

**System Dynamics Modeling of
Generic Quality Improvement Programs**

by
Omar S. Khan

Submitted to the Department of Electrical Engineering and Computer Science
in Partial Fulfillment of the Requirements for the Degrees of
Bachelor of Science in Electrical Engineering and Computer Science
and Master of Engineering in Electrical Engineering and Computer Science
at the Massachusetts Institute of Technology

May 23, 1997

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ABSTRACT

Members of the MIT Sloan School of Management's System Dynamics Group have conducted field research to document the history of quality improvement programs at four companies: *Ford Motor Company, Harley-Davidson, Lucent Technologies, and National Semiconductor*. This research is supported through the Transformations to Quality Organizations program of the National Science Foundation and by the four corporate partners. The thesis documents the incorporation of the dynamics discovered during the aforementioned case studies into a generic system dynamics model. The model is designed to serve as the core dynamic engine of a TQM Management Flight Simulator with which managers and students can gain insight into the design and testing of robust and sustainable TQM initiatives.

Thesis Supervisor: John D. Sterman

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System Dynamics Modeling of Generic Quality Improvement Programs

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1.0 Introduction

1.1 Background

Corporations around the globe have implemented TQM (Total Quality Management) and other continuous improvement programs to improve various facets of the organization. Firms implement improvement initiatives to sustain the success of their respective businesses. Firms such as Motorola and Xerox, as well as many Japanese firms, attribute a large part of their financial success to successfully implemented TQM initiatives. Quality improvement programs such as “10X cycle time reduction” and “Six Sigma” propelled Motorola in its successful pursuit of the Malcolm Baldrige National Quality Award. While the Baldrige award coincided with great financial prosperity for Motorola, other firms have not observed a clear correlation between improvement efforts and financial reward. Research has shown that successful quality improvement programs do not necessarily guarantee the fiscal success of the firm, nor do they guarantee sustained competitive or technical advantages. In a 1991 study, Ernst & Young found that firms which were active in TQM were no more profitable than similar firms not emphasizing TQM.

The question that naturally arises is why some quality improvement programs are successful and why others are not. Many firms have made a determined effort to implement initiatives to improve their organizations. These programs have often succeeded in improving operational results such as manufacturing yields, labor productivity, and product quality. These same organizations have subsequently suffered from poor financial results, excess capacity, and layoffs. This observed paradox was the basis and motivation for field research conducted with our research partners: *Ford Motor Company, Harley-Davidson, Lucent Technologies, and National Semiconductor*. All partners have implemented successful improvement programs yielding improvements in quality and productivity, but, despite notable successes, have experienced unanticipated

side effects such as excess capacity, imbalances between functions such as manufacturing and product development, failed improvement initiatives, etc. (Sterman, 1996).

The field research has identified many of the causal relationships that play a key role in the dynamics of improvement effort success or failure. Even improvement initiatives focused on improving only one specific aspect of the organization interact with many seemingly unrelated aspects of the organization. Finance, accounting, research & development activities, human resource policies, employee morale, manufacturing, and fiscal performance may all be affected by improvement initiatives in any one area and as a result may play a key role in the dynamics of such a program. Failure to recognize interdependencies between the various aforementioned aspects of the organization may be responsible for many failed efforts. (Sterman, 1996)

The research also illuminates the complex timing issues of an improvement program. Even highly successful improvement programs can, under certain conditions, lead to significant short-run deterioration in fiscal performance, excess capacity, and a subsequent loss of commitment to the improvement program (Sterman, 1996; Sterman, Repenning, and Kofman, 1997; Kraemer & Oliva, 1995). Using system dynamics modeling techniques, these complex feedback relationships can be modeled to test our understanding and develop robust policy. Partial models of improvement programs and organizations have been undertaken in order to understand individual company cases.

This thesis extends and strengthens those efforts by formulating a generic system dynamics model for any improvement program. The following section provides an overview of the model structure. Technical documentation of the model formulation and testing constitutes the bulk of this document. The completed model serves as the core engine of a TQM management flight simulator. This tool will be used with other teaching materials to assist managers, students, and researchers in developing insight into the successful implementation of TQM initiatives within a complex organization. The flight simulator provides a fast and cost effective way to test strategies for the successful introduction of TQM initiatives. Documentation of the interface design used to turn the

TQM model into a management flight simulator concludes this thesis.

1.2 Overview

The generic TQM model incorporates the following key sectors:

- demand
- production
- process attributes
- cost accounting
- commitment
- human resources
- capacity
- pricing
- financial accounting

The sector diagram for the model is shown in Figure 1.

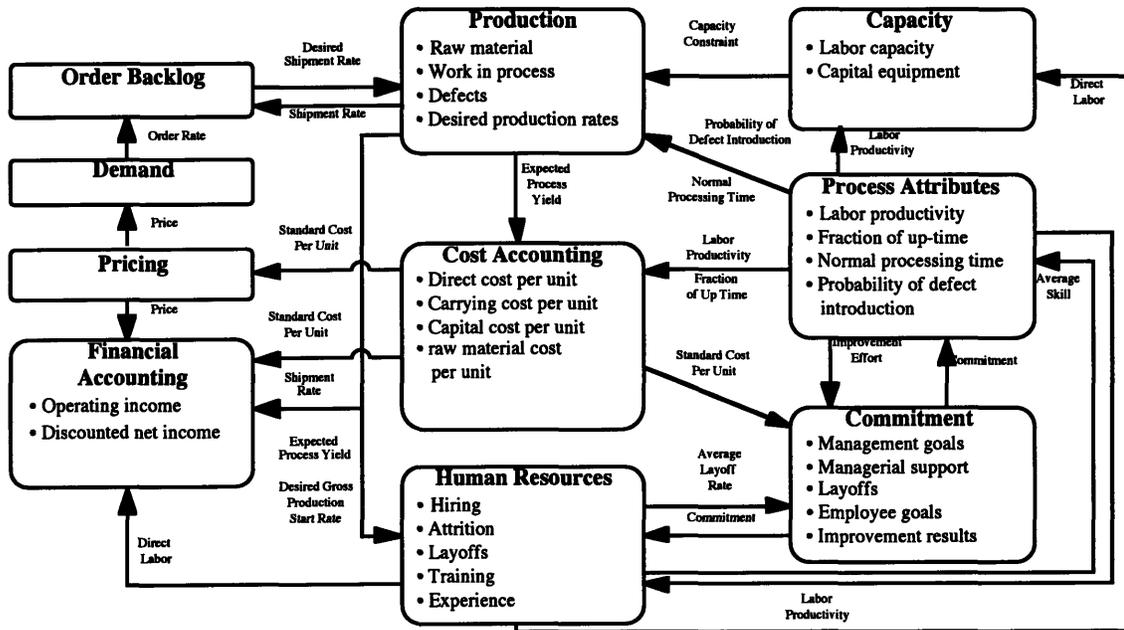


Figure 1: Sector Diagram for the generic TQM model

1.2.1 Demand Sector

The demand sector controls the orders flowing into the backlog of the production sector. Demand is a function of the price charged by the firm. For the purposes of this model, a linear and downward sloping demand curve is assumed. The model will,

however, serve as a robust core to which future work (i.e. competition, financial markets, etc.) can be appended and function as an integrated portion of the TQM management flight simulator.

1.2.2 Production Sector

The backlog of orders drives desired production. This sector controls the flow of both conforming and defective product through the process pipeline. Product can move into the defect flow at various stages. While product is in raw materials inventory, defects can be discovered by two methods: inspectors can discover good material that they believe to be defective and material that is truly defective. Defects present in the work in process flow include undiscovered defects during raw material inspection and defects introduced during processing. Defects can be discovered after completion by two methods: testing can uncover good product that tests as defective and product that is truly defective. Key outputs of the production sector include the *process yield* and the *net completion rate*.

1.2.3 Process Attributes Sector

The process attributes sector determines the status of four improvable parameters: *probability of defect introduction*, *fractional up time*, *normal processing time*, and *labor productivity*. Labor productivity in manufacturing, for instance, can measure the number of units that can be completed in a certain amount of time; labor productivity in product development, however, can measure the number of drawings/designs that are completed in a certain amount of time. Similarly, the other process attributes can be generalized to various parts of the firm. The commitment of the firm's employees and their average skill level is the source of improvements in process attributes. Commitment determines the amount of improvement effort to be divided up among the four generic TQM programs. Average skill determines the effectiveness of improvement effort to be divided up among the four generic TQM programs. These parameters directly affect the

production, standard cost, human resources, and capacity sectors and those effects are propagated throughout the entire model.

1.2.4 Cost Accounting Sector

The standard cost sector calculates a standard per unit cost for the product or service the firm provides. Productivity, fractional up time, and process yield attributes all affect the standard cost calculation. They are used to formulate an aggregate internal cost parameter used to set prices and monitor the success of an improvement program. As a proxy for program results, improvements in standard costs are a key driver of employee commitment.

1.2.5 Commitment Sector

The commitment sector determines the level of employee commitment to the improvement programs. Commitment is built up or eroded by five forces: *management's goal for commitment, employees' personal goals, management's support of improvement programs, layoffs, and program results*. Each of the four forces has unique dynamics with respect to magnitude and time. Their combined effect results in a complex and dynamic formulation for employee commitment. Employee commitment plays a critical role in improvement program success. Looking at the drivers and effects of commitment explicitly will create very important insights for those who interact with the flight simulator or the model directly.

1.2.6 Human Resources Sector

The human resources sector tracks the employees of the firm and their relative skill with improvement programs. The key drivers of this sector are: *demand, productivity, and commitment*. Demand and productivity determine the magnitude of the required labor force; as demand and productivity change, hiring rates and layoff rates will

change. Furthermore, the average skill of employees with improvement programs changes with training and on-the-job experience as well as with turnover in the labor force.

1.2.7 Capacity Sector

The capacity sector tracks the working capacity of the production sector. The key drivers of this sector are: *labor*, *capital*, and *productivity*. These factors, together, determine working capacity. Capacity plays a key role in the dynamics of the production sector and effects are subsequently felt throughout the model of the firm.

1.2.8 Pricing Sector

The firm sector tracks the price of the product or service provided by the firm. The key driver of this sector is the *standard cost per unit*. The price set by the firm is a standard markup over the standard cost per unit. The price set by the firm is used to determine the market demand for the product or service provided by the firm as well as the revenues generated by the firm.

1.2.9 Financial Accounting Sector

The financial accounting sector tracks the firm's revenues, costs, and cumulative net income. The key drivers of this sector are: *direct labor*, *price*, *standard cost per unit*, and *net completion rate*. For the purposes of this model, the financial accounting sector tracks the financial health of the firm. In future versions, the outputs of the sector may be used to determine the financial stress on the firm which subsequently could affect employee commitment.

2.0 Scenarios

There are four sample scenarios included in this chapter. These scenarios are simple case examples that demonstrate the utility of a process improvement flight simulator. Each scenario is accompanied by a standard set of six graphs. The six graphs show the following:

- Commitment, Improvement Effort, and Average Skill
- Net Income
- Production Stocks
- Process Attributes
- Standard Cost Per Unit
- Pricing & Demand

2.1 Base Case

The base case is representative of a firm in equilibrium with no improvement programs in place. The key graphs for the base case are shown below.

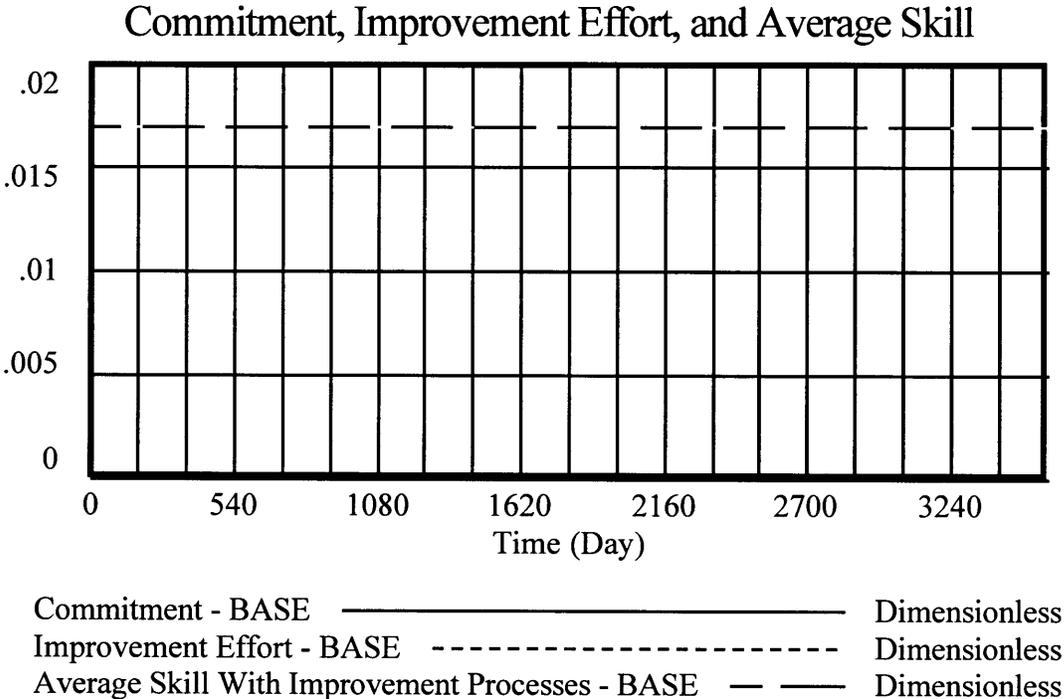


Figure 2: Base Case - Commitment, Improvement Effort, and Average Skill

Though somewhat hidden in Figure 2, improvement effort and commitment remain at zero as the firm has no improvement programs in place. There is, however, an equilibrium level of skill as new employees have skill with improvement programs from previous jobs. The firm's equilibrium is confirmed by the graphs shown in Figures 3 through 7 that follow. Net income, backlog, the process attributes, standard cost per unit, price, and demand all remain constant for the duration of the model run (10 years).

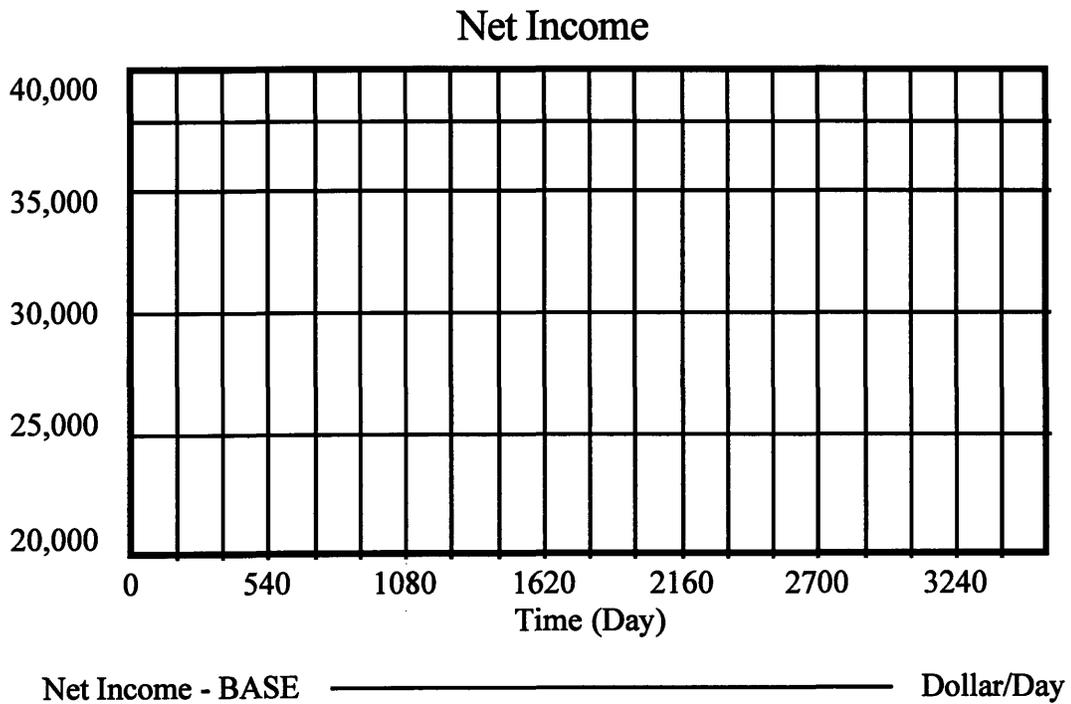


Figure 3: Base Case - Net Income

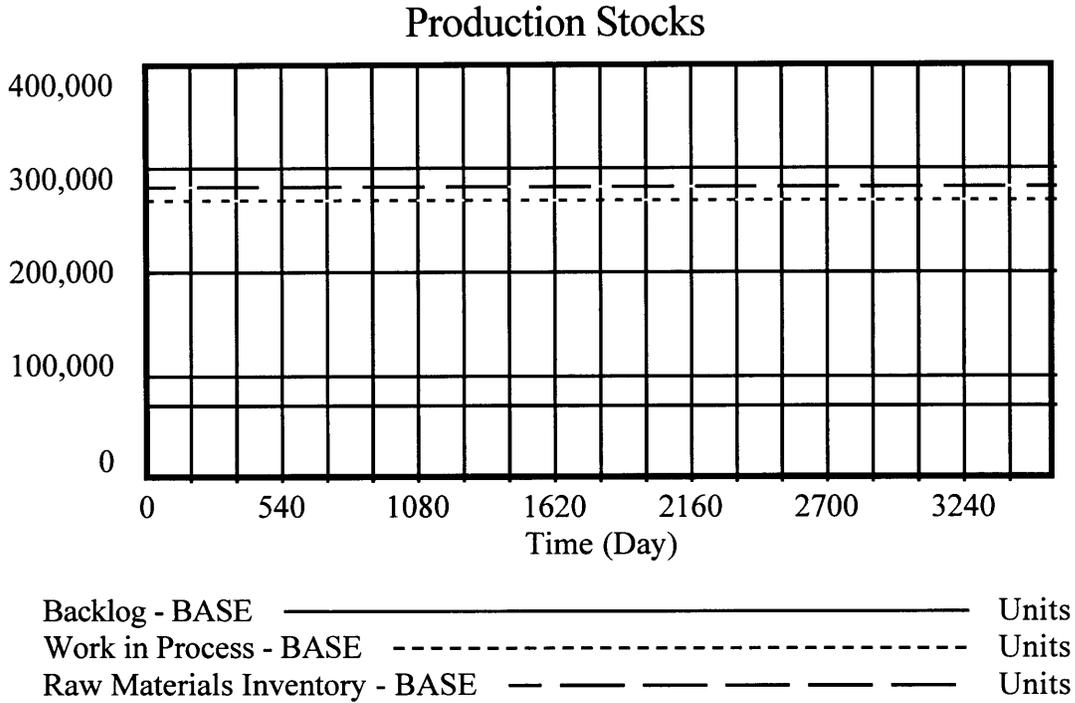


Figure 4: Base Case - Production Stocks

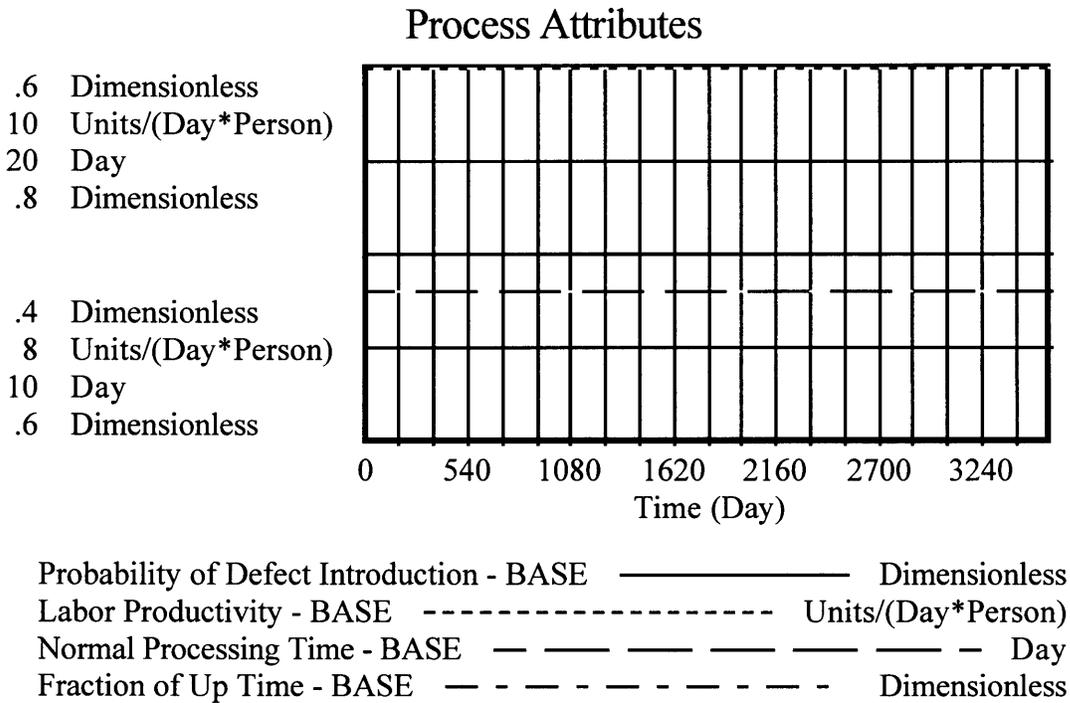


Figure 5: Base Case - Process Attributes

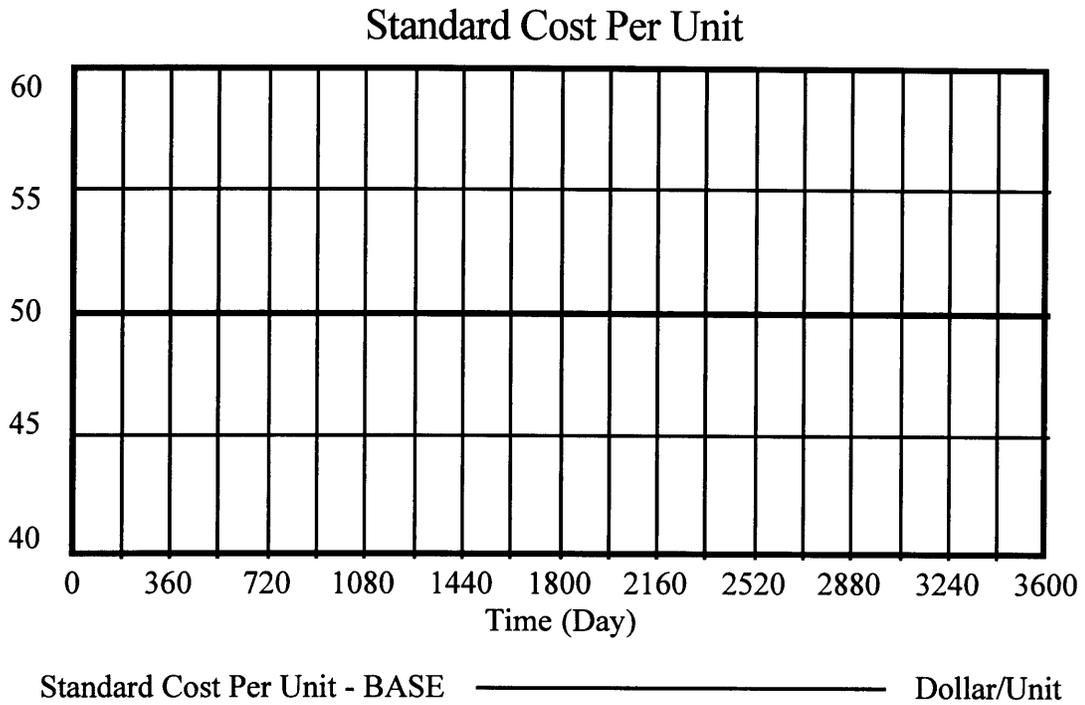


Figure 6: Base Case - Standard Cost Per Unit

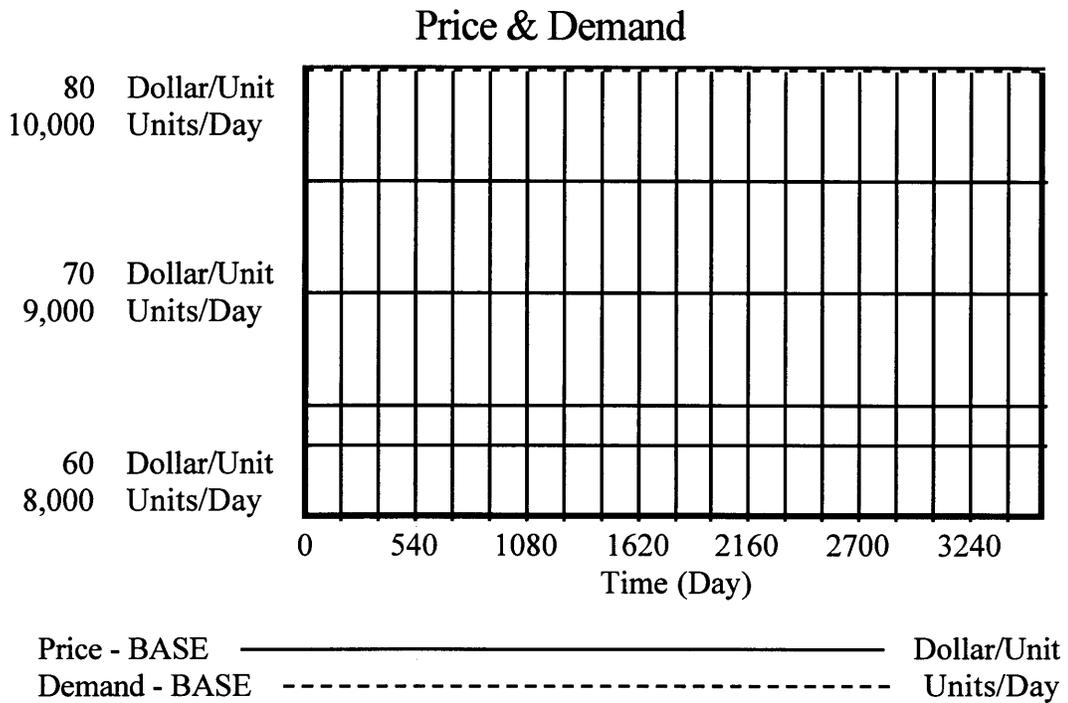


Figure 7: Base Case - Price & Demand

2.2 Improvement I

The Improvement I case represents a firm that begins in equilibrium, but implements an improvement program after the first quarter. The firm is extremely loyal to its employees and is unwilling to lay off excess labor when times are bad. The product market is highly differentiated and the firm is equally committed to improving each process attribute. The key graphs for this run are shown below.

As shown in Figure 8, commitment rises to its maximum value in approximately two years, then decays away to an equilibrium level of slightly greater than 50%. Improvement effort lags the increase in commitment as average skill has not reached its maximum value.

The equilibrium commitment level is achieved when two opposing influences become equal. Only the effects of results and performance goal on commitment play a role in these dynamics. As the decrease in standard cost per unit begins to slow (Figure 12), the effect of results on commitment begins to decline until it becomes negative due to a lack of results. Also, after standard cost per unit falls below the employees' own goal, the effect of performance goal on commitment becomes negative and detracts from commitment as well.

Net income drops significantly (Figure 9) despite the fact that standard cost per unit has fallen. These savings have been passed directly on to the consumer because markup has remained constant and due to the fact that the firm produces a highly differentiated product, the lower price has not increased demand enough to overcome this effect (Figure 13). Furthermore, because the firm chooses not to lay off excess labor, its labor costs are not significantly reduced. As shown in Figure 10, the production stocks fall as the decline in the probability of defect introduction increases the amount of production that is shippable and as normal processing time falls (Figure 11).

This scenario has depicted a firm that has improved its internal processes, but due to poor price setting policies and its inability to deal with excess labor, suffered from fiscal distress. Constant markup pricing is shown to be a detriment in a highly

differentiated market. This markup policy may seem bit absurd, but case studies indicate that firms have suffered from such pricing policies in the past (Sterman, Repping, and Kofman, 1997).

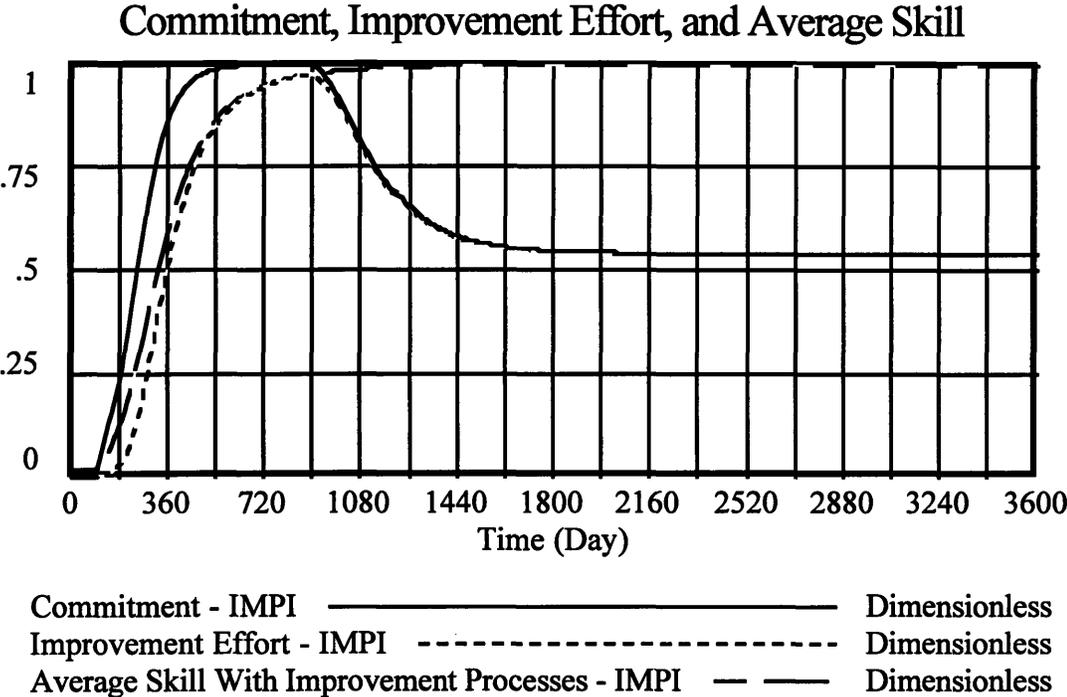


Figure 8: Improvement I - Commitment, Improvement Effort, and Average Skill

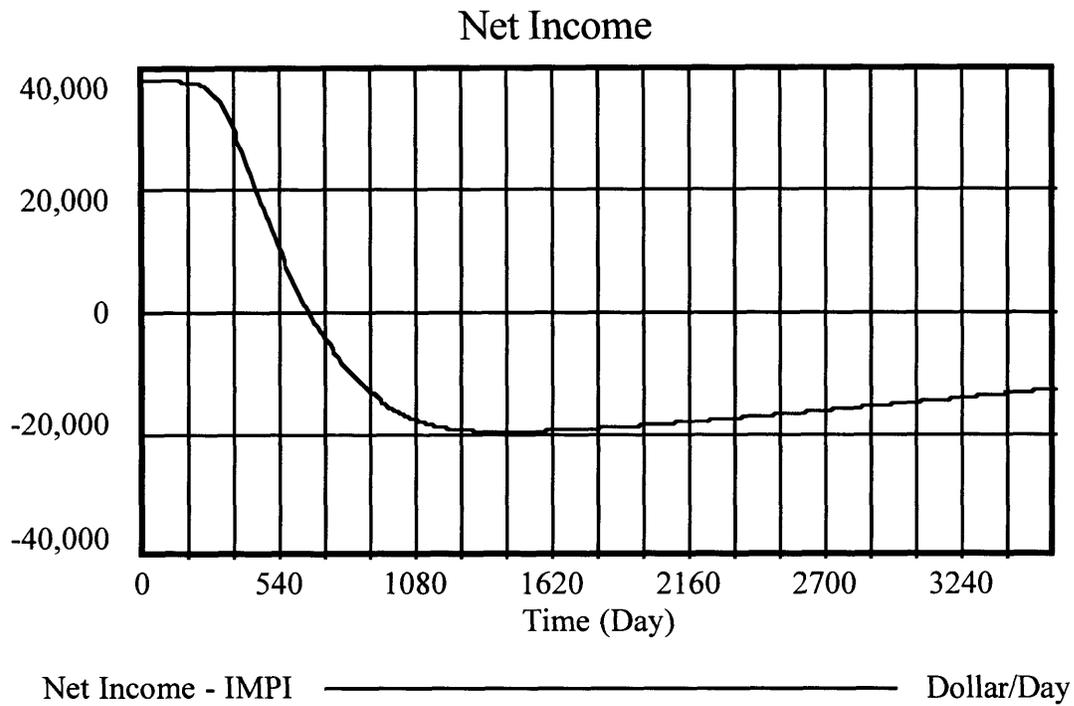


Figure 9: Improvement I - Net Income

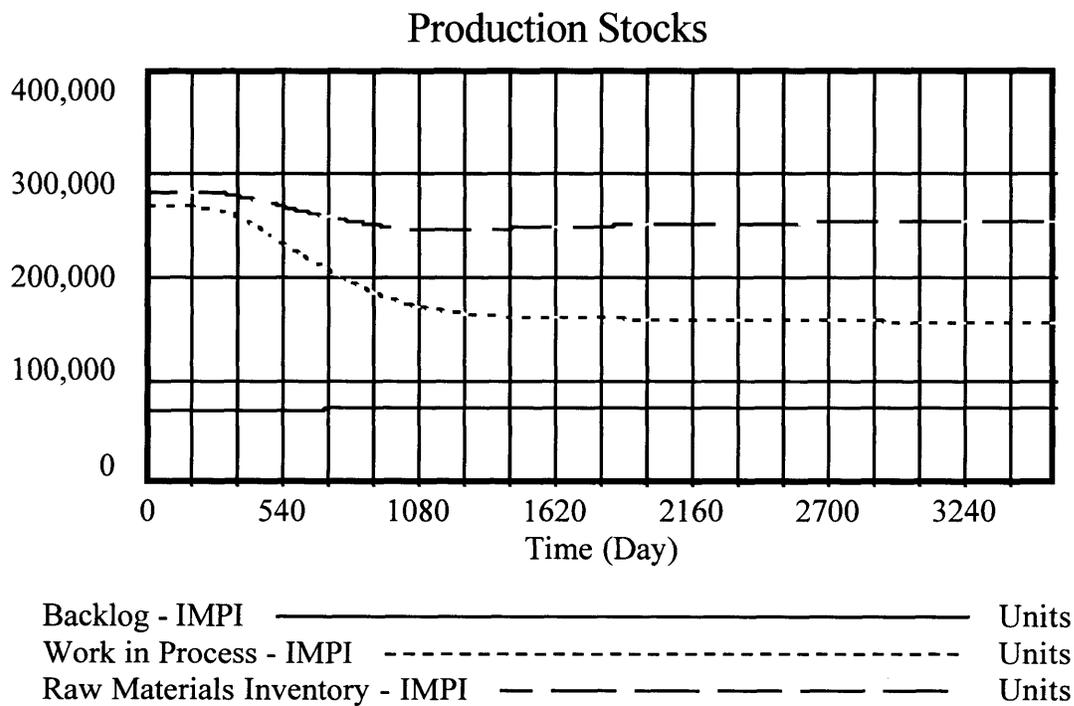


Figure 10: Improvement I - Production Stocks

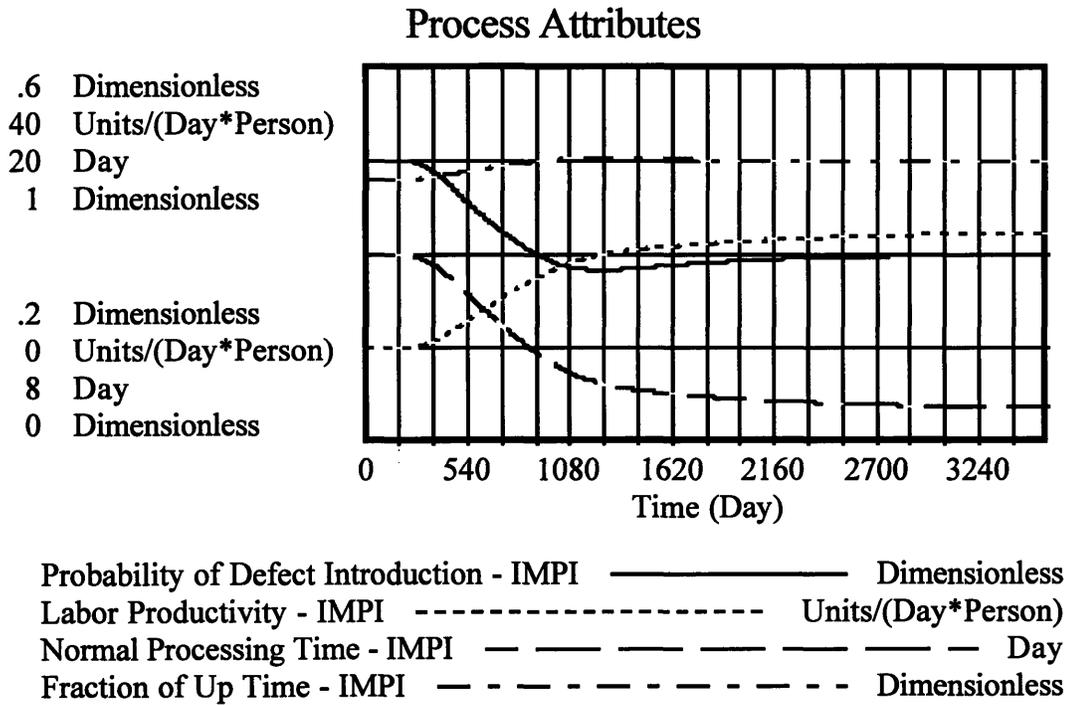


Figure 11: Improvement I - Process Attributes

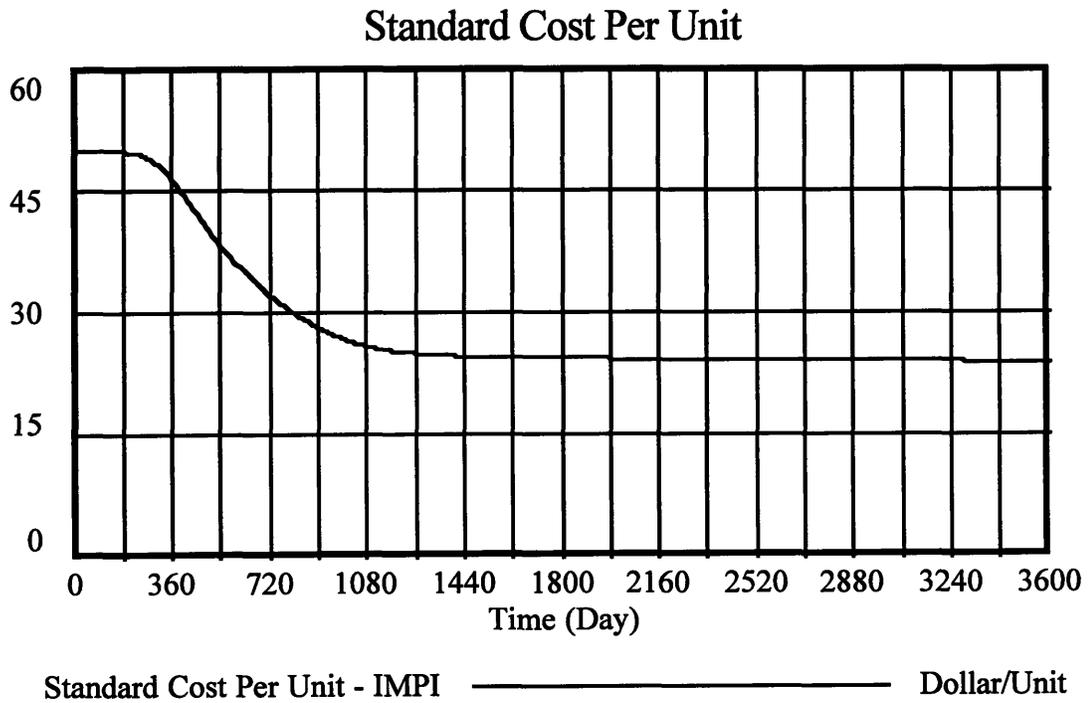


Figure 12: Improvement I - Standard Cost Per Unit

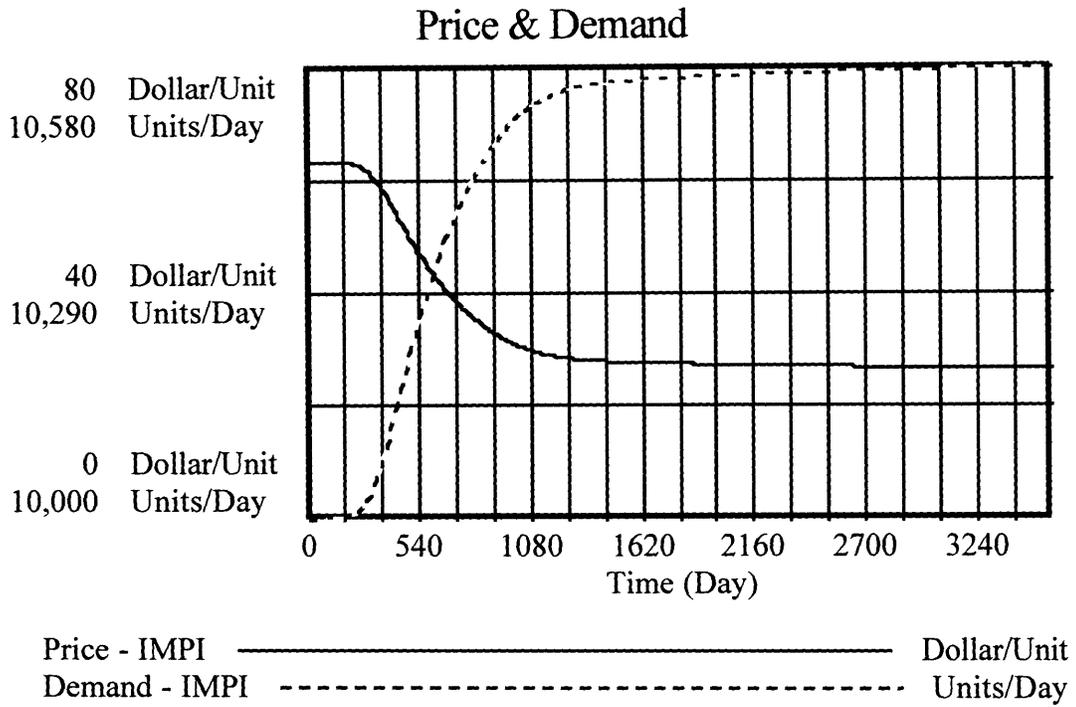


Figure 13: Improvement I - Price & Demand

2.3 Improvement II

The Improvement II case represents a firm that begins in equilibrium, but implements an improvement program after the first quarter. The firm is, however, willing to lay off excess labor when times are bad. The product market is highly differentiated and the firm is equally committed to improving each process attribute. The key graphs for this run are shown below. (*Note: Improvement I and Improvement II only differ on management's willingness to lay off excess labor.*)

As shown in Figure 14, commitment rises to its maximum value in slightly less than two years, then decays away within six months to approximately 30% of its maximum value due to layoffs. It rebounds slowly as it takes five years for the memory of layoffs to wear off.

The process attributes do not improve as quickly as in Improvement I because of the decline in commitment following the layoffs. Because the firm did lay off excess labor in this case, net income did not suffer as much as it did in Improvement I (Figure 15) since labor costs were reduced and the markup remained constant at 50%.

This scenario has depicted a firm that has improved its internal processes, but due to poor price setting policies, suffered from fiscal distress. The firm did, however, perform better than the firm depicted in Improvement I because it revised its labor policies and allowed management to lay off excess labor.

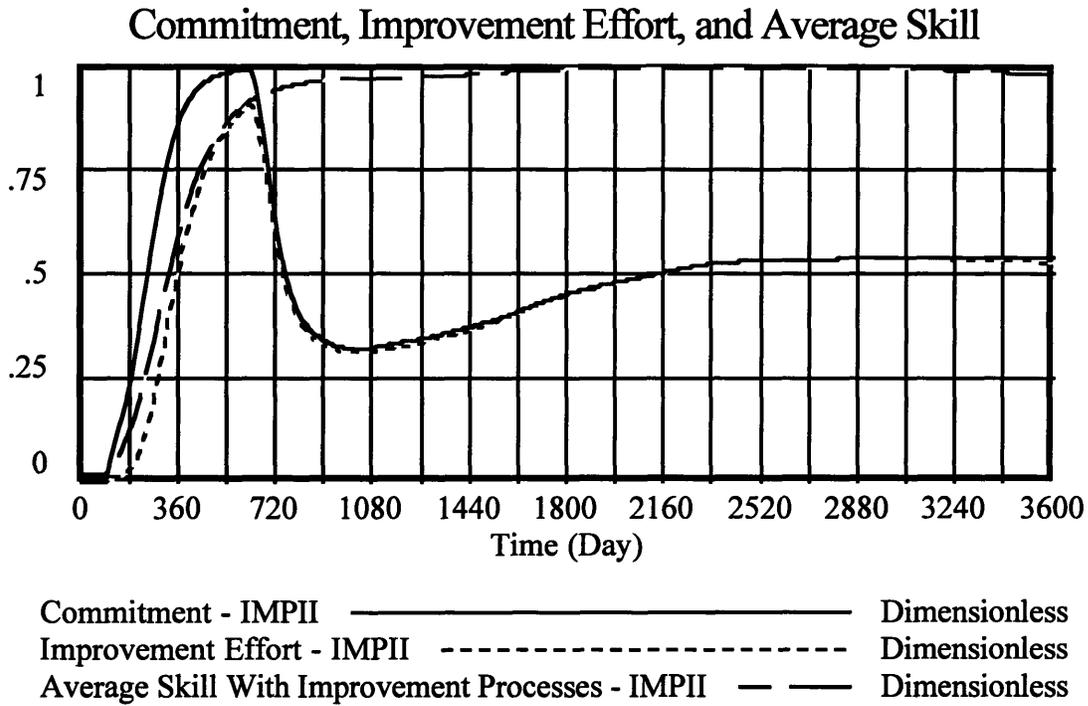


Figure 14: Improvement II - Commitment, Improvement Effort, and Average Skill

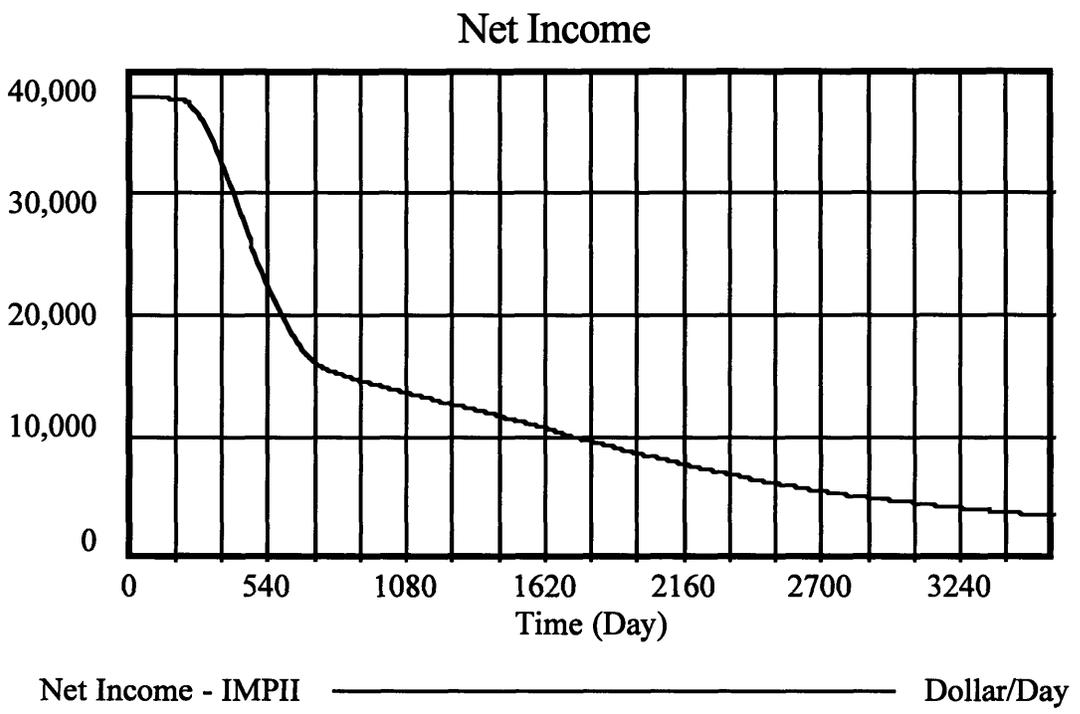


Figure 15: Improvement II - Net Income

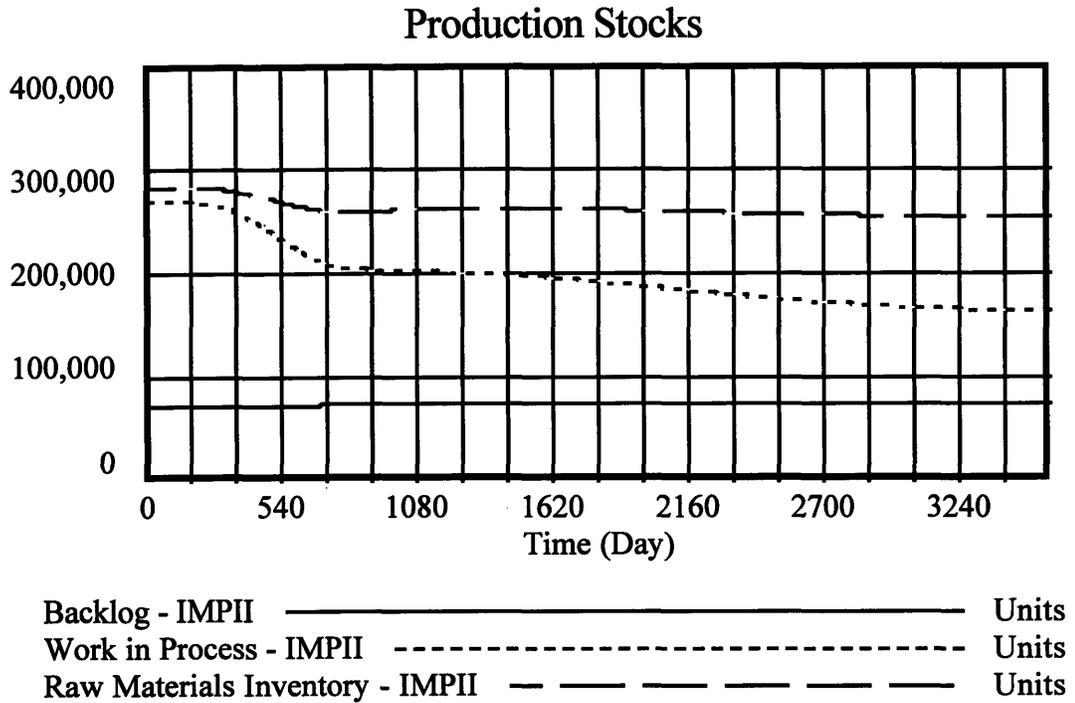


Figure 16: Improvement II - Production Stocks

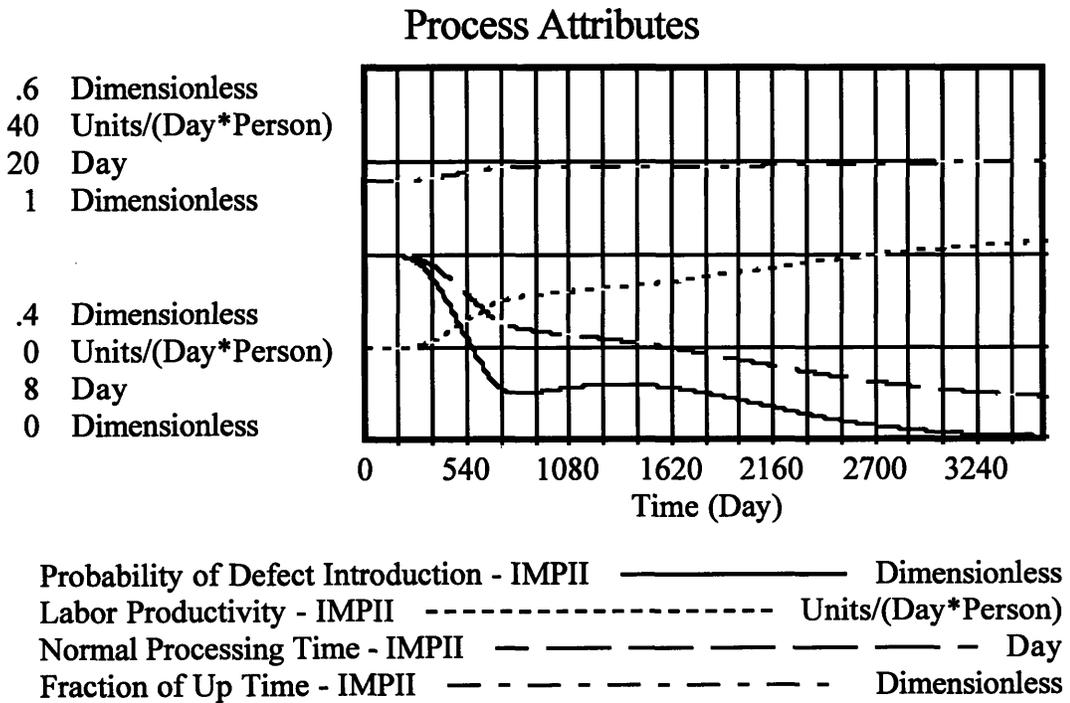


Figure 17: Improvement II - Process Attributes

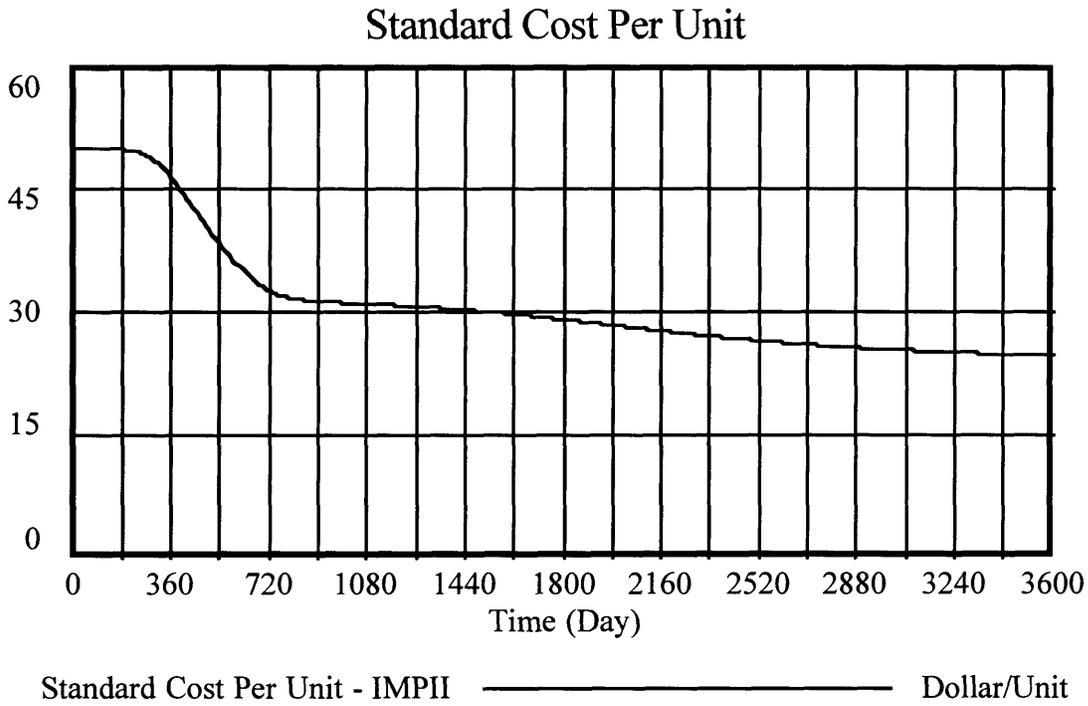


Figure 18: Improvement II - Standard Cost Per Unit

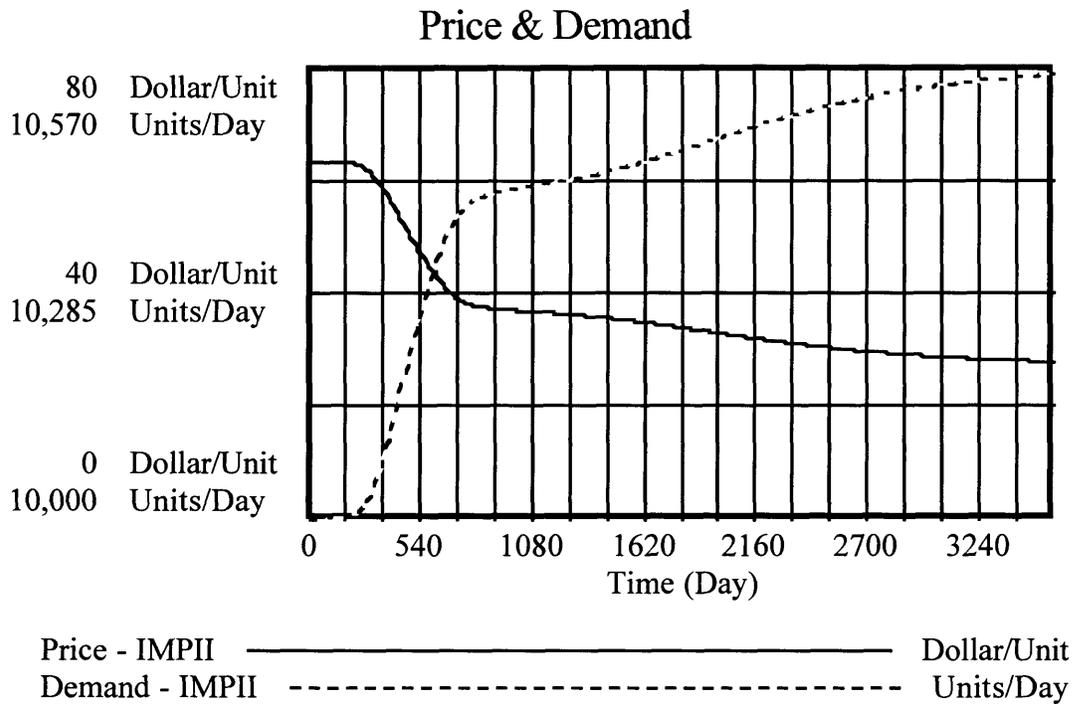


Figure 19: Improvement II - Price & Demand

2.4 Improvement III

The Improvement III case represents a firm that begins in equilibrium, but implements an improvement program after the first quarter. In this case, however, the firm is competing in a commodity product market and faces highly elastic demand. The firm is willing to lay off excess labor when times are bad and is equally committed to improving each process attribute. The key graphs for this run are shown below. (*Note: Improvement II and Improvement III only differ on the market's price elasticity of demand.*)

As shown in Figure 20, commitment rises to its maximum value in approximately two years, then decays away to an equilibrium level slightly above 50%. The dynamics of commitment were very similar to the case shown in Improvement I. As the decrease in standard cost per unit begins to slow (Figure 24), the effect of results on commitment begins to decline until it becomes negative due to a lack of results. Also, after standard cost per unit falls below the employees' own goal, the effect of performance goal on commitment becomes negative and detracts from commitment as well.

In this case, however, demand is very elastic and reacts quickly to the drop in price (Figure 25). As price drops to approximately half of its original value, demand increases by fifteen fold. Because of the increase in demand, massive layoffs were not necessary. As shown in Figure 21, net income prospers with the increase in demand, but then falls away. This occurs because as time passes and price falls, total internal costs do not fall as fast as the standard cost per unit on which price is based.

This scenario has depicted a firm that has improved its internal processes, and prospered from increased demand. Due to a simplified perception of internal costs and poor price setting policies, the firm suffered a fiscal downturn. The firm did, however, perform better than the firm depicted in Improvement I because it faced more responsive demand and benefited initially from lowering price.

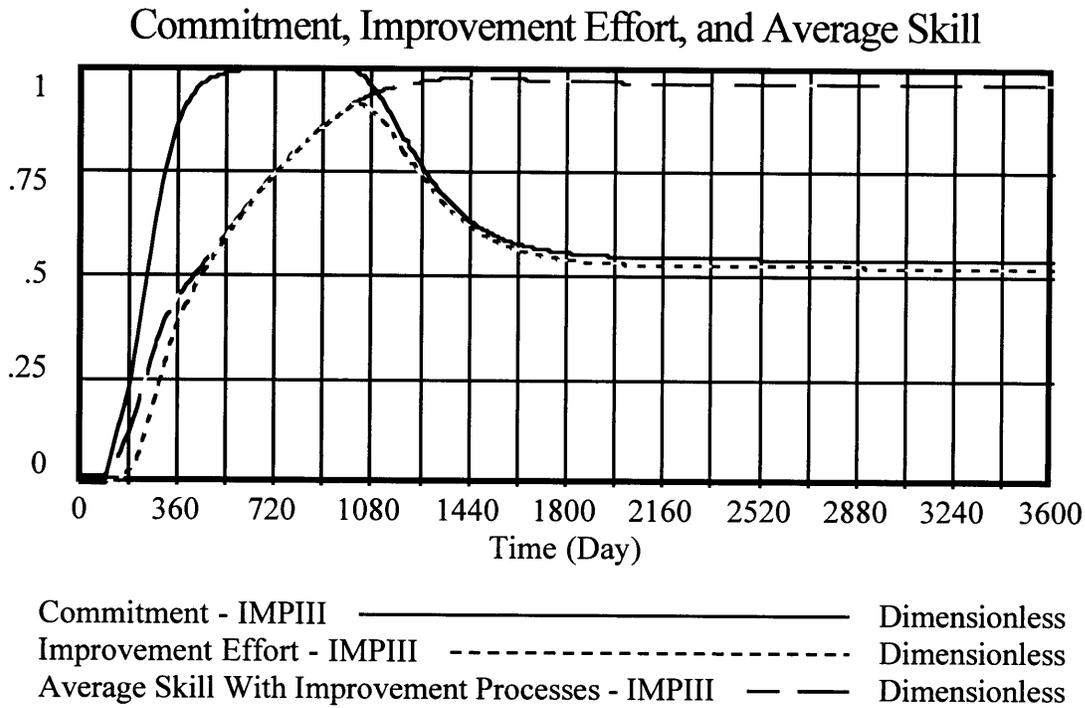


Figure 20: Improvement III - Commitment, Improvement Effort, and Average Skill

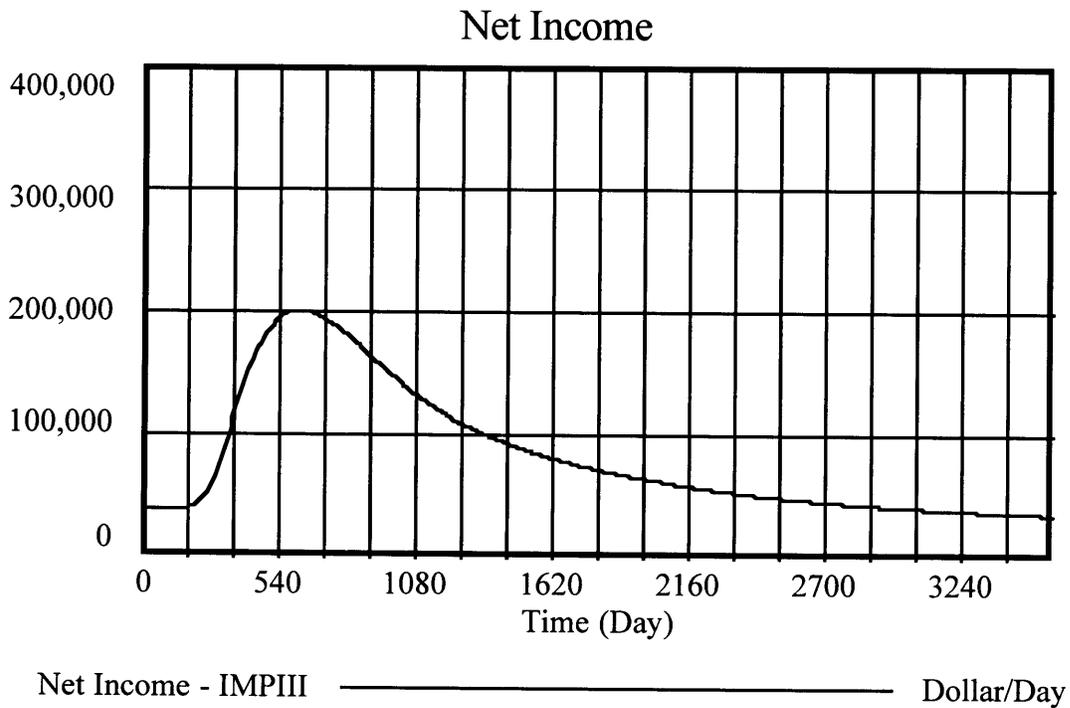


Figure 21: Improvement III - Net Income

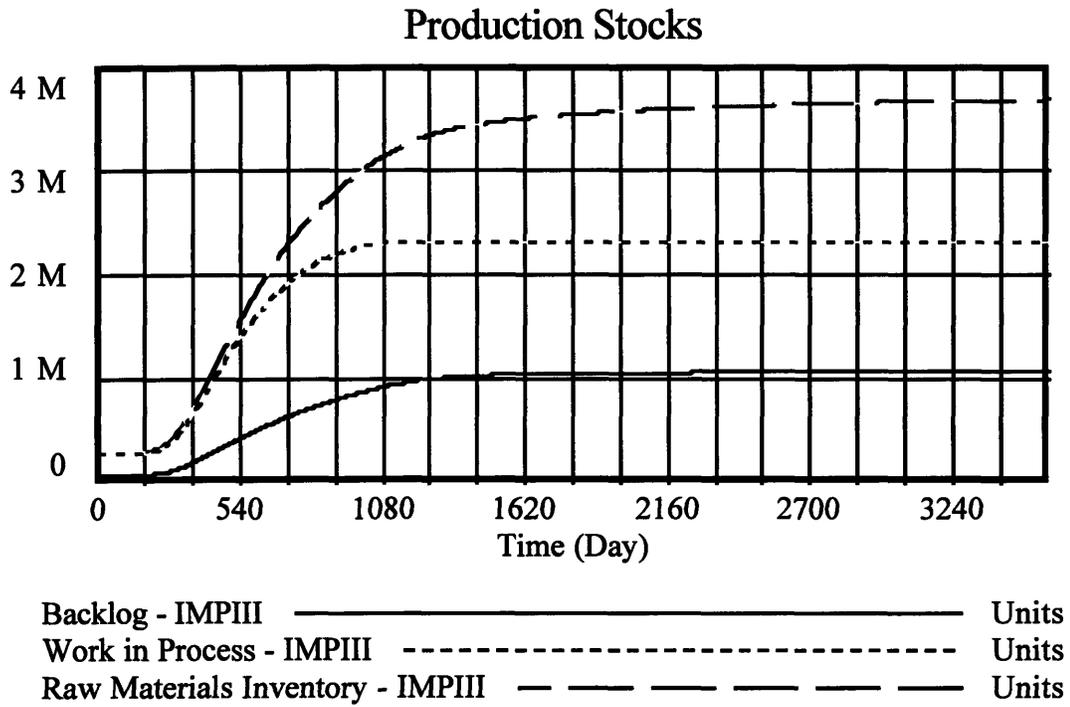


Figure 22: Improvement III - Production Stocks

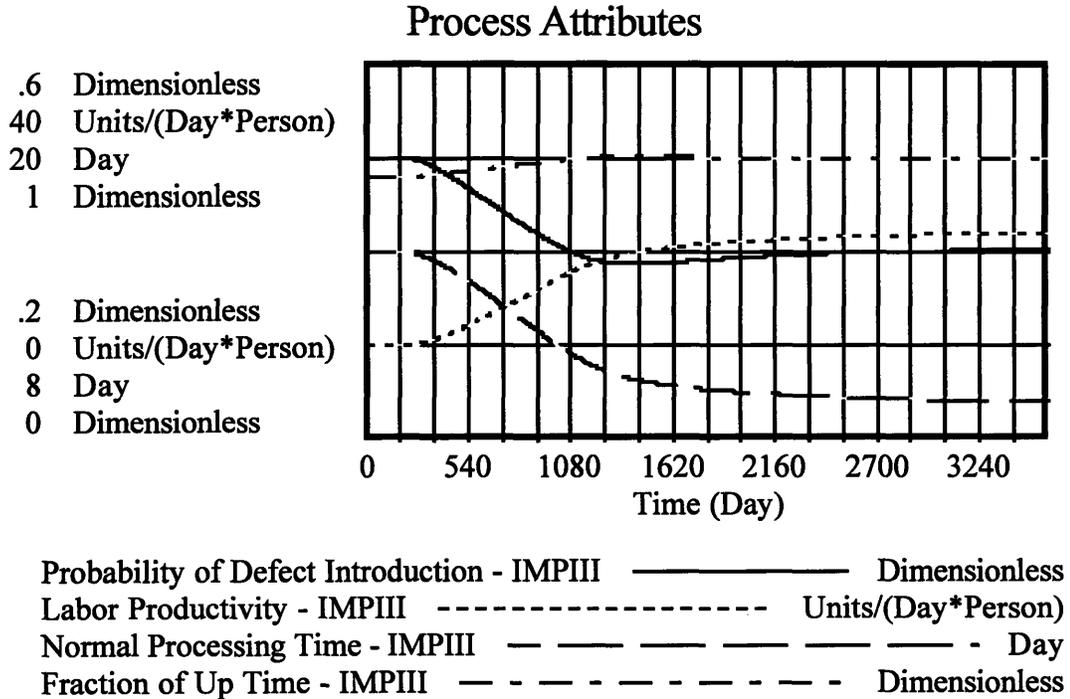


Figure 23: Improvement III - Process Attributes

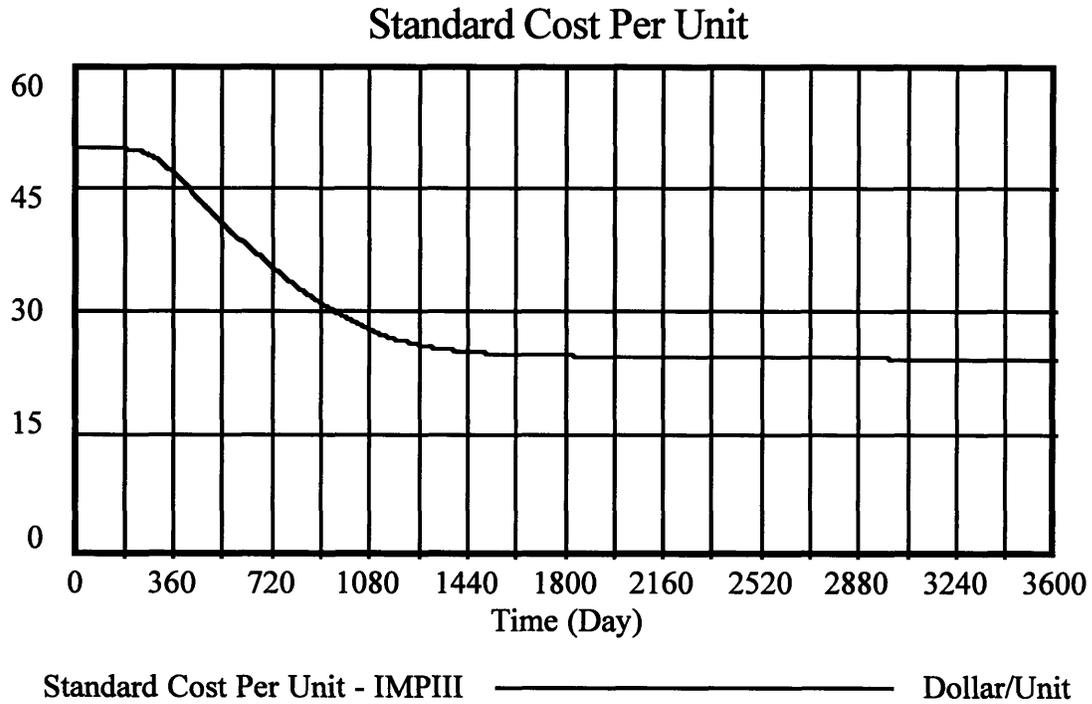


Figure 24: Improvement III - Standard Cost Per Unit

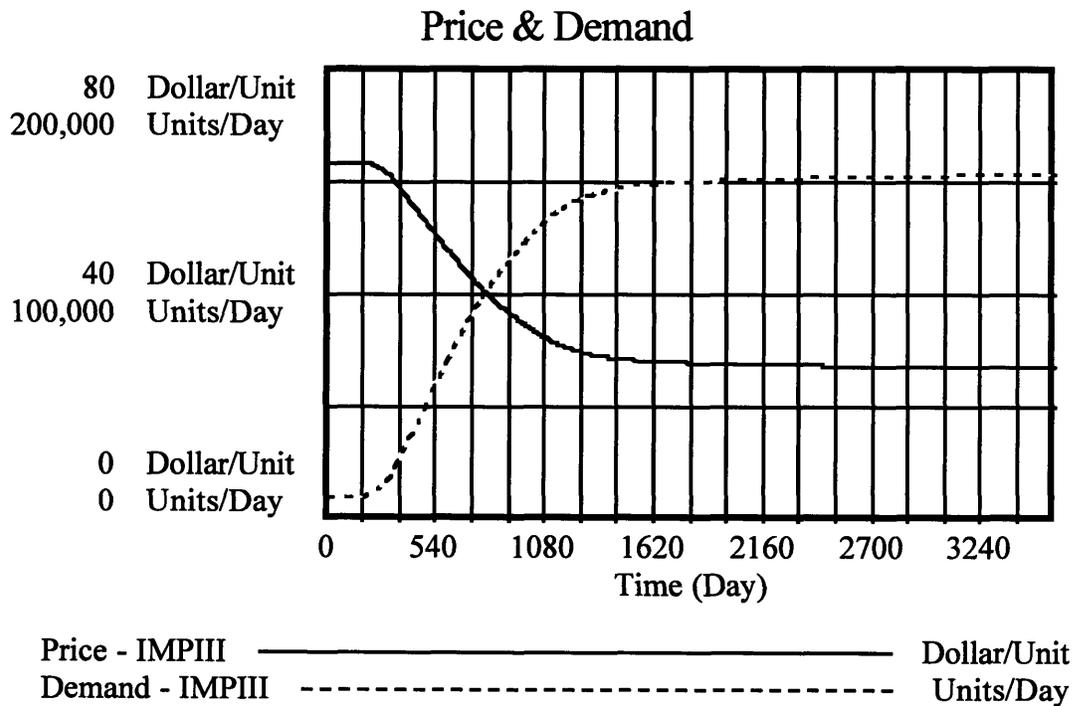


Figure 25: Improvement III - Pricing & Demand

2.5 Improvement IV

The Improvement IV case represents a firm that begins in equilibrium, but implements an improvement program after the first quarter. The firm is, however, only dedicated to reducing the probability of introducing defects during processing. The firm is willing to lay off excess labor when times are bad and the product market is highly differentiated. The key graphs for this run are shown below. (*Note:* Improvement II and Improvement IV only differ on the allocation of improvement effort.)

As shown in Figure 26, commitment rises to a value slightly less than one in approximately a year and a half, then decays away to approximately 30% of its maximum value during the run due to layoffs (see Section 2.3). Because the firm was only working to reduce the probability of defect introduction (Figure 29), the standard cost per unit does not fall nearly as much (Figure 30) as when all process attributes were being improved equally. This occurs because the probability of defect introduction is realized to be less influential on standard cost per unit than some of the other process attributes. Also, there are diminishing returns to the amount of effort the firm puts towards improving one attribute. Therefore, price does not fall as much (Figure 31) and leads to a much better net income (Figure 27) than in Improvement II. The behavior patterns displayed in the remaining graphs are similar to those described in Section 2.3 for Improvement II.

This scenario has depicted a firm that has improved an internal process, but due to poor price setting policies, did not benefit fiscally. Due to the fact that demand was relatively inelastic to changes in price, the firm could have increased markup and benefited from the decrease in internal costs. The firm did, however, perform better than the firm depicted in Improvement II because it did not lower price as much while facing the same demand.

Commitment, Improvement Effort, and Average Skill

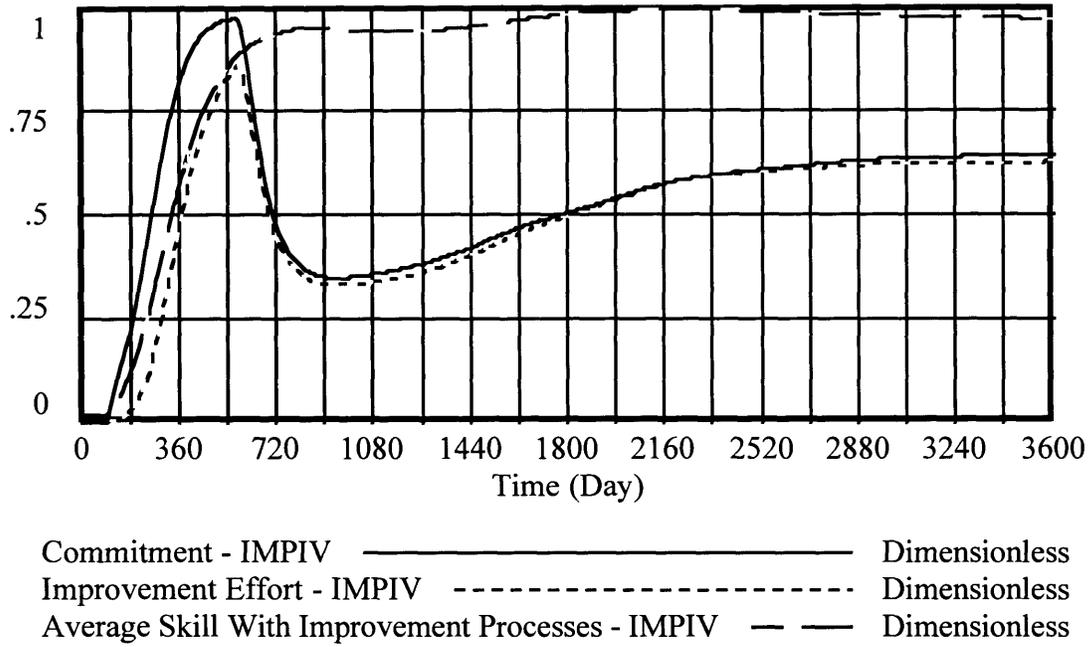


Figure 26: Improvement IV - Commitment, Improvement Effort, Average Skill

Net Income

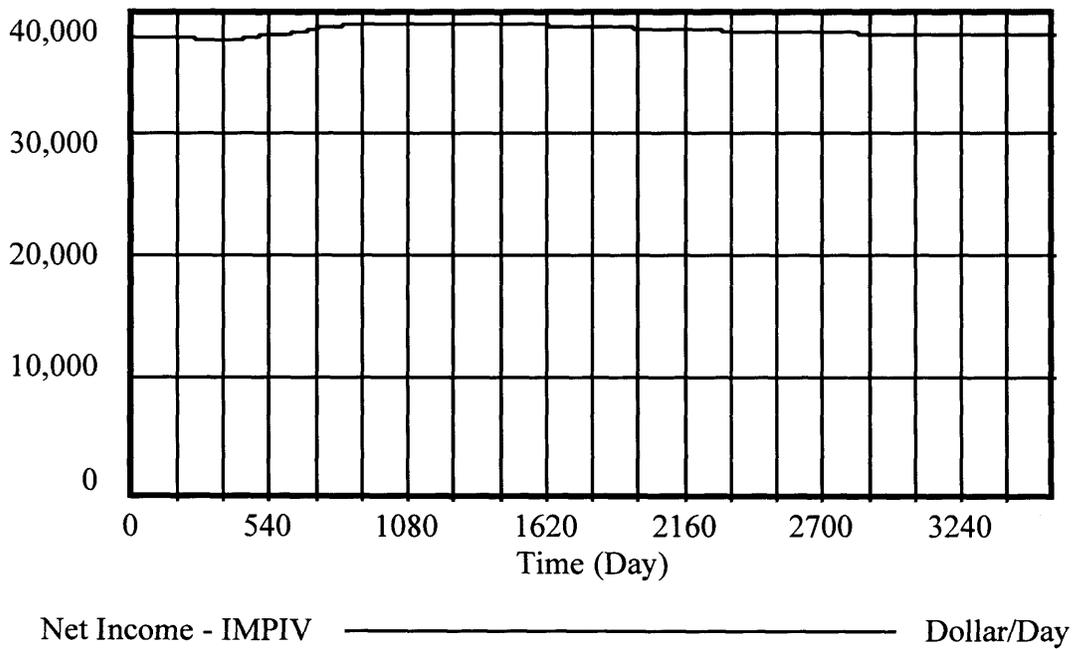


Figure 27: Improvement IV - Net Income

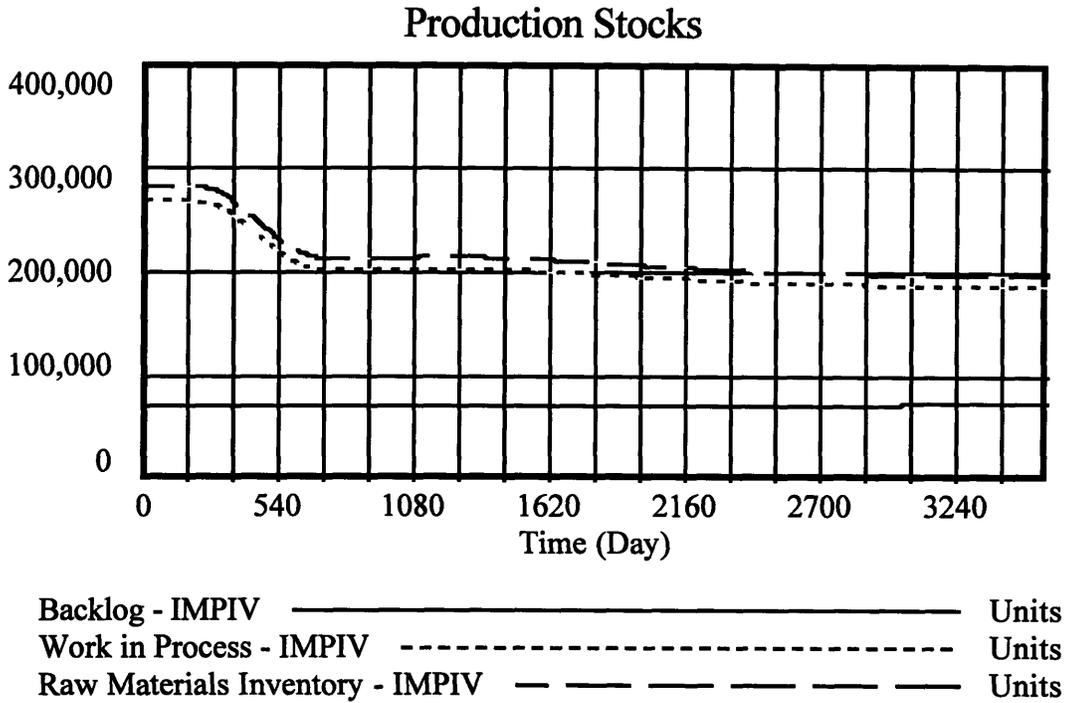


Figure 28: Improvement IV - Production Stocks

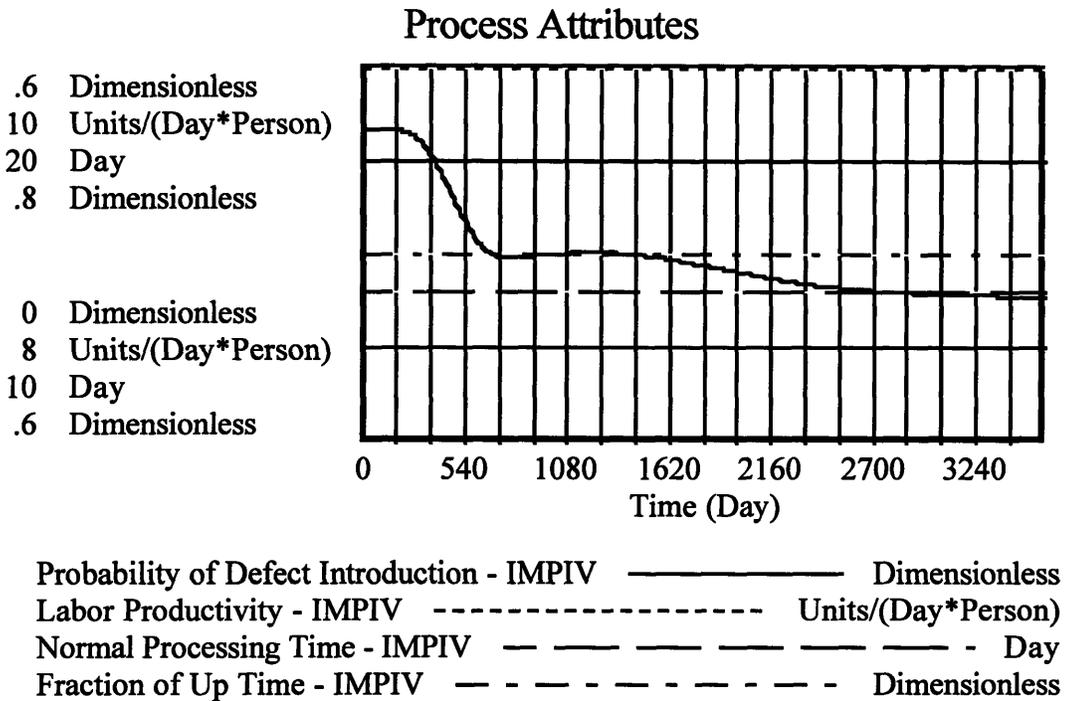


Figure 29: Improvement IV - Process Attributes

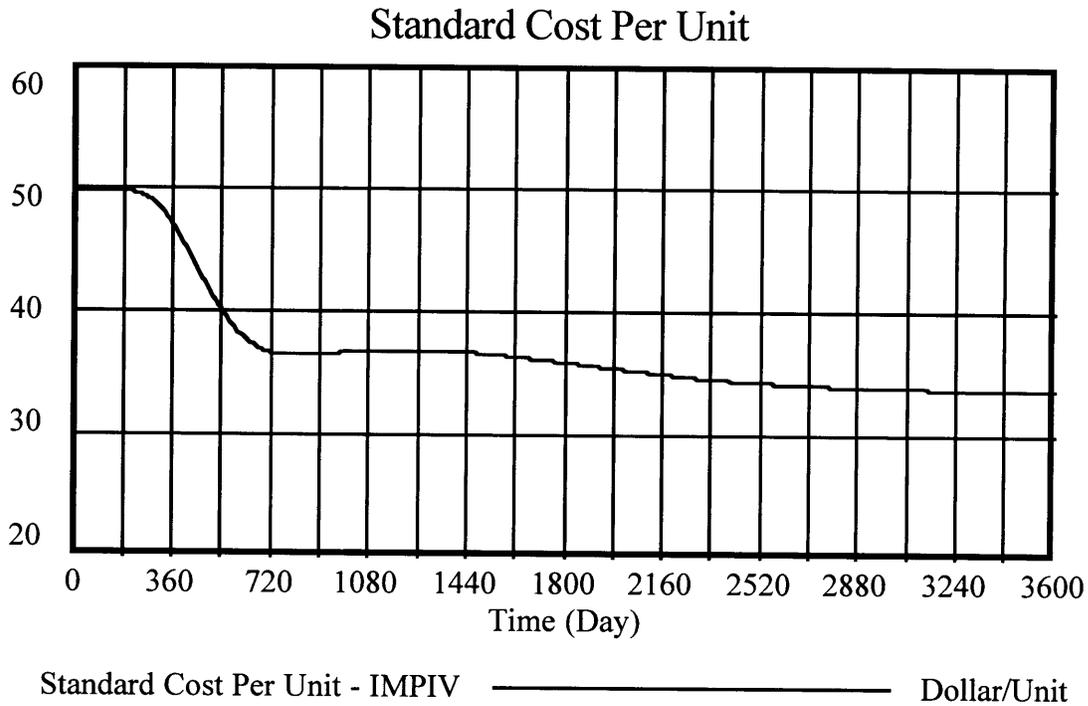


Figure 30: Improvement IV - Standard Cost Per Unit

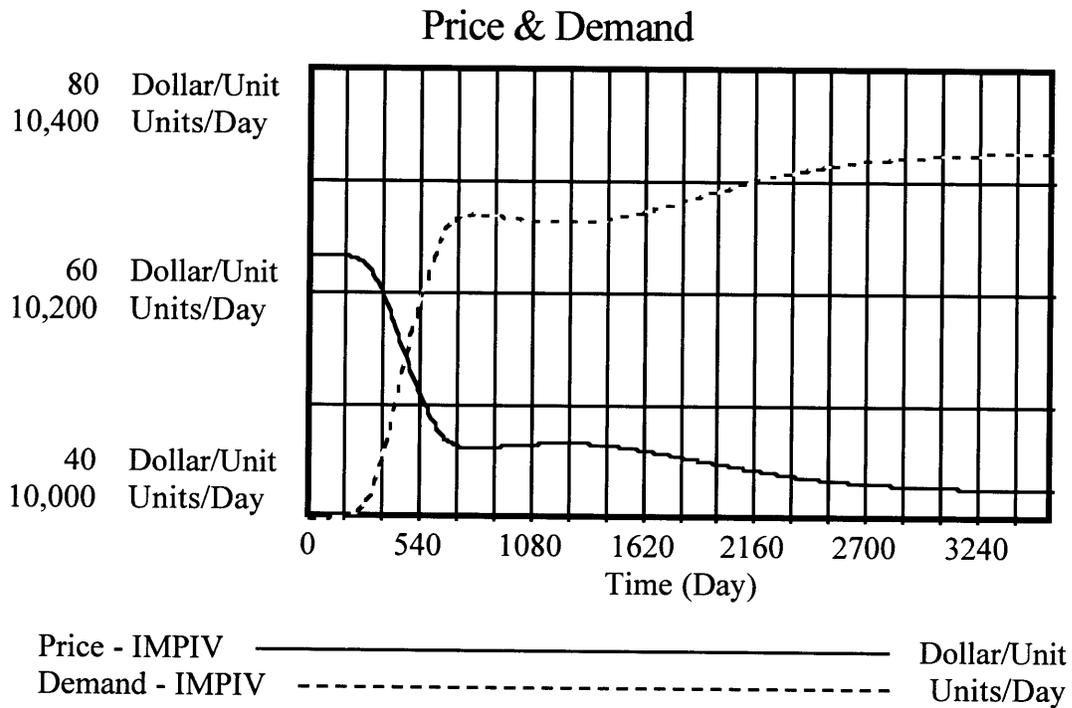


Figure 31: Improvement IV - Price & Demand

3.0 Flight Simulator Interface

3.1 Overview

A flight simulator interface allowing user-friendly interaction with the model was designed using VenappTM¹. The process improvement flight simulator allows the user to step into the role of managing a firm through process improvement programs and the perils that accompany them. The following section steps through the screens and features available to the user. Appendix 5.1 contains the technical code of the flight simulator.

3.2 Input Screens

The first two screens shown in Figures 32 and 33 are the title and welcome screens, respectively. The following screen depicted in Figure 34 is referred to as the “state of the business” screen. It allows the user to enter pertinent data that initializes the model. The user is asked to enter the following: initial price elasticity of demand, initial quantity demand, employee wage, raw material cost, book value of depreciable capital, and average lifetime of capital. Once those values have been entered, the model is initialized for one quarter in equilibrium. The next screen depicted in Figure 35 shows the user “how to play.” It provides directions on how to enter values, check on the status of the firm, and how to advance in time. Once the user is comfortable with the control center, he or she can begin the game. The control center shown in Figure 36 is the main screen. From there, the user can click on any of the reports shown on the bottom of the screen to check on the status of the firm. Those screens are shown in Figures 37 through 43. The user can modify any of the eight game parameters and advance in time from the main screen as well as from any of the report screens. The eight parameters that the user can modify are: management’s enactment of an improvement program, fraction of effort

¹ “Uses a model combined with a set of rules for interacting with the model to allow easy access to the use and results of the model.” (Ventana Systems, Inc., 1995)

for improving labor productivity, fraction of effort for reducing the probability of introducing defects, fraction of effort for reducing normal processing time, fraction of effort for improving fraction of up time, willingness to lay off labor, desired markup, and annual training time per employee.

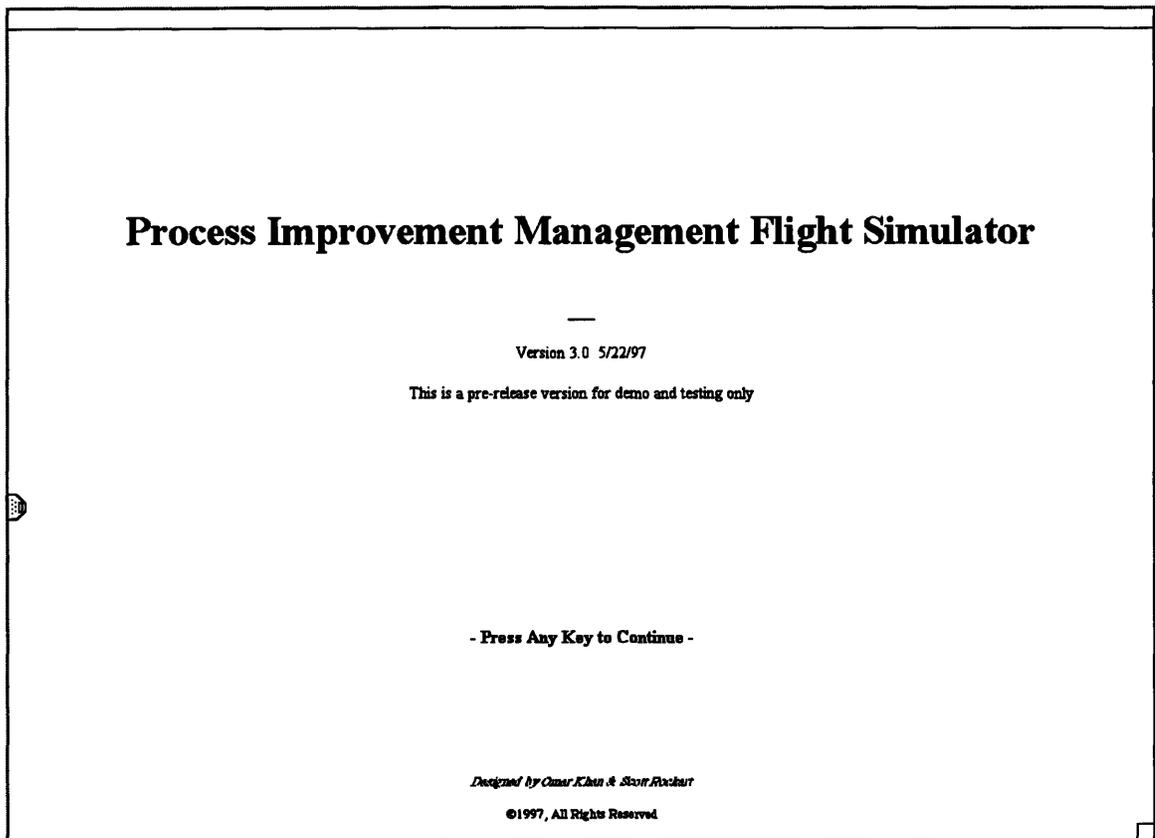


Figure 32: Title Screen



Figure 33: Welcome Screen

State of the business...

What kind of industry are you in? Commodity or highly differentiated?
Please enter an elasticity of demand below (e.g. commodity = 50 or highly differentiated = 0.5)

What is the initial demand for your product or service in units produced per year? (e.g. 3,600,000)

Please enter the cost structure for your business:

Average wage per employee in \$/year including benefits (e.g. \$72,000):

Raw material cost per unit in \$/unit (e.g. \$2):

What is the book value of your depreciable capital? (e.g. \$10,000,000)

What is the average lifetime of your capital? (e.g. 10 years)

Figure 34: State of the Business

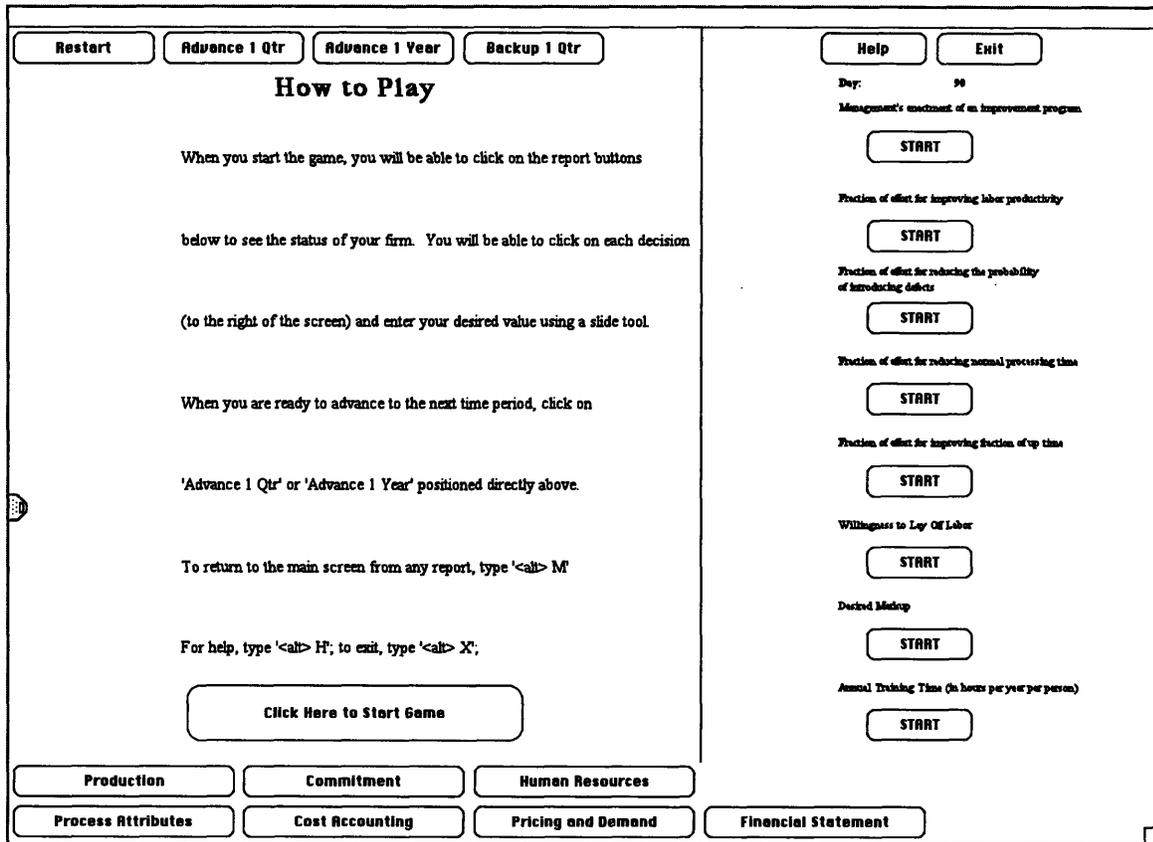


Figure 35: Instruction Screen

Restart	Advance 1 Qtr	Advance 1 Year	Backup 1 Qtr	Finish Game	Help	Exit
----------------	----------------------	-----------------------	---------------------	--------------------	-------------	-------------

Flight Simulator Control Center

Management's enactment of an Improvement program =====>

A value of zero corresponds to no Improvement program
A value of one corresponds to management enacting an improvement program

Fraction of effort for improving labor productivity (0 -> 1) =====>

Fraction of Improvement effort dedicated to increasing labor productivity
Note: The four fractions of effort must sum to one!

Fraction of effort for reducing the probability of introducing defects (0 -> 1) =====>

Fraction of Improvement effort dedicated to reducing the prob. of introducing defects during processing
Note: The four fractions of effort must sum to one!

Fraction of effort for reducing normal processing time (0 -> 1) =====>

Fraction of Improvement effort dedicated to completing work in process faster
Note: The four fractions of effort must sum to one!

Fraction of effort for improving fraction of up time (0 -> 1) =====>

Fraction of Improvement effort dedicated to decreasing down time of machines, computers, etc.
Note: The four fractions of effort must sum to one!

Willingness to lay off labor (0 -> 1) =====>

Managements willingness to lay off excess labor
Zero corresponds to no layoffs and one corresponds to full willingness to lay off excess labor

Desired Markup (over unit costs) =====>

Zero corresponds to selling at cost and two corresponds to a 200% markup over cost

Annual Training Time in Process Improvement (in hours per year per person) =====>

Recommended training time: 40

Day: 90

Management's enactment of an Improvement program

?

Fraction of effort for improving labor productivity

?

Fraction of effort for reducing the probability of introducing defects

?

Fraction of effort for reducing normal processing time

?

Fraction of effort for improving fraction of up time

?

Willingness to Lay Off Labor

?

Desired Markup

?

Annual Training Time (in hours per year per person)

?

Production	Commitment	Human Resources
Process Attributes	Cost Accounting	Pricing and Demand
Financial Statement		

Figure 36: Control Center

Restart	Advance 1 Qtr	Advance 1 Year	Backup 1 Qtr	Finish Game	Help	Exit
----------------	----------------------	-----------------------	---------------------	--------------------	-------------	-------------

Production	
New Orders (units/day)	10000
Shipments (units/day)	10000
Order Backlog (units)	70000
Raw Materials (units)	283390
Raw Materials Inspection Yield	0.95
Work in Process (units)	268583
Process Yield	0.52
Cycle Time (days)	28

Order Backlog	Process Yield	
New Orders	Raw Mat Insp Yield	Raw Materials Inventory
Shipments	Cycle Time	Work in Process

Day:	90
Managements enactment of an improvement program	<input type="text" value="0"/> ?
Fraction of effort for improving labor productivity	<input type="text" value="0.25"/> ?
Fraction of effort for reducing the probability of introducing defects	<input type="text" value="0.25"/> ?
Fraction of effort for reducing normal processing time	<input type="text" value="0.25"/> ?
Fraction of effort for improving fraction of up time	<input type="text" value="0.25"/> ?
Willingness to Lay Off Labor	<input type="text" value="0"/> ?
Desired Markup	<input type="text" value="1.5"/> ?
Annual Training Time (in hours per year per person)	<input type="text" value="0"/> ?

Main Screen >

Figure 37: Production Screen

Restart		Advance 1 Qtr		Advance 1 Year		Backup 1 Qtr		Finish Game		Help		Exit	
Process Attributes													
Improvement Effort (0 -> 1)				0.00						Day: 80			
Labor Productivity (units completed daily per person)				10.0						Management's enactment of an improvement program		<input type="text" value="0"/> ?	
Fraction of effort for increasing labor productivity (LP) (0 -> 1)				0.25						Fraction of effort for improving labor productivity		<input type="text" value="0.25"/> ?	
Probability of Defect Introduction (during processing) (0 -> 1)				0.50						Fraction of effort for reducing the probability of introducing defects		<input type="text" value="0.25"/> ?	
Fraction of effort for reducing the probability of defect introduction (PDI) (0 -> 1)				0.25						Fraction of effort for reducing normal processing time		<input type="text" value="0.25"/> ?	
Normal Processing Time (days)				14.0						Fraction of effort for improving fraction of up time		<input type="text" value="0.25"/> ?	
Fraction of effort for reducing normal processing time (NPT) (0 -> 1)				0.25						Willingness to Lay Off Labor		<input type="text" value="0"/> ?	
Fraction of Up Time (0 -> 1)				0.70						Desired Markup		<input type="text" value="1.5"/> ?	
Fraction of effort for improving fractional up time (FUT) (0 -> 1)				0.25						Annual Training Time (in hours per year per person)		<input type="text" value="0"/> ?	
Improvement Effort		NPT Improvement Fraction		Prob of Defect Intro									
LP Improvement Fraction		FUT Improvement Fraction		Normal Processing Time									
PDI Improvement Fraction		Labor Productivity		Fraction of Up Time								Main Screen >	

Figure 38: Process Attributes Screen

Restart		Advance 1 Qtr		Advance 1 Year		Backup 1 Qtr		Finish Game		Help		Exit	
Commitment										Day: 90			
Ratio of Observed Results to Expected Results				0.00		<input type="text" value="0"/> <input <="" td="" type="button" value="?"/> <td colspan="2"> Managements enactment of an improvement program </td> <td colspan="2"></td> <td colspan="2"></td>		Managements enactment of an improvement program					
		<input type="button" value="Info"/>											
Perceived Job Security (0 -> 1)				1.00		<input type="text" value="0.25"/> <input <="" td="" type="button" value="?"/> <td colspan="2"> Fraction of effort for improving labor productivity </td> <td colspan="2"></td> <td colspan="2"></td>		Fraction of effort for improving labor productivity					
		<input type="button" value="Info"/>											
Ratio of Managerial Support Allocated to Managerial Support Required				1.00		<input type="text" value="0.25"/> <input <="" td="" type="button" value="?"/> <td colspan="2"> Fraction of effort for reducing the probability of introducing defects </td> <td colspan="2"></td> <td colspan="2"></td>		Fraction of effort for reducing the probability of introducing defects					
		<input type="button" value="Info"/>											
Ratio of Observed Performance to Employees' Goal for Performance				2.00		<input type="text" value="0.25"/> <input <="" td="" type="button" value="?"/> <td colspan="2"> Fraction of effort for reducing normal processing time </td> <td colspan="2"></td> <td colspan="2"></td>		Fraction of effort for reducing normal processing time					
		<input type="button" value="Info"/>											
Employee Commitment to Improvement Programs (0 -> 1)				0.00		<input type="text" value="0.25"/> <input <="" td="" type="button" value="?"/> <td colspan="2"> Fraction of effort for improving fraction of up time </td> <td colspan="2"></td> <td colspan="2"></td>		Fraction of effort for improving fraction of up time					
								Willingness to Lay Off Labor		<input type="text" value="0"/> <input <="" td="" type="button" value="?"/> <td colspan="2"></td>			
								Desired Markup		<input type="text" value="0.5"/> <input <="" td="" type="button" value="?"/> <td colspan="2"></td>			
								Annual Training Time (in hours per year per person)		<input type="text" value="0"/> <input <="" td="" type="button" value="?"/> <td colspan="2"></td>			
<input type="button" value="Mgmt Goal Commitment"/>		<input type="button" value="Effect of Results"/>										<input type="button" value="Main Screen >"/>	
<input type="button" value="Commitment"/>		<input type="button" value="Effect of Job Security"/>											
<input type="button" value="Word of Mouth"/>		<input type="button" value="Effect of Support"/>		<input type="button" value="Effect of Employee Goal"/>									

Figure 39: Commitment Screen

<input type="button" value="Restart"/> <input type="button" value="Advance 1 Qtr"/> <input type="button" value="Advance 1 Year"/> <input type="button" value="Backup 1 Qtr"/> <input type="button" value="Finish Game"/>		<input type="button" value="Help"/> <input type="button" value="Exit"/>	
<p>Cost Accounting</p>		<p>Day: 90</p>	
Direct Labor Cost Per Unit	(\$/Unit)	38.37	<p>Management's enactment of an improvement program</p> <input type="text" value="0"/> <input type="button" value="?"/>
Raw Material Cost Per Unit		3.84	<p>Fraction of effort for improving labor productivity</p> <input type="text" value=".25"/> <input type="button" value="?"/>
Direct Cost Per Unit		42.21	<p>Fraction of effort for reducing the probability of introducing defects</p> <input type="text" value=".25"/> <input type="button" value="?"/>
Carrying Cost Per Unit		0.08	<p>Fraction of effort for reducing normal processing time</p> <input type="text" value=".25"/> <input type="button" value="?"/>
Capital Cost Per Unit		7.61	<p>Fraction of effort for improving fraction of up time</p> <input type="text" value=".25"/> <input type="button" value="?"/>
Standard Cost Per Unit		49.90	<p>Willingness to Lay Off Labor</p> <input type="text" value="0"/> <input type="button" value="?"/>
			<p>Desired Markup</p> <input type="text" value="1.5"/> <input type="button" value="?"/>
			<p>Annual Training Time (in hours per year per person)</p> <input type="text" value="0"/> <input type="button" value="?"/>
<input type="button" value="Standard Cost Per Unit"/> <input type="button" value="Raw Material Cost Per Unit"/>		<input type="button" value="Main Screen >"/>	
<input type="button" value="Direct Cost Per Unit"/> <input type="button" value="Carrying Cost Per Unit"/>			
<input type="button" value="Direct Labor Cost Per Unit"/> <input type="button" value="Capital Cost Per Unit"/>			

Figure 40: Cost Accounting Screen

Human Resources

Direct Labor (person)	3883
Desired Direct Labor (person)	3883
New Hires (person/day)	0.5
Attrition (person/day)	0.5
Layoffs (person/day)	0.0
Average Skill with Improvement Programs (0 -> 1)	0.02
Effective of on-the-job Experience on Average Skill (0 -> 1)	0.02
Effect of Training on Average Skill (0 -> 1)	0.00

Day: 90

Managements enactment of an improvement program

Fraction of effort for improving labor productivity

Fraction of effort for reducing the probability of introducing defects

Fraction of effort for reducing normal processing time

Fraction of effort for improving fraction of up time

Willingness to Lay Off Labor

Desired Markup

Annual Training Time (in hours per year per person)

Figure 41: Human Resources Screen

<input type="button" value="Restart"/> <input type="button" value="Advance 1 Qtr"/> <input type="button" value="Advance 1 Year"/> <input type="button" value="Backup 1 Qtr"/> <input type="button" value="Finish Game"/>		<input type="button" value="Help"/> <input type="button" value="Exit"/>	
<p>Pricing and Demand</p>		<p>Day: 90</p> <p>Management's enactment of an improvement program</p> <p><input type="text" value="0"/> <input <="" input="" type="button" value="?"/></p>	
<p>Desired Profit Margin 0.50</p>		<p>Fraction of effort for improving labor productivity</p> <p><input type="text" value=".25"/> <input <="" input="" type="button" value="?"/></p>	
<p>Price (\$/Unit) 63.31</p>		<p>Fraction of effort for reducing the probability of introducing defects</p> <p><input type="text" value=".25"/> <input <="" input="" type="button" value="?"/></p>	
<p>Demand (Units/Day) 10000</p>		<p>Fraction of effort for reducing normal processing time</p> <p><input type="text" value=".25"/> <input <="" input="" type="button" value="?"/></p>	
		<p>Fraction of effort for improving fraction of up time</p> <p><input type="text" value=".25"/> <input <="" input="" type="button" value="?"/></p>	
		<p>Willingness to Lay Off Labor</p> <p><input type="text" value="0"/> <input <="" input="" type="button" value="?"/></p>	
		<p>Desired Markup</p> <p><input type="text" value=".5"/> <input <="" input="" type="button" value="?"/></p>	
		<p>Annual Training Time (in hours per year per person)</p> <p><input type="text" value="0"/> <input <="" input="" type="button" value="?"/></p>	
<input type="button" value="Desired Profit Margin"/> <input type="button" value="Price"/> <input type="button" value="Demand"/>		<input type="button" value="Main Screen >"/>	

Figure 42: Pricing & Demand Screen

<input type="button" value="Restart"/> <input type="button" value="Advance 1 Qtr"/> <input type="button" value="Advance 1 Year"/> <input type="button" value="Backup 1 Qtr"/> <input type="button" value="Finish Game"/>		<input type="button" value="Help"/> <input type="button" value="Exit"/>																														
<p>Income Statement</p> <table border="0"> <tr> <td>Sales Revenue</td> <td>633089.13</td> </tr> <tr> <td>Cost of Goods Sold</td> <td>498955.84</td> </tr> <tr> <td>Gross Profit</td> <td>134133.28</td> </tr> <tr> <td colspan="2"><hr/></td> </tr> <tr> <td>Operating Expense</td> <td></td> </tr> <tr> <td>R and D</td> <td>0.00</td> </tr> <tr> <td>Indirect Expense</td> <td>77667.28</td> </tr> <tr> <td>General, Selling & Admin.</td> <td>0.00</td> </tr> <tr> <td>Total Expense</td> <td>77667.28</td> </tr> <tr> <td>Operating Income</td> <td>56466.00</td> </tr> <tr> <td colspan="2"><hr/></td> </tr> <tr> <td>Interest Expense</td> <td>0.00</td> </tr> <tr> <td>Tax Payments</td> <td>18633.78</td> </tr> <tr> <td>Net Income</td> <td>37832.22</td> </tr> <tr> <td>Cumulative Discounted Net Income</td> <td>2986198.25</td> </tr> </table>			Sales Revenue	633089.13	Cost of Goods Sold	498955.84	Gross Profit	134133.28	<hr/>		Operating Expense		R and D	0.00	Indirect Expense	77667.28	General, Selling & Admin.	0.00	Total Expense	77667.28	Operating Income	56466.00	<hr/>		Interest Expense	0.00	Tax Payments	18633.78	Net Income	37832.22	Cumulative Discounted Net Income	2986198.25
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<table border="0"> <tr> <td><input type="button" value="Gross Profit"/></td> <td><input type="button" value="Operating Expense"/></td> <td><input type="button" value="Net Income"/></td> </tr> <tr> <td><input type="button" value="COGS"/></td> <td><input type="button" value="Operating Income"/></td> <td><input type="button" value="Cum Discounted Net Inc"/></td> </tr> <tr> <td><input type="button" value="Sales Revenue"/></td> <td><input type="button" value="Tax Payments"/></td> <td><input type="button" value="Indirect Costs"/></td> </tr> </table>			<input type="button" value="Gross Profit"/>	<input type="button" value="Operating Expense"/>	<input type="button" value="Net Income"/>	<input type="button" value="COGS"/>	<input type="button" value="Operating Income"/>	<input type="button" value="Cum Discounted Net Inc"/>	<input type="button" value="Sales Revenue"/>	<input type="button" value="Tax Payments"/>	<input type="button" value="Indirect Costs"/>																					
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		<p>Day: 90</p> <p>Managements enactment of an improvement program</p> <p><input type="text" value="0"/> <input <="" p="" type="button" value="?"/> <p>Fraction of effort for improving labor productivity</p> <p><input type="text" value="0.25"/> <input <="" p="" type="button" value="?"/> <p>Fraction of effort for reducing the probability of introducing defects</p> <p><input type="text" value="0.25"/> <input <="" p="" type="button" value="?"/> <p>Fraction of effort for reducing normal processing time</p> <p><input type="text" value="0.25"> <input <="" p="" type="button" value="?"/> <p>Fraction of effort for improving fraction of up time</p> <p><input type="text" value="0.25"> <input <="" p="" type="button" value="?"/> <p>Willingness to Lay Off Labor</p> <p><input type="text" value="0"> <input <="" p="" type="button" value="?"/> <p>Desired Markup</p> <p><input type="text" value="1.5"> <input <="" p="" type="button" value="?"/> <p>Annual Training Time (in hours per year per person)</p> <p><input type="text" value="0"> <input <="" p="" type="button" value="?"/> <p><input type="button" value="Main Screen >"/></p> </input></p></input></p></input></p></input></p></input></p></p></p></p>																														

Figure 43: Financial Statement Screen

4.0 Technical Documentation

4.1 Demand Sector

The firm faces a linear and downward sloping demand curve. Demand is a function of initial demand, the elasticity of demand, and the price. Demand elasticity at the initial price and quantity is set exogenously.

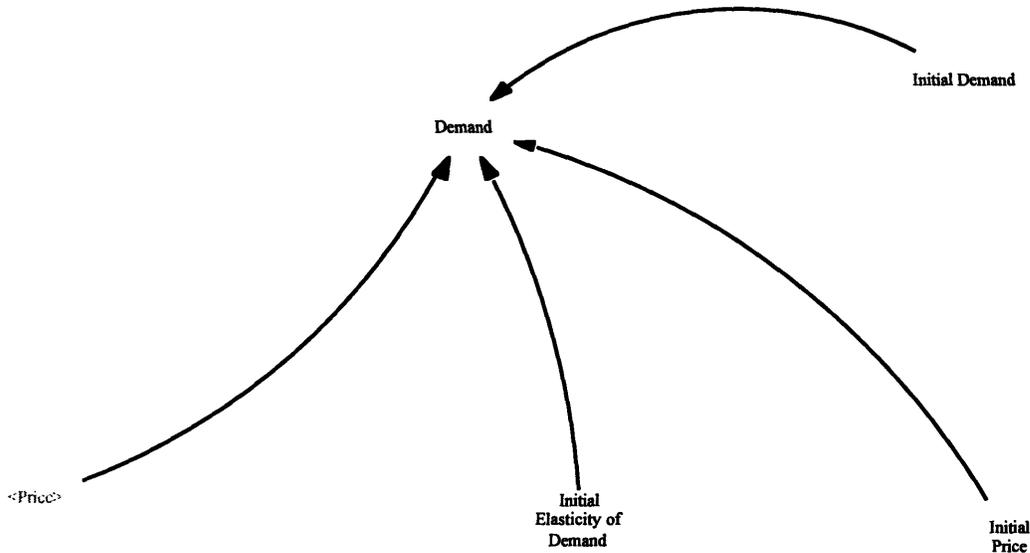


Figure 44: Demand Sector

Equations:

$$\text{Demand} = \max(0, \text{Initial Demand} * (1 - \text{Initial Elasticity of Demand} * ((\text{Price} - \text{Initial Price}) / \text{Initial Price})))$$

~ Units/Day

~ Using a constant elasticity of demand function so that an optimal markup can be determined at all operating points simply from the stated elasticity of substitution.

Initial Demand = 10000

~ Units/Day

Initial Elasticity of Demand = 2

~ Dimensionless

Initial Price = 50

~ Dollar/Unit

~ This price helps specify the demand, but when the simulator is not in use, actual price will be set optimally.

4.2 Production Sector

4.2.1 Material Flow

4.2.1a Raw Material Flow

The raw materials inventory flow group determines the flow into work in process, which is defined as the net production start rate. The net production start rate is the gross production start rate less the scrap rate of raw materials. The gross production start rate is determined by the desired gross production start rate as long as the raw materials inventory is sufficient.

The group includes two material flows. There is a flow of truly defective raw materials which includes defects present in the raw materials upon arrival. Defective material can be removed from the material flow during inspection based upon the probability of rejecting bad material. Also, good material can be thrown out on the probability of rejecting good material.

The desired level of raw materials inventory is determined by the desired inventory coverage and the desired gross production start rate. The desired gross production start rate is determined by the desired net production start rate and the expected raw material inspection yield. The desired net production start rate is the desired gross completion rate plus an adjustment for work in process.

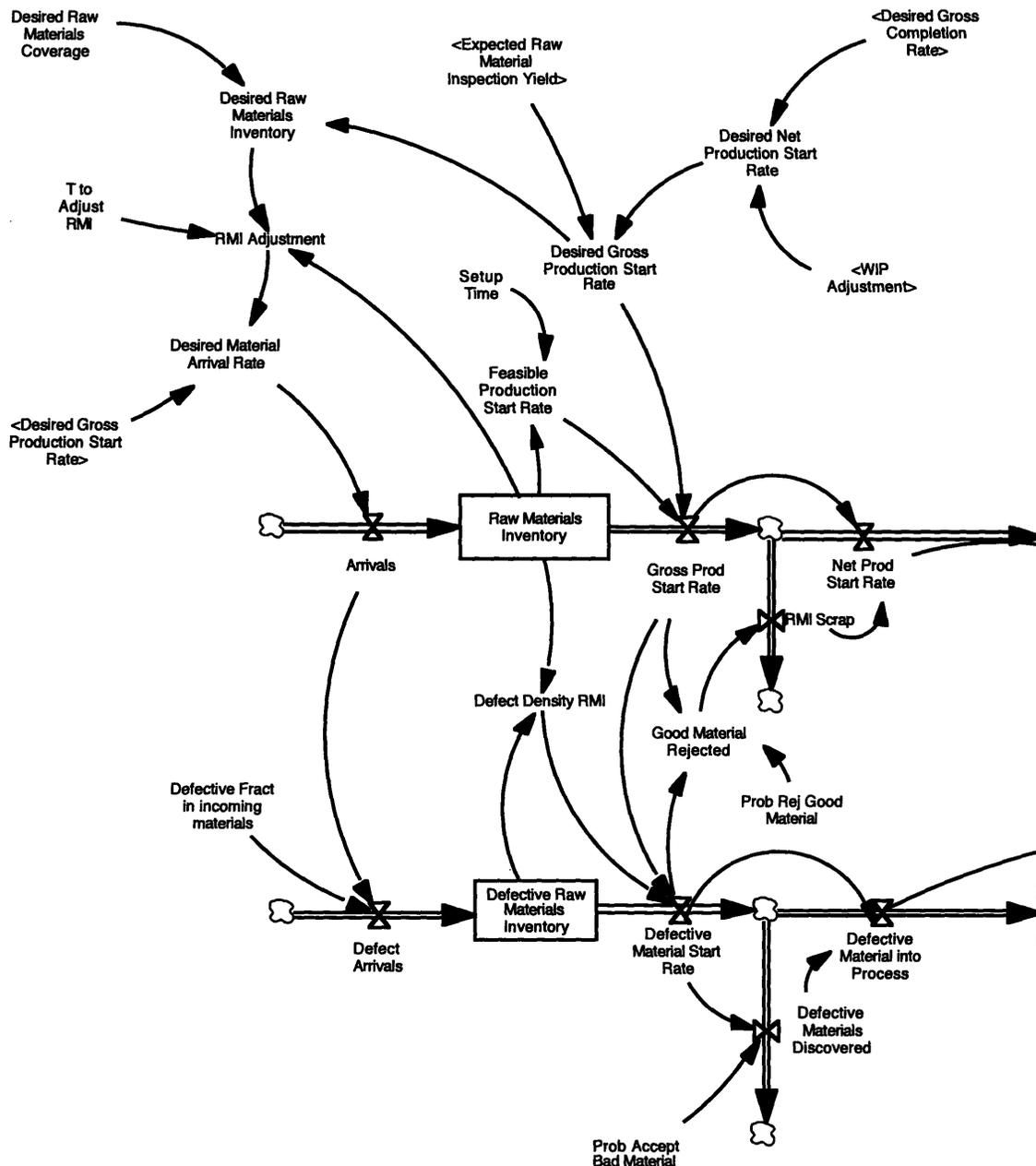


Figure 45: Raw Material Flow

Equations:

$$\text{Net Prod Start Rate} = \text{Gross Prod Start Rate} - \text{RMI Scrap}$$

~ Units/Day

~ The net production start rate is the number of materials into process. It is equal to the gross production start rate less the amount of material scrapped.

$$\text{Gross Prod Start Rate} = \min(\text{Desired Gross Production Start Rate}, \text{Feasible Production Start Rate})$$

~ Units/Day

~ The total number of materials started is the minimum of the desired level and the feasible level as

determined by the inventory of materials.

Desired Gross Production Start Rate = (Desired Net Production Start Rate / Expected Raw Material Inspection Yield)

~ Units/Day

~ Equivalent to the number of materials needed for WIP scaled by the expected loss of material defects.

Desired Net Production Start Rate = max(0, Desired Gross Completion Rate + WIP Adjustment)

~ Units/Day

~ The desired number of units flowing into WIP as determined by the desired completion rate and the adjustment for any shortfalls in WIP.

Feasible Production Start Rate = Raw Materials Inventory/Setup Time

~ Units/Day

~ The units that can be started as determined by the materials inventory and the setup time.

Raw Materials Inventory = INTEG(Arrivals-Gross Prod Start Rate, Desired Raw Materials Inventory)

~ Units

~ Number of units waiting to be moved into the process. Initially, is equal to the desired level of raw materials inventory. The change is determined by the arrival rate less the gross production start rate in a given time period.

Arrivals=Desired Material Arrival Rate

~ Units/Day

~ The arrival rate is assumed to be determined by the shipment rate of the upstream process. (For testing a single segment in equilibrium, the arrival rate is assumed to be equal to requests to the desired arrival rate.)

Desired Material Arrival Rate =max(0, (RMI Adjustment+Desired Gross Production Start Rate))

~ Units/Day

~ The desired material arrival rate accounts for the number of desired gross production starts plus the adjustment for the shortfall/excess in the raw materials inventory.

RMI Adjustment = (Desired Raw Materials Inventory-Raw Materials Inventory)/T to Adjust RMI

~ Units/Day

~ The firm seeks to adjust RMI to desired levels over a time to adjust RMI.

Desired Raw Materials Inventory = Desired Raw Materials Coverage*Desired Gross Production Start Rate

~ Units

~ The desired raw materials inventory is the desired number of gross starts per day multiplied by the desired coverage in number of days.

Desired Raw Materials Coverage = 14

~ Day

~ The number of days worth of materials desired for the raw materials inventory

T to Adjust RMI = 14

~ Day

~ The number of days it takes to adjust the raw materials inventory to desired levels.

Setup Time = 1

~ Day

~ The amount of time required for setting up handling of the materials (i.e. machine setup).

RMI Scrap = Good Material Rejected

+ Defective Materials Discovered

~ Units/Day

~ The number of units scrapped is equal of good units scrapped plus bad units scrapped.

Good Material Rejected = Prob Rej Good Material*(Gross Prod Start Rate-Defective Material Start Rate)
~ Units/Day
~ The number of good units scrapped is the number of good units started multiplied by the prob of rejecting good material. The number of good units started is equal to the number of units started less the number of bad units started.

Prob Rej Good Material = 0.005
~ Dimensionless
~ Probability of rejecting (scraping) good material.

Defective Material Start Rate = Defect Density RMI * Gross Prod Start Rate
~ Units/Day
~ The amount of defective material started is the overall amount of material started multiplied by the fraction of the total material which is defective.

Defect Density RMI = zidz(Defective Raw Materials Inventory,Raw Materials Inventory)
~ Dimensionless
~ The fraction of RMI that is defective.

Defective Raw Materials Inventory = INTEG(Defect Arrivals-Defective Material Start Rate, Initial Def RMI)
~ Units
~ The stock of defective units in the raw materials inventory. The inflow is the number of defective arrivals and the outflow is the number of defective units started into production.

Defect Arrivals = Arrivals*Defective Fract in incoming materials
~ Units/Day
~ The number of defective units arriving is the number of total arrivals multiplied by the expected fraction of the defective arrivals.

Defective Fract in incoming materials = 0.05
~ Dimensionless
~ Normally, this will be determined by the defective shipment fraction from the upstream process.

Initial Def RMI = Desired Raw Materials Inventory*Defective Fract in incoming materials
~ Units
~ The initial defective RMI is the desired RMI level multiplied by the def fraction of incoming materials.

Defective Materials Discovered = Defective Material Start Rate* (1 - Prob Accept Bad Material)
~ Units/Day
~ The number of defective units discovered/rejected in any given time period is equal to the number of defective units started multiplied by the probability of rejecting a bad unit. The probability of rejecting a bad unit is 1 less the probability of accepting a bad unit.

Prob Accept Bad Material = 0.05
~ Dimensionless
~ Probability of accepting a defective unit.

Defective Material into Process = Defective Material Start Rate - Defective Materials Discovered
~ Units/Day
~ The number of defective materials not discovered and passed into the process.

4.2.1b Work in Process Flow

The work in process flow group determines the shipment rate, which is assumed to equal to the net completion rate. The net completion rate is the gross completion rate less the final rejection rate. The gross completion rate is determined by the level of work in process and the normal processing time as long as labor and capital resources are sufficient.

The group includes two product flows. There is a flow of defective product which includes defects present when the raw materials enter the process as well as defects introduced during the completion process. Defective product can be discovered during testing based upon the probability of rejecting bad product. Also, good product can be found defective based on the probability of rejecting good product.

The desired level of work in process is determined by the desired gross completion rate. The desired gross completion rate, in turn, is determined by the desired net completion rate and the effective process yield. The desired net completion rate is determined by the order backlog and the delivery delay.

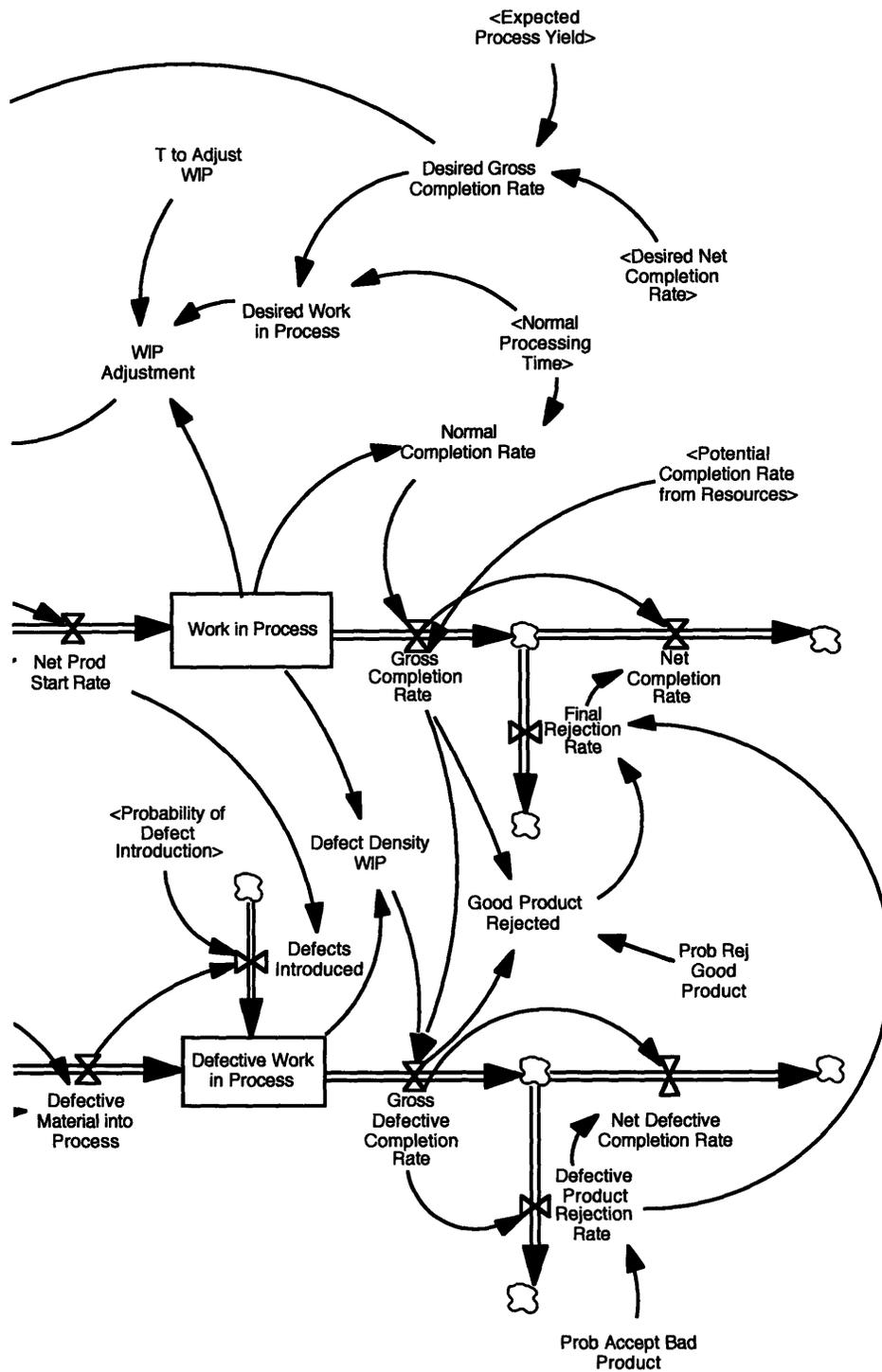


Figure 46: Work in Process Flow

Equations:

$$\text{Net Completion Rate} = \text{Gross Completion Rate} - \text{Final Rejection Rate}$$

~ Units/Day

~ The number of units shipped is equal to the total finishing rate less the final scrap rate.

Gross Completion Rate = min(Potential Completion Rate from Resources, Normal Completion Rate)

~ Units/Day

~ The gross completion rate is the minimum allowed by either the available resources or the normal completion rate.

Normal Completion Rate = Work in Process/Normal Processing Time

~ Units/Day

~ The normal completion rate is determined by the available units to be completed and the normal processing time.

Work in Process = INTEG(Net Prod Start Rate-Gross Completion Rate, Initial WIP)

~ Units

~ Number of units in process waiting to be completed. Initially, is equal to the desired level of work in process. The change is determined by the net material start rate less the gross completion rate in a given time period.

Initial WIP = Desired Work in Process

~ Units

~ Initial WIP is set at the desired level.

Desired Work in Process = Desired Gross Completion Rate*Normal Processing Time

~ Units

~ The desired level of WIP is determined by the desired gross completion rate and the normal processing time for completing units.

Desired Gross Completion Rate = (Desired Net Completion Rate/Expected Process Yield)

~ Units/Day

~ The desired number of units completed is the net number of units completed adjusted by the expected process yield.

Desired Net Completion Rate = Backlog/Desired Delivery Delay

~ Units/Day

~ The required number of units required by downstream processes/customers (order backlog) in units per day.

Desired Delivery Delay = 7

~ Day

~ The desired number of days an order is to be filled for a downstream recipient.

Final Rejection Rate = Good Product Rejected+Defective Product Rejection Rate

~ Units/Day

~ The number of units scrapped include the good scrapped and the bad scrapped.

Good Product Rejected = (Gross Completion Rate-Gross Defective Completion Rate) *

Prob Rej Good Product

~ Units/Day

~ The amount of good product rejected is the number good products completed multiplied by the probability of rejecting a good unit. The number of good units completed is the number of total units completed less the number of defective units completed.

Prob Rej Good Product = 0.005

~ Dimensionless

~ Probability of rejecting (scrapping) a good unit.

Gross Defective Completion Rate =Gross Completion Rate*Defect Density WIP

~ Units/Day

~ The number of units completed multiplied by the fraction of total units which are defective.

Defect Density WIP = $\frac{\text{Defective Work in Process}}{\text{Work in Process}}$

~ Dimensionless

~ The fraction of WIP which is defective.

Defective Work in Process = $\text{INTEG}(\text{Defective Material into Process} + \text{Defects introduced}$

- Gross Defective Completion Rate, Initial Def WIP)

~ Units

~ The stock of defective units in process. The inflow is the number of defective materials into process and the outflow is the gross number of defective units completed.

Defects introduced = $(\text{Net Prod Start Rate} - \text{Defective Material into Process})$

* Probability of Defect Introduction

~ Units/Day

~ These are good units made defective by handling or processing. They are equal to the number of good units started multiplied by probability of defect introduction. Defects can only be introduced into material that is originally good.

Initial Def WIP = Initial WIP * Initial Defective Fraction WIP

~ Units

~ Initial defective WIP is the fraction of WIP that is defective multiplied by the total initial WIP.

Defective Product Rejection Rate = $\text{Gross Defective Completion Rate} * (1 - \text{Prob Accept Bad Product})$

~ Units/Day

~ The number of defective material completed that is discovered and rejected. It equals the gross defective completion rate multiplied by one less the probability of accepting a bad unit.

Prob Accept Bad Product = 0.05

~ Dimensionless

~ The testing probability of accepting a bad unit.

Net Defective Completion Rate = $\text{Gross Defective Completion Rate} - \text{Defective Product Rejection Rate}$

~ Units/Day

~ The number of defective units discovered prior to shipment. Equals the gross defective units completed less the defective product discovered (rejected).

~:SUPPLEMENTARY

WIP Adjustment = $(\text{Desired Work in Process} - \text{Work in Process}) / T$ to Adjust WIP

~ Units/Day

~ The firm seeks to adjust the WIP to desired levels over a time to adjust WIP.

T to Adjust WIP = 14

~ Day

~ The number of days it takes to adjust the WIP to desired levels.

4.2.2 Backlog

The backlog group keeps track of incoming orders to determine the backlog. The order backlog increases as new orders are received, and falls as shipments are made.

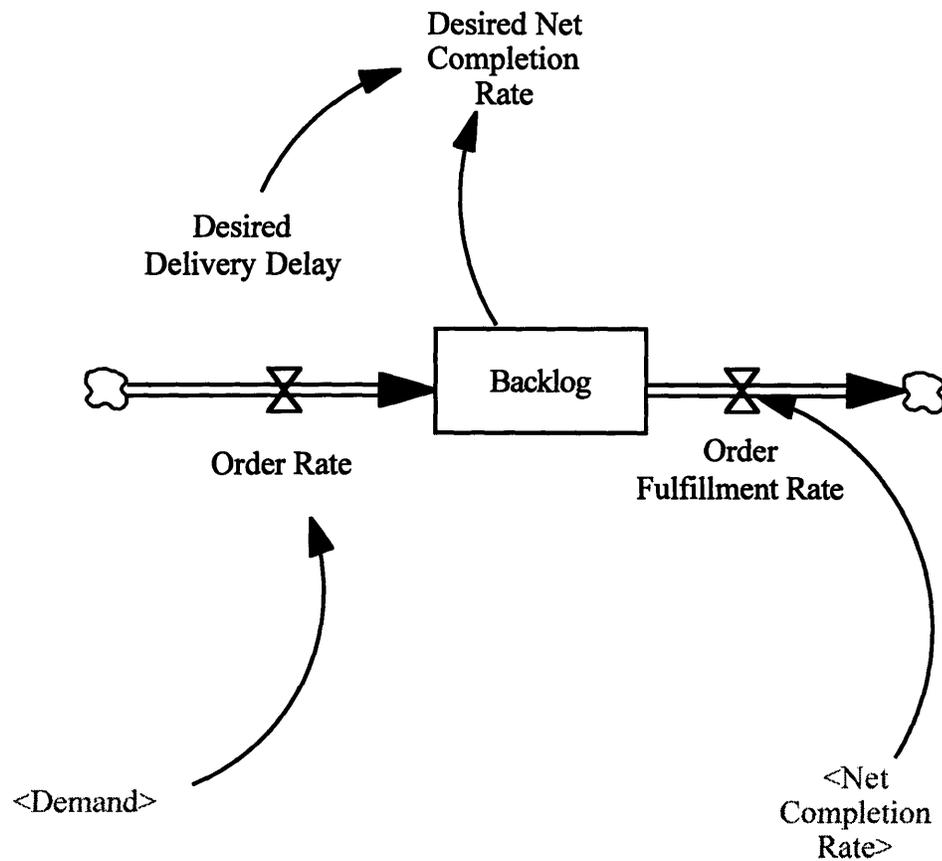


Figure 47: Backlog

Equations:

$\text{Backlog} = \text{INTEG}(+\text{Order Rate} - \text{Order Fulfillment Rate}, \text{Order Rate} * \text{Desired Delivery Delay})$

~ Units

~ The stock of unfilled orders is increased by the number of orders placed and reduced by the number of fulfilled orders.

$\text{Order Rate} = \text{Demand}$

~ Units/Day

~ The number of new orders placed by a downstream recipient.

$\text{Order Fulfillment Rate} = \text{Net Completion Rate}$

~ Units/Day

~ The rate at which orders fulfilled for the downstream recipient.

4.2.3 Yield

The yield group keeps track of the expected process yield and the expected raw material inspection yield. The expected process yield is a delayed perception of the

actual process yield. Similarly, the expected raw material inspection yield is a delayed perception of the actual raw material inspection yield.

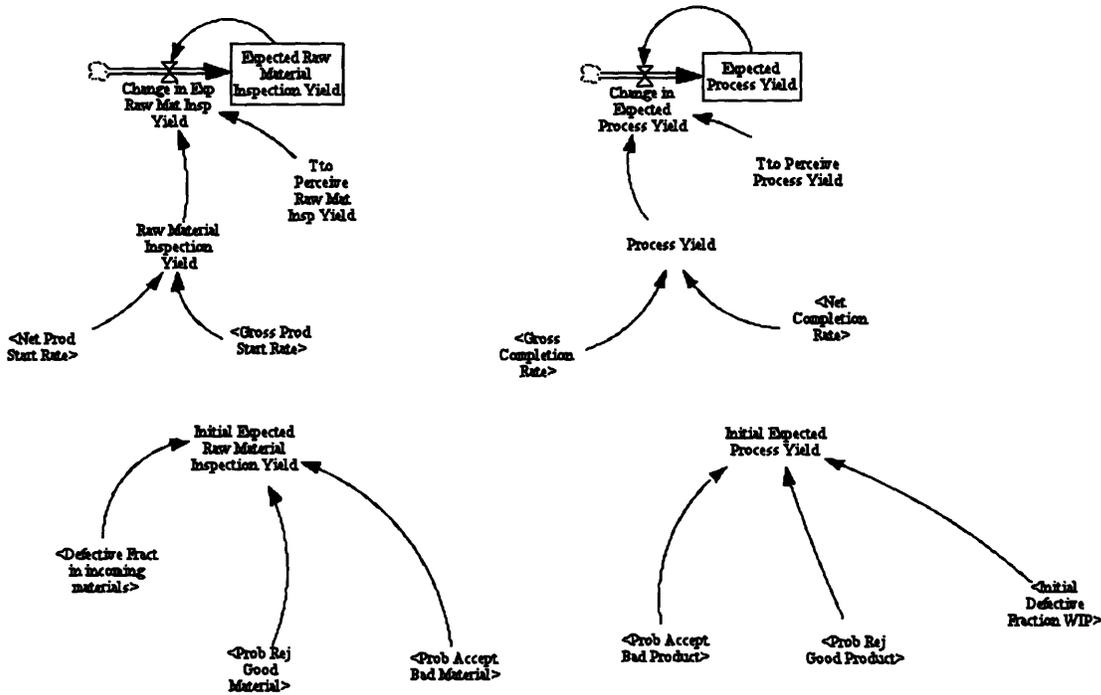


Figure 48: Yield

Equations:

Expected Process Yield = INTEG(Change in Expected Process Yield*(1-Expected process yield test switch),Initial Expected Process Yield)

~ Dimensionless

~ The expected process yield is an exponential smoothing of the past process yield.

Change in Expected Process Yield = (Process Yield-Expected Process Yield)/T to Perceive Process Yield

~ 1/Day

~ The change in the expected process yield is determined by the gap between the process yield and the previous value of the expected process yield over the time required to perceive changes in the process yield.

T to Perceive Process Yield =7

~ Day

~ The amount of time it takes to perceive changes in the process yield.

Process Yield = zidz(Net Completion Rate,Gross Completion Rate)

~ Dimensionless

~ The process yield is the ratio of the number of net units shipped/completed to the total completed.

Initial Expected Process Yield = (1 - Initial Defective Fraction WIP) * (1 - Prob Rej Good Product) + (Initial Defective Fraction WIP) * Prob Accept Bad Product

~ Dimensionless

~ The initial expected process yield is set to start the model in equilibrium. The fraction of processed units that will be accepted as good, will be equal to the fraction that are good and are accepted as good plus the fraction that are bad and are accepted as good.

Initial Defective Fraction WIP = $((1 - \text{Prob Rej Good Material}) * (1 - \text{Defective Fract in incoming materials}) * \text{Probability of Defect Introduction} + \text{Prob Accept Bad Material} * \text{Defective Fract in incoming materials}) / ((1 - \text{Prob Rej Good Material}) * (1 - \text{Defective Fract in incoming materials}) + \text{Prob Accept Bad Material} * \text{Defective Fract in incoming materials})$

~ Dimensionless

~ The defective fraction in WIP is the amount of defective product in WIP divided by the total amount in WIP. The defective product in WIP is determined by the number of bad accepted into WIP plus the number of good product made bad while in process. The number of bad accepted into WIP is the defective fraction multiplied by the prob of accepting bad material. The number of good product made bad while in process is equal to one less the defective fraction multiplied by one less the prob of rejecting good material multiplied by the probability of defect introduction. The total WIP is the good accepted plus the bad accepted. The good accepted is one less the defective fraction multiplied by one less the prob of rejecting good material. The bad accepted is the defective fraction multiplied by the prob of accepting bad material.

Expected Raw Material Inspection Yield = $\text{INTEG}(\text{Change in Exp Raw Mat Insp Yield, Initial Expected Raw Material Inspection Yield})$

~ Dimensionless

~ The expectation of the quality of future raw materials is based on past experience.

Change in Exp Raw Mat Insp Yield = $(\text{Raw Material Inspection Yield} - \text{Expected Raw Material Inspection Yield}) / T$ to Perceive Raw Mat Insp Yield

~ 1/Day

~ The change is the gap between the raw material yield and the expected raw mat yield divided by the time constant of perception.

T to Perceive Raw Mat Insp Yield = 7

~ Day

~ The amount of time it takes to perceive changes in the raw material yield.

Raw Material Inspection Yield = $\text{zidz}(\text{Net Prod Start Rate, Gross Prod Start Rate})$

~ Dimensionless

~ The raw material inspection yield is the percentage of raw materials inventory that is passed in the process.

Initial Expected Raw Material Inspection Yield = $(1 - \text{Prob Rej Good Material}) * (1 - \text{Defective Fract in incoming materials}) + \text{Prob Accept Bad Material} * \text{Defective Fract in incoming materials}$

~ Dimensionless

~ The raw material inspection yield is the good accepted and the bad accepted divided by the total starts. The good accepted is equal to one less the probability of rejecting a good unit (i.e. $1 - \text{Prob Rej Good Material}$) multiplied by the percentage of good units, and the bad accepted is the probability of accepting a bad unit (ie. Type II error) multiplied the percentage of bad units.

4.2.4 Cycle Time

The cycle time group measures the time it takes to process the product/service.

The total cycle time is a sum of the residence times in the raw materials inventory flow as well as the work in process flow. Total cycle time is a key performance metric used to track the efficiency of a firm.

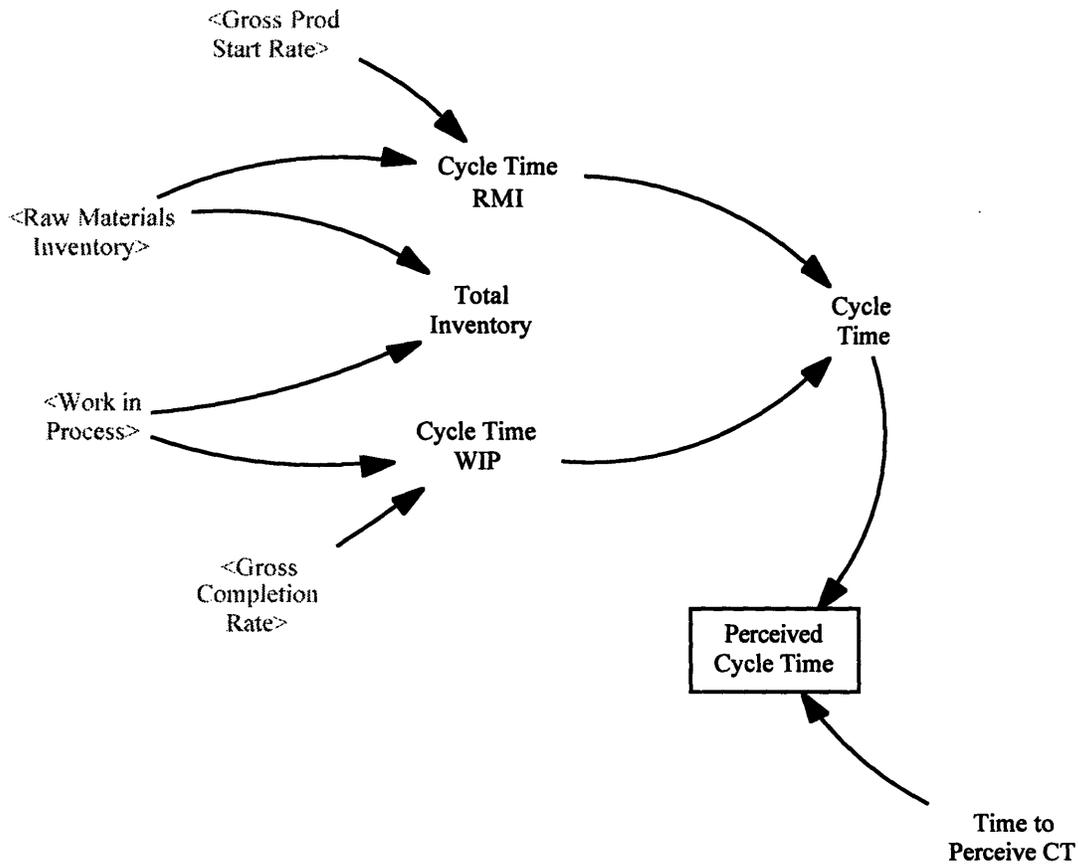


Figure 49: Cycle Time

Equations:

Perceived Cycle Time = SMOOTH(Cycle Time, Time to Perceive CT)
 ~ Day
 ~ ~:SUPPLEMENTARY

Time to Perceive CT = 7
 ~ Day

Cycle Time = Cycle Time WIP + Cycle Time RMI
 ~ Day
 ~ The actual process cycle time equals the sum of the residence times in the raw materials inventory and in process.

Cycle Time WIP = zidz(Work in Process, Gross Completion Rate)
 ~ Day
 ~ The amount of residence time for a unit in WIP.

Cycle Time RMI = zidz(Raw Materials Inventory, Gross Prod Start Rate)
 ~ Day
 ~ The amount of residence time for a unit in RMI.

Total Inventory = Raw Materials Inventory + Work in Process

- ~ Units
- ~ The total inventory includes the material waiting for processing and the material in process.
- ~:SUPPLEMENTARY

4.3 Process Attributes Sector

The process attributes group tracks the four improvable parameters: probability of defect introduction, normal processing time, labor productivity, and fraction of up time. The improvement or decline of these attributes is determined by the improvement effort divided up among improvement programs and the natural times for these attributes to change. Improvement effort is a product of employee commitment to improvement programs and employee skill with those programs.

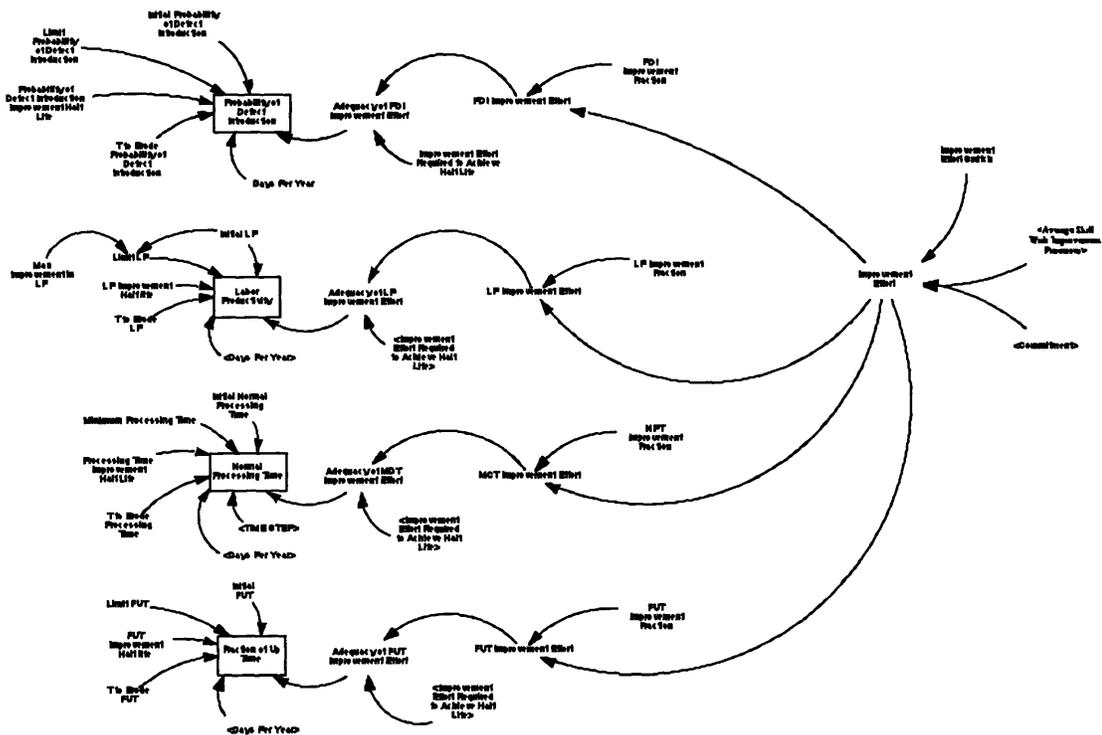


Figure 50: Process Attributes

Equations:

Probability of Defect Introduction = $\text{attribute}(\text{Initial Probability of Defect Introduction}, \text{T to Erode Probability of Defect Introduction} * \text{Days Per Year}, \text{Limit Probability of Defect Introduction}, \text{Probability of Defect Introduction Improvement Half Life}, \text{Adequacy of PDI Improvement Effort})$

~ Dimensionless

~ The percent of units into which no defect is introduced during processing. (Note: This is not the observed yield out of WIP. This will be higher since the yield out of WIP is also lowered by defective raw materials).

Initial Probability of Defect Introduction = 0.5

~ Dimensionless

~ The initial probability that a defect will be introduced into a good unit during processing.

T to Erode Probability of Defect Introduction = 2

~ Year

~ Time to erode probability of defect introduction. 2 years.

Limit Probability of Defect Introduction = 0

~ Dimensionless

~ The minimum probability of introducing a defect into a good unit during processing.

Probability of Defect Introduction Improvement Half Life = 270

~ Day

~ The amount of time required to decrease the probability of defect introduction by a factor of one-half.

Adequacy of PDI Improvement Effort = PDI Improvement Effort
/Improvement Effort Required to Achieve Half Life

~ Dimensionless

~ Improvement Effort as a fraction of the improvement effort required to achieve the estimated half-life.

Improvement Effort Required to Achieve Half Life = 1

~ Dimensionless

~ The half-life assumption has an 'assumed' level of effort required to achieve it.

It was made explicit in this model based on normal Intensity and allocating 100% of their time to improvement.

PDI Improvement Effort = Improvement Effort * PDI Improvement Fraction

~ Dimensionless

~ The fractional amount of improvement effort towards PDI improvement.

PDI Improvement Fraction = 0.25

~ Dimensionless

~ The fraction of total dedication required for the PDI improvement effort.

Improvement Effort = max(0,(Commitment * Average Skill With Improvement Processes * Improvement Effort Switch)

~ Dimensionless

Improvement Effort Switch = 1

~ Dimensionless

~ Allows the user to deactivate the TQM initiative by setting the switch to zero.

Labor Productivity = max(0,attribute(Initial LP, T to Erode LP * Days Per Year, Limit LP,
LP Improvement Half life, Adequacy of LP Improvement Effort))

~ Units/(Person * Day)

~ Fraction of units achieved per of person*hours.

Initial LP = 10

~ Units/(Person*Day)

~ Initialization of the Product Development Productivity in equilibrium conditions.

Max Improvement in LP = 5

~ Dimensionless

~ The maximum improvement multiple of labor productivity.

T to Erode LP = 5

- ~ Year
- ~ Time to erode process improvements. 5 years

Limit LP = Initial LP * Max Improvement in LP

- ~ Units/(Person*Day)
- ~ Minimum Labor Productivity. Used just to determine the 'end-point' of the improvement effort.

LP Improvement Half life = 360

- ~ Day
- ~ Half Life of the Product Development Productivity

Adequacy of LP Improvement Effort = LP Improvement Effort/Improvement Effort Required to Achieve Half Life

- ~ Dimensionless
- ~ Improvement Effort as a fraction of the improvement effort required to achieve the estimated half-life.

LP Improvement Effort = Improvement Effort * LP Improvement Fraction

- ~ Dimensionless
- ~ The fractional amount of improvement effort towards LP improvement.

LP Improvement Fraction = 0.25

- ~ Dimensionless
- ~ The fraction of total dedication required for the LP improvement effort.

Normal Processing Time = max(TIME STEP, attribute(Initial Normal Processing Time, T to Erode Processing Time * Days Per Year, Minimum Processing Time, Processing Time Improvement Half Life, Adequacy of MDT Improvement Effort))

- ~ Day
- ~ Minimum time to process because of logistical constraints

Initial Normal Processing Time = 14

- ~ Day
- ~ The initial value for normal processing time.

T to Erode Processing Time = 5

- ~ Year
- ~ Time to erode normal processing time. 5 years.

Minimum Processing Time = 1

- ~ Day
- ~ The smallest amount of time to perform the task given sufficient resources (e.g. the time required for a cake in an oven). It is assumed that the minimum for this process to be 1 day.

Processing Time Improvement Half Life = 270

- ~ Day
- ~ Time required to decrease the normal processing time by a factor of 2.

Adequacy of MDT Improvement Effort = MCT Improvement Effort/Improvement Effort Required to Achieve Half Life

- ~ Dimensionless
- ~ Improvement Effort as a fraction of the improvement effort required to achieve the estimated half-life.

MCT Improvement Effort = Improvement Effort * NPT Improvement Fraction

- ~ Dimensionless
- ~ The fractional amount of improvement effort towards MCT improvement.

NPT Improvement Fraction = 0.25

- ~ Dimensionless
- ~ The fraction of total dedication required for the NPT improvement effort.

Fraction of Up Time = $\text{attribute}(\text{Initial FUT}, T \text{ to Erode FUT} * \text{Days Per Year}, \text{Limit FUT}, \text{FUT Improvement Half life}, \text{Adequacy of FUT Improvement Effort})$

- ~ Dimensionless
- ~ Fraction of uptime for the process (reliability)

Initial FUT = 0.7

- ~ Dimensionless
- ~ Initialization of the Fraction of Up Time in equilibrium conditions.

T to Erode FUT = 2

- ~ Year
- ~ Time to erode the Fraction of Up Time. 1 year

Limit FUT = 1

- ~ Dimensionless
- ~ Maximum Fraction of Up Time achievable. Used just to determine the 'end-point' of the improvement effort.

FUT Improvement Half life = 360

- ~ Day
- ~ Half Life of the Product Development Productivity

Adequacy of FUT Improvement Effort = $\frac{\text{FUT Improvement Effort}}{\text{Improvement Effort Required to Achieve Half Life}}$

- ~ Dimensionless
- ~ Improvement Effort as a fraction of the improvement effort required to achieve the estimated half-life.

FUT Improvement Effort = Improvement Effort * FUT Improvement Fraction

- ~ Dimensionless
- ~ The fractional amount of improvement effort towards FUT improvement.

FUT Improvement Fraction = 0.25

- ~ Dimensionless
- ~ The fraction of total dedication required for the FUT improvement effort.

Days Per Year = 360

- ~ Day/Year
- ~ The number of days in a year.

4.4 Cost Accounting Sector

The cost accounting group tracks the standard cost per unit produced or provided by the firm. The standard cost per unit is a sum of the standard direct cost per unit, the standard capital cost per unit, and the standard work in process carrying cost per unit. The standard direct cost per unit is a function of wage, standard labor productivity, and raw material cost. The standard capital cost per unit is a function of depreciation and

fraction of up time. The standard work in process carrying cost is a function of the standard raw material cost per unit and the fractional carrying cost.

The standard cost per unit is used to set prices and by the workforce as an aggregate measure of the success of improvement programs. If the cost is falling, the workforce will view the results as positive. If the cost is rising, the workforce will view the results as negative.

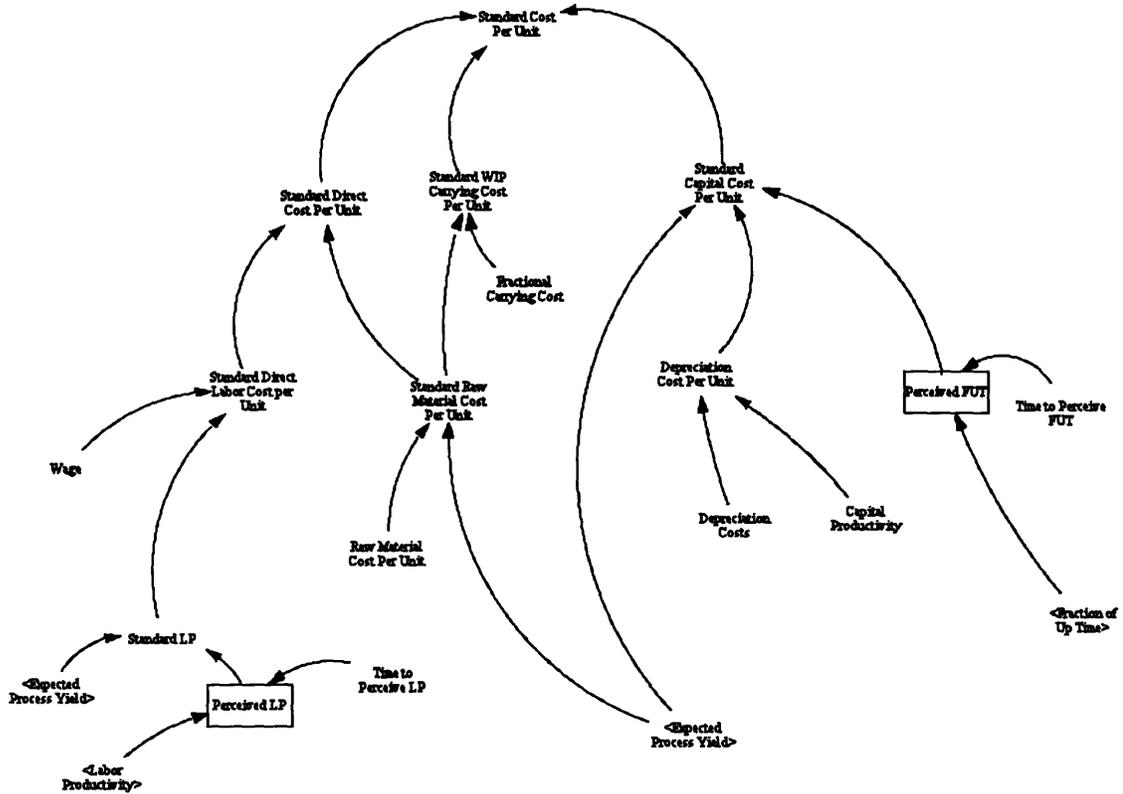


Figure 51: Cost Accounting

Equations:

$$\text{Standard Cost Per Unit} = (\text{Standard Direct Cost Per Unit} + \text{Standard Capital Cost Per Unit} + \text{Standard WIP Carrying Cost Per Unit})$$

~ Dollar/Unit

~ Aggregate performance reflects the feasible cost per unit if labor and machines were at ideal levels. Cost is the sum of labor cost, capital cost, and raw material cost (this assumes that costs from raw material inspection yield loss is not attributed to this area).

$$\text{Standard Direct Cost Per Unit} = \text{Standard Direct Labor Cost per Unit} + \text{Standard Raw Material Cost Per Unit}$$

~ Dollar/Unit

~ Direct cost is assumed to be calculated as the cost due to labor and the cost due to raw material

Standard Direct Labor Cost per Unit = Wage / Standard LP
~ Dollar/Unit

Wage = 200
~ Dollar/(Day*Person)
~ The average daily wage of an employee of the firm. This cost includes salary, benefits, and overhead.

Standard LP = Perceived LP*Expected Process Yield
~ Units/(Day*Person)
~ Standard labor productivity is the number of good units that an employee can produce in one day.

Perceived LP = SMOOTH(Labor Productivity, Time to Perceive LP)
~ Units/(Day*Person)
~ Perceived labor productivity is a smoothing of actual labor productivity over the time which it takes to perceive changes in labor productivity.

Time to Perceive LP = 7
~ Day
~ The time it takes to perceive changes in labor productivity.

Standard Raw Material Cost Per Unit = Raw Material Cost Per Unit / Expected Process Yield
~ Dollar/Unit

Raw Material Cost Per Unit = 2
~ Dollar/Unit

Standard Capital Cost Per Unit = (Depreciation Cost Per Unit)/
(Expected Process Yield * Perceived FUT)
~ Dollar/Unit

Depreciation Cost Per Unit = Depreciation Costs / Capital Productivity
~ Dollar/Unit

Depreciation Costs = 0.05
~ Dollar/(Day*Capital Unit)

Capital Productivity = 10
~ Units/(Capital Unit*Day)
~ The amount of production that would be possible for each unit of capital if the labor constraint is not binding.

Perceived FUT = SMOOTH(Fraction of Up Time , Time to Perceive FUT)
~ Dimensionless

Time to Perceive FUT = 7
~ Day

Standard WIP Carrying Cost Per Unit = Standard Raw Material Cost Per Unit*
Fractional Carrying Cost
~ Dollar/Unit

Fractional Carrying Cost = 0.02
~ Dimensionless

4.5 Commitment Sector

The commitment group tracks the level of employee commitment to improvement programs. Commitment ranges from zero to one. Employee commitment is a function of management's goal for commitment and word of mouth. Word of mouth combines the effects of results, job security, performance goal, and managerial support.

The effect of results on commitment is a function of the ratio of actual to expected results. Expected results are based on an exogenous view of the expected half life and the level of past improvement effort. When results are better than expected, the effect of results on commitment is positive, otherwise, the effect negatively impacts word of mouth.

The effect of job security on commitment is a function of the workforce's memory of layoffs. Layoffs affect the memory of layoffs very quickly, but the memory of layoffs takes a much longer time to overcome. If there are no layoffs and job security is at its maximum value, the effect of security on commitment is zero, but as layoffs occur the effect of security on commitment is negative and can overcome any other positive effects on word of mouth.

The effect of support on commitment is a function of the ratio of support allocated to support required. Required support is directly determined by improvement effort. If the support allocated is adequate, the effect of support on commitment is zero, but if the support is inadequate, the effect of support on commitment is negative.

The effect of performance goal on commitment is a function of performance and the employees' own goal for performance. Performance is measured by the standard cost per unit. It is assumed that employees have their own personal goals for performance. If performance matches employees' own goals, the effect of performance goals on commitment is zero. If performance is below employees' own goals, the effect of performance goal on commitment is positive. In other words, if the standard cost per unit exceeds the employees' own goals, the employees become more committed to reducing it.

If standard cost per unit is lower than the employees' own goals, then the effect of performance goal on commitment is negative and commitment suffers.

The combinations of these four effects are explored further in Appendix 5.2.

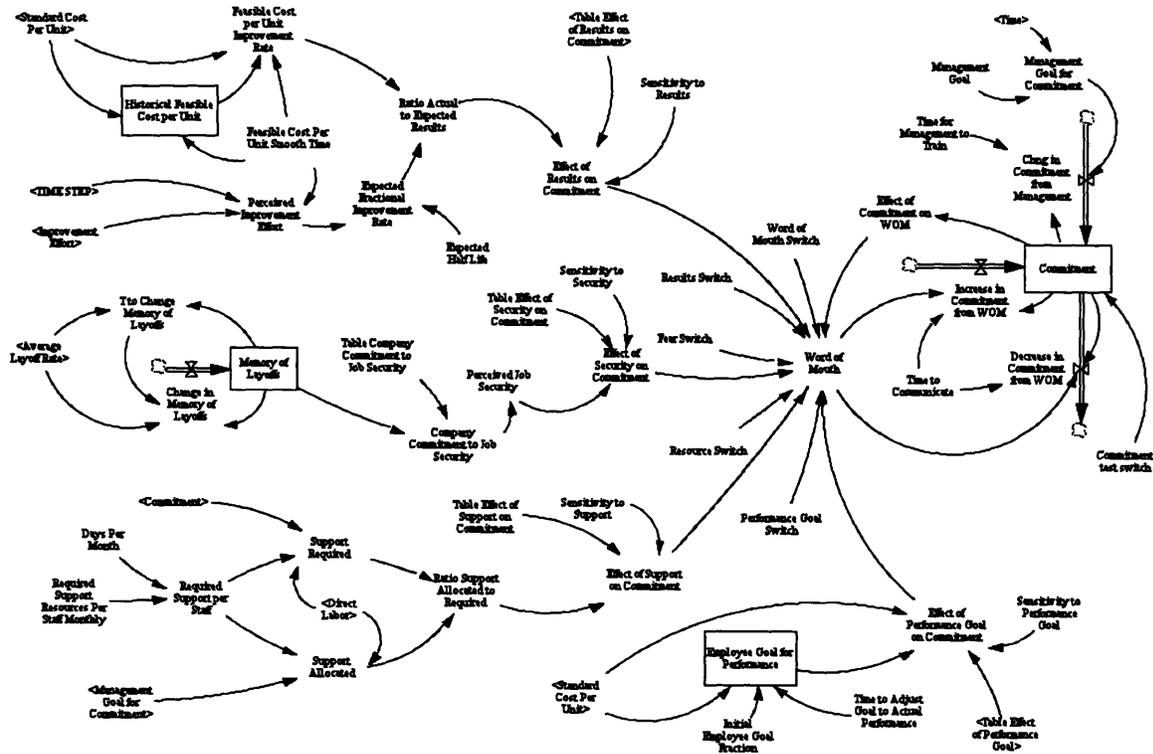


Figure 52: Commitment

Equations:

$$\text{Commitment} = \text{INTEG}((\text{Chng in Commitment from Management} + \text{Increase in Commitment from WOM} + \text{Decrease in Commitment from WOM}), 0)$$

~ Dimensionless

~ Commitment is constrained to be between 0 and 1. It is a measure of the average commitment of workers to the improvement program.

$$\text{Chng in Commitment from Management} = (\text{Management Goal for Commitment} - \text{Commitment}) / \text{Time for Management to Train}$$

~ 1/Day

~ The change in commitment due to management is a closing of the gap between management's goal for commitment and the current level of commitment over a time for management to train employees.

$$\text{Time for Management to Train} = 360$$

~ Day

~ The time required for management to train workers to commit to an improvement program.

$$\text{Management Goal for Commitment} = \max(\text{Management Goal}, 0)$$

~ Dimensionless

~ Management's goal for commitment towards an improvement program.

Increase in Commitment from WOM = $\max(0, ((1 - \text{Commitment}) * \text{Word of Mouth}) / \text{Time to Communicate})$

~ 1/Day

~ The change in commitment from results is a product of word of mouth regarding the improvement program and one less the previous level of commitment or worker's lack of commitment to the improvement program. Hence, the more committed workers are, the less effective word of mouth is changing their level of commitment.

Time to Communicate = 120

~ Day

~ The amount of time required for word of mouth to take effect.

Word of Mouth = (Resource Switch * Effect of Support on Commitment
+ Results Switch * Effect of Results on Commitment
+ Fear Switch * Effect of Security on Commitment
+ Performance Goal Switch * Effect of Performance Goal on Commitment)
* Effect of Commitment on WOM * Word of Mouth Switch

~ Dimensionless

~ Word of mouth is a function of effects due to support/resources, job security, and improvement results.

Resource Switch = 1

~ Dimensionless

~ When the value is one, resources/support affect word of mouth. When the value is zero, word of mouth is independent of resources.

Effect of Support on Commitment = Table Effect of Support on Commitment
(Ratio Support Allocated to Required) * Sensitivity to Support

~ Dimensionless

~ Effect of support on support is a function of support resources allocated towards the improvement program.

Sensitivity to Support = $(1/3) * (1.5 * \text{Sensitivity to Results} + \text{Sensitivity to Performance Goal}) + 1$

~ Dimensionless

~ |

Table Effect of Support on Commitment $[(0,-3)-(1,0)],(0,-3)$
,(0.05,-2.97),(0.1,-2.92),(0.15,-2.84),(0.2,-2.75),(0.25,-2.64)
,(0.3,-2.5),(0.35,-2.31),(0.4,-2.07),(0.45,-1.8),(0.5,-1.5),
(0.55,-1.2),(0.6,-0.93),(0.65,-0.69),(0.7,-0.5),(0.75,-0.36)
,(0.8,-0.25),(0.85,-0.17),(0.9,-0.1),(0.95,-0.04),(1,0)

~ Dimensionless

Ratio Support Allocated to Required = $\min(\text{Support Allocated} / \text{Support Required}, 1)$

~ Dimensionless

~ The ratio of support allocated to required is the support allocated divided by the support required. The ratio is constrained to a maximum value of 1.

Support Allocated = $\max(0, \text{Management Goal for Commitment} * \text{Direct Labor} * \text{Required Support per Staff})$

~ Hours/Day

~ Managers allocate sufficient time and effort to support the level of commitment they desire.

Required Support per Staff = $\text{Required Support Resources Per Staff Monthly} / \text{Days Per Month}$

~ Hours/Person/Day

~ The management support required by each employee to successfully implement an improvement initiative.

Required Support Resources Per Staff Monthly = 1
~ Hours/(Person*Month)

Days Per Month = 30
~ Day/Month

Support Required = $\max(0, \text{Commitment} * \text{Direct Labor} * \text{Required Support per Staff})$
~ Hours/Day
~ The total support resources required by employees in successfully implementing an improvement program.

Results Switch = 1
~ Dimensionless

Effect of Results on Commitment =
Table Effect of Results on Commitment(Ratio Actual to Expected Results)
* Sensitivity to Results
~ Dimensionless
~ The effect of results on commitment is a function of the actual results of the improvement program relative to the expected results.

Sensitivity to Results = 1
~ Dimensionless

Table Effect of Results on Commitment $((0, -0.5) - (1, 1.5)),$
 $(0, -0.5), (0.1, -0.46), (0.2, -0.37), (0.3, -0.16), (0.4, 0.13), (0.5, 0.51)$
 $, (0.6, 0.89), (0.7, 1.18), (0.8, 1.36), (0.9, 1.45), (1, 1.5)$
~ Dimensionless

Ratio Actual to Expected Results = $\text{zidz}(\text{Feasible Cost per Unit Improvement Rate}, \text{Expected Fractional Improvement Rate})$
~ Dimensionless

Feasible Cost per Unit Improvement Rate = $((\text{Historical Feasible Cost per Unit} - \text{Standard Cost Per Unit}) / \text{Historical Feasible Cost per Unit}) / \text{Feasible Cost Per Unit Smooth Time}$
~ 1/Day

Historical Feasible Cost per Unit = $\text{SMOOTH}(\text{Standard Cost Per Unit}, \text{Feasible Cost Per Unit Smooth Time})$
~ Dollar/Unit

Feasible Cost Per Unit Smooth Time = 90
~ Day

Expected Fractional Improvement Rate =
 $\max(\text{Perceived Improvement Effort} * (\text{LN}(2) / \text{Expected Half Life}), 0.01 * (\text{LN}(2) / \text{Expected Half Life}))$
~ 1/Day
~ The fractional rate at which improvement would occur if the expected half life was being achieved, given the amount of effort being put to the program.

Expected Half Life = 270
~ Day

Perceived Improvement Effort = $\text{SMOOTH}(\text{Improvement Effort}, \text{TIME STEP} + 1 * (\text{Feasible Cost Per Unit Smooth Time}))$
~ Dimensionless

Fear Switch = 1

~ Dimensionless

~ When the value is one, job security affects word of mouth. When the value is zero, word of mouth is independent of job security.

Effect of Security on Commitment = Table Effect of Security on Commitment
(Perceived Job Security) * Sensitivity to Security

~ Dimensionless

~ The effect of security on commitment is a function of perceived job security.

Sensitivity to Security = $0.2 * (1.5 * \text{Sensitivity to Results} + \text{Sensitivity to Performance Goal}) + 1$

~ Dimensionless

Table Effect of Security on Commitment ((0,-5)-(1,0]),
(0,-5),(0.1,-5),(0.2,-5),(0.3,-5),(0.4,-5),(0.5,-5),(0.6,-5)
,(0.7,-5),(0.75,-4.96),(0.775,-4.87),(0.8,-4.58),(0.825,-3.84)
,(0.85,-2.5),(0.875,-1.16),(0.9,-0.42),(0.925,-0.13),(0.95,-0.04)
,(0.975,-0.012),(1,0))

~ Dimensionless

Perceived Job Security = Company Commitment to Job Security

~ Dimensionless

~ The perceived level of job security is equivalent to the company commitment to job security as perceived by the workers.

Company Commitment to Job Security = Table Company Commitment to Job Security
(Memory of Layoffs)

~ Dimensionless

Table Company Commitment to Job Security ((0,0)-(0.05,1]),
(0,1),(0.005,0.38),(0.01,0.18),(0.015,0.085),(0.02,0.045),(0.025,0.025)
,(0.03,0.01),(0.035,0.005),(0.04,0),(0.045,0),(0.05,0))

~ Dimensionless

Memory of Layoffs = INTEG(Change in Memory of Layoffs,0)

~ 1/Day

~ The memory of layoffs is initialized to be zero and changes as a result of the change in memory of layoffs.

Change in Memory of Layoffs = (Average Layoff Rate-Memory of Layoffs)
/ T to Change Memory of Layoffs

~ 1/(Day * Day)

~ The change in memory of layoff is closing the gap between the layoff fraction and memory of layoffs over a time to change the memory of layoffs.

T to Change Memory of Layoffs = IF THEN ELSE(Average Layoff Rate>Memory of Layoffs,30,1800)

~ Day

~ The time to change the memory of layoffs is 1 month if the current layoff fraction is greater than the recent memory of layoffs. If the current layoff fraction is less than the recent memory of layoffs, the time to change the memory of layoffs is 5 years. It is much easier to lose the confidence of employees than it is to rebuild it.

Performance Goal Switch = 1

~ Dimensionless

Effect of Performance Goal on Commitment = Table Effect of Performance Goal
(Standard Cost Per Unit / Employee Goal for Performance) * Sensitivity to Performance Goal

~ Dimensionless

Sensitivity to Performance Goal = $0.4 \times$ Sensitivity to Results
~ Dimensionless

Table Effect of Performance Goal $[(0,-1)-(2,1)]$,
(0,-1),(0.1,-0.98),(0.2,-0.95),(0.3,-0.91),(0.4,-0.85),(0.5,-0.77)
,(0.6,-0.67),(0.7,-0.55),(0.8,-0.41),(0.9,-0.25),(1,0),(1.1,0.25)
,(1.2,0.41),(1.3,0.55),(1.4,0.67),(1.5,0.77),(1.6,0.85),(1.7,0.91)
,(1.8,0.95),(1.9,0.98),(2,1))
~ Dimensionless

Employee Goal for Performance = SMOOTHI(Standard Cost Per Unit ,
Time to Adjust Goal to Actual Performance, Standard Cost Per Unit * Initial Employee Goal Fraction)
~ Dollar/Unit

Time to Adjust Goal to Actual Performance = $1e+012$
~ Day

Initial Employee Goal Fraction = 0.5
~ Dimensionless
~ |

Effect of Commitment on WOM = Commitment
~ Dimensionless
~ A measure of how sensitive workers are to word of mouth when committing to an improvement program.

Word of Mouth Switch = 1
~ Dimensionless

Decrease in Commitment from WOM = $\min(0 ,$
Commitment * Word of Mouth / Time to Communicate)
~ 1/Day

Commitment test switch = 0
~ Dimensionless

Management Goal = 0
~ Dimensionless

4.6 Human Resources Sector

4.6.1 Labor

The human resources group determines the size of the labor force, the hiring rate, the attrition rate, and the layoff rate. The average layoff rate is the perceived percentage of direct labor that gets laid off. Direct labor is increased by direct labor hires. Direct labor is hired to replace those who leave due to attrition and to fill the gap, if any, between the desired direct labor and current level of direct labor. If direct labor exceeds desired direct labor, the discrepancy will warrant layoffs. The layoffs will only occur if management's willingness to layoff is non-zero.

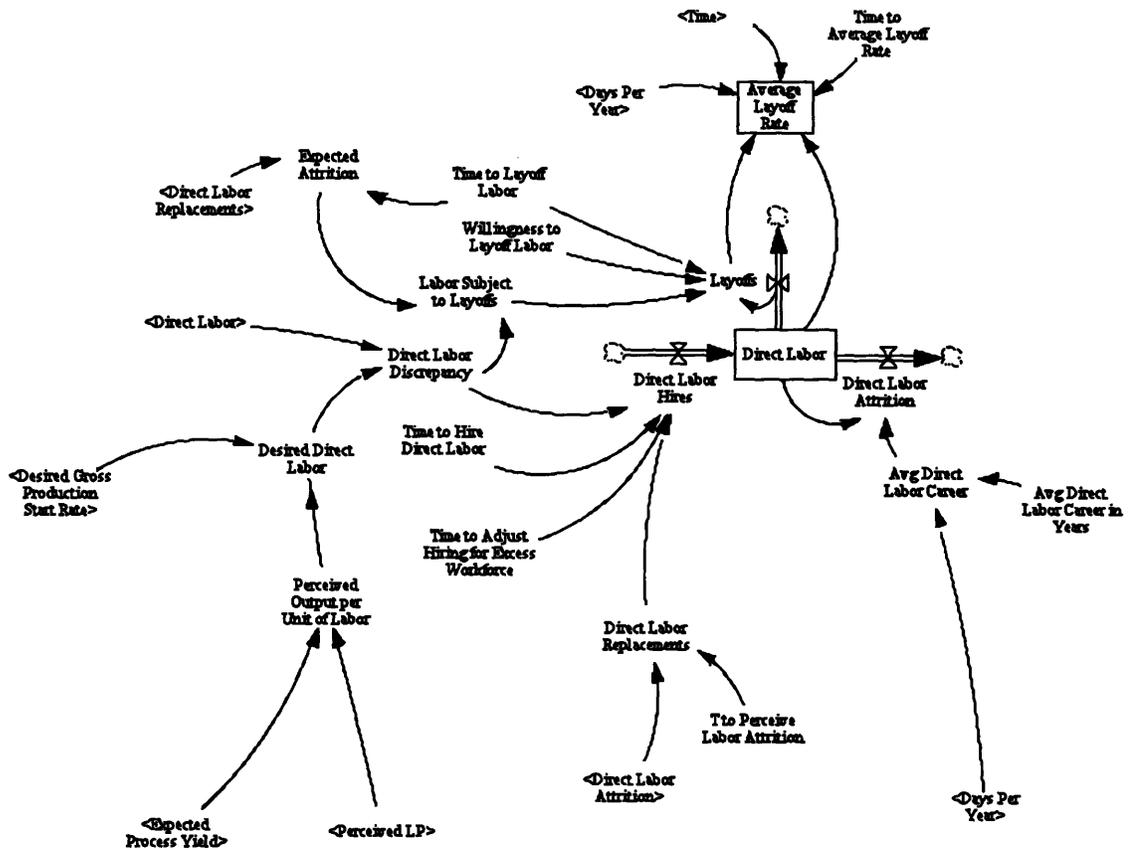


Figure 53: Labor

Equations:

$$\text{Average Layoff Rate} = \text{zidz}(\text{SMOOTH}(\text{Layoffs}, \text{Days Per Year} * \text{Time to Average Layoff Rate}), \text{Direct Labor})$$

~ 1/Day

$$\text{Time to Average Layoff Rate} = 1$$

~ Year

$$\text{Layoffs} = \max(\text{Labor Subject to Layoffs} / \text{Time to Layoff Labor}, 0) * \text{Willingness to Layoff Labor}$$

~ Person/Day

$$\text{Time to Layoff Labor} = 30$$

~ Day

$$\text{Willingness to Layoff Labor} = 0$$

~ Dimensionless

$$\text{Labor Subject to Layoffs} = -\text{Direct Labor Discrepancy} - \text{Expected Attrition}$$

~ Person

$$\text{Direct Labor Discrepancy} = \text{Desired Direct Labor} - \text{Direct Labor}$$

~ Person

$$\text{Desired Direct Labor} = \text{zidz}(\text{Desired Gross Production Start Rate}, \text{Perceived Output per Unit of Labor})$$

~ Person

Perceived Output per Unit of Labor = Expected Process Yield*Perceived LP
~ Units/(Person*Day)

Direct Labor = INTEG((Direct Labor Hires-Direct Labor Attrition
-Layoffs),
Desired Direct Labor)
~ Person

Direct Labor Hires = IF THEN ELSE(Direct Labor Discrepancy> 0,max(Direct Labor Replacements
+(Direct Labor Discrepancy/Time to Hire Direct Labor),0) , max(0, Direct Labor Replacements
+ Direct Labor Discrepancy / Time to Adjust Hiring for Excess Workforce))
~ Person/Day
~ Hiring is set to adjust for historic attrition rates and to correct any reasonable labor discrepancy
(where reasonable means that layoffs are not necessary). Whenever the actual labor force
is below the desired level, hiring is set to be the sum of hiring for replacement of
attrition and hiring to close the discrepancy in labor force over a given hiring time.
When the actual labor force is above the desired level, hiring only occurs if the
expected attrition rate is enough to more than offset the labor discrepancy in one day.

Direct Labor Replacements = SMOOTH(Direct Labor Attrition,T to Perceive Labor Attrition)
~ Person/Day

T to Perceive Labor Attrition = 30
~ Day

Direct Labor Attrition = (Direct Labor / Avg Direct Labor Career)
~ Person/Day

Avg Direct Labor Career =Avg Direct Labor Career in Years*Days Per Year
~ Day

Avg Direct Labor Career in Years = 20
~ Year

Time to Hire Direct Labor = 90
~ Day

Time to Adjust Hiring for Excess Workforce = 1
~ Day
~ The amount of time it takes to back off hiring to replace attrition in order to reduce a negative
(excess) labor discrepancy (workforce).

Expected Attrition = Direct Labor Replacements*Time to Layoff Labor
~ Person

4.6.2 Skill

The average skill group determines the employee skill level with improvement programs. Average skill is a function of on-the-job experience and formal training. Both on-the-job experience and formal training have decreasing returns with respect to time spent on the job and training, respectively. On-the-job experience contributes more to

average skill than does formal training. Therefore, an employee with an abundance of on-the-job experience and little formal training is more effective than an employee with an abundance of formal training and little on-the-job experience. This formulation is explored further in Appendix 5.3.

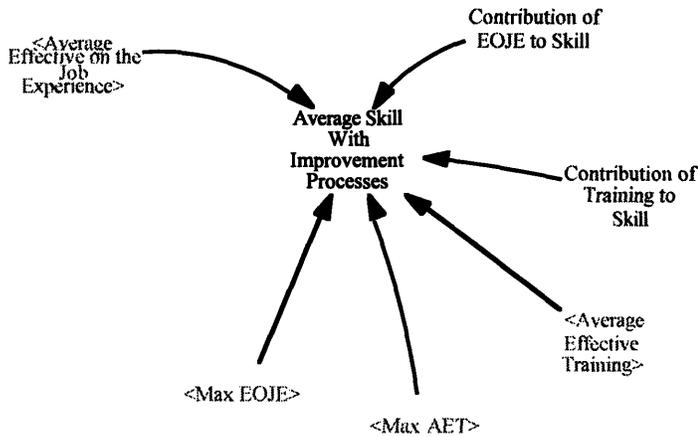


Figure 54: Average Skill

Equations:

$$\text{Average Skill With Improvement Processes} = (\min(1, \text{Contribution of EOJE to Skill} * (\text{Average Effective on the Job Experience} / \text{Max EOJE}) + \text{Contribution of Training to Skill} * (\text{Average Effective Training} / \text{Max AET})))$$

~ Dimensionless

~ The fraction indicating the level of experience with improvement relative to the required experience with improvement for complete implementation of an improvement program.

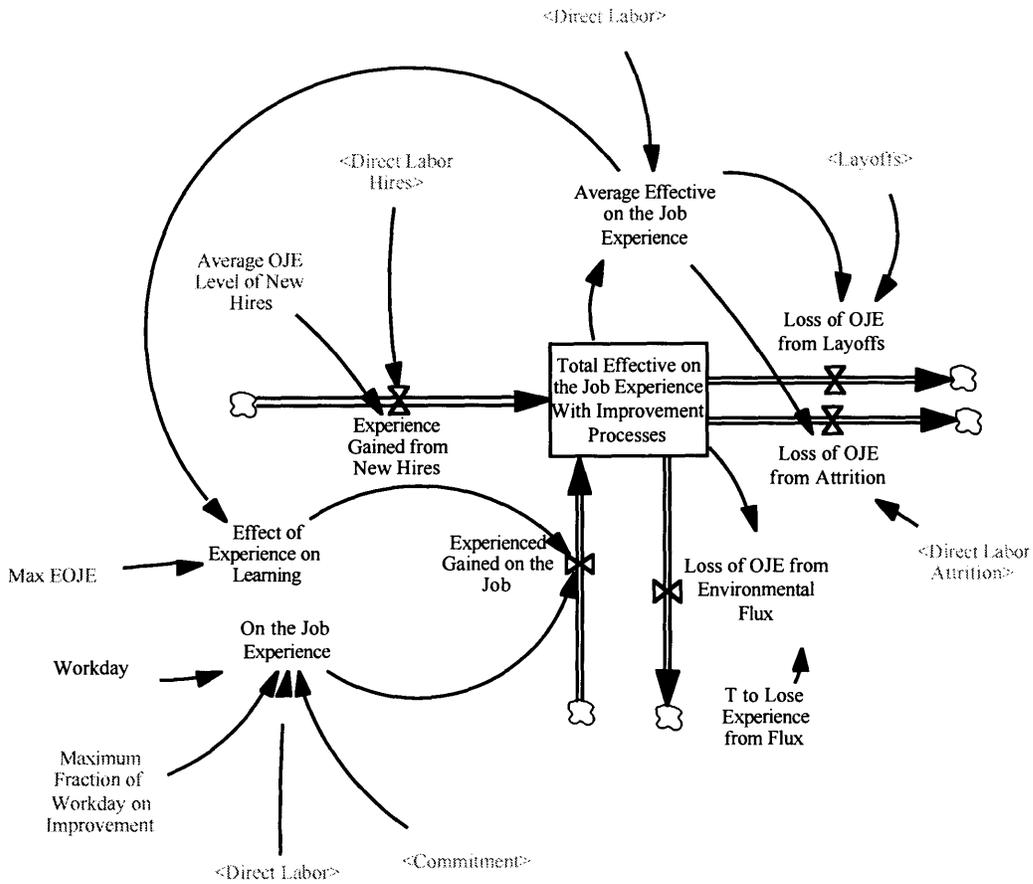


Figure 55: Experience & Training

Equations:

Contribution of EOJE to Skill = 0.8
~ Dimensionless

Average Effective on the Job Experience = $\text{zidz}(\text{Total Effective on the Job Experience With Improvement Processes, Direct Labor})$
~ Hours/Person

Total Effective on the Job Experience With Improvement Processes = $\text{INTEG}(\text{Experience Gained from New Hires} + \text{Experienced Gained on the Job} - \text{Loss of OJE from Attrition} - \text{Loss of OJE from Environmental Flux} - \text{Loss of OJE from Layoffs, Initial Total Effective on the Job Experience})$
~ Hours

Experience Gained from New Hires = $\text{Direct Labor Hires} * \text{Average OJE Level of New Hires}$
~ Hours/Day

Average OJE Level of New Hires = 2
~ Hours / Person

Experienced Gained on the Job = $\text{On the Job Experience} * \text{Effect of Experience on Learning}$
~ Hours/Day

On the Job Experience = $\text{Direct Labor} * \text{Commitment} * \text{Workday} * \text{Maximum Fraction of Workday on Improvement}$
~ Hours/Day

Workday = 8
~ Hours/(Person * Day)

Maximum Fraction of Workday on Improvement = 0.1
~ Dimensionless
~ The fraction of the workday that would be put to improvement efforts if the commitment level was 100 percent.

Effect of Experience on Learning = $\text{max}(0, 1 - \text{Average Effective on the Job Experience} / \text{Max EOJE})$
~ Dimensionless

Max EOJE = 100
~ Hours/Person
~ The amount of experience required to be fully effective toward achieving the improvement half-life which is assumed to be the most experienced anyone could ever be.

Loss of OJE from Attrition = $\text{Direct Labor Attrition} * \text{Average Effective on the Job Experience}$
~ Hours/Day

Loss of OJE from Environmental Flux = $\text{Total Effective on the Job Experience With Improvement Processes} / \text{T to Lose Experience from Flux}$
~ Hours/Day

T to Lose Experience from Flux = 1e+009
~ Day

Loss of OJE from Layoffs = $\text{Average Effective on the Job Experience} * \text{Layoffs}$
~ Hours/Day

Initial Total Effective on the Job Experience = $\text{zidz}(\text{Direct Labor} * \text{Direct Labor Hires} * \text{Average OJE Level of New Hires, (Direct Labor Attrition} + \text{Layoffs)})$
~ Hours

Contribution of Training to Skill = 0.2
~ Dimensionless

Max AET = 40
~ Hours/Person
~ The maximum number of effective hours of training per person.

Average Effective Training = zidz(Total Effective Training With Improvement Processes , Direct Labor)
~ Hours/Person

Total Effective Training With Improvement Processes = INTEG(Training Level of New Hires+Effective Training-Loss of Training from Layoffs-Loss of Training from Environmental Flux -Loss of Training Attrition,Initial Total Effective Training)
~ Hours

Training Level of New Hires = Direct Labor Hires * Average Training Level of New Hires
~ Hours/Day

Average Training Level of New Hires = 0.2
~ Hours/Person

Effective Training = (Annual Program Training Time / Days Per Year) * Direct Labor
* Effect of Prior Training on Learning
~ Hours/Day

Annual Program Training Time = Management Goal for Commitment * Max AET / Time to Train
~ Hours/(Year*Person)

Effect of Prior Training on Learning = max(0 , 1 - Average Effective Training / Max AET)
~ Dimensionless

Time to Train = 1
~ Year
~ The average amount of chronological time over which management desires to provide the maximum training.

Loss of Training from Layoffs = Average Effective Training * Layoffs
~ Hours/Day

Loss of Training from Environmental Flux =
Total Effective Training With Improvement Processes/T to Lose Training from Flux
~ Hours/Day

T to Lose Training from Flux = 1e+009
~ Day

Loss of Training Attrition = Direct Labor Attrition * Average Effective Training
~ Hours/Day

Initial Total Effective Training = zidz(Direct Labor*Direct Labor Hires*
Average Training Level of New Hires, (Layoffs+Direct Labor Attrition))
~ Hours

4.7 Capacity

The capacity group is used to calculate the capacity due to resources. Labor and capital capacity are inputs to a Leontiev production function that is a constraint for the gross completion rate in the production sector.

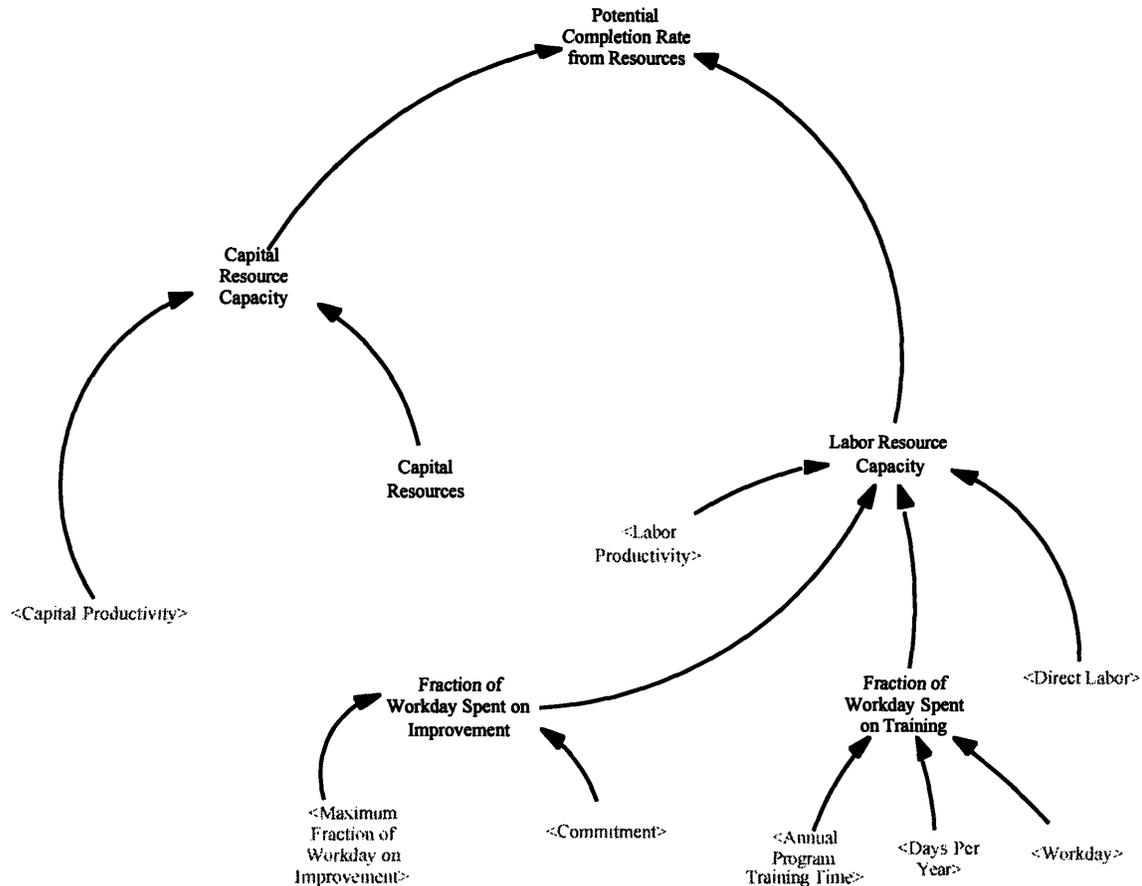


Figure 56: Capacity

Equations:

Potential Completion Rate from Resources = $\min(\text{Capital Resource Capacity}, \text{Labor Resource Capacity})$

~ Units/Day

~ The completion rate due to resources will be a function of available capital and labor. For testing purposes, it is a very large constant which will not limit the production start rate.

Eventually this will become a Leontiev production function of effective labor (where effective labor is based on productivity and the amount of labor) and capital as productive inputs (i.e. $\min(\text{potential output from effective labor}, \text{potential output from capital})$)

Labor Resource Capacity = $\max(0, \text{Direct Labor} * \text{Labor Productivity} * (1 - \text{Fraction of Workday Spent on Training} - \text{Fraction of Workday Spent on Improvement}))$

(1 - Fraction of Workday Spent on Training - Fraction of Workday Spent on Improvement)

~ Units/Day

~ This is the feasible throughput based on labor availability if capital is not binding.

Fraction of Workday Spent on Training = (Annual Program Training Time/Days Per Year)/
Workday

~ Dimensionless

Fraction of Workday Spent on Improvement = Maximum Fraction of Workday on Improvement

* Commitment

~ Dimensionless

Capital Resource Capacity = Capital Productivity * Capital Resources

~ Units/Day

~ Total daily capacity due to capital resources.

Capital Resources = 1e+009

~ Capital Unit

4.8 Pricing Sector

The price charged by the firm is a simple markup over standard cost.

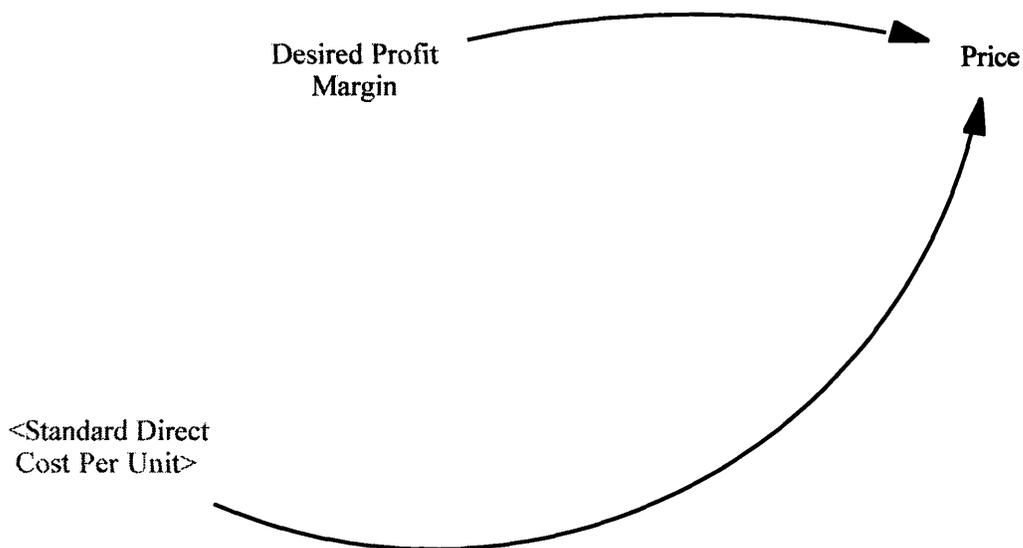


Figure 57: Pricing

Equations:

Price = max(0 , Standard Direct Cost Per Unit * (1 + Desired Profit Margin))

~ Dollar/Unit

Desired Profit Margin = 0.5

~ Dimensionless

~ The producer is assumed to follow a simple markup rule.

4.9 Financial Accounting Sector

The financial accounting group determines the cumulative discounted net income. Discounted net income is taxable income less tax payments. Taxable income is operating income less interest expense which is tax-deductible. Operating income is the gross margin less operating expenses. Gross margin takes into account sales revenue and the cost of goods sold. Operating expense takes into account SG&A, R&D expenses, and all indirect costs. Discounted net income may be used to determine the financial health of the firm and the relative success of quality improvement strategies.

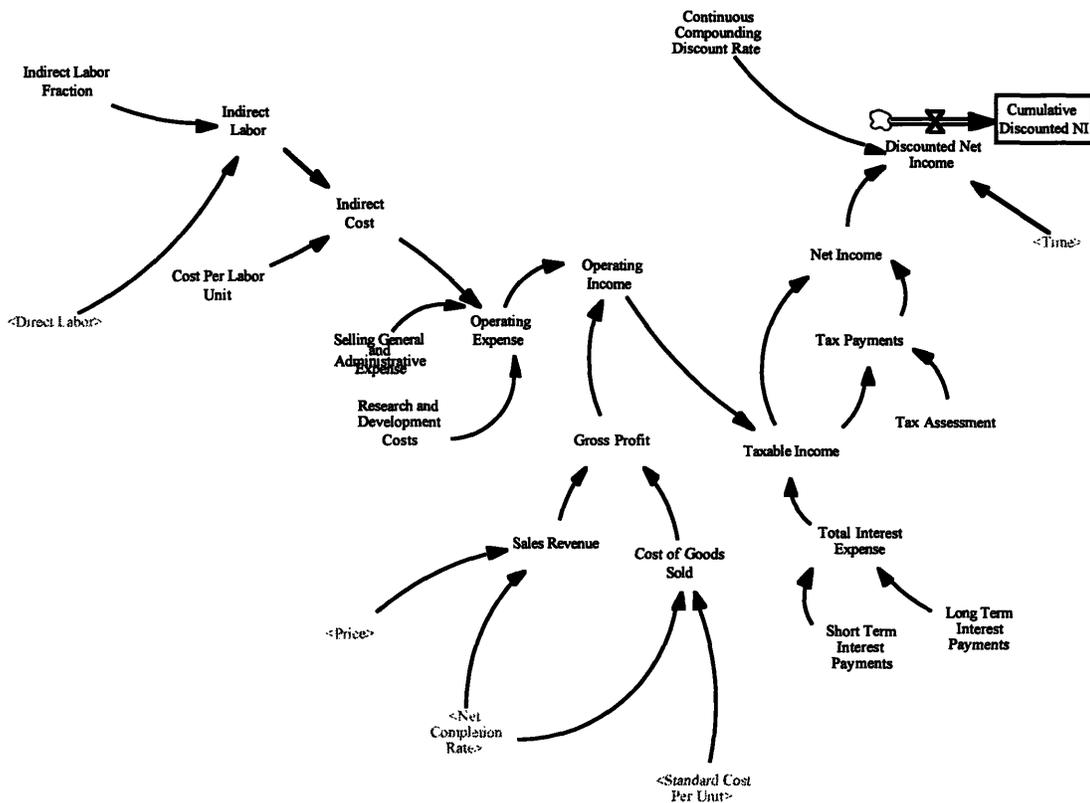


Figure 58: Financial Accounting

Equations:

$$\text{Cumulative Discounted NI} = \text{INTEG}(\text{Discounted Net Income}, 0)$$

~ Dollar

~ ~:SUPPLEMENTARY

$$\text{Discounted Net Income} = \text{Net Income} * \exp(-\text{Continuous Compounding Discount Rate} * \text{Time})$$

~ Dollar/Day

Continuous Compounding Discount Rate = 0.003
~ Dimensionless

Net Income = Taxable Income - Tax Payments
~ Dollar/Day

Taxable Income = Operating Income - Total Interest Expense
~ Dollar/Day

Operating Income = Gross Profit - Operating Expense
~ Dollar/Day

Gross Profit = Sales Revenue - Cost of Goods Sold
~ Dollar/Day
~ The gross profit is the total revenue less the cost of goods sold.

Sales Revenue = Price * Net Completion Rate
~ Dollar/Day

Cost of Goods Sold = Standard Cost Per Unit * Net Completion Rate
~ Dollar/Day
~ The feasible direct cost per unit is assumed to be used as the standard cost per unit in determining the cost of goods.

Operating Expense = Research and Development Costs +
Selling General and Administrative Expense + Indirect Cost
~ Dollar/Day

Research and Development Costs = 0
~ Dollar/Day

Selling General and Administrative Expense = 0
~ Dollar/Day

Indirect Cost = Cost Per Labor Unit * Indirect Labor
~ Dollar/Day

Cost Per Labor Unit = 100
~ Dollar/(Day * Person)

Indirect Labor = Direct Labor * Indirect Labor Fraction
~ Person

Indirect Labor Fraction = 0.2
~ Dimensionless
~ The amount of indirect labor as a fraction of direct labor.

Total Interest Expense = Long Term Interest Payments + Short Term Interest Payments
~ Dollar/Day

Long Term Interest Payments = 0
~ Dollar/Day

Short Term Interest Payments = 0
~ Dollar/Day

Tax Payments = Tax Assessment * Taxable Income
~ Dollar/Day

Tax Assessment = 0.33
~ Dimensionless

5.0 Appendices

5.1 Simulator Interface Code

```
!-----!  
!           TQM Flight Simulator  
!-----!  
! Omar Khan  May 1997  
!-----!  
:SCREEN INTRO  
  
SCREENFONT, Times New Roman|10| |0-0-0|  
COMMAND,"",0,0,0,0,,SPECIAL>SETTITLE|Process Improvement Management Flight Simulator  
  
COMMAND,"",0,0,0,0,, SPECIAL>LOADMODEL|game2.vmf  
COMMAND,"",0,0,0,0,,SPECIAL>CLEARRUNS  
COMMAND,"",0,0,0,0,,SIMULATE>RUNNAME|Curr.vdf  
  
TEXTONLY,"Process Improvement Management Flight Simulator",0,15,100,20,C||36|B|0-0-255  
  
TEXTONLY,"___",0,25,100,20,C||12||255-0-0  
TEXTONLY,"Version 3.0 5/22/97",0,30,100,20,C||14||255-0-0  
TEXTONLY,"This is a pre-release version for demo and testing only",0,35,100,20,C||14||255-0-0  
  
TEXTONLY,"- Press Any Key to Continue -",0,65,100,20,C||16|B|100-100-100  
  
TEXTONLY,"Designed by Omar Khan & Scott Rockart",0,83,100,20,C|Times|12|I|0-0-255  
TEXTONLY,"©1997, All Rights Reserved",0,87,100,20,C|Times|12||0-0-255  
  
ANYKEY,,,,,,,,,DIRECT  
  
!-----!  
:SCREEN DIRECT  
  
SCREENFONT, Times New Roman|10| |0-0-0|  
COMMAND,"",0,0,0,0,,SPECIAL>SETTITLE|Process Improvement Management Flight Simulator
```

TEXTONLY,"Welcome to the wonderful world of quality and improvement!!",0,5,100,20,C||24|I|0-0-255

TEXTONLY,"Many firms have tried to implement quality improvement programs.",0,15,100,20,C||14|

TEXTONLY,"Only a handful have been successful for a sustained period.",0,20,100,20,C||14|

TEXTONLY,"Now, it is YOUR turn to try a hand at quality improvement...",0,25,100,20,C||14|

TEXTONLY,"Directions:",0,35,100,20,C||18|B|255-0-0

TEXTONLY,"• On the next screen, you will be asked a few questions to evaluate the current state of your business",0,40,100,20,C||14||255-0-0

TEXTONLY,"• Once you have answered those questions, you will proceed to the next screen,",0,45,100,20,C||14||255-0-0

!TEXTONLY," where you will receive a new set of instructions.",0,50,100,20,C||14||255-0-0

TEXTONLY,"Prepare to take off into the world of quality improvement!",0,70,100,20,C||18|B|255-0-0

TEXTONLY,"Good Luck!!!",0,80,100,20,C||18|I|255-0-0

TEXTONLY,"- Press Any Key to Continue -",0,85,100,20,C||16|B|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN INITIALIZE

SCREENFONT, Times New Roman|10| |0-0-0|

COMMAND,"",0,0,0,0,,,SPECIAL>SETTITLE|Initialization Screen

TEXTONLY,"State of the business...",0,5,100,20,C||18|I|0-0-255

TEXTONLY,"What kind of industry are you in? Commodity or highly differentiated?",0,10,100,20,C||14|

TEXTONLY,"Please enter an elasticity of demand below (e.g. commodity = 50 or highly differentiated = 0.5)",0,12,100,20,C||14|

MODVAR,"Initial Elasticity of Demand",45,25,10,5,H,I|.01|50]

BUTTON,"Info",55,25,5,5,L,Hh,,ElastHelp

TEXTONLY,"What is the initial demand for your product or service in units produced per year? (e.g. 3,600,000)",0,22,100,20,C||14|

MODVAR,"Initial Demand",45,35,10,5,C
BUTTON,"Info",55,35,5,5,L,Hh,,DemandHelp

TEXTONLY,"Please enter the cost structure for your business:",0,34,100,20,C||16|B|0-0-255
TEXTONLY,"Average wage per employee in \$/year including benefits (e.g. \$72,000):",0,37,100,20,C||14|
MODVAR,"Wage",45,49,10,5,C
BUTTON,"Info",55,49,5,5,L,Hh,,WageHelp

TEXTONLY,"Raw material cost per unit in \$/unit (e.g. \$2):",0,47,100,20,C||14|
MODVAR,"Raw Material Cost Per Unit",45,59,10,5,C
BUTTON,"Info",55,59,5,5,L,Hh,,RawHelp

TEXTONLY,"What is the book value of your depreciable capital? (e.g. \$10,000,000)",0,57,100,20,C||14|
MODVAR,"Book Value",45,69,10,5,C
BUTTON,"Info",55,69,5,5,L,Hh,,BookHelp

TEXTONLY,"What is the average lifetime of your capital? (e.g. 10 years)",0,67,100,20,C||14|
MODVAR,"Average Lifetime of Capital",45,79,10,5,C
BUTTON,"Info",55,79,5,5,L,Hh,,LifeHelp

Button,"Click Here to
Proceed",50,90,30,8,C,,MENU>GAME&GAME>GAMEINTERVAL|90&GAME>GAMEON,INSTRUC
T

!-----!
:SCREEN ElastHelp

TEXTONLY,"Help for Initial Elasticity of Demand",10,20,,,L||18|B|
TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|
TEXTONLY,"The elasticity of demand is the percentage by which demand will change if price changes by 1%.",15,35,,,L||14|
TEXTONLY,"For example, in a highly differentiated market, the initial elasticity of demand may have a value of 0.5.",15,40,,,L||14|
TEXTONLY,"In other words, if price rises by 1%, demand will drop 0.5%.",15,45,,,L||14|
TEXTONLY,"In a highly commoditized market, the initial elasticity of demand may have a value of 50.",15,50,,,L||14|
TEXTONLY,"In other words, if price rises by 1%, demand will drop 50%.",15,55,,,L||14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN DemandHelp

TEXTONLY,"Help for Initial Demand",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"What is the initial annual demand for your product or service?",15,35,,,L||14|

TEXTONLY,"For example, if your firm manufactures widgets, how many widgets do you ship",15,40,,,L||14|

TEXTONLY,"in one year?",15,45,,,L||14|

TEXTONLY,"If you are a design engineer, how many new designs does your",15,50,,,L||14|

TEXTONLY,"firm expect every year?",15,55,,,L||14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN WageHelp

TEXTONLY,"Help for Wage",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"What is the annual wage per employee including benefits?",15,35,,,L||14|

TEXTONLY,"Wage includes the hourly or salaried wage, benefits, and overhead.",15,40,,,L||14|

TEXTONLY,"For example, benefits may include medical insurance, life insurance, employer",15,45,,,L||14|

TEXTONLY,"contribution to 401(k) plan, etc.",15,50,,,L||14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN RawHelp

TEXTONLY,"Help for Raw Material Cost Per Unit",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"What is the raw material cost per unit produced?",15,35,,,L||14|

TEXTONLY,"For instance, if you produce PC boards, the raw material cost may include",15,40,,,L||14|

TEXTONLY,"the PC board, chips, resistors, capacitors, etc.",15,45,,L|14|
TEXTONLY,"If you are a dry cleaner, raw material cost may include the cleaning",15,50,,L|14|
TEXTONLY,"solution, hangers, plastic bags, etc.",15,55,,L|14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN BookHelp

TEXTONLY,"Help for Book Value of Depreciable Capital",10,20,,L|18|B|
TEXTONLY,"Press any key to return to the previous screen.",15,30,,L|14|
TEXTONLY,"What is the book value of your depreciable capital equipment in dollars?",15,35,,L|14|
TEXTONLY,"Capital equipment may include physical plant (e.g. buildings, etc.) and",15,40,,L|14|
TEXTONLY,"equipment (e.g. machines, computers, etc.).",15,45,,L|14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN LifeHelp

TEXTONLY,"Help for Average Lifetime of Capital",10,20,,L|18|B|
TEXTONLY,"Press any key to return to the previous screen.",15,30,,L|14|
TEXTONLY,"What is the average lifetime of your capital equipment?",15,35,,L|14|
TEXTONLY,"Capital equipment may include machines, computers, fabs, chip shooters,
etc.",15,40,,L|14|
TEXTONLY,"For example, a typical machine may have an average useful lifetime of 10
years.",15,45,,L|14|
TEXTONLY,"solution, hangers, plastic bags, etc.",15,55,,L|14|

ANYKEY,,,,,,,,,INITIALIZE

!-----!

:SCREEN INSTRUCT

COMMAND,"",0,0,0,0,,SPECIAL>SETTITLE|Process Improvement Management Flight Simulator
TEXTONLY,"How to Play",30,6,,C|Times|24|B|
TEXTONLY,"When you start the game, you will be able to click on the report buttons",15,15,,L|14|

TEXTONLY,"below to see the status of your firm. You will be able to click on each decision",15,25,,L||14|

TEXTONLY,"(to the right of the screen) and enter your desired value using a slide tool.",15,35,,L||14|

TEXTONLY,"When you are ready to advance to the next time period, click on",15,45,,L||14|

TEXTONLY,"Advance 1 Qtr' or 'Advance 1 Year' positioned directly above.",15,55,,L||14|

TEXTONLY,"To return to the main screen from any report, type '<alt> M'",15,65,,L||14|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,75,,L||14|

LINE,"",60,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,

BUTTON,"Exit",80,0,10,5,L,XX,SPECIAL>EXIT1

TEXTONLY,"Day:",72,6,,L||10|B|

SHOWVAR, "Time",82,6,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,L||10|

BUTTON,"START",74,12,10,5,H,,MainScreen

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,L||10|

BUTTON,"START",74,23,10,5,H,,MainScreen

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,L||10|

TEXTONLY, "of introducing defects",72,31,,L||10|

BUTTON,"START",74,33,10,5,H,,MainScreen

TEXTONLY,"Fraction of effort for reducing normal processing time",72,40,,L||10|

BUTTON,"START",74,43,10,5,H,,MainScreen

TEXTONLY,"Fraction of effort for improving fraction of up time",72,50,,L||10|

BUTTON,"START",74,53,10,5,H,,MainScreen

TEXTONLY,"Willingness to Lay Off Labor",72,60,,L||10|

BUTTON,"START",74,63,10,5,H,,MainScreen

TEXTONLY,"Desired Markup",72,70,,L||10|

BUTTON,"START",74,73,10,5,H,,MainScreen

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|
BUTTON,"START",74,83,10,5,H,,,MainScreen

BUTTON,"Restart",0,0,13,5,,,,Intro

BUTTON, "Production",0,90,20,5,L,,,
BUTTON, "Process Attributes",0,95,20,5,L,,,

BUTTON, "Commitment",20,90,20,5,L,,,
BUTTON, "Cost Accounting",20,95,20,5,L,,,

BUTTON, "Human Resources",40,90,20,5,L,,,
BUTTON, "Pricing and Demand",40,95,20,5,L,,,

BUTTON, "Financial Statement",60,95,20,5,L,,,

BUTTON,"Advance 1 Qtr",13,0,13,5,,,

BUTTON,"Advance 1 Year",26,0,13,5,,,

BUTTON,"Backup 1 Qtr",39,0,13,5,,,

Button,"Click Here to Start Game",30,80,30,8,C,,,MainScreen

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:SCREEN MainScreen

SCREENFONT, Arial|10| |0-0-0|

TEXTONLY, "Flight Simulator Control Center",10,7,,,L||14|B|

TEXTONLY, "Management's enactment of an improvement program",12,10,,,L||12|

TEXTONLY, "A value of zero corresponds to no improvement program ",15,14,,,L||10|

TEXTONLY, "A value of one corresponds to management enacting an improvement program",15,16,,,L||10|

TEXTONLY,"=====>",54,10,,,L||14|

TEXTONLY, "Fraction of effort for improving labor productivity (0 -> 1)",12,21,,,L||12|

TEXTONLY, "Fraction of improvement effort dedicated to increasing labor productivity",15,25,,,L||10|

TEXTONLY, "Note: The four fractions of effort must sum to one!",15,27,,,L||10|I|255-0-0

TEXTONLY,"=====>",54,21,,,L||14|

TEXTONLY, "Fraction of effort for reducing the probability of introducing defects (0 -> 1)",12,31,,,L||12|

TEXTONLY, "Fraction of improvement effort dedicated to reducing the prob. of introducing defects during processing",15,35,,,L||10|

TEXTONLY, "Note: The four fractions of effort must sum to one!",15,37,,,L||10|I|255-0-0

TEXTONLY,"=====>",54,31,,,L||14|

TEXTONLY,"Fraction of effort for reducing normal processing time (0 -> 1)",12,41,,,L||12|

TEXTONLY, "Fraction of improvement effort dedicated to completing work in process faster",15,45,,,L||10|

TEXTONLY, "Note: The four fractions of effort must sum to one!",15,47,,,L||10|I|255-0-0

TEXTONLY,"=====>",54,41,,,L||14|

TEXTONLY, "Fraction of effort for improving fraction of up time (0 -> 1)",12,51,,,L||12|

TEXTONLY, "Fraction of improvement effort dedicated to decreasing down time of mahines, computers, etc.",15,55,,,L||10|

TEXTONLY, "Note: The four fractions of effort must sum to one!",15,57,,,L||10|I|255-0-0

TEXTONLY,"=====>",54,51,,,L||14|

TEXTONLY, "Willingness to lay off labor (0 -> 1)",12,61,,,L||12|

TEXTONLY, "Management's willingness to lay off excess labor",15,65,,,L||10|

TEXTONLY, "Zero corresponds to no layoffs and one corresponds to full willingness to lay off excess labor",15,67,,,L||10|

TEXTONLY,"=====>",54,61,,,L||14|

TEXTONLY,"Desired Markup (over unit costs)",12,71,,,L||12|

TEXTONLY, "Zero corresponds to selling at cost and two corresponds to a 200% markup over cost",15,75,,,L||10|

TEXTONLY,"=====>",54,71,,,L||14|

TEXTONLY,"Annual Training Time in Process Improvement (in hours per year per person)",12,81,,,L||12|

TEXTONLY,"Recommended training time:",15,85,,,L||10|

SHOWVAR,"Max AET",30,85,,,L||10|

TEXTONLY,"=====>",54,81,,,L||14|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,MainScreenHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,,Intro

TEXTONLY,"Day:",72,6,,,L||10|B|

SHOWVAR,"Time",82,6,,,L||10|B|

TEXTONLY,"Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR,"Management Goal",74,12,10,5,H,I[0|1|1]

BUTTON,"?",86,12,5,5,L,,,MgtHelp

TEXTONLY,"Fraction of effort for improving labor productivity",72,20,,,L||10|

SLIDEVAR,"LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]

BUTTON,"?",86,23,5,5,L,,,LPHelp

TEXTONLY,"Fraction of effort for reducing the probability",72,29,,,L||10|

TEXTONLY,"of introducing defects",72,31,,,L||10|

SLIDEVAR,"PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]

BUTTON,"?",86,33,5,5,L,,,PDIHelp

TEXTONLY,"Fraction of effort for reducing normal processing time",72,40,,,L||10|

SLIDEVAR,"NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]

BUTTON,"?",86,43,5,5,L,,,NPTHelp

TEXTONLY,"Fraction of effort for improving fraction of up time",72,50,,,L||10|

SLIDEVAR,"FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]

BUTTON,"?",86,53,5,5,L,,,FUTHelp

SLIDEVARTIE,"4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY,"Willingness to Lay Off Labor",72,60,,,L||10|

SLIDEVAR,"Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]

BUTTON,"?",86,63,5,5,L,,,LayoffHelp

TEXTONLY,"Desired Markup",72,70,,,L||10|

SLIDEVAR,"Desired Profit Margin",74,73,10,5,H,I[0|5|.1]

BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|

SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]

BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Production",0,90,20,5,L,,,Production

BUTTON, "Process Attributes",0,95,20,5,L,,,Process

BUTTON, "Commitment",20,90,20,5,L,,,Commitment

BUTTON, "Cost Accounting",20,95,20,5,L,,,Cost

BUTTON, "Human Resources",40,90,20,5,L,,,HR

BUTTON, "Pricing and Demand",40,95,20,5,L,,,Pricing

BUTTON, "Financial Statement",60,95,20,5,L,,,Financial

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:SCREEN MainScreenHelp

TEXTONLY,"Help for Control Center",0,15,100,20,C||18|

TEXTONLY,"To return to the Control Center from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN MgtHelp

TEXTONLY,"Help for Management's desire to implement an improvement program",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,,L||14|

TEXTONLY,"Do you want to implement an improvement program?",15,35,,,L||14|

TEXTONLY,"If the answer is yes, then enter 1",15,40,,,L||14|

TEXTONLY,"If the answer is no, then enter 0",15,45,,,L||14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN LPHelp

TEXTONLY,"Help for Fraction of effort for improving labor productivity",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,,L||14|

TEXTONLY,"How much of the improvement effort do you want to put towards improving labor productivity?",15,35,,,L||14|

TEXTONLY,"The fractional value can range from zero to one.",15,40,,,L||14|

TEXTONLY,"The sum of all four fractions must sum to one.",15,45,,,L||14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN PDIHelp

TEXTONLY,"Help for Fraction of effort for reducing the probability of introducing defects",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,,L||14|

TEXTONLY,"How much of the improvement effort do you want to put towards reducing the probability of introducing defects?",15,35,,L||14|

TEXTONLY,"The fractional value can range from zero to one.",15,40,,L||14|

TEXTONLY,"The sum of all four fractions must sum to one.",15,45,,L||14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN NPTHelp

TEXTONLY,"Help for Fraction of effort for reducing normal processing time",10,20,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,L||14|

TEXTONLY,"How much of the improvement effort do you want to put towards reducing normal processing time?",15,35,,L||14|

TEXTONLY,"The fractional value can range from zero to one.",15,40,,L||14|

TEXTONLY,"The sum of all four fractions must sum to one.",15,45,,L||14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN FUTHelp

TEXTONLY,"Help for Fraction of effort for improving the fraction of up time",10,20,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,L||14|

TEXTONLY,"How much of the improvement effort do you want to put towards improving the fraction of up time?",15,35,,L||14|

TEXTONLY,"The fractional value can range from zero to one.",15,40,,L||14|

TEXTONLY,"The sum of all four fractions must sum to one.",15,45,,L||14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN LayoffHelp

TEXTONLY,"Help for Willingness to Lay Off Labor",10,20,,L||18|B|

TEXTONLY,"Press any key to return to the main screen.",15,30,,L||14|

TEXTONLY,"Are you willing to lay off excess labor?",15,35,,L|14|
TEXTONLY,"If your answer is yes, then enter 1",15,40,,L|14|
TEXTONLY,"If your answer is no, then enter 0",15,45,,L|14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN MarkupHelp

TEXTONLY,"Help for Desired Markup",10,20,,L|18|B|
TEXTONLY,"Press any key to return to the main screen.",15,30,,L|14|
TEXTONLY,"What is your desired markup over unit cost?",15,35,,L|14|
TEXTONLY,"For example, if you want to sell at cost, the desired markup is zero.",15,40,,L|14|
TEXTONLY,"For example, if you want to sell at twice the cost, the desired markup is two.",15,45,,L|14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN TrainHelp

TEXTONLY,"Help for Annual Training Time in Process Improvement",10,20,,L|18|B|
TEXTONLY,"Press any key to return to the main screen.",15,30,,L|14|
TEXTONLY,"How many hours do you want to train your employees regarding process improvement each year?",15,35,,L|14|
TEXTONLY,"For example, if you want to train your employees one week each year, then enter 40 hours.",15,40,,L|14|
TEXTONLY,"Please keep in mind that increasing training hours exhibits diminishing returns.",15,45,,L|14|

ANYKEY,,,,,,,,MainScreen

!-----!

:SCREEN Production

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON, "Help", 70, 0, 10, 5, L, Hh, , ProductionHelp
BUTTON, "Exit", 80, 0, 10, 5, L, Xx, SPECIAL>EXIT1

BUTTON, "Restart", 0, 0, 13, 5, , , , Intro

TEXTONLY, "Day:", 72, 6, , , L||10|B|
SHOWVAR, "Time", 82, 6, , , L||10|B|

TEXTONLY, "Management's enactment of an improvement program", 72, 9, , , L||10|
SLIDEVAR, "Management Goal", 74, 12, 10, 5, H, I[0|1|1]
BUTTON, "?", 86, 12, 5, 5, L, , , MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity", 72, 20, , , L||10|
SLIDEVAR, "LP Improvement Fraction", 74, 23, 10, 5, H, I[0|1|.01]
BUTTON, "?", 86, 23, 5, 5, L, , , LPHelp

TEXTONLY, "Fraction of effort for reducing the probability", 72, 29, , , L||10|
TEXTONLY, "of introducing defects", 72, 31, , , L||10|
SLIDEVAR, "PDI Improvement Fraction", 74, 33, 10, 5, H, I[0|1|.01]
BUTTON, "?", 86, 33, 5, 5, L, , , PDIHelp

TEXTONLY, "Fraction of effort for reducing normal processing time", 72, 40, , , L||10|
SLIDEVAR, "NPT Improvement Fraction", 74, 43, 10, 5, H, I[0|1|.01]
BUTTON, "?", 86, 43, 5, 5, L, , , NPTHelp

TEXTONLY, "Fraction of effort for improving fraction of up time", 72, 50, , , L||10|
SLIDEVAR, "FUT Improvement Fraction", 74, 53, 10, 5, H, I[0|1|.01]
BUTTON, "?", 86, 53, 5, 5, L, , , FUTHelp

SLIDEVARTIE, "4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3", 0, 0, 0, 0

TEXTONLY, "Willingness to Lay Off Labor", 72, 60, , , L||10|
SLIDEVAR, "Willingness to Layoff Labor", 74, 63, 10, 5, H, I[0|1|.01]
BUTTON, "?", 86, 63, 5, 5, L, , , LayoffHelp

TEXTONLY, "Desired Markup", 72, 70, , , L||10|
SLIDEVAR, "Desired Profit Margin", 74, 73, 10, 5, H, I[0|5|.1]

BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|

SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]

BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Order Backlog",0,85,20,5,L,,SPECIAL>SETWBITEM|Backlog\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "New Orders",0,90,20,5,L,,SPECIAL>SETWBITEM|Order Rate\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Shipments",0,95,20,5,L,,SPECIAL>SETWBITEM|Order Fulfillment Rate\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Process Yield",20,85,20,5,L,,SPECIAL>SETWBITEM|Expected Process Yield\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Raw Mat Insp Yield",20,90,20,5,L,,SPECIAL>SETWBITEM|Expected Raw Material
Inspection Yield\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Cycle Time",20,95,20,5,L,,SPECIAL>SETWBITEM|Perceived Cycle Time\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Cycle Time",40,85,20,5,L,,SPECIAL>SETWBITEM|Perceived Cycle Time\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Raw Materials Inventory",40,90,20,5,L,,SPECIAL>SETWBITEM|Raw Materials Inventory\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Work in Process",40,95,20,5,L,,SPECIAL>SETWBITEM|Work in Process\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Production",10,10,,,L||20|B|

TEXTONLY, "New Orders (units/day)",15,15,,,L||14||

SHOWVAR, "Order Rate%8.0f",50,15,,,R||14||

TEXTONLY, "Shipments (units/day)",15,20,,,L||14||

SHOWVAR, "Order Fulfillment Rate%8.0f",50,20,,,R||14||

TEXTONLY, "Order Backlog (units)",15,25,,,L||14||

SHOWVAR, "Backlog%8.0f",50,25,,,R||14||

TEXTONLY, "Raw Materials (units)",15,30,,,L||14||

SHOWVAR, "Raw Materials Inventory%8.0f",50,30,,,R||14||

TEXTONLY, "Raw Materials Inspection Yield",15,35,,,L||14||

SHOWVAR, "Expected Raw Material Inspection Yield%8.2f",50,35,,,R||14||

TEXTONLY, "Work in Process (units)",15,40,,,L||14||

SHOWVAR, "Work in Process%8.0f",50,40,,,R||14||

TEXTONLY, "Process Yield",15,45,,,L||14||

SHOWVAR, "Expected Process Yield%8.2f",50,45,,,R||14||

TEXTONLY, "Cycle Time (days)",15,50,,,L||14||

SHOWVAR, "Perceived Cycle Time%8.0f",50,50,,,R||14||

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:SCREEN ProductionHelp

TEXTONLY,"Help for Production Screen",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||14|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||14|

ANYKEY,,,,,,,,,Production

!-----!

:SCREEN Process

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,ProcessHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,,Intro

TEXTONLY,"Day:",72,6,,,L||10|B|

SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR,"Management Goal",74,12,10,5,H,I[0|1|1]

BUTTON,"?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|

SLIDEVAR,"LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]

BUTTON,"?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|

TEXTONLY, "of introducing defects",72,31,,,L||10|

SLIDEVAR,"PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]

BUTTON,"?",86,33,5,5,L,,,PDIHelp

TEXTONLY,"Fraction of effort for reducing normal processing time",72,40,,,L||10|

SLIDEVAR,"NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]

BUTTON,"?",86,43,5,5,L,,,NPTHelp

TEXTONLY,"Fraction of effort for improving fraction of up time",72,50,,,L||10|

SLIDEVAR,"FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]

BUTTON,"?",86,53,5,5,L,,,FUTHelp

SLIDEVARTIE,"4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY,"Willingness to Lay Off Labor",72,60,,L||10|

SLIDEVAR,"Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]

BUTTON,"?",86,63,5,5,L,,,LayoffHelp

TEXTONLY,"Desired Markup",72,70,,L||10|

SLIDEVAR,"Desired Profit Margin",74,73,10,5,H,I[0|5|.1]

BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,L||10|

SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]

BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Improvement Effort",0,85,20,5,L,,SPECIAL>SETWBITEM|Improvement Effort\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "LP Improvement Fraction",0,90,20,5,L,,SPECIAL>SETWBITEM|LP Improvement
Fraction\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "PDI Improvement Fraction",0,95,20,5,L,,SPECIAL>SETWBITEM|PDI Improvement
Fraction\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "NPT Improvement Fraction",20,85,20,5,L,,SPECIAL>SETWBITEM|NPT Improvement
Fraction\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "FUT Improvement Fraction",20,90,20,5,L,,SPECIAL>SETWBITEM|FUT Improvement
Fraction\

&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Labor Productivity",20,95,20,5,L,,SPECIAL>SETWBITEM|Labor Productivity\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Prob of Defect Intro",40,85,20,5,L,,SPECIAL>SETWBITEM|Probability of Defect
Introduction\

&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Normal Processing Time",40,90,20,5,L,,SPECIAL>SETWBITEM|Normal Processing
Time\

&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Fraction of Up Time",40,95,20,5,L,,SPECIAL>SETWBITEM|Fraction of Up Time\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Process Attributes",10,10,,,L||20|B|

TEXTONLY, "Improvement Effort (0 -> 1)",12,15,,,L||14||
SHOWVAR, "Improvement Effort%8.2f",65,15,,,R||14||

TEXTONLY, "Fraction of effort for increasing labor productivity (LP) (0 -> 1)",12,30,,,L||14||
SHOWVAR, "LP Improvement Fraction%8.2f",65,30,,,R||14||

TEXTONLY, "Fraction of effort for reducing the probability of defect introduction (PDI) (0 ->
1)",12,45,,,L||14||
SHOWVAR, "PDI Improvement Fraction%8.2f",65,45,,,R||14||

TEXTONLY, "Fraction of effort for reducing normal processing time (NPT) (0 -> 1)",12,60,,,L||14||
SHOWVAR, "NPT Improvement Fraction%8.2f",65,60,,,R||14||

TEXTONLY, "Fraction of effort for improving fractional up time (FUT) (0 -> 1)",12,75,,,L||14||
SHOWVAR, "FUT Improvement Fraction%8.2f",65,75,,,R||14||

TEXTONLY, "Labor Productivity (units completed daily per person)",12,25,,,L||14|
SHOWVAR, "Labor Productivity%8.1f",65,25,,,R||14|

TEXTONLY, "Probability of Defect Introduction (during processing) (0 -> 1)",12,40,,,L||14|
SHOWVAR, "Probability of Defect Introduction%8.2f",65,40,,,R||14|

TEXTONLY, "Normal Processing Time (days)",12,55,,,L||14|
SHOWVAR, "Normal Processing Time%8.1f",65,55,,,R||14|

TEXTONLY, "Fraction of Up Time (0 -> 1)",12,70,,,L||14|
SHOWVAR, "Fraction of Up Time%8.2f",65,70,,,R||14|

!-----!

:SCREEN ProcessHelp

TEXTONLY,"Help for Process Attributes Screen",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,,Process

!-----!

!-----!

:SCREEN Commitment

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,CommitmentHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,,Intro

TEXTONLY,"Day:",72,6,,,L||10|B|

SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR,"Management Goal",74,12,10,5,H,I[0|1|1]

BUTTON,"?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|

SLIDEVAR,"LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]

BUTTON,"?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|

TEXTONLY, "of introducing defects",72,31,,,L||10|

SLIDEVAR,"PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]

BUTTON,"?",86,33,5,5,L,,,PDIHelp

TEXTONLY,"Fraction of effort for reducing normal processing time",72,40,,,L||10|

SLIDEVAR,"NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]

BUTTON,"?",86,43,5,5,L,,,NPTHelp

TEXTONLY,"Fraction of effort for improving fraction of up time",72,50,,,L||10|

SLIDEVAR,"FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]

BUTTON,"?",86,53,5,5,L,,,FUTHelp

SLIDEVARTIE," $4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3$ ",0,0,0,0

TEXTONLY,"Willingness to Lay Off Labor",72,60,,,L||10|

SLIDEVAR,"Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]

BUTTON,"?",86,63,5,5,L,,,LayoffHelp

TEXTONLY,"Desired Markup",72,70,,,L||10|

SLIDEVAR,"Desired Profit Margin",74,73,10,5,H,I[0|5|.1]

BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|

SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]

BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Mgmt Goal Commitment",0,85,20,5,L,,SPECIAL>SETWBITEM|Management Goal for
Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Commitment",0,90,20,5,L,,SPECIAL>SETWBITEM|Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Word of Mouth",0,95,20,5,L,,SPECIAL>SETWBITEM|Word of Mouth\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effect of Results",20,85,20,5,L,,SPECIAL>SETWBITEM|Effect of Results on Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effect of Job Security",20,90,20,5,L,,SPECIAL>SETWBITEM|Effect of Security on
Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effect of Support",20,95,20,5,L,,SPECIAL>SETWBITEM|Effect of Support on
Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effect of Employee Goal",40,95,20,5,L,,SPECIAL>SETWBITEM|Effect of Performance Goal
on Commitment\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Commitment",10,10,,L||20|B|

TEXTONLY, "Ratio of Observed Results to Expected Results",12,15,,L||16|

SHOWVAR, "Ratio Actual to Expected Results%8.2f",65,15,,R||16|

BUTTON, "Info",20,18,5,5,L,,ResultHelp

TEXTONLY, "Perceived Job Security (0 -> 1)",12,25,,,L||16||
SHOWVAR, "Perceived Job Security%8.2f",65,25,,,R||16||
BUTTON, "Info",20,28,5,5,L,,,SecHelp

TEXTONLY, "Ratio of Managerial Support Allocated to Managerial Support Required",12,35,,,L||16||
SHOWVAR, "Ratio Support Allocated to Required%8.2f",65,35,,,R||16||
BUTTON, "Info",20,38,5,5,L,,,SupportHelp

TEXTONLY, "Ratio of Observed Performance to Employees' Goal for Performance ",12,45,,,L||16||
SHOWVAR, "Ratio Actual Performance to Employee Goal for Performance%8.2f",65,45,,,R||16||
BUTTON, "Info",20,48,5,5,L,,,PerfHelp

!TEXTONLY, "Word of Mouth (weighted function of all four effects)",12,55,,,L||16||
!SHOWVAR, "Word of Mouth%8.3f",65,55,,,R||16||

!TEXTONLY, "Management's Goal for Commitment",12,65,,,L||16||
!SHOWVAR, "Management Goal for Commitment%8.2f",65,65,,,R||16||

TEXTONLY, "Employee Commitment to Improvement Programs (0 -> 1)",10,55,,,L||18|B|
SHOWVAR, "Commitment%8.2f",65,55,,,R||18|B|

!-----!

:SCREEN CommitmentHelp

TEXTONLY,"Help for Commitment Screen",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,,Commitment

!-----!

:SCREEN ResultHelp

TEXTONLY,"Help for Ratio of Observed Results to Expected Results",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"If the ratio is less than one, then results fall short of expectations.",15,35,,,L||14|

TEXTONLY,"If the ratio is equal to one, then result meet expectations.",15,40,,,L||14|

TEXTONLY,"If the ratio is greater than one, then results exceed expectations.",15,45,,,L||14|

ANYKEY,,,,,,,,,Commitment

!-----!

:SCREEN SecHelp

TEXTONLY,"Help for Perceived Job Security",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"A value of one means that employees are completely secure and ",15,35,,,L||14|

TEXTONLY,"there is no fear of layoffs..",15,40,,,L||14|

TEXTONLY,"A value of zero means that perceive no job security and fear that ",15,45,,,L||14|

TEXTONLY,"they may be laid off at any time.",15,50,,,L||14|

ANYKEY,,,,,,,,,Commitment

!-----!

:SCREEN SupportHelp

TEXTONLY,"Help for Ratio of Managerial Support Allocated to Managerial Support
Required",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"If the ratio is less than one, then support falls short of requirements.",15,35,,,L||14|

TEXTONLY,"If the ratio is equal to one, then support meets requirements.",15,40,,,L||14|

TEXTONLY,"If the ratio is greater than one, then support exceeds requirements.",15,45,,,L||14|

ANYKEY,,,,,,,,,Commitment

!-----!

:SCREEN PerfHelp

TEXTONLY,"Help for Ratio of Observed Performance to Employees' Own Goal for
Performance",10,20,,,L||18|B|

TEXTONLY,"Press any key to return to the previous screen.",15,30,,,L||14|

TEXTONLY,"If the ratio is less than one, then the firm's performance is better than employees' goal for
performance.",15,35,,,L||14|

TEXTONLY,"If the ratio is equal to one, then the firm's performance meets employees' goal for
performance",15,40,,,L||14|

TEXTONLY,"If the ratio is greater than one, then the firm's performance falls short of employees' goal for
performance",15,45,,,L||14|

ANYKEY,,,,,,,,,Commitment

!-----!

:SCREEN Cost

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,CostHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,,Intro

TEXTONLY,"Day:",72,6,,,L||10|B|

SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR,"Management Goal",74,12,10,5,H,I[0|1|1]

BUTTON,"?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|

SLIDEVAR,"LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]

BUTTON,"?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|

TEXTONLY, "of introducing defects",72,31,,,L||10|

SLIDEVAR,"PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]

BUTTON,"?",86,33,5,5,L,,,PDIHelp

TEXTONLY, "Fraction of effort for reducing normal processing time",72,40,,,L||10|

SLIDEVAR,"NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]

BUTTON,"?",86,43,5,5,L,,,NPTHelp

TEXTONLY, "Fraction of effort for improving fraction of up time",72,50,,,L||10|

SLIDEVAR,"FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]

BUTTON, "?" ,86,53,5,5,L,,,FUTHelp

SLIDEVARTIE, "4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY, "Willingness to Lay Off Labor",72,60,,,L||10|

SLIDEVAR, "Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]

BUTTON, "?" ,86,63,5,5,L,,,LayoffHelp

TEXTONLY, "Desired Markup",72,70,,,L||10|

SLIDEVAR, "Desired Profit Margin",74,73,10,5,H,I[0|5|.1]

BUTTON, "?" ,86,73,5,5,L,,,MarkupHelp

TEXTONLY, "Annual Training Time (in hours per year per person)",72,80,,,L||10|

SLIDEVAR, "Annual Program Training Time",74,83,10,5,H,I[0|100|1]

BUTTON, "?" ,86,83,5,5,L,,,TrainHelp

BUTTON, "Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON, "Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Standard Cost Per Unit",0,85,20,5,L,,,SPECIAL>SETWBITEM|Standard Cost Per Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Direct Cost Per Unit",0,90,20,5,L,,,SPECIAL>SETWBITEM|Standard Direct Cost Per Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Direct Labor Cost Per Unit",0,95,20,5,L,,,SPECIAL>SETWBITEM|Standard Direct Labor
Cost per Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Raw Material Cost Per Unit",20,85,20,5,L,,SPECIAL>SETWBITEM|Standard Raw
Material Cost Per Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Carrying Cost Per Unit",20,90,20,5,L,,SPECIAL>SETWBITEM|Standard WIP Carrying
Cost Per Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Capital Cost Per Unit",20,95,20,5,L,,SPECIAL>SETWBITEM|Standard Capital Cost Per
Unit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Effect of Employee Goal",40,95,20,5,L,,SPECIAL>SETWBITEM|Effect of Performance Goal
on Commitment\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH
!BUTTON, "Normal Processing Time",40,90,20,5,L,,SPECIAL>SETWBITEM|Normal Processing
Time\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH
!BUTTON, "Fraction of Up Time",40,95,20,5,L,,SPECIAL>SETWBITEM|Fraction of Up Time\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Cost Accounting",10,10,,,L||20|B|

TEXTONLY, "Direct Labor Cost Per Unit (\$/Unit)",12,15,,,L||16|

SHOWVAR, "Standard Direct Labor Cost per Unit%8.2f",65,15,,,R||16|

TEXTONLY, "Raw Material Cost Per Unit",12,25,,,L||16|

SHOWVAR, "Standard Raw Material Cost Per Unit%8.2f",65,25,,,R||16|

LINE,"",58,30,10,0,C|||

TEXTONLY, "Direct Cost Per Unit",12,35,,,L||16|

SHOWVAR, "Standard Direct Cost Per Unit%8.2f",65,35,,,R||16|

TEXTONLY, "Carrying Cost Per Unit",12,45,,,L||16|

SHOWVAR, "Standard WIP Carrying Cost Per Unit%8.2f",65,45,,,R||16|

TEXTONLY, "Capital Cost Per Unit",12,55,,,L||16|
SHOWVAR, "Standard Capital Cost Per Unit%8.2f",65,55,,,R||16|

LINE,"",58,60,10,0,C|||

TEXTONLY, "Standard Cost Per Unit",12,65,,,L||16|B|
SHOWVAR, "Standard Cost Per Unit%8.2f",65,65,,,R||16|B|

!TEXTONLY, "Employee Commitment to Improvement Programs",12,75,,,L||16|B|
!SHOWVAR, "Commitment%8.3f",65,75,,,R||16|B|

!TEXTONLY, "Normal Processing Time (days)",12,60,,,L||14|
!SHOWVAR, "Normal Processing Time%8.3f",65,60,,,R||14|

!TEXTONLY, "Fraction of Up Time (zero-one scale)",12,75,,,L||14|
!SHOWVAR, "Fraction of Up Time%8.3f",65,75,,,R||14|

!-----!

:SCREEN CostHelp

TEXTONLY,"Help for Cost Accounting Screen",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,,Cost

!-----!

:SCREEN HR

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,HRHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,,Intro

TEXTONLY, "Day:",72,6,,,L||10|B|
SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|
SLIDEVAR, "Management Goal",74,12,10,5,H,I[0|1|1]
BUTTON, "?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|
SLIDEVAR, "LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]
BUTTON, "?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|
TEXTONLY, "of introducing defects",72,31,,,L||10|
SLIDEVAR, "PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]
BUTTON, "?",86,33,5,5,L,,,PDIHelp

TEXTONLY, "Fraction of effort for reducing normal processing time",72,40,,,L||10|
SLIDEVAR, "NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]
BUTTON, "?",86,43,5,5,L,,,NPTHelp

TEXTONLY, "Fraction of effort for improving fraction of up time",72,50,,,L||10|
SLIDEVAR, "FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]
BUTTON, "?",86,53,5,5,L,,,FUTHelp

SLIDEVARTIE, "4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY, "Willingness to Lay Off Labor",72,60,,,L||10|
SLIDEVAR, "Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]
BUTTON, "?",86,63,5,5,L,,,LayoffHelp

TEXTONLY, "Desired Markup",72,70,,,L||10|
SLIDEVAR, "Desired Profit Margin",74,73,10,5,H,I[0|5|.1]
BUTTON, "?",86,73,5,5,L,,,MarkupHelp

TEXTONLY, "Annual Training Time (in hours per year per person)",72,80,,,L||10|
SLIDEVAR, "Annual Program Training Time",74,83,10,5,H,I[0|100|1]
BUTTON, "?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,"GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,"GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,"GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,"GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Direct Labor",0,85,20,5,L,,SPECIAL>SETWBITEM|Direct Labor\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "New Hires",0,90,20,5,L,,SPECIAL>SETWBITEM|Direct Labor Hires\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Attrition",0,95,20,5,L,,SPECIAL>SETWBITEM|Direct Labor Attrition\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Layoffs",20,85,20,5,L,,SPECIAL>SETWBITEM|Layoffs\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Desired Direct Labor",20,90,20,5,L,,SPECIAL>SETWBITEM|Desired Direct Labor\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effectiveness from Exper",20,95,20,5,L,,SPECIAL>SETWBITEM|Effectiveness Due to
Experience\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Effectiveness from Training",40,95,20,5,L,,SPECIAL>SETWBITEM|Effectiveness Due to
Training\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Average Skill",40,90,20,5,L,,SPECIAL>SETWBITEM|Average Skill With Improvement
Processes\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "",40,95,20,5,L,,SPECIAL>SETWBITEM|Fraction of Up Time\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Human Resources",10,10,,,L||20|B|

TEXTONLY, "Direct Labor (person)",12,15,,,L||15|

SHOWVAR, "Direct Labor%8.0f",65,15,,,R||15|

TEXTONLY, "New Hires (person/day)",12,29,,,L||15|

SHOWVAR, "Direct Labor Hires%8.1f",65,29,,,R||15|

TEXTONLY, "Attrition (person/day)",12,36,,,L||15|

SHOWVAR, "Direct Labor Attrition%8.1f",65,36,,,R||15|

TEXTONLY, "Layoffs (person/day)",12,43,,,L||15|

SHOWVAR, "Layoffs%8.1f",65,43,,,R||15|

TEXTONLY, "Desired Direct Labor (person)",12,22,,,L||15|

SHOWVAR, "Desired Direct Labor%8.0f",65,22,,,R||15|

TEXTONLY, "Effective of on-the-job Experience on Average Skill (0 -> 1)",12,57,,,L||15|

SHOWVAR, "Effectiveness Due to Experience%8.2f",65,57,,,R||15|

TEXTONLY, "Effect of Training on Average Skill (0 -> 1)",12,64,,,L||15|

SHOWVAR, "Effectiveness Due to Training%8.2f",65,64,,,R||15|

TEXTONLY, "Average Skill with Improvement Programs (0 -> 1)",10,50,,,L||15|B|

SHOWVAR, "Average Skill With Improvement Processes%8.2f",65,50,,,R||15|B|

!-----!

:SCREEN HRHelp

TEXTONLY, "Help for Human Resources Screen",0,15,100,20,C||18|

TEXTONLY, "To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY, "For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,,HR

!-----!

:SCREEN Pricing

SCREENFONT, Arial|10| |0-0-0|

LINE, "",70,0,0,90,C|||

BUTTON, "Help",70,0,10,5,L,Hh,,PricingHelp

BUTTON, "Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON, "Restart",0,0,13,5,,,,Intro

TEXTONLY, "Day:",72,6,,,L||10|B|

SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR, "Management Goal",74,12,10,5,H,l[0|1|1]

BUTTON, "?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|

SLIDEVAR, "LP Improvement Fraction",74,23,10,5,H,l[0|1|.01]

BUTTON, "?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|

TEXTONLY, "of introducing defects",72,31,,,L||10|

SLIDEVAR, "PDI Improvement Fraction",74,33,10,5,H,l[0|1|.01]

BUTTON, "?",86,33,5,5,L,,,PDIHelp

TEXTONLY, "Fraction of effort for reducing normal processing time",72,40,,,L||10|

SLIDEVAR, "NPT Improvement Fraction",74,43,10,5,H,l[0|1|.01]

BUTTON, "?",86,43,5,5,L,,,NPTHHelp

TEXTONLY, "Fraction of effort for improving fraction of up time",72,50,,,L||10|

SLIDEVAR, "FUT Improvement Fraction",74,53,10,5,H,l[0|1|.01]

BUTTON, "?",86,53,5,5,L,,,FUTHHelp

SLIDEVARTIE, "4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY,"Willingness to Lay Off Labor",72,60,,,L||10|
SLIDEVAR,"Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]
BUTTON,"?",86,63,5,5,L,,,LayoffHelp

TEXTONLY,"Desired Markup",72,70,,,L||10|
SLIDEVAR,"Desired Profit Margin",74,73,10,5,H,I[0|5|.1]
BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|
SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]
BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "Desired Profit Margin",0,95,20,5,L,,SPECIAL>SETWBITEM|Desired Profit Margin\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Direct Cost Per Unit",0,90,20,5,L,,SPECIAL>SETWBITEM|Standard Direct Cost Per
Unit\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Direct Labor Cost Per Unit",0,95,20,5,L,,SPECIAL>SETWBITEM|Standard Direct Labor
Cost per Unit\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Raw Material Cost Per Unit",20,85,20,5,L,,SPECIAL>SETWBITEM|Standard Raw
Material Cost Per Unit\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Carrying Cost Per Unit",20,90,20,5,L,,SPECIAL>SETWBITEM|Standard WIP Carrying
Cost Per Unit\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!&WORKBENCH>TABLE&WORKBENCH>GRAPH
BUTTON, "Price",20,95,20,5,L,,SPECIAL>SETWBITEM|Price\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Effect of Employee Goal",40,95,20,5,L,,SPECIAL>SETWBITEM|Effect of Performance Goal
on Commitment\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Normal Processing Time",40,90,20,5,L,,SPECIAL>SETWBITEM|Normal Processing
Time\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Demand",40,95,20,5,L,,SPECIAL>SETWBITEM|Demand\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Pricing and Demand",10,25,,,L||20|B|

TEXTONLY, "Desired Profit Margin",12,35,,,L||18||
SHOWVAR, "Desired Profit Margin%8.2f",55,35,,,R||18||

TEXTONLY, "Price (\$/Unit)",12,50,,,L||18||
SHOWVAR, "Price%8.2f",55,50,,,R||18||

!LINE,"",58,30,10,0,C|||

TEXTONLY, "Demand (Units/Day)",12,65,,,L||18||
SHOWVAR, "Demand%8.0f",55,65,,,R||18||

!TEXTONLY, "Carrying Cost Per Unit",12,45,,,L||16||
!SHOWVAR, "Standard WIP Carrying Cost Per Unit%8.2f",65,45,,,R||16||

!TEXTONLY, "Capital Cost Per Unit",12,55,,,L||16||
!SHOWVAR, "Standard Capital Cost Per Unit%8.2f",65,55,,,R||16||

!LINE,"",58,60,10,0,C|||

!TEXTONLY, "Standard Cost Per Unit",12,65,,,L||16|B|
!SHOWVAR, "Standard Cost Per Unit%8.2f",65,65,,,R||16|B|

!TEXTONLY, "Employee Commitment to Improvement Programs",12,75,,,L||16|B|
!SHOWVAR, "Commitment%8.3f",65,75,,,R||16|B|

!TEXTONLY, "Normal Processing Time (days)",12,60,,,L||14|
!SHOWVAR, "Normal Processing Time%8.3f",65,60,,,R||14|

!TEXTONLY, "Fraction of Up Time (zero-one scale)",12,75,,,L||14|
!SHOWVAR, "Fraction of Up Time%8.3f",65,75,,,R||14|

!-----!

:SCREEN PricingHelp

TEXTONLY,"Help for Pricing and Demand Screen",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,Pricing

!-----!

:SCREEN Financial

SCREENFONT, Arial|10| |0-0-0|

LINE,"",70,0,0,90,C|||

BUTTON,"Help",70,0,10,5,L,Hh,,PricingHelp

BUTTON,"Exit",80,0,10,5,L,Xx,SPECIAL>EXIT1

BUTTON,"Restart",0,0,13,5,,,Intro

TEXTONLY,"Day:",72,6,,,L||10|B|

SHOWVAR, "Time",82,6,,,L||10|B|

TEXTONLY, "Management's enactment of an improvement program",72,9,,,L||10|

SLIDEVAR,"Management Goal",74,12,10,5,H,l[0|1|1|

BUTTON,"?",86,12,5,5,L,,,MgtHelp

TEXTONLY, "Fraction of effort for improving labor productivity",72,20,,,L||10|
SLIDEVAR,"LP Improvement Fraction",74,23,10,5,H,I[0|1|.01]
BUTTON,"?",86,23,5,5,L,,,LPHelp

TEXTONLY, "Fraction of effort for reducing the probability",72,29,,,L||10|
TEXTONLY, "of introducing defects",72,31,,,L||10|
SLIDEVAR,"PDI Improvement Fraction",74,33,10,5,H,I[0|1|.01]
BUTTON,"?",86,33,5,5,L,,,PDIHelp

TEXTONLY,"Fraction of effort for reducing normal processing time",72,40,,,L||10|
SLIDEVAR,"NPT Improvement Fraction",74,43,10,5,H,I[0|1|.01]
BUTTON,"?",86,43,5,5,L,,,NPTHelp

TEXTONLY,"Fraction of effort for improving fraction of up time",72,50,,,L||10|
SLIDEVAR,"FUT Improvement Fraction",74,53,10,5,H,I[0|1|.01]
BUTTON,"?",86,53,5,5,L,,,FUTHelp

SLIDEVARTIE,"4=1.0,1|2|3|4,2|1|3|4,3|1|2|4,4|1|2|3",0,0,0,0

TEXTONLY,"Willingness to Lay Off Labor",72,60,,,L||10|
SLIDEVAR,"Willingness to Layoff Labor",74,63,10,5,H,I[0|1|.01]
BUTTON,"?",86,63,5,5,L,,,LayoffHelp

TEXTONLY,"Desired Markup",72,70,,,L||10|
SLIDEVAR,"Desired Profit Margin",74,73,10,5,H,I[0|5|.1]
BUTTON,"?",86,73,5,5,L,,,MarkupHelp

TEXTONLY,"Annual Training Time (in hours per year per person)",72,80,,,L||10|
SLIDEVAR,"Annual Program Training Time",74,83,10,5,H,I[0|100|1]
BUTTON,"?",86,83,5,5,L,,,TrainHelp

BUTTON,"Advance 1 Qtr",13,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Advance 1 Year",26,0,13,5,,,GAME>GAMEINTERVAL|360.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON,"Backup 1 Qtr",39,0,13,5,,,GAME>GAMEINTERVAL|90.0&Game>BACKUP\
&SPECIAL>REFRESH

&SPECIAL>REFRESH

BUTTON,"Finish Game",52,0,13,5,,,GAME>GAMEINTERVAL|3510.0&Game>GAMEON\
&SPECIAL>REFRESH

BUTTON, "COGS",0,90,20,5,L,,SPECIAL>SETWBITEM|Cost of Goods Sold\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Sales Revenue",0,95,20,5,L,,SPECIAL>SETWBITEM|Sales Revenue\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Gross Profit",0,85,20,5,L,,SPECIAL>SETWBITEM|Gross Profit\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Operating Expense",20,85,20,5,L,,SPECIAL>SETWBITEM|Operating Expense\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Operating Income",20,90,20,5,L,,SPECIAL>SETWBITEM|Operating Income\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Tax Payments",20,95,20,5,L,,SPECIAL>SETWBITEM|Tax Payments\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Net Income",40,85,20,5,L,,SPECIAL>SETWBITEM|Net Income\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Cum Discounted Net Inc",40,90,20,5,L,,SPECIAL>SETWBITEM|Cumulative Discounted
NI\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Indirect Costs",40,95,20,5,L,,SPECIAL>SETWBITEM|Indirect Cost\
&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Overhead Cost",60,85,20,5,L,,SPECIAL>SETWBITEM|Overhead Cost\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "R and D Exp",60,90,20,5,L,,SPECIAL>SETWBITEM|R and D Expense\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

!BUTTON, "Sales Revenue",60,95,20,5,L,,SPECIAL>SETWBITEM|SalesRevenue\
!&WORKBENCH>TABLE&WORKBENCH>GRAPH

BUTTON, "Main Screen >",75,95,20,5,L,Mm,,MainScreen

TEXTONLY, "Income Statement",10,7,,,L||14|B|

TEXTONLY, " (\$/day)",40,1,,,L||14||

TEXTONLY, "Sales Revenue",15,10,,,L||12||

SHOWVAR, "Sales Revenue%8.2f",60,10,,,R||12||

TEXTONLY, "Cost of Goods Sold", 15,15,,,L||12||

SHOWVAR, "Cost of Goods Sold%8.2f",60,15,,,R||12||

LINE, "",12,19,27,,

LINE, "",50,19,10,,

TEXTONLY, "Gross Profit",12,20,,,L||12|B|

SHOWVAR, "Gross Profit%8.2f",60,20,,,R||12|B|

TEXTONLY, "Operating Expense",12,30,,,L||12||

TEXTONLY, "R and D",15,35,,,L||12||

SHOWVAR, "Research and Development Costs%8.2f",60,35,,,R||12||

TEXTONLY, "Indirect Expense",15,40,,,L||12||

SHOWVAR, "Indirect Cost%8.2f",60,40,,,R||12||

TEXTONLY, "General, Selling & Admin.",15,45,,,L||12||

SHOWVAR, "Selling General and Administrative Expense%8.2f",60,45,,,R||12||

LINE, "",15,48,24,,

LINE, "",50,48,10,,

TEXTONLY, "Total Expense",15,50,,,L||12||

SHOWVAR, "Operating Expense%8.2f",60,50,,,R||12||

LINE, "",12,54,27,,

LINE, "",50,54,10,,

TEXTONLY, "Operating Income",12,55,,,L||12|B|

SHOWVAR, "Operating Income%8.2f",60,55,,,R||12|B|

TEXTONLY, "Interest Expense",15,65,,,L||12||

SHOWVAR, "Total Interest Expense%8.2f",60,65,,,R||12||

TEXTONLY, "Tax Payments",15,70,,,L||12||

SHOWVAR, "Tax Payments%8.2f",60,70,,,R||12||

LINE, "",12,74,27,,

LINE, "",50,74,10,,

TEXTONLY, "Net Income",12,75,,,L||12|B|

SHOWVAR, "Net Income%8.2f",60,75,,,R||12|B|

PROMPT,"",0,0,0,0

TEXTONLY, "Cumulative Discounted Net Income", 12,80,,,L||13|B|

SHOWVAR, "Cumulative Discounted NI%8.2f",60,80,,,R||13|B|

!_____!

:SCREEN FinancialHelp

TEXTONLY,"Help for Financial Statement",0,15,100,20,C||18|

TEXTONLY,"To return to the Main Screen from any report, type '<alt> M'",15,75,,,L||10|

TEXTONLY,"For help, type '<alt> H'; to exit, type '<alt> X';",15,80,,,L||10|

ANYKEY,,,,,,,,,Financial

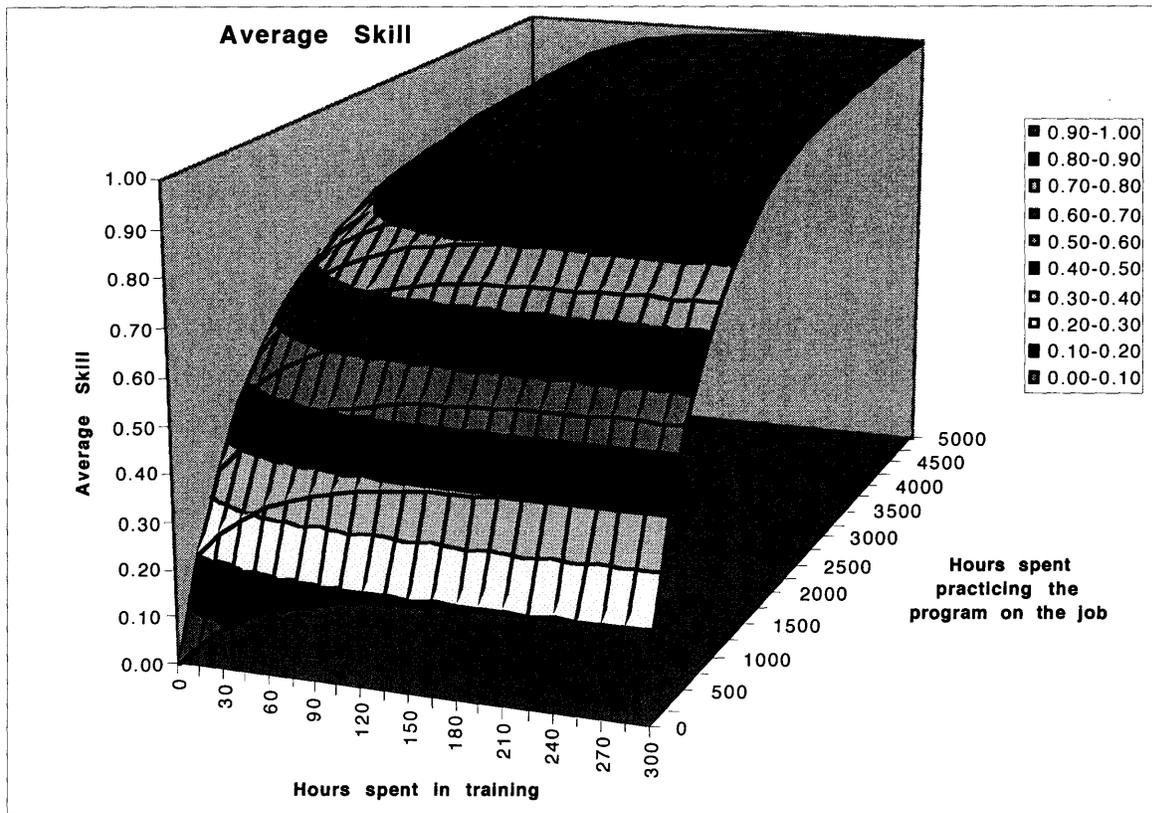
5.2 Relative Effects on Commitment

Effect of Results	Effect of Performance Goal	Effect of Job Security	Effect of Support	Total Effect on Word of Mouth	Rank (from negative to positive)
HIGH	HIGH	HIGH	HIGH	1.9	16
HIGH	HIGH	HIGH	LOW	-3	12
HIGH	HIGH	LOW	HIGH	-5	9
HIGH	LOW	HIGH	HIGH	1.1	15
LOW	HIGH	HIGH	HIGH	-0.1	14
HIGH	HIGH	LOW	LOW	-9.9	4
HIGH	LOW	HIGH	LOW	-3.8	11
LOW	HIGH	HIGH	LOW	-5.0	9
HIGH	LOW	LOW	HIGH	-5.8	7
LOW	HIGH	LOW	HIGH	-7.0	6
LOW	LOW	HIGH	HIGH	-0.9	13
LOW	LOW	LOW	HIGH	-7.8	5
LOW	LOW	HIGH	LOW	-5.8	7
HIGH	LOW	LOW	LOW	-10.7	3
LOW	HIGH	LOW	LOW	-12.9	2
LOW	LOW	LOW	LOW	-13.7	1

Effect of Results: HIGH = 1.5, LOW = -0.5
 Effect of Performance Goal: HIGH = 0.4, LOW = -0.4
 Effect of Job Security: HIGH = 0, LOW = -6.9
 Effect of Support: HIGH = 0, LOW = -4.9

The table shows the relative strengths of the four effects that comprise word of mouth. For instance, #16 is the most positive effect. This occurs when all four effects are high or that their maximum values. The negative strength of a lack of support overwhelms all other positive effects as shown in rank #12. Also, the negative strength of a lack of job security overwhelms all other positive effects as shown in rank #9. The strength of a negative effect of performance goal, however, cannot overcome all other positive effects as shown in rank #15; it simply detracts from the overall positive effect. Finally, a lack of results guarantee a negative overall effect as shown in rank #14.

5.3 Training, Experience, and Average Skill



The curve is designed to illuminate two points:

- Hours spent on the job with improvement programs add more skill to the employee than do hours spent in training.
- Effectiveness due to on the job experience, and effectiveness due to training, exhibit diminishing returns with the number of hours on the respective activities. The closer an employee approaches full effectiveness, the more difficult it becomes to obtain that last bit of effectiveness.

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