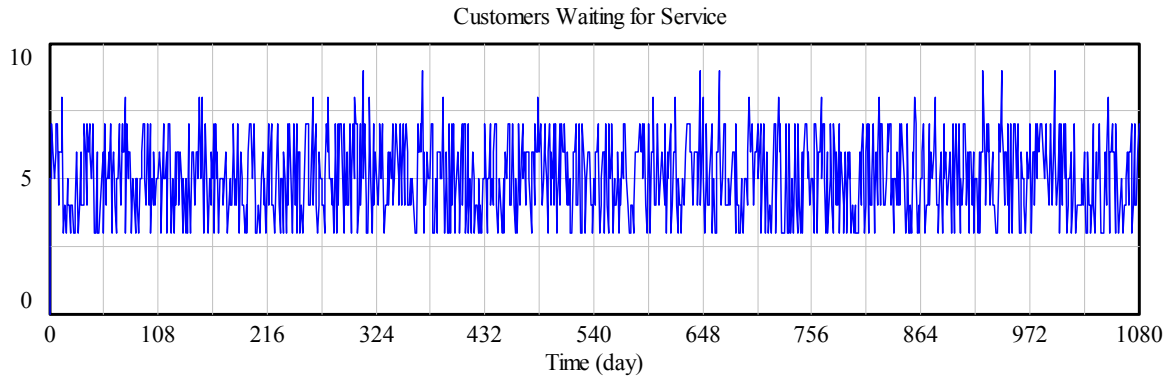
Beadle Machines Breakdown Open Tasks : Maintenance three years ————— Task

Quality Assurance Subsystem:

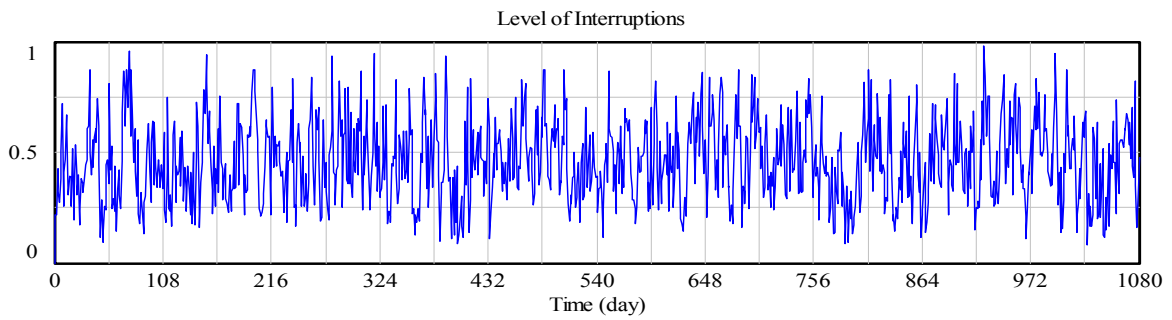


Inventory Subsystem:



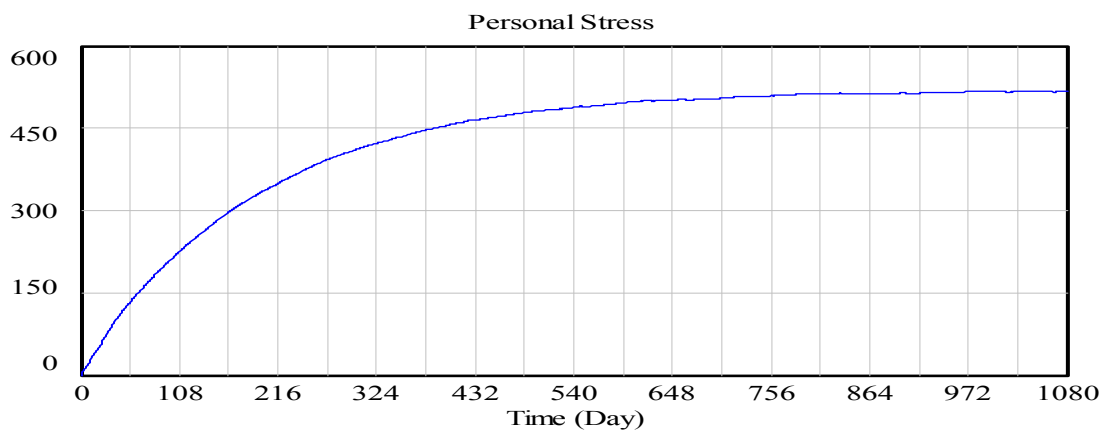


Customers Waiting for Service : Inventory three years ————— Customer

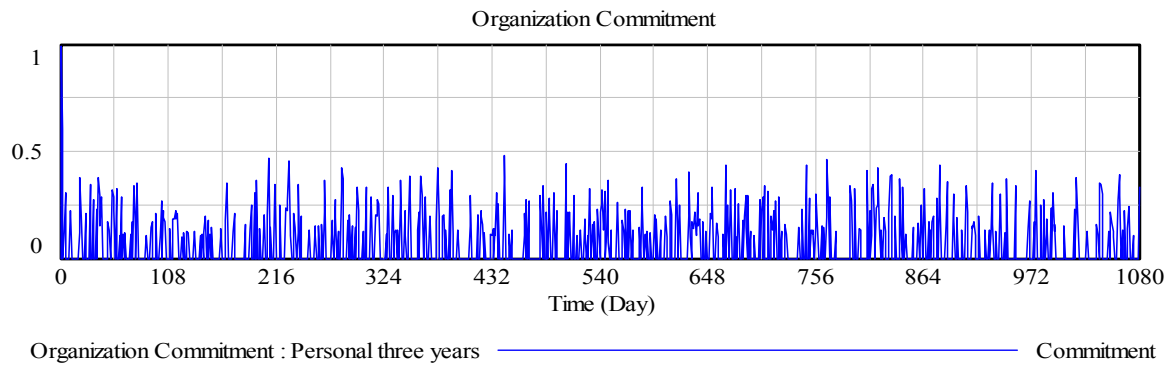
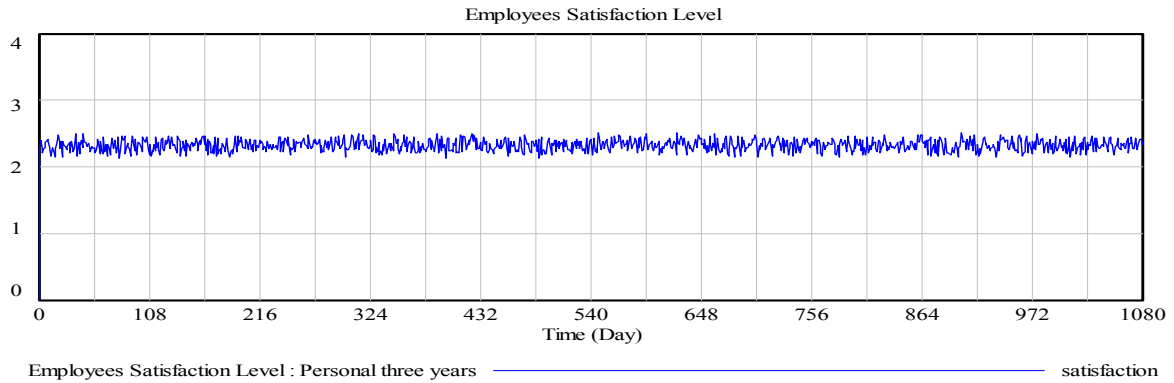


Level of Interruptions : Inventory three years ————— Dimensionless

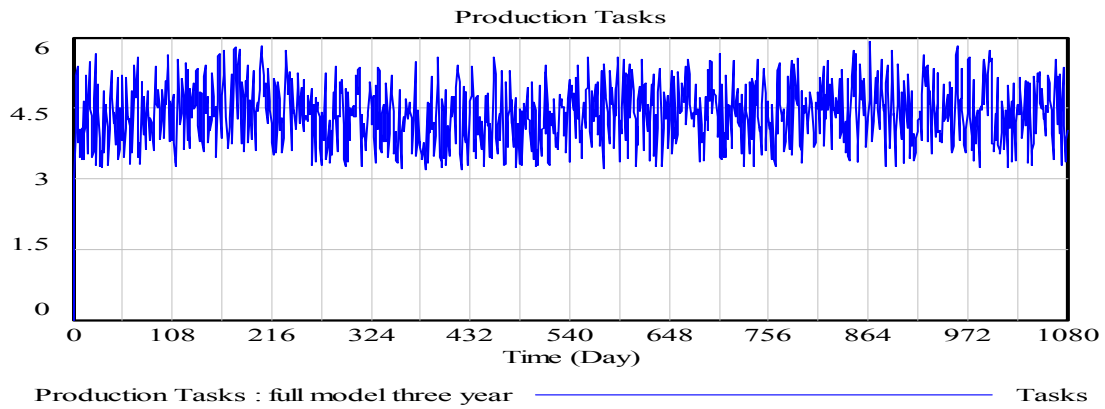
Personal Subsystem:



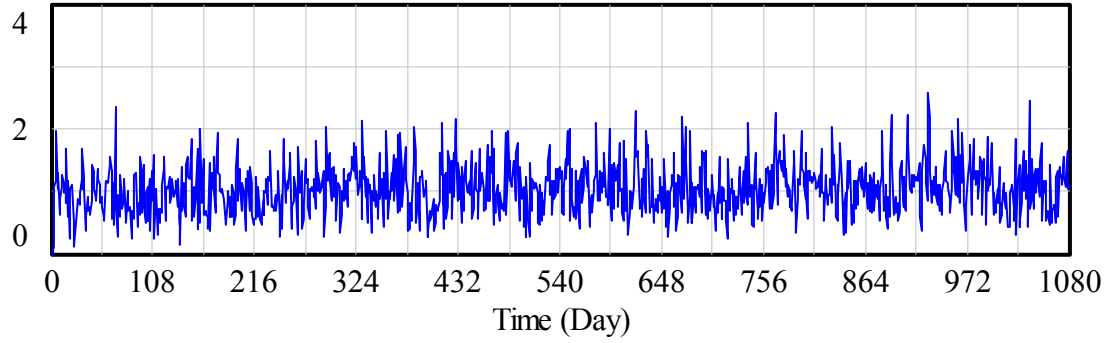
Personal Stress : Personal three years ————— stress



Full Model:

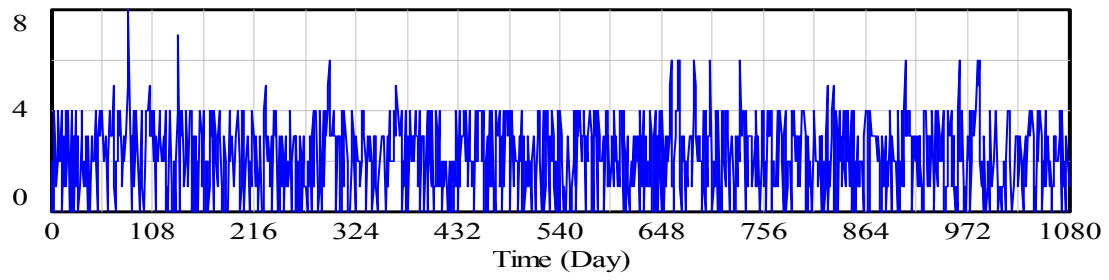


Problems and Malfunctions



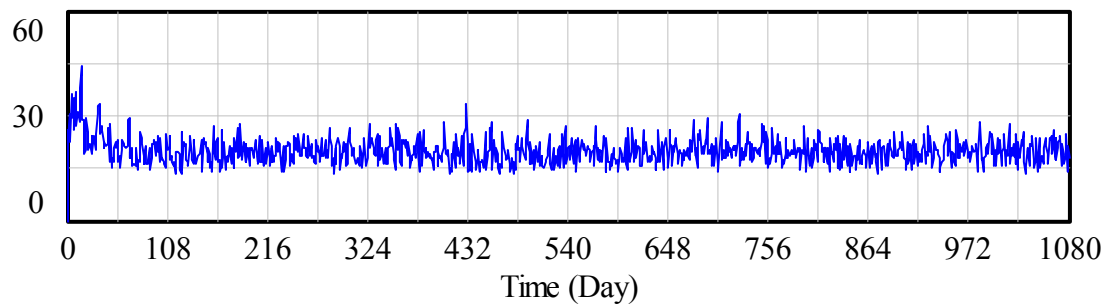
Problems and Malfunctions : full model three year ———— Task

SetUp Tasks



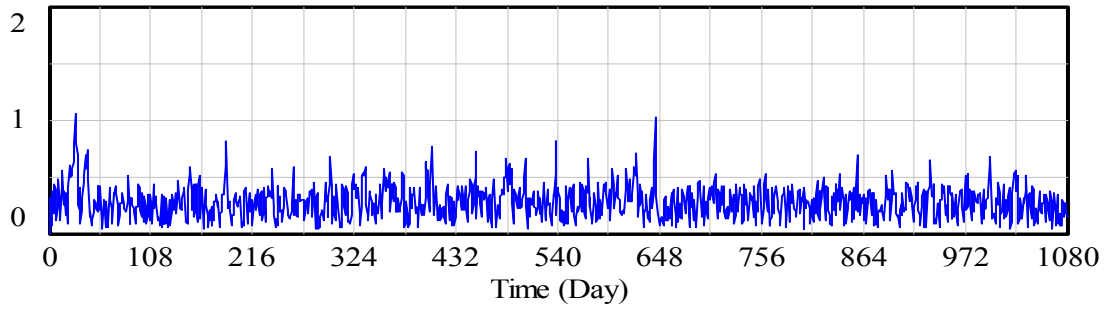
SetUp Tasks : full model three year ———— Task

Corrective Maintenance Tasks



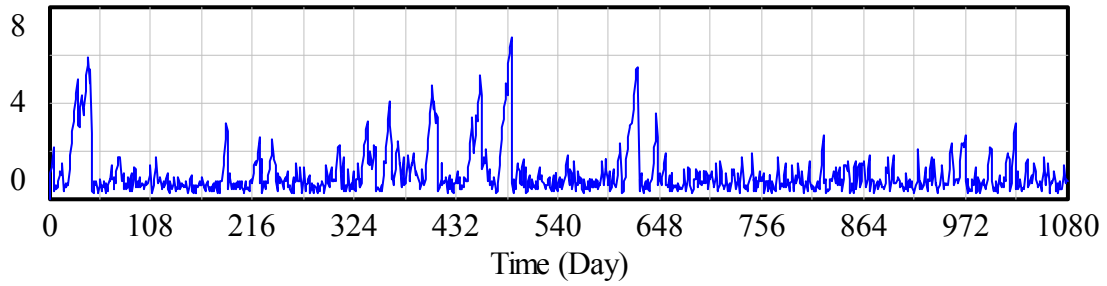
Corrective Maintenance Tasks : full model three year ———— Task

Machine Breakdown Open Tasks



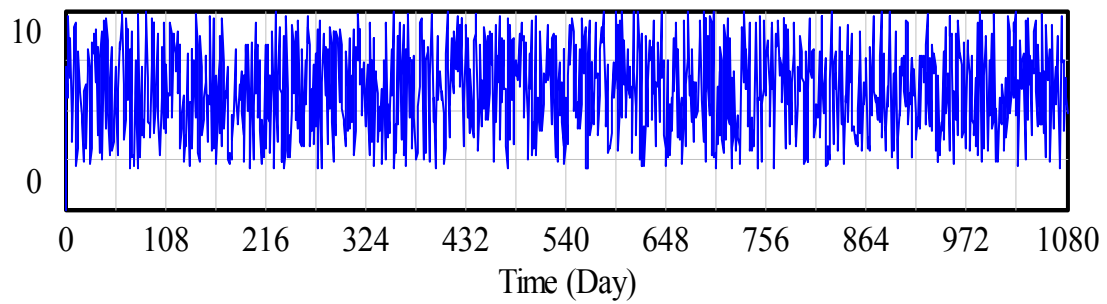
Machine Breakdown Open Tasks : full model three year ——— Task

Beadle Machines Breakdown Open Tasks



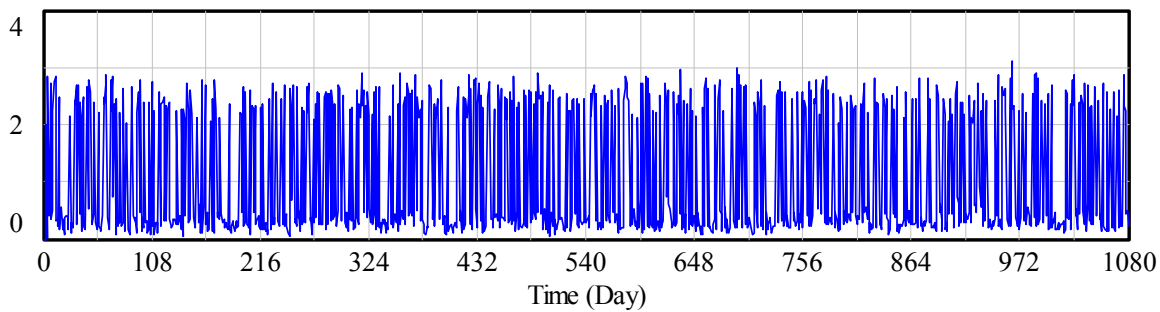
Beadle Machines Breakdown Open Tasks : full model three year ——— Task

Open Quality Tasks



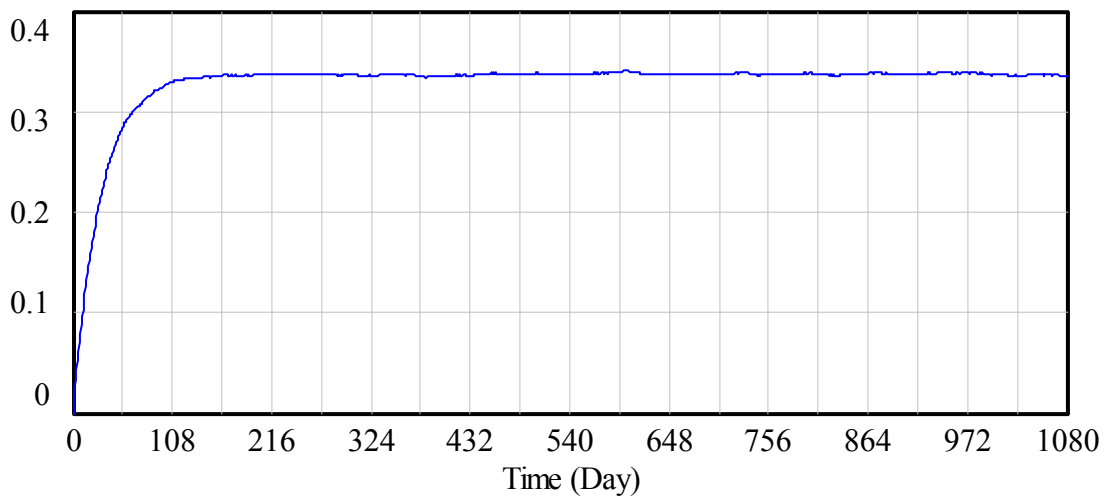
Open Quality Tasks : full model three year ——— Tasks

Urgent Quality Tasks



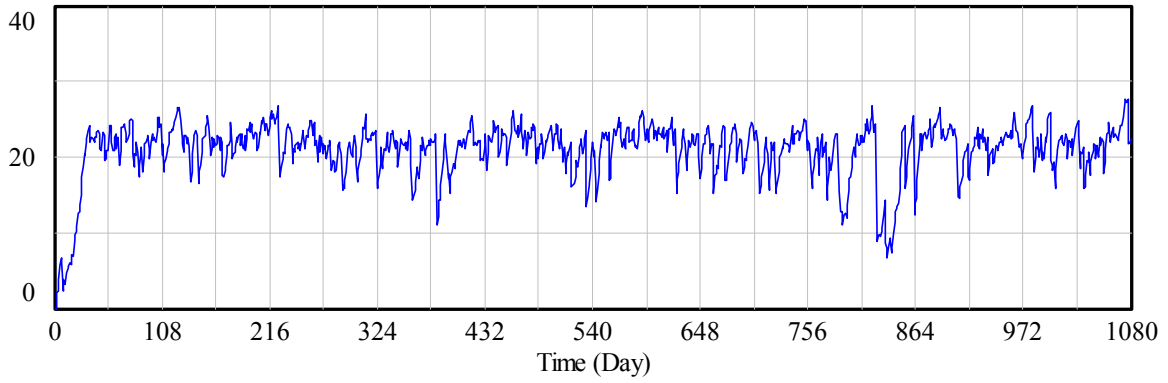
Urgent Quality Tasks : full model three year ——— Tasks

Quality Culture Level



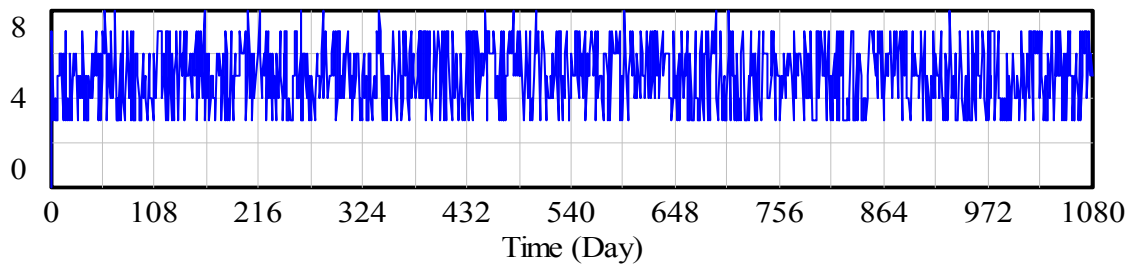
Quality Culture Level : full model three year ——— Tasks/Day

Open Inventory Tasks for Production



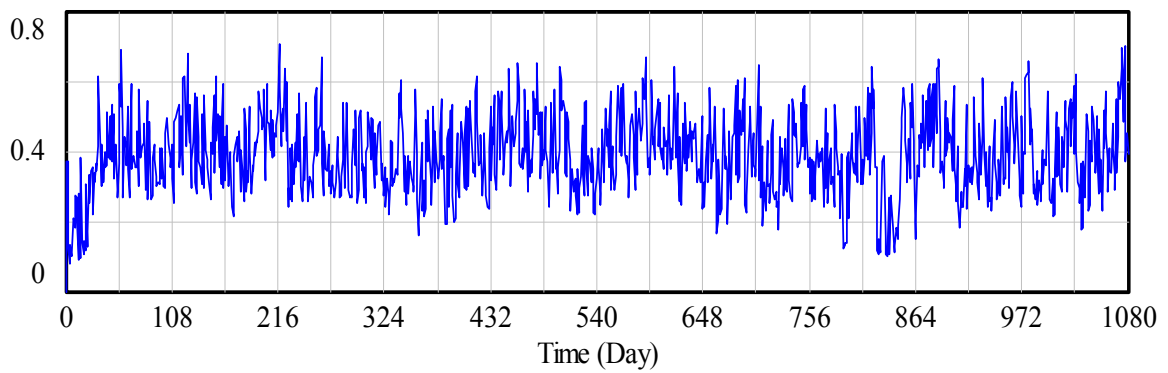
Open Inventory Tasks for Production : full model three year ——— Tasks

Customers Waiting for Service



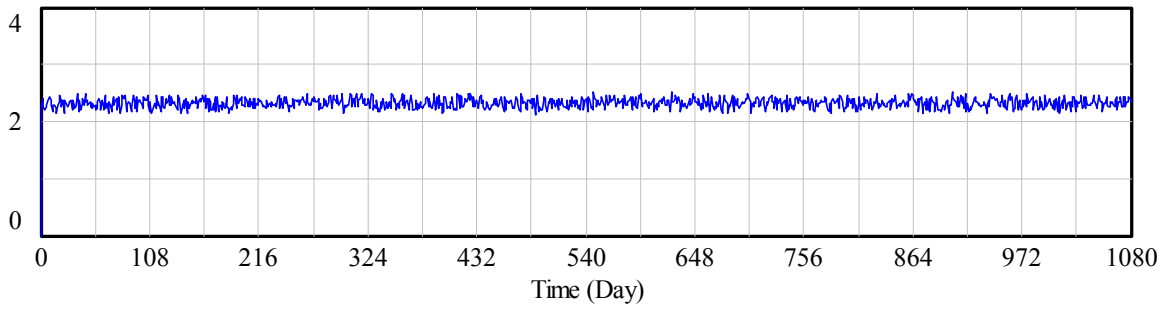
Customers Waiting for Service : full model three year ——— Customer

Level of Interruptions



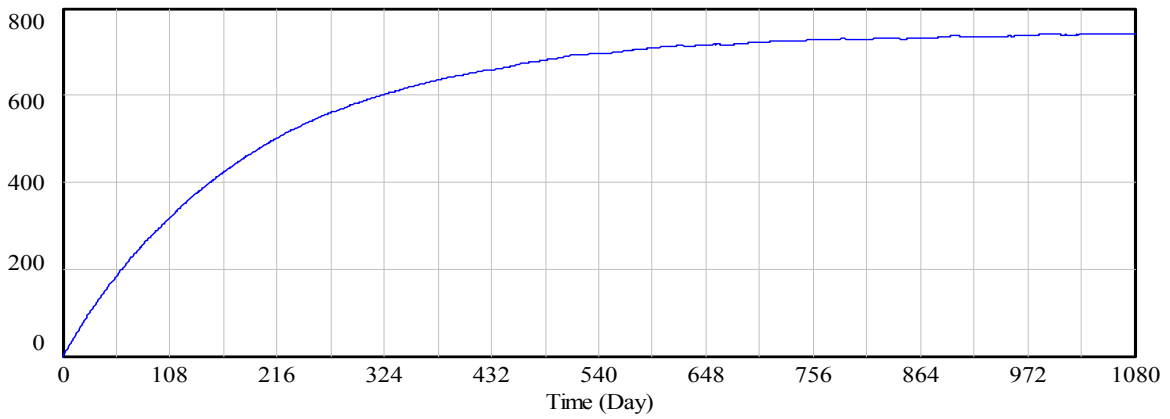
Level of Interruptions : full model three year ——— Dimensionless

Employees Satisfaction Level



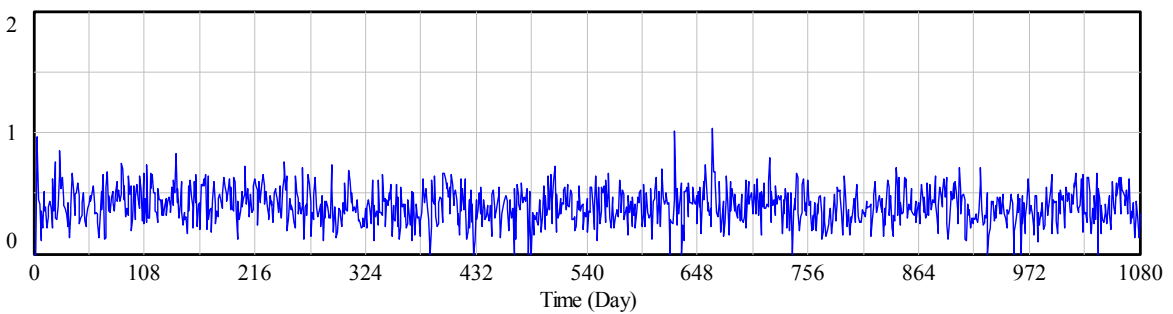
Employees Satisfaction Level : full model three year ————— satisfaction

Personal Stress



Personal Stress : full model three year ————— stress

Organization Commitment



Organization Commitment : full model three year ————— Commitment

Appendix M

Questionnaire for Stress Assessment, Perceived Control in the Job, Job Satisfaction and Organizational Commitment

Questions about stress assessment - 1-5

Questions about perceived control in the job- 6-8

Questions about job satisfaction - 9-16

Questions about organizational commitment- 17-24

Workers Results:

1 I strongly disagree	2 I disagree	3 I am not sure	4 I agree	5 I strongly agree	Sentence	No
2	8	5	4	3	I am very stressed currently (Based on Sheridan question # 1)	.1
2	3	5	5	7	When I am stressed, I feel angry, nervous, sadness (Based on Sheridan question #11)	.2
	5	10	6	1	Many things are stressing me lately (Based on Sheridan question # 6)	.3
1	2	9	8	2	General, stressors cause me body symptoms like: headaches, tiredness, fast heartbeat (Based on Sheridan question # 9)	.4
1	2	8	7	4	My work situation does not stress me (Based on Sheridan question # 17)	.5
3	4	7	6	2	I have latitude in the work of my job (Based on Karasek & Theorell pp. 318)	.6
8	4	8	2		In my work situation, I feel I am unable to control what happens (Based on Sheridan question # 17)	.7
	3	3	11	5	In my work, I have decision latitude referring my job (Based on Karasek & Theorell pp. 318)	.8
13	6	2	1		I feel I am being paid a fair amount for the work I do (Based on Spector, question # 1)	.9
	1	5	6	10	I like the people I work with (Based on Spector, question # 7)	.10
1	6	7	8		When I do a good job, I receive the recognition for it that I should receive (Based on Spector, question # 5)	.11
	4	5	8	5	There is really too little chance for	.12

					promotion on my job (Based on Spector, question # 2)	
5	9	4	2	2	I sometimes feel my job is meaningless (Based on Spector, question # 8)	.13
	2	3	10	7	I like doing the things I do at work (Based on Spector, question # 17)	.14
5	3	6	8		I do not feel that the work I do is appreciated (Based on Spector, question # 14)	.15
5	5	6	5	1	Those who do well on the job stand a fair chance of being promoted (Based on Spector, question # 11)	.16
2	4	4	7	5	I am quite proud to be able to tell people who it is I work for (Based on Cook & Wall, question # 1)	.17
1	3	10	4	4	I sometimes feel like leaving this employment for good (Based on Cook & Wall, question # 2)	.18
6	4	4	6	2	I feel myself to be part of the organization (Based on Cook & Wall, question # 5)	.19
9	6	3	2	2	I am not willing to put myself out just to help the organization (Based on Cook & Wall, question # 3)	.20
	3	2	7	10	The offer of a bit more money with another employer would make me think of changing my job (Based on Cook & Wall, question #7)	.21
		1	12	9	In my work I like to feel I am making some effort, not just for myself but for the organization as well (Based on Cook & Wall, question # 6)	.22
		1	12	9	To know that my own work had made a contribution to the good of the organization would please me (Based on Cook & Wall, question # 9)	.23
4	8	5	4	1	I would not recommend a close friend to join our staff (Based on Cook & Wall, question # 8)	.24

Managers Results:

1 I strongly disagree	2 I disagree	3 I am not sure	4 I agree	5 I strongly agree	Sentence	No
		3	2	1	I am very stressed currently (Based on Sheridan question # 1)	.1
	1		3	2	When I am stressed, I feel angry, nervous, sadness (Based on Sheridan question #11)	.2
		3	2	1	Many things are stressing me lately (Based on Sheridan question # 6)	.3
1	3		1	1	General, stressors cause me body symptoms like: headaches, tiredness, fast heartbeat (Based on Sheridan question # 9)	.4
1	1	3	1		My work situation does not stress me (Based on Sheridan question # 17)	.5
	1		4	1	I have latitude in the work of my job (Based on Karasek and Theorell, pp. 318)	.6
1	3	1		1	In my work situation, I feel I am unable to control what happens (Based on Sheridan question # 17)	.7
		3	1	2	In my work, I have decision latitude referring my job (Based on Karasek and Theorell pp. 318)	.8
2	1	2	1		I feel I am being paid a fair amount for the work I do (Based on Spector, question # 1)	.9
		1	4	1	I like the people I work with (Based on Spector, question # 7)	.10
	1	3	2		When I do a good job, I receive the recognition for it that I should receive (Based on Spector, question # 5)	.11
		4	2		There is really too little chance for promotion on my job (Based on Spector, question # 2)	.12
	4	1	1		I sometimes feel my job is meaningless (Based on Spector, question # 8)	.13
		3	2	1	I like doing the things I do at work (Based on Spector, question # 17)	.14
		2	4		I do not feel that the work I do is appreciated (Based on Spector, question # 14)	.15
		3	3		Those who do well on the job stand a fair chance of being promoted (Based on Spector, question # 11)	.16
	1	1	4		I am quite proud to be able to tell people who it is I work for (Based on Cook & Wall, question # 1)	.17
		2	1	3	I sometimes feel like leaving this employment for good	.18

					(Based on Cook & Wall, question # 2)	
		2	3	1	I feel myself to be part of the organization (Based on Cook & Wall, question # 5)	.19
	2	1	2	1	I am not willing to put myself out just to help the organization (Based on Cook & Wall, question # 3)	.20
		2	1	3	The offer of a bit more money with another employer would make me think of changing my job (Based on Cook & Wall, question #7)	.21
		1	4	1	In my work I like to feel I am making some effort, not just for myself but for the organization as well (Based on Cook & Wall, question # 6)	.22
		1	4	1	To know that my own work had made a contribution to the good of the organization would please me (Based on Cook & Wall, question # 9)	.23
		3	2	1	I would not recommend a close friend to join our staff (Based on Cook & Wall, question # 8)	.24

Scoring the Questionnaire

Stress assessment:

For the following items: 5

$$1 = 4$$

$$2 = 3$$

$$3 = 2$$

$$4 = 1$$

$$5 = 0$$

For item: 1, 2, 3, 4

$$1 = 0$$

$$2 = 1$$

$$3 = 2$$

$$4 = 3$$

$$5 = 4$$

Perceived control in the job:

For the following items: 7

$$1 = 4$$

$$2 = 3$$

$$3 = 2$$

$$4 = 1$$

$$5 = 0$$

For item: 6, 8

$$1 = 0$$

$$2 = 1$$

$$3 = 2$$

$$4 = 3$$

$$5 = 4$$

Job satisfaction:

For the following items: 12, 13, 15

$$1 = 4$$

$$2 = 3$$

$$3 = 2$$

$$4 = 1$$

$$5 = 0$$

For item: 9, 10, 11, 14, 16

$$1 = 0$$

$$2 = 1$$

$$3 = 2$$

$$4 = 3$$

$$5 = 4$$

Organizational commitment:

For the following items: 18, 20, 21, 24

$$1 = 4$$

$$2 = 3$$

$$3 = 2$$

$$4 = 1$$

$$5 = 0$$

For item: 17, 19, 22, 23

$$1 = 0$$

$$2 = 1$$

$$3 = 2$$

$$4 = 3$$

$$5 = 4$$

**Questionnaire for Stress Assessment, Perceived Control in the Job,
Job Satisfaction and Organizational Commitment (Workers)**

Workers	Mean =Total/22	Managers	Mean =Total/6	Sentence	No
	1.91		2.67	I am very stressed currently	1
	2.55		2.83	When I am stressed, I feel angry, nervous, sadness	2
	2.14		2.67	Many things are stressing me lately	3
	2.36		1.67	General stressors cause me body symptoms like headaches, tiredness, fast heartbeat	4
	2.45		2.33	My work situation does not stress me	5
Average	2.282	Average	2.434		
SD	0.257235	SD	0.4644		
Sum	11.41	Sum	12.17		
	2		2.83	I have latitude in the work of my job	6
	2.82		2	In my work situation, I feel I am unable to control what happens	7
	2.82		2.83	In my work situation, I feel I am unable to control what happens	8
Average	2.546667	Average	2.5533		
SD	0.473427	SD	0.4792		
Sum	7.64	Sum	7.66		
	0.59		1.17	I feel I am being paid a fair amount for the work I do	9
	3.14		3	I like the people I work with	10
	2		2.17	When I do a good job, I receive the recognition for it that I should receive	11
	1.36		1.67	There is really too little chance for promotion on my job	12
	2.59		2.5	I sometimes feel my job is meaningless	13
	3		2.67	I like doing the things I do at work	14
	2.23		1.33	I do not feel that the work I do is appreciated	15
	1.64		2.5	Those who do well on the job stand a fair chance of being promoted	16
Average	2.06875	Average	2.1263		
SD	0.86107	SD	0.6652		
Sum	16.55	Sum	17.01		
	2.41		2.5	I am quite proud to be able to tell people who it is I work for	17
	1.68		0.83	I sometimes feel like leaving this employment for good	18
	1.73		2.83	I feel myself to be part of the organization	19
	2.82		1.67	I am not willing to put myself out just to help the organization	20
	0.91		0.83	The offer of a bit more money with another employer would make me think of changing my job	21
	3.36		3	In my work I like to feel I am making some effort, not just for myself but for the organization as well	22
	3.36		3	To know that my own work had made a contribution to the good of the organization would please me	23
	2.45		1.33	I would not recommend a close friend to join our staff	24
Average	2.34	Average	1.9988		
SD	0.860299	SD	0.9437		
Sum	18.72	Sum	15.99		

Results Discussion

Workers are less stressed (2.282) than managers (2.434). Managers' standard deviation is 0.464, workers' standard deviation is 0.257.

Workers and managers are almost equal concerning perceived control in the job (workers: 2.547, managers: 2.553). Standard deviation for most groups is almost equal (workers: 0.473, managers: 0.479).

Managers are more satisfied from their job (2.126) than workers (2.06875). Standard deviation is low in both groups (workers: 0.86, managers: 0.66).

Managers are less committed (1.999, standard deviation: 0.944) than the workers (2.34, standard deviation: 0.86).

Appendix N

Questionnaire – Weighting Variables in Personal Loop

1. Assuming the employee's perception of his control over his work is distributed
between 1-5: Which number will represent higher stress?
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5

2. If the rate of increasing stress is due to the following factors: personal stress, management's attitude, control over work- What is the weight of each?
 - a. Personal stress
 - b. Management's attitude
 - c. Control over work

3. Assuming we are stressed out, we might become sick –or decide to take few days
off- How do these help to decrease stress at work?

4. From your own experience, how much is sick leave used amid employees?

5. Considering stress relief, weigh the following factors (in order of importance)
 - a. Control over work
 - b. Sick leave
 - c. Work satisfaction

6. Considering work satisfaction, weigh the following factors:
 - a. Interest in work
 - b. Social environment
 - c. Control over work

7. Considering factors for burnout, weigh the following:
 - a. Overtime
 - b. Opportunities for advancement
 - c. Monetary compensation
 - d. Management's concern
 - e. Control or lack of it over work

8. To what extent do workers get training for awareness and handling of issues in the workplace? (1-5)
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5

9. To what extent do training, guidance and learning impact control over work? Rank between 1-5 or in percentages.

10. How often is overtime required during the week? How many hours and how many workers are needed?

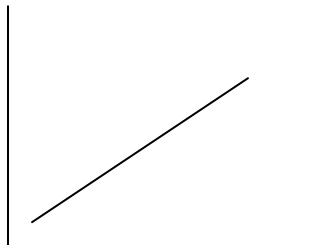
11. Is there any connection between the number of quality tasks and the gap of quality culture in the firm?

12. Is there a connection between the gap in quality culture and the number of breakdowns and problems in production? If yes, to what extent?

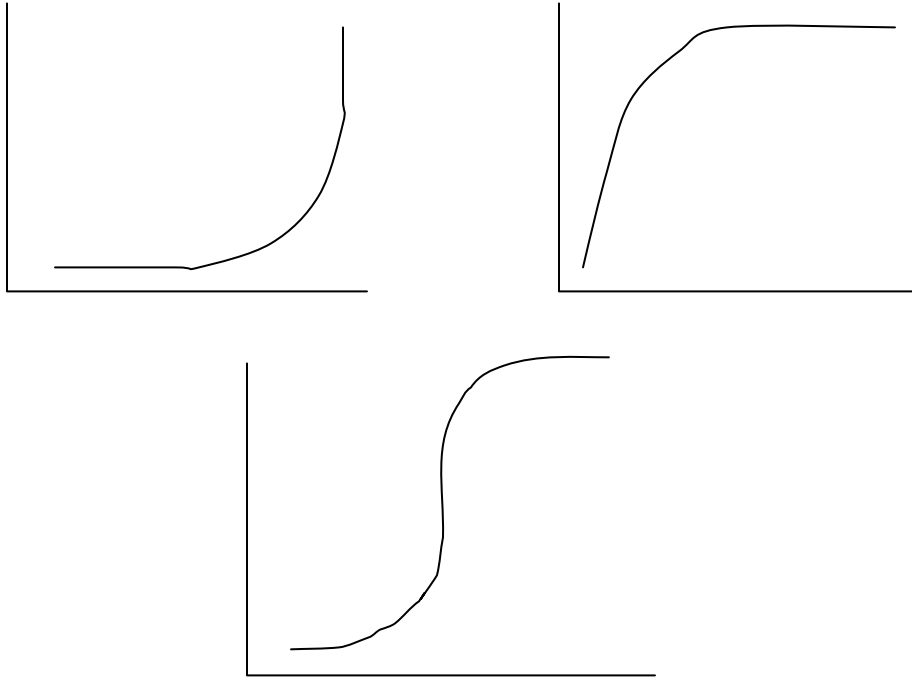
13. Is there any connection between employees' satisfaction and quality culture? Is it true that the higher the satisfaction the lower is the awareness of the quality culture?

14. Is there a connection between employees' satisfaction and their commitment to the firm? Is it linear, meaning if X denotes employee' satisfaction and Y- commitment- does Y increase when X increases?

a. Linear



b. Non Linear

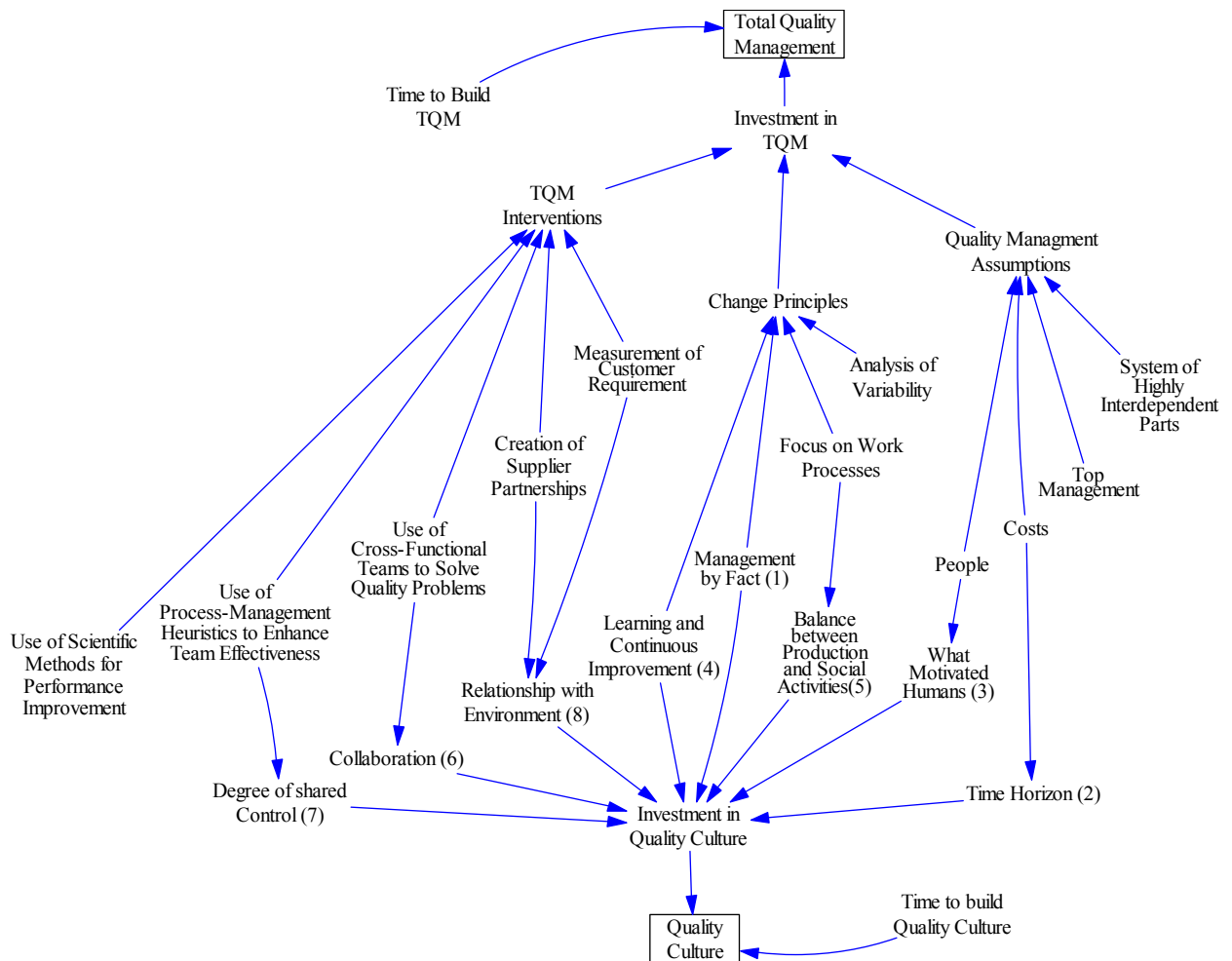


15. What causes the lack of commitment to your firm?

Appendix O

The Table for Computing the Values of Quality Culture and TQM

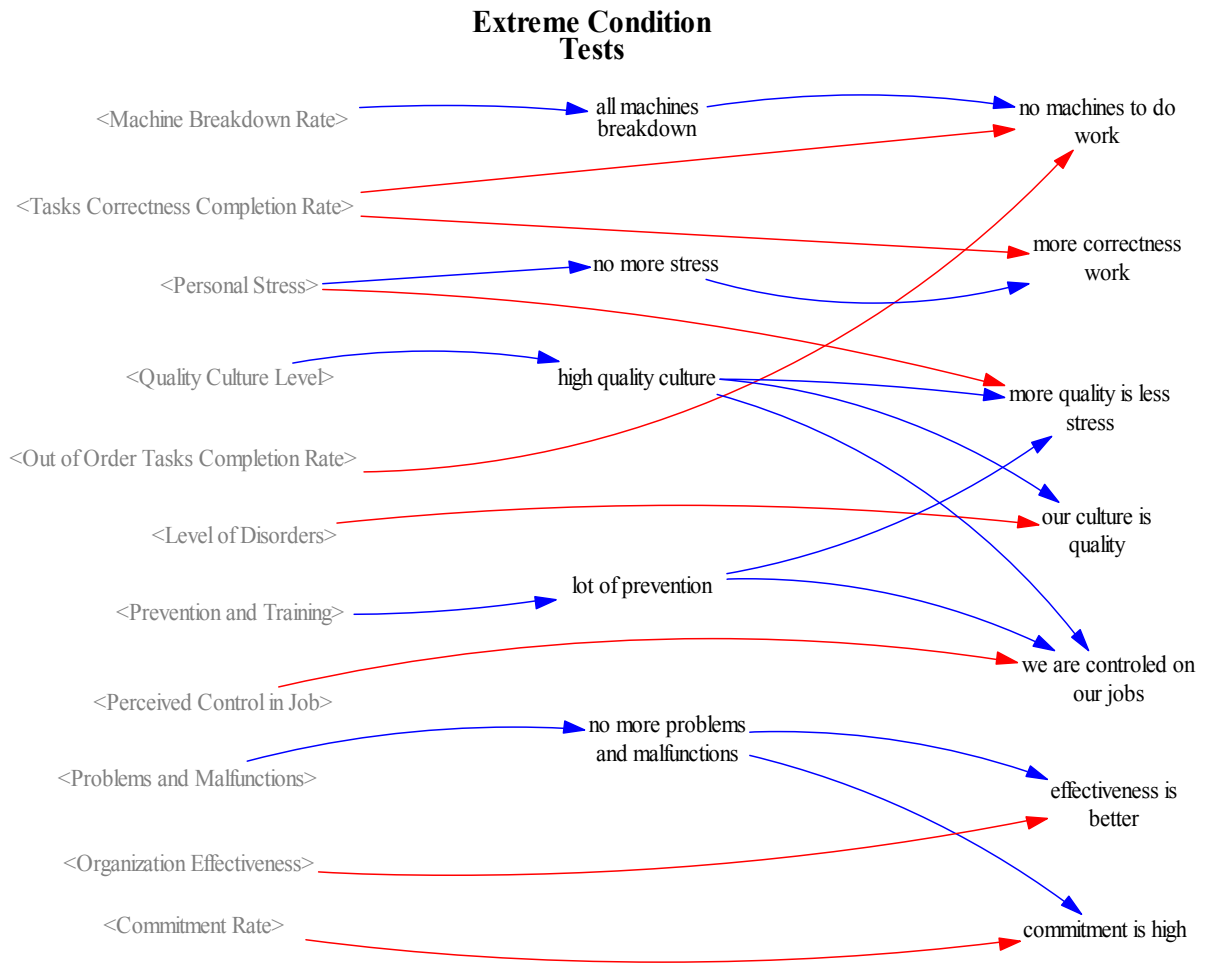
TQM	Quality Culture	Worker A	Worker B	Worker C	Worker D	
System of highly interdependent parts		0	0	0	0	0
Top management		0	0	0	0	0
costs	Time horizon	0	0	0.1	0.1	0-0.1
People	What motivated humans	0	0	0.1	0.1	0-0.1
Analysis of variability		0	0	0	0	0
Focus on work processes	Balance between production & social activities	0.3	0.2	0.2	0.1	0.2-0.3 (0.1)
Management by fact		0.6	0.5	0.7	0.6	0.6-0.7 (0.5)
Learning and continuous improvement		0.2	0.2	0.2	0.2	0.2
Measurement of customer requirement	Relationship with environment	0	0.2	0.1	0.3	0.1-0.3 (0)
Creation of supplier partnerships		0	0	0	0	0
Use of cross-functional teams to solve quality problems	Collaboration	0.8	0.8	0.8	0.8	0.8
Use of process-management heuristics to enhance team effectiveness	Degree of shared control	0.6	0.6	0.6	0.6	0.6
Use of scientific methods for performance improvement		0	0	0	0	0



Dimensions of TQM and Quality Culture (adapted of Detert, et al., 2000; Hackman and Wagman, 1995)

Appendix P – Validity Tests Figure

Extreme Condition Tests



The Linkages between the Model Variables and the Extreme Condition Tests

The Reality Check Equations Definition

Test Inputs:

all machines breakdown :TEST INPUT:

Machine Breakdown Rate=7

all machines breakdown

high quality culture :TEST INPUT:

Quality Culture Level=1

high quality culture

lot of prevention :TEST INPUT:

Training>0.8

no more problems and malfunctions :TEST INPUT:

Problems and Malfunctions= 0

no more stress :TEST INPUT:

Personal Stress = 0

Constraints :

commitment is high :THE CONDITION:

no more problems and malfunctions :IMPLIES: Commitment Rate>= RC
STEP CHECK

(10, Commitment Rate, 1)

effectiveness is better :THE CONDITION:

no more problems and malfunctions :IMPLIES: Organization
Effectiveness>= RC GROW CHECK

(10, Organization Effectiveness, 12)

more correctness work :THE CONDITION:

no more stress :IMPLIES: Tasks Correctness Completion Rate>= RC GROW
CHECK (

5, Tasks Correctness Completion Rate, 10)

more quality is less stress :THE CONDITION:

high quality culture :AND: lot of prevention :IMPLIES: Personal
Stress>=RC DECAY CHECK
(10, Personal Stress,12)

no machines to do work :THE CONDITION:

all machines breakdown>6:IMPLIES:Tasks Correctness Completion
Rate<=0.01:AND:
Out of Order Tasks Completion Rate<=0.01

our culture is quality :THE CONDITION:

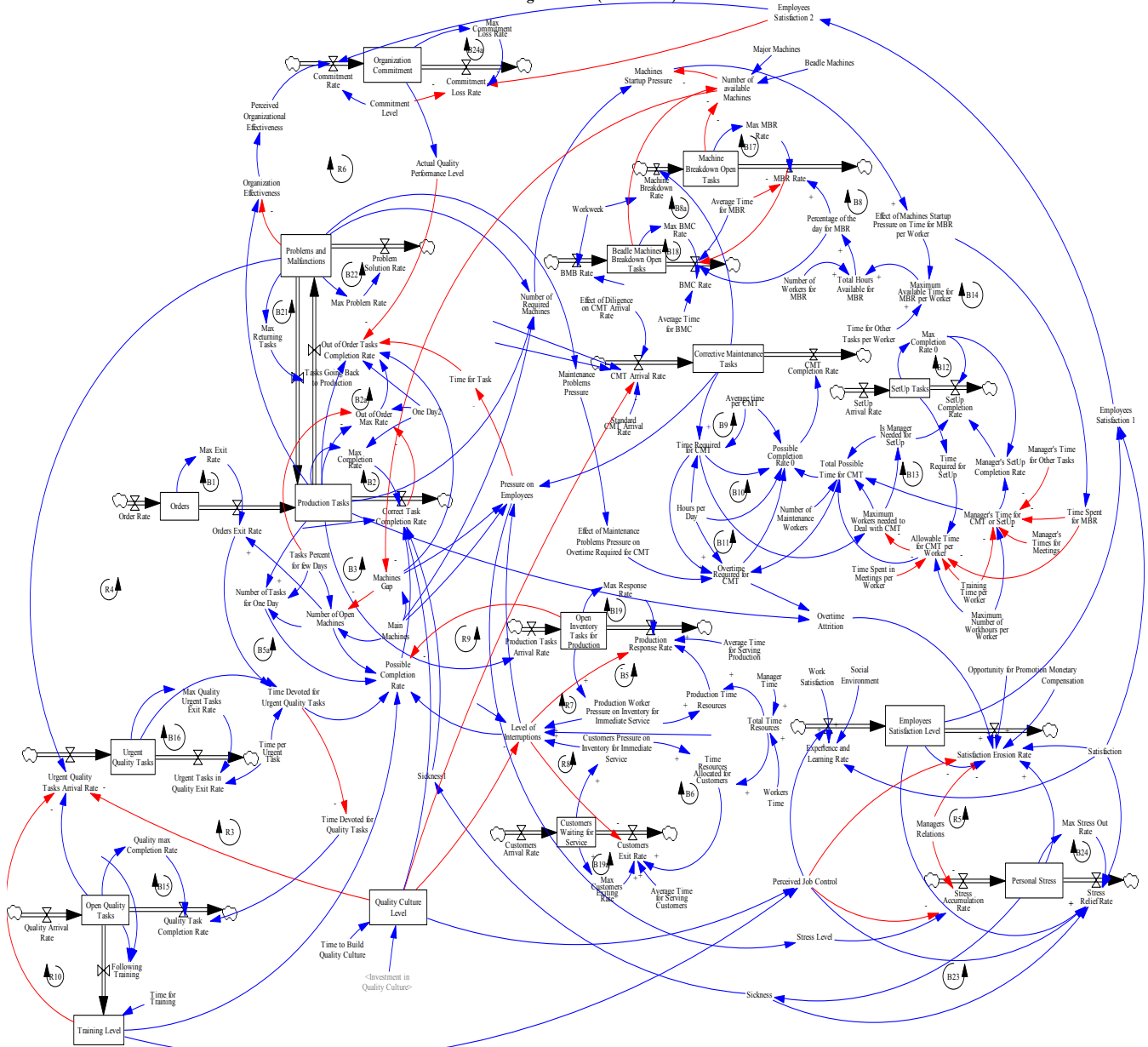
high quality culture :IMPLIES: Level of Interruptions<= RC STEP
CHECK (5, high quality culture
, 3)

we are controlled on our jobs :THE CONDITION:

high quality culture :AND: lot of prevention :IMPLIES: Perceived
Control in Job
>=RC STEP CHECK (10, Perceived Control in Job, 0.5)

Appendix Q – The New Model (Including the Policy Changes)

The Linkage between Quality Culture and
Employees Health in the Field
Organization (Full Model)



The new Equations:

Following Training=
 $\text{Max}(\text{Open Quality Tasks} \times 0.15 / \text{Day}, 0)$
 Units: Tasks/Day

Learning and Continuous Improvement=
 $\text{RANDOM UNIFORM}(0.7, 0.9, 0.7)$
 Units: Dimensionless

Open Quality Tasks= INTEG (
 $\text{Quality Arrival Rate} - \text{Quality Task Completion Rate} - \text{Following Training},$
 0)
 Units: Tasks

Perceived Job Control=
 $\text{MIN}(\text{RANDOM UNIFORM}(2, 2.83, 1) * (1 + 0.1 * \text{Training Level} * \text{Day} / \text{Task}) * (1 +$
 $0.1 * \text{Quality Culture Level} * \text{Day} / \text{Task}), 5)$
 Units: Dimensionless

Possible Completion Rate=
 $\text{Max}(\text{IF THEN ELSE}(\text{Number of Open Machines} > \text{Number of Tasks for One Day} /$
 $\text{Tasks1}, \text{Number of Tasks for One Day} * (1 - \text{Time Devoted for Urgent Quality Tasks}$
 $/ \text{One Day for Task}) / \text{One Day for Task} - ((0.01$
 $*$
 $\text{Open Inventory Tasks for Production} / \text{One Day for Task}) * (\text{RANDOM}$
 $\text{NORMAL}(0.001$
 $, 0.0012, 0.0014, 0.001, 0))),$
 $\text{Number of Open Machines} * \text{Tasks1} * (1 - \text{Time Devoted for Urgent Quality Tasks}$
 $/ \text{One Day for Task}) / \text{One Day for Task} - ((0.01 *$
 $\text{Open Inventory Tasks for Production}$
 $/ \text{One Day for Task}) * (\text{RANDOM NORMAL}(0.001, 0.0012, 0.0014, 0.001, 0)))) - ($
 $\text{Level of Interruptions}$
 $) * 0.01 * (\text{Training Level} + 1), 0)$
 Units: Tasks/Day

Relationship with Environment=
 $\text{RANDOM UNIFORM}(0.6, 0.8, 0.6)$
 Units: Dimensionless

Time for Training=
 30
 Units: Day

Top Management=
 $\text{RANDOM NORMAL}(0.6, 1, 0.8, 0.1, 0)$

Units: Dimensionless

Training Level= INTEG (
(Following Training-Training Level)/Time for Training,
0)

Units: Tasks/Day

Urgent Quality Tasks Arrival Rate=

Max ((Problems and Malfunctions/Day
* (RANDOM UNIFORM (0.2, 0.4, 0)) + IF THEN ELSE
(Open Quality Tasks > 7, EXP (Open Quality Tasks
/(Task7*10)), 0)*Task7/Day) *(1 - 0.2*Training Level*Day/Task7)*(1-0.2*Quality

Culture Level

) *Day/Task7, 0)

Units: Tasks/Day

What Motivated Humans=

RANDOM UNIFORM (0.7, 0.9, 0.7)

Units: Dimensionless

Appendix R

Glossary of Terms

Arrow: an object connecting two variables on a sketch of a model

Beadle machines: machines that provide materials and packaging.

Causal: a system, including a model, in which direct physical or logical causality can be attributed.

Constant: a variable that is set equal to a number.

Construct: an abstract entity combined or arranged by the relationship between its parts and elements, which are mainly views, beliefs and feelings.

Corrective maintenance tasks: The urgent maintenance tasks.

Culture: the commonly held beliefs, values, and feelings about how the organization is and should be operating. Culture represents the organization's cumulative learning, which is reinforced through organizational policies and processes.

Customers exit rate: the service rate for customers.

Endogenous: it is defined as "arising from within", that is, from inside the boundary of the model.

Exogenous: It is defined as "arising from without", that is, from outside the boundary of the model.

Facilitator: the one who conducts and manages the group session, with an aim of facilitating the expression of views of all the key players involved in the modeling exercise.

Maintenance gap: the gap between the desired preventive maintenance and the actual preventive maintenance.

Management methods: in this research refers to management style and strategies that value workers' concerns and satisfaction.

Non-linear system: systems in which the relationships among various variables and parameters are not linear in nature.

Organizational efficiency: the extent of fit between the internal components of the social system. The more congruity exists between these components the more the organization will function smoothly, with relatively little dissatisfaction on the part of organizational members. Higher efficiency occurs when there is relatively little interpersonal or intergroup conflict among various constituencies, such as supervisors and subordinates or union and management.

Organizational effectiveness (according to the research company): the percentage between the quality products and the total number of products.

Organizational effectiveness (according to literature): the degree to which the actual outcome of an organization meets the expected outcomes set by the organization. The degree organizational performance indicators such as customer satisfaction, profitability, market share or growth, are positive (high).

Organizational health: the state in which people and practices are combined and coordinated to produce exceptional performance. Such an organization is likely to maintain organizational efficiency and effectiveness in the long term.

Perceived control in job gap: the gap between the desired perceived control in job and the actual perceived control in job.

Perceived organizational effectiveness: $1 - (\text{quality products} / \text{total products manufactured})$.

Personal stress: a physical or psychological stimulus that can produce mental tension or physiological reactions that may lead to illness.

Prevention and training schedule: the gap between what is done for prevention and training and what should have been done

Production performance gap: the gap between the production performance target and the actual production performance.

Quality: meeting or exceeding customers (internal and external) expectation

Resources gap: the gap between the needed resources and the available resources.

Satisfaction gap: the gap between the desired satisfaction and the actual satisfaction.

Social system: a system in which the social fabric is the most substantial component of the system and without it, the system loses its existence. A social system converts inputs from the environment into outputs that are useable by the environment.

Strain: state of nervousness that derives from mental stress

Stress at work: state of nervousness that derives from situations or relationships at work

System structure: the relationship among the various variables and parameters in the system is referred to as its structure

VITA

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Education:

- PhD, Industrial & Systems Engineering, 2006, Virginia Polytechnic Institute and State University, Falls Church, Virginia
- MEA, Engineering Administration, 2001, Virginia Polytechnic Institute and State University, Falls Church, Virginia
- BS, Industrial Engineering and Management, 1977, Ben-Gurion University, Beer-Sheva, Israel

Experience:

Shenkar College of Engineering and Design, Ramat-Gan, Israel, 2002 - Present

Instructor, subjects of teaching include: Applied Statistics, Introduction to Quality Management, Statistical Process Control.

Amal B Adult College for Practical Engineering, Petach-Tiqva, Israel, 2002-2004

Principal of the school. Also teaching the following subjects: Introduction to Quality Management, Statistical Quality Control, Operation Research and Engineering Economy.

Virginia Polytechnic Institute and State University, Falls Church, Virginia, 2002-1998

Teaching Assistant for Quality & Reliability Engineering, Productivity, Systems Dynamics, Engineering Economy

Amal B, College & School of Science & Technology, Petach-Tiqva, Israel, 1991-1997

Industrial Engineering Department Coordinator and Teacher. Subjects of teaching include: Work Study & Measuring, Engineering Economy, Production & Planning Control, Quality Control, Statistics, Production Management, Productivity, Ergonomics, Entrepreneurship, Marketing Management.

Ministry of Education, Tel-Aviv, Israel, 1991-1997

Consultant for the academic program development and evaluation of Industrial Engineering & Management program in High schools and Vocational Colleges.

Judea & Shomron College, Ariel, Israel, 1993-1994

College for Practical Engineering, Teaching Work Study & Measuring.

Bar-Ilan University, Ramat-Gan, Israel, 1987-1988

Department of Life Science, Systems Programming

I.A.I. (Israel Aircraft Industry) , Lod, Israel, 1984-1987

CAD/CAM Engineering, including Configuration Management Systems, using Oracle (version 4) with Fortran-77 on Vax/Vms and Aes/Vs, projects as product's Tree and Automatic Library, development interfaces for I.G.E.S. and applications, backup and maintenance of Euclid.

Government of Israel, Ministry of Defense, New-York, New-York, 1977-1983

Supervision of employee screening, clearance, placement and relocation.

Ben-Gurion University, Beer-Sheva, Israel, 1977-1978

Teaching Fellow. Courses included Industrial Psychology, Marketing Management, Research in Cost Analysis.

Israel Defense Forces, Israel, 1969-1971

Army Service, discharged with rank of Lieutenant. Responsible for training of new recruits.

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ISQ, Certificate Quality Manager, 2001

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