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Development and implementation of a capacity planning model for the service industry

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DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY PLANNING MODEL FOR THE SERVICE INDUSTRY

BY

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ABSTRACT

DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY PLANNING MODEL FOR THE SERVICE INDUSTRY

by

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Adviser: Professor David Dannenbring

The model developed for this dissertation applies capacity planning principles and concepts to a direct mail response "paperwork" process, subject to attrition and variable customer response times.

Paperwork processing is a major function for all banks, insurance companies and many other service providers. Capacity in a service environment is normally defined as the number of items processed, or number of customers served within a particular time period. This is sometimes referred to as "throughput".

Many service firms avail themselves of marketing promotions, such as television and radio advertisement, and more recently, direct mail solicitations to attract customers. Processing the response to mail solicitations is

known as Direct Mail Response Processing (DMRP). Frequently, these campaigns can be characterized as generating intense activity for discrete periods of time. The above will be referred to as "Campaign Demand".

One of the distinguishing aspects of a customer-generated paperwork process is rework due to customer error. Items with omitted or incorrect information are returned to the customer, or a letter sent, to obtain the required information before processing can be completed. During this stage, there is attrition, since only a percentage of customers respond to the request, and then repair work for the returned items. The resubmitted items have a variable return time that is outside the control of the company, since some customers forward information promptly, and others delay response. The effect of both attrition and variable return time can be significant and therefore need to be accounted for to produce a capacity plan that accurately reflects a paperwork environment.

Due to high volumes, the adverse impact of delays on revenues, the increase and decrease in workforce size due to the use of temporary workers, and the need to allocate resources effectively in order to succeed in a competitive environment, adapting capacity planning to this situation is a relevant and fruitful direction for research.

A general spreadsheet model is developed to provide the number of staff and machines needed on a daily basis and identify under and over capacity situations. The major features of the model are: 1) campaign demand response pattern, 2) variable return time, 3) prescriptive as well as descriptive variations, 4) cost tradeoffs, and 5) the ability to handle operational occurrences such as equipment breakdowns and interrupted mail delivery, among others.

The general model was adapted to an actual case study in a major US Bank, focusing on the responses to solicitations for credit cards. This case study demonstrated that the model is beneficial for resource planning since it identified potential backlogs and idle time in advance, and provided for scenario analysis.

For marketing campaigns, the capacity plan assumes items arrive according to a Normal distribution. However, the model can reflect alternative arrival patterns and there are two major modifications. The first is a "steady arrivals" model for environments with a constant level of incoming work. The other accounts for "weekend mail". In many cases, mail is delivered six days per week, but the organization works only five. Hence, Monday's work volume is double that of other days.

This model can be applied to a wide variety of service organizations. Any large organization receiving paperwork

originating from consumers, that must (in the case of omitted information), obtain additional information in order to complete processing can potentially benefit from this model.

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CHAPTER 1
INTRODUCTION

a. Overview

In this study, a general capacity planning model for a paperwork process is developed. Features common to many paperwork processes such as loss of control when customers do part of the processing and demand patterns resulting from high-volume marketing campaigns are modeled. The model was then applied in an actual case study. Using data collected from interviews with area managers, department reports and system journals, the capacity plan was adapted and successfully implemented in a division of a major US Bank.

b. Definition of Key Terms

Capacity planning focuses on the allocation of resources to achieve production goals. Companies are always working under constraints, and dealing with these constraints or limited resources is key to managing effectively and maintaining competitive position. Adam and Surkis (1977) note, "One of the main functions of the capacity planning component is to forecast the work load at each work center for each time period in the future, to assist management in adjusting resources, getting advance

notice of bottlenecks, and estimating reliable due dates for incoming jobs", (p. 1012).

According to Dervitsiotis, (1981), there are three types of capacity related problems. The succeeding type works within the framework of the preceding type:

1) System design capacity, which deals with the issue of large increments in capacity needed for changes in demand over the long term, say five to ten years ahead.
2) Aggregate planning which relies on the use of inventories and changes in the size of the work force through hiring and layoffs, use of overtime and subcontracting orders to another firm, and,
3) Operations scheduling, which refers to the finer adjustments in capacity that may be needed to cope with short term random fluctuations in demand. This is done on a weekly or even daily basis, (paraphrased, p. 196).

"Demand" in this case is the volume of work needing to be processed as a result of consumer response. This paper focuses on short term, operational planning. System design capacity, and long term planning is not discussed here, although model results can be used to suggest where changes need to be made in capacity choices of the other two types.

Capacity planning has been defined by various authors. Dervitsiotis (1981) states that, "Productive capacity, generally measured in physical units, refers either to the maximum output rate for products or services or to the amounts of key resources available in each operating period", (p. 195). According to Cheng (1990a), "Capacity management involves planning the best quantity to produce in each of the time periods in the intermediate-range horizon and planning the most economical method of acquiring the capacity to meet production requirements. The objectives of capacity planning are to develop plans that are feasible and, hopefully optimal, i.e. plans that meet the demand and use the resources as wisely as possible while keeping the costs as low as possible. The capacity of a production system is the maximum amount of productive resources available to perform the necessary operations per unit of time", (p. 521).

Another perspective tying together the strategic elements of capacity planning, is that of Marucheck and McClelland (1992), "Capacity has been defined as 'the level of resources available to the firm'. This definition implies that initially a strategic decision determines the level of resources available to meet forecast demand; this level in turn becomes a constraint at the operational level

where decisions are made to determine how available resources should be utilized most effectively", (p. 18).

For computer network capacity planning, Wilson, Parmar and Kirkland (1992) state that, "The reason for doing capacity planning is simple. Its purpose is to forecast when the 'system' will no longer be able to deliver the required service. Forecasting must be done at a point early enough however, to allow sufficient time for the planning, budgeting, and implementation of required upgrades", (pp. 1-2).

In the literature, it appears that most capacity models are designed for a manufacturing environment. The proposed focus of this research is to apply capacity planning to a service environment. Specifically, to design a model to predict necessary staff levels, and number of machines, (i.e. computer terminals), for a paperwork process. More specifically, this model is designed to plan for processing customer responses from a marketing campaign. During marketing campaigns, potential customers are contacted via radio/television commercials or direct mail solicitation. Responses arrive within a definite time period, often with an endpoint, as when an offer expires on a predetermined date. Companies employ large amounts of resources on a temporary basis to handle telephone calls or returned mail.

c. A Changing Environment for Banking

Recent trends in the service sector, especially banking, have created opportunities for developing more sophisticated planning models.

Although in recent years, due to economic conditions, there have been employee layoffs in both the manufacturing and service sectors, one major long-term trend is the growth of jobs in the service sector relative to the manufacturing sector. Because of this, and also major competitive, consumer, technological and legal trends during the past decade, service organizations such as banks can take advantage of centralization, specialization of function and other strategies previously available only to manufacturing organizations. These trends are described below.

Years ago, most banking activities took place at the local branch. All activities including posting deposits and payments, generating statements, granting credit approvals, collecting delinquent debts, transferring funds, obtaining responses to questions and resolving problems took place at the branch. More recently, because of advances in technology, many of these customer services can be provided from central locations. Customers can still "walk in" and "mail in", but with increased use of 800 numbers, it's more convenient for customers to "phone in". With access to worldwide networks of Automated Teller Machines (ATMs), Home

Banking Networks, Electronic Funds Transfer and Voice Response Units, whereby customers can access account information, transfer funds, and place orders via a touch tone phone, consumers can also "zap in".

Since there are new modes of communication and access, it is no longer necessary for customers to be close to their branch for many banking services (safe deposit boxes are a notable exception). "Products" aren't shipped, they are mailed. It costs the same $.32 whether a statement is mailed within the same town or across the country.

Deregulation enables banks to offer more products, and offer these products across state lines. From one perspective, increasing the potential customer base nationwide offers a great opportunity to expand business. However, from the other perspective, banks that previously enjoyed a measure of competitive protection from out-of-state banks and "non-banks" offering banking products are under intense competitive pressure to become increasingly efficient. Recent trends toward banking mergers and acquisitions increase the size of banks.

In addition, consumers are more sophisticated. Years ago, consumers were more likely to have all banking services such as deposit accounts, retirement accounts, loans, mortgages, etc., at one bank. Today, customers are more likely to shop around due to the additional variety of

products and the easy access to banking services regardless of location. Banks have changed the way they market to potential customers. There is greater use of national advertising and direct mail solicitations.

All of the above factors created the unprecedented opportunity for banks to centralize services. The majority of bank employees are now specialists, not generalists. This large concentration of individuals performing identical jobs led to the development of specialized processing equipment such as Automated Call Distributors (ACDs) for departments comprised of hundreds of customer service representatives, and optical imaging systems for handling large volumes of paperwork.

d. Justification for Research: Contribution to the Literature

Prevalent in paperwork processing is rework due to customer error. Any customer-generated items with omitted or incorrect information are returned to the customer, or a letter sent, to obtain the required information before processing can resume. During this stage, there is attrition, since only a percentage of customers respond to the request, and then repair work for the returned items. The resubmitted items have a variable return time that is outside the control of the company, since some customers forward information promptly, and others delay response.

The effects of both attrition and variable return time are modeled in the same stage to produce a capacity plan that accurately reflects a paperwork environment.

The existing models reviewed in the literature are not applicable for three major reasons. First, the loss of control that occurs when customers do part of the processing is not accounted for. Second, many of the underlying assumptions of established models, such as a steady state environment, Poisson arrivals, and others do not hold. Third, the complexities involved with rework loops, variable return time and campaign demand are not included in the models reviewed.

In light of the continuing growth of jobs in the service sector, nationwide customer bases for service organizations, the increase in direct mail solicitation by financial service organizations, and the competitive nature of business, developing models for the service industry represents a relevant and fruitful direction for research.

As the larger banks become more like the factories of their manufacturing counterparts with regard to division of labor, specialization of function, uniformity of processing, and increased mechanization, there is tremendous opportunity to develop management tools for banking, similar to those that have served the manufacturing industry so well for decades. The new banking organizations require much

different tools to manage than in previous decades. Developing analogous tools to those used in manufacturing could have a significant impact on the efficiency of the banking industry as a whole. This dissertation is one step toward developing these tools.

Begley, Kainen and Maggard (1983) note that in many service areas, "managers do not have the benefit [as in manufacturing] of established traditions, long term industry experience or procedural applications from research to guide their efforts," (p. 220). This dissertation aims to prove that, with appropriate extensions to accommodate certain unique characteristics, a capacity plan for a paperwork process with campaign demand can be successfully modeled.

e. Statement of Research Objectives

The overall goal of this research is to design a capacity planning model for a multistage paperwork processing environment that is campaign demand driven and features possible return to customers with attrition and variable return time. This research study is designed to:

1) Identify and study the factors and variables important to this environment.
2) Gain insight regarding how these factors relate to each other.
3) Identify relevant measures of performance.

4) Develop a general model to capture the effects of campaign demand and loss of control when customers partially process the work.
5) Model the complex system of an actual processing environment.
6) Adapt and implement the model in a paperwork processing environment.

f. Goals for the Model

The major goals of the proposed capacity planning model are to:

1) Determine needed staffing levels to process forecasted volumes.
2) Identify where there exists an under capacity situation, indicating that without overtime or temporary help, throughput goals will not be met.
3) Determine where there exists an over capacity situation, indicating that there are excess resources that may be redeployed for other job tasks.
4) Provide for scenario analysis. To provide information regarding how a change in productivity, an increase in volume, a routing change, etc., will impact volume, costs and resource requirements.

5) Put the capacity plan into a Personal Computer (P.C.) format to facilitate ease of use and ease of revision.

Evidence that the model's extensions and modifications are practical is provided by applying the model to an actual paperwork process in a major US banking corporation. The model is used as a planning tool for processing work resulting from marketing campaigns. The development of the model, including the role of feedback from department managers is described later.

g. Relationship to Existing Work

While developing a capacity model tailored to the situation under study, principles and concepts learned from previous research in the field of Management Science serve as a foundation. For example, from queuing theory, we learn of the importance of knowing the timing and magnitude of incoming work and reliable service rates in order to handle throughput and achieve wait time goals.

From Materials Requirements Planning (MRP) and scheduling, we are aware of the critical nature of dependent demand, scheduling resources and time phased demand. It is not enough to plan the final output. All processes and stages contributing to the final output must be viewed individually for workload and resources in order to meet the overall goal.

From the Management Information Systems (MIS) field we know of the importance of having good information to base decisions on. If a process cannot be measured it cannot be managed. Also from MIS research, we know that decision support systems can be a tremendous help for evaluating alternative scenarios, strategies and policies.

Inventory modeling demonstrates that, to be cost effective, tradeoffs must be quantified for idle capacity, potential backlogs and expansion policy (number of people to hire).

Strategic Management teaches that effective strategic implementation at the tactical level is critical to the success of the overall strategic plan. In this case, the major strategy is to increase new business by mass solicitations. The implementation plan designs the operational processes to book new accounts. Capacity planning supports implementation of the strategic plan.

The current model will incorporate all of the above key principles.

h. Relevance to Other Fields of Business

Although this dissertation is written within the field of Management Planning Systems, there is relevance to other fields of Business Administration. They are listed below:

- Marketing - This model is designed to plan capacity in response to a mass solicitation marketing

campaign. The model is capable of analyzing the impact of different response rates. Response rate is defined as the percentage of individuals who respond to the solicitation.

- Industrial Psychology/Organizational Behavior - Campaign demand driven activities employ large numbers of individuals on a temporary basis, which have implications for recruitment and training. Interface issues arise since processing often crosses departmental or divisional lines. There are co-ordination issues since people, not machines are primarily processing the work. Also, merely observing a process can bring changes to that process, the "Hawthorne Effect".
- Accounting/Finance - Allocating resources necessarily involves the responsible use of funds, including budgeting and unit cost analysis. The cost trade-offs between labor and backlogs effect the allocated level of resources.
- Statistics - There is relevance in the areas of Simulation, Quality Control and Probability. Regarding Simulation, the ability to test changes in assumptions is a major part of the model. The model strives to correspond to the situation it represents. For Quality Control, goals for

timeliness of processing are an integral part of service goals. Backlogs that lead to delays can cause customer dissatisfaction, postpone revenue streams and possibly cause customers to cancel accounts. If a new customer waits too long for a requested product or service, the new business relationship starts out with a negative bias. Since all items will not follow the same path, and the need for exception processing is under the control of the customer, not the organization, the amount of work to be processed by different areas is a probabilistic function.

i. Limitations of the Study

This model is applicable to a processing environment that assumes incoming work can be forecast with a reasonable degree of accuracy. Also, since there are massive computations embedded in the model, a Personal Computer is needed for implementation. The model was tested during one marketing campaign. A broader validation would test the model for multiple marketing campaigns over a period of several years.

j. Nature and Order of Presentation

In Chapter 2, the existing literature is reviewed, including a summary of various approaches to capacity planning, applied models and case studies, success factors

for models, applications to quality control and customer service, and a critical evaluation of literature.

Chapter 3 reviews the conceptual framework, general model and methodology, including comparison and contrasts for the manufacturing vs. service environment, a statement of purpose and objectives, and a description of the general capacity planning model (descriptive and prescriptive).

Chapter 4 details the development of the model regarding experimental design, and adaptation to an actual case study. This chapter contains a description of the processing environment, types of data collected and methodology, and a description of the applied models.

Chapter 5 discusses model implementation, data collection, data analysis and model validation. Topics covered also include a comparison of planned to actual and an assessment of the strengths and weaknesses of the model.

Chapter 6 is a summary and suggestions for future research. Here are conclusions with respect to model validation, extensions and further applications.

There are four appendices, containing scenario analysis, spreadsheets for the General Capacity Planning Model, mathematical notation for the general model, and the Applied/Actual Capacity Planning Model, respectively.

CHAPTER 2
REVIEW OF EXISTING LITERATURE

a. Overview of Research and General Findings

In the capacity planning literature, models generally fall into two categories:

1) Models that specify a given production level and require the determination of resources to achieve the goal.
2) Models that specify a given level of resources and require a determination of the amount of product that can be produced.

Based on a review of the literature, capacity planning is a two-step process. The first step is predictive with regard to output (demand) or resources (supply). The second step, following the paradigm of the first, can be descriptive or prescriptive. Descriptive models detail what the situation will be given the first step. Prescriptive models, or optimizing models give instructions regarding how to get the best results given the first step.

Most models were originally designed for a manufacturing environment. However, in the recent literature, a number of authors have adapted capacity planning models to service

environments such as health care, computer configurations and airline travel. A rich variety of assumptions are included by various authors for the models reviewed. Some of the more prominent differences regarding assumptions are:

- Steady state, vs. not steady state.
- Variable or constant transport time between stages.
- Whether attrition occurs at any stage.
- Variable or constant service/process time per item.
- Variable or constant arrival rate of items. If variable, the arrival is assumed to be from the following; replacement from a predetermined list, via Monte Carlo simulation or according to the Poisson or Normal distributions.
- Types of givens or constraints include; resources, constrained resources, production/demand level, cost constraints, or service level requirements.
- Objectives, or information resulting from the model include; items produced, resources required, resources required subject to constraints, costs, a schedule of activities, or service level.
- Effects of a learning curve or other impact on efficiency vs. constant production rate over the planning horizon. With a learning curve, as newer employees become more experienced, items processed

per hour increases due to enhanced familiarity and knowledge of job tasks.

- Whether items are produced singly or in lots or batches.
- Whether inventories or safety stocks are used to buffer fluctuations in demand or productive capacity.
- Fixed vs. variable workforce.
- Whether the approach is prescriptive, (gives instructions to get the best result), or descriptive, (what will happen given the circumstances).
- Whether the model provides for scenario analysis.
- If items are processed according to "first in - first out" (FIFO) or another order such as a priority order. In FIFO processing, items are processed in the order that they are received.
- If production comprises multiple products or a single product.

The above provides a general overview of the nature and character of the variety of variables and assumptions included by authors in the literature. More detail is provided about these models in the following section. Also, please refer to the summary grid, Table 2-1, at the end of this chapter.

b. Review of Capacity Planning Literature

1) Summary of various approaches to capacity planning. While reviewing the variety of approaches it is important to note that capacity planning cannot be addressed in isolation. Capacity planning is part of the greater whole of strategic and operations planning that is embedded in, overlaps, and interacts with other planning frameworks. There are several approaches to capacity planning because there are several approaches to production planning. The method of capacity planning used reflects the nature and character of that greater process. Some of the major approaches are the following; queuing analysis, inventory models, MRP/Scheduling, simulation, decision support systems (DSS) and special adaptations for computer systems.

Some of the following authors' models could be classified under more than one approach. In this study, when there is more than one applicable category, (i.e., a decision support system using queuing theory), the categorization is according to the underlying theory (i.e., queuing theory) rather than the manner or purpose for which the model is used (i.e., decision support system). The following is an overview of models grouped by classification.

Queuing Theory. Rao (1992) states that, "Three major areas of manufacturing management where queuing theory and

analysis can be applied are (1) capacity planning and control, (2) job shops and, (3) FMS and FAS - flexible manufacturing systems and flexible assembly systems", (p. 221). He notes that manufacturing situations are analogous to queuing models since, "The work centers are servers, the jobs arriving are the inputs, the finished jobs are the outputs, the work performed at the center is the service, the WIP [work in process] are the queues. In general, what obtains is a G/G/S queuing network. To improve manufacturing efficiency, one has to control WIP, assign priorities, vary capacity of work centers (service rates, number of machines, etc.), batch jobs and improve throughput. These find obvious equivalents in queuing analysis", (p. 222).

Lazowska (1984) states that, "Queuing network models have emerged as the preferred performance modeling technology for many capacity planning applications," (p. 48). His definition is as follows, "A network of queues is a collection of service centers, which represent system resources (e.g., processors, disks), and customers, which represent users or transactions", (p.49). Solberg (1981) developed a model for capacity planning with a stochastic work flow that assumes queuing characteristics with regard to resource utilization. A computer program "CAN-Q" was developed to perform calculations.

Van Hee and Wijbrand's (1988) capacity planning model is a decision support system for container terminal planning based on queuing networks.

Characterizing a flexible manufacturing line as an M/G/1 queue system, Chow (1986) developed a model to evaluate various line configurations, seeking to optimize capital investment and space utilization.

Srikar and Vinod (1989) designed a closed queuing network performance model for capacity planning in a landing gear shop at American Airlines.

In the health care area, Fandel and Hegemann (1989) developed a queuing model for a diagnostic system (areas for sonograms, x-rays, endoscopy, etc.), in a hospital in Germany. After rearranging aspects of the system, the average total load of the diagnostic system increased by 18% and average patient waiting time decreased by 20%, (p. 220).

Several authors adapted queuing models for computer systems capacity planning. Trivedi and Wagner (1979) developed a model for computer configurations. They formulated the design problem as a decision model for closed queuing networks.

Dutta and Lim (1992) implemented a multiperiod capacity planning model for computer networks, "Using standard assumptions of Poisson arrival of external traffic at each node, Exponential packet length distribution, infinite

buffers and error-free links, each link can be regarded as an M/M/1 queue...", (p. 692). Installation and maintenance costs are added to the model, to assess the overall consequences of expansion.

Likewise, Deitch (1982) developed an analytic model for Customer Information Control System (CICS) capacity planning. This provided a "tool that can predict on-line system performance as a function of a business's increasing workload", (p. 454). The model evaluates the impact of expanding memory or increasing speed by obtaining additional equipment.

Inventory Models. Other authors base capacity planning models on inventory models. Collier (1980) notes the importance of determining, for capacity management, the tradeoffs for setup costs, inventory carrying costs, and capacity change costs when determining lot sizes.

Tang (1990) designed a model for a multi-stage production system assuming uncertain output rates at each stage and uncertain demand for the finished product. This approach makes production rate adjustments to regulate the inventory level at each stage. Although a production model, Tang considers this model useful for capacity planning since constraints on production can be imposed.

Luss (1984) developed a deterministic multiperiod capacity expansion model that seeks to determine the optimal

expansion policy and minimize the total costs for capacity expansion, idle capacity and shortages, over multiple time periods. Luss states that this expands the classical dynamic lot size model produced by Wagner and Whitin.

MRP and Scheduling. The following section focuses on MRP and scheduling based capacity planning models. General inventory models assume independent demand. The MRP approach for managing inventories assumes dependent demand for items. Demand for component parts is dependent on the overall production schedule for end-items. We begin by defining MRP terminology.

In the area of scheduling, Hendry and Kingsman (1989) note differences with regard to capacity planning between make-to-stock (MTS) companies and make-to-order (MTO) companies. Capacity in MTS companies is, "Based on forecast demand. Planned well in advance. Adjusted later if necessary", (p. 1). For MTO companies, capacity planning is, "Based on receipt of customer orders. Cannot be planned for in advance", (p. 1). He notes that the nature of production scheduling and capacity control systems must be adapted to the special needs of each.

Fisher and Archer (1991) define MRP as, "...an information system used to plan and control all manufacturing activities within an organization. It consists of data and procedures through which demands for

end products are translated into requirements for parts and components by means of parts data, bills of material, production routings, work center data and so on...In MPS [Master Production Scheduling], a schedule of required end products to satisfy a sales demand is planned. Starting from this, requirements planning generates details of all components and parts needed to meet the planned sales demand by exploding the MPS plan through the bills of material, to determine the total quantity of each component required", (p. 114).

Schuelke (1992) provides a definition of MRPII, a refinement of MRP, "MRPII basically consists of several modules - master production planning, requirements planning, capacity planning, shop floor control, and production accounting - that support the process of procuring and converting raw materials into finished products", (p. 16).

Within MRP, capacity planning is defined as the following by Lankford (1990), "Capacity planning, of course, means for most companies capacity requirements planning - a future projection of the output required by each work center in each time period in order to produce on time the products in the master schedule", (p. 40).

Within the literature using an MRP framework, the clearest examples of integrating capacity planning with the overall planning process are found. Using an MRP framework,

Afentakis (1985) proposed a model to integrate the lot-sizing and the job sequencing problem for multistage systems with capacity constraints.

Also using an MRP framework, Bahl and Ritzman (1984) developed a mixed integer nonlinear programming model to integrate master scheduling, lot sizing for components and changing capacity. In a study by Blackburn and Millen (1984), the objective was stated to be, "Rather than treat capacity planning as a separate module in the production planning process, the objective here is to integrate it with the MRP lot-sizing process", (p. 84). In their study, capacity restrictions are constraints on lot-sizing decisions. The effectiveness measure is the sum of system holding and ordering costs over the planning horizon.

Other authors view capacity planning as more of a loading and scheduling decision. For Sadowski, Waller and McNeely (1981), capacity planning is considered to be the machine loading problem. The capacity plan determines whether the production plan is feasible, and if necessary, revises the production plan. Their model was applied to a division of General Motors that produced machined component parts for vehicles.

Cheng (1990a) took a product load profile (PLP) approach to capacity planning in MRP, "The PLP of a product is essentially a time-phased demand of all constituent parts

and components making up the product for the type of productive resources provided by the work center", (p. 522). In Cheng's model, capacity plans are developed first by backwards scheduling, and then the work load is reviewed for each work center. Simulation experiments of an actual MRP system generated accurate capacity plans.

To model situations occurring in a production environment, some authors include the effect of set-up costs and lead times. Archer and Harrison (1992) state, "Capacity is consumed by both process and set-up/clean-down times, and the sequencing of jobs can dramatically alter the effective capacity of the plant", (p. 97).

The model developed by Martin (1989) takes into account all production steps and lead times. The constraint of finite capacity for each type of product was introduced to an MRP system, and simulation evaluated several campaign plans.

Holt, Modigliani and Simon (1955) developed a decision rule for production scheduling problems, to determine production rate and workforce size.

Simulation. For other authors, the main approach of their research is simulation. As per Mellichamp's (1984) definition, "Simulation can be defined as a procedure in which experiments are performed on a model of a system in order to determine how the system would respond to changes

either in its structure or in its environment", (p. 78). In addition, "Whether we are interested in evaluating a proposed design for a system to be created, assessing the impact of changing a policy, evaluating the feasibility of new products or assessing the impact of additional resources, simulation can give us estimates that describe the efficiency with which inputs are being used", (p. 78).

Marucheck and McClelland (1992), designed a simulation model for a hypothetical Assemble-to-Order firm using a standard MRP system. In a classroom situation, Walker's (1991) simulator used Lotus 1-2-3 to develop a master scheduling plan to balance customer service, inventory investment and factory productivity. Penalty functions were used to arrive at the optimal master plan.

Thinnes and Kachitvichyanukul's (1989) simulation model predicted production output of a printed circuit-board manufacturer, given information such as equipment capacity and manpower levels. This model was used as a decision support tool to study the effects of varying manpower levels and evaluate proposed system changes.

Ravindran, Foote, Badiru et. al. (1989) designed a simulation to allocate personnel, machines and floor space at a modular repair center at Tinker Airforce Base in Oklahoma. This model was successfully employed during a reconstruction (after a fire), resulting in better routing

of parts, reduction of space requirements, reduced flow time, labor savings, equipment savings, and reduced defective rates.

Using the term "simulated scenarios", Hosni and Alsebaise (1987) designed a P.C. based job shop model that projected the effects of acquiring more resources, shifting work loads, increasing work time and subcontracting work orders on measures such as utilization and timeliness/delay of jobs.

Lee, Park and Economides' (1978) simulation model determined the appropriate combination of manpower and equipment resources needed for a Naval Air Rework Facility in California. The above simulations facilitated "what-if" analyses. By changing variables and assumptions, new scenarios were generated.

Decision Support Systems. For other authors, their main goal was to create a decision support system (DSS) to assist managers in the capacity planning process.

Writing of a decision support system called a "visual interactive planning board" at Alcan Aluminum, Walker and Woolven (1991) state, "The computational power and accuracy of the computer provides a method of producing a plan at high speed and presenting the results in a variety of formats", (p. 303).

Eppen, Martin, and Schrage (1989) describe a DSS developed for General Motors to aid in making decisions about capacity for four of their auto lines. They state, "Manufacturing and service firms typically are forced to make capacity decisions before demand is known", (p. 517). Their approach is to start with pessimistic, standard and optimistic forecasts, and evaluate several capacity configurations for each scenario. The capacity configuration yielding the largest profit is selected.

Dijkstra, Kroon et. al. (1991) describe a capacity planning DSS developed for KLM airlines for inspections that take place between the time an aircraft lands and takes off again. "The analysis module enables the analysis of a selected scenario through functions for estimating the workload and the workforce, evaluating the matching between the workload and the workforce, and for generating specifications for the organization of the workforce", (pp. 73-74).

Computer Configurations. Planning for computer networks added a new dimension to capacity planning. The following focuses on a systems approach for computer networks. Lipner (1990) provides a definition, "For a capacity planner, this means supporting the effort to deliver agreed-upon service levels to end-users at reasonable costs, while dealing with changes in both technology and workloads", (p. 5).

For computer systems, Wilson, Parmar and Kirkland (1992), "Divide network capacity planning into three parts, monitoring, planning and design. Monitoring provides the accurate information to check whether the required level of service to do business is being achieved. Planning ensures that the delivery of that service is a continuing process, and design is essential to provide the most appropriate plan for the network", (p. 3). Capacity Management Review (1992) notes that for systems planning, the level of service and workloads are forecasted. Then changes are derived in available resources to meet required service levels.

Chakravarty and Jain (1990) take a two-step capacity planning process for a distributed computer system, "The design objective is to minimize the total cost, which consists of investment costs, processing costs, and the increase in data communication cost due to remote processing of jobs. Once the initial design of the system is complete, a procedure for optimal loading of the system is required. The operation control procedure should balance the load on different processors in the system by considering variations in the cost of processing a transaction, job delays in the system, and communication costs for remote processing", (p. 254). The first step, set up as a resource planning model, determines the level of resources. The second step,

allocation of resources, is set up as a loading problem, and both are solved via linear programming.

2) Applied models/case studies. The following section describes successful applications of capacity planning models to actual situations. Stone (1990) writes of a successful application of capacity planning at Grief Companies, a leading manufacturer of men's clothing. "This function [time phased capacity plan] is used by production planning to see, week by week, how actual demand compares to planned capacity by shop and major garment feature for many months into the future", (p. 102). This identification of potential material shortages enables Grief Companies to take action to prevent missed deadlines.

Macairt and Perros (1982) presented a cost model to determine the optimal (lowest cost) configuration for school meals, taking into consideration the daily intake, size of sittings, number of sittings, type of accommodation, number of ovens and storage capacity. Set up as a dynamic programming model, a Fortran program enumerated all feasible possibilities for the number and size of sittings for a school in Dublin, Ireland.

Randhawa and Pendakur (1990) designed a capacity planning system for a dental equipment manufacturer that automated scheduling and load balancing decisions using a

P.C. program. In this case study, the model also provided database information for sales orders and product structure.

Burd and Kassicieh (1991) developed a decision support system for computer capacity planning at Sandia National Laboratories. The benefits were, "The system met its primary goals of increased mathematical rigor and reduced time to generate acquisition analyses...A by-product of this increase in analysis speed was a substantial increase in the number of scenarios that were evaluated", (p. 376).

Randhawa, Mechling and Joerger (1989) implemented a simulation model for Oregon Motor Vehicle Department offices. One result was increased staff utilization and a decrease in customer wait time.

Harris, Hoffman and Saunders (1987), developed a model based on queuing analysis for the IRS Telephone Taxpayer Information System. This model was successful in determining the number of telephone lines and employees to meet service goals.

It is apparent that capacity planning enables efficient use of resources, benefitting both companies and consumers. Following is a description of factors that result in successful capacity plans.

3) Success factors for models. The literature demonstrates that models are successful if all relevant variables and assumptions are included for the particular

process. Following is a list of factors from various authors that lead to models that are practical and applied.

Management support for capacity planning is crucial. Bryan (1989) states, "Capacity planning should start with a commitment from management to support the concept and fund it", (p. 46). Aitken (1992) states, "The importance of good communication of the results and implications of a capacity plan are essential to better management understanding of the plan, as well as better decision making as a result of the plan. The decision making process needs to travel upward within an enterprise, and there is a need to sell the recommendation at all levels in an organization", (p. 1).

A good forecast for demand is crucial, as Willis and Aby (1988) note, "This estimate of demand for the products is the main ingredient for setting the overall direction of the manufacturing planning and control", (p. 10). Jinks (1991) states, "The key to getting better model results lies not in fine-tuning the model, as many planners believe, but rather in fine-tuning work load estimates", (p. 76).

Bryan (1989) notes the importance of using historical data to make good decisions. With regard to forecasting, fluctuations in demand must be accounted for in order to develop an accurate model. Finlay (1983) developed a production capacity planning model that accounted for a

year-to-year trend, seasonal fluctuations and random, unexplained fluctuation.

Good estimation and relevant measures lead to viable models. Solberg (1981) states, "One of the key elements in successful production planning is the accurate estimation of the productive capacity of available resources", (p. 116).

While evaluating the true productive capacity of a system, a number of authors discuss the role of learning curves. According to Towill (1990), the learning or experience curve is, "an important industrial requirement for many purposes, including costing, process capacity planning, manpower planning, batch sizing and delivery date projections", (p. 25). According to Smunt (1986), "When learning occurs in a firm, its accurate prediction will improve planning", (p. 1175). Pananiswami and Bishop (1991) note that, "Different workers may have different learning rates, but in practice, it may be possible to apply only an average learning rate", (p. 157).

Stevens (1991) states, "One element of a good capacity planning program is an early warning system to give notice of impending difficulties", (p. 3). Also, "Three qualities shared by good measures are utility, trustworthiness, and timeliness; two others are simplicity and directness", (p. 5).

Hegseth (1984) notes that production planning must take into account scrap vs. "good" units since producing scrap consumes resources.

The inter-relatedness of all the various departments that work together on a particular item must be considered. It is important to recognize that a bottleneck in one area effects other areas. As Funk (1989) notes, "Constraints often 'shift' from one area to the next with changes in the product mix or the sales order backlog, quite often creating a 'wave effect' of workload against capacity, cycling from one function to the next throughout the company", (p. 40).

Reid and Asprey (1991) describe success factors for computer performance models that also apply to capacity models in general. They state, "Continual comparisons between planned and actual resource usage scenarios are required to develop effective control procedures", (p. 3). Also, "In addition, the recognition that the behavior of each system component has some effect on the performance of every other part - as well as overall system performance - is critical to productivity enhancing decisions", (p. 5). These authors also note the importance of differentiating variables that are controllable from those that are non-controllable.

According to McCarthy and Barber (1990), tiers of resources should be considered, "The system would not only

check for primary resource (usually machine) availability, but would also check that the secondary resource (e.g. operator) and possibly tertiary resource (e.g. tooling) are available to support the process", (p. 195).

According to several authors, problems occur when capacity planning is treated as if it were an isolated function. Successful capacity plans are integrated into the overall planning process.

Kanet (1988) cautions, "Somehow, over the years, we have contorted the task of manufacturing logistics by assuming it could be parceled into so many individual activities - inventory planning, production planning, capacity planning, as if they were all separable, unrelated functions each having different objectives. We need to get back to the same simple straightforward thinking that people like Henry Gantt used more than half a century ago", (p. 60).

Henderson, Krajewski and Showalter (1982) state that in service organizations, both staff sizing and staff scheduling must be determined, "Given the sensitivity of service organizations to fluctuations in demand, it seems clear that the service level goal must allow for the interdependence between staff sizing and staff scheduling decisions", (p. 62). Problems can arise when staff scheduling decisions are made by lower level staff and staff size decisions are made by upper management. As per their

integrated approach, "...various system inputs must be specified by managers at both the aggregate and detailed levels of decision making. The inputs can be categorized as process and managerial. Process inputs define both the structure of the service system and the impact of uncontrollable variables, and include capacity at the various work centers or departments, productivities, work flow designs, and service requirements. The managerial inputs consist of work system parameters and the criteria to be used to evaluate various aggregate staffing plans. The work system parameters include size limits for a work team and work time constraints", (p. 65).

Askin and Mitwasi (1992) likewise note the importance of integrating various production decisions such as facility layout, process selection and capacity planning. They developed a mixed integer mathematical program for their integrated model.

Berry, Schmitt and Vollman (1982) state, "In choosing a capacity planning technique, it is necessary to consider the entire manufacturing planning and control system, as well as the environment that the firm faces", (p. 23). It is also important to know how the information will be used, and the type of decisions based on the analysis. For example, the approach may be to change the capacity to match the expected

requirements vs. changing the requirements to match the expected capacity, (p. 23).

Working in the health care field, Bain and Wilhelm (1983) compared the applicability of models (capacity rating index, queuing models, semi-Markov process analysis, and CAN-Q), for a surgical intensive care unit. One of their findings highlights the importance of choosing the right model, since the various models can indicate different recommendations based on the same data.

4) Applications to quality control and customer service. For banks and other service providers, capacity planning facilitates presenting a quality product and meeting customer requirements and timeliness deadlines. In light of the pressures on banking such as deregulation, the scope of competition, advances in technology, and more sophisticated consumers, it is imperative that banks become more cost efficient (as well as providing superior quality) in order to attract and maintain customers. Inefficient (over capacitated) banks that pass on excess costs to consumers will not remain competitive. Banks that do not process work in a timely manner due to backlogs and under capacity situations alienate their customer base.

Classen and Malstrom (1982) state, "It is also clear that to be successful, a manufacturing company must produce a reliable product on schedule to meet demand. In order to

accomplish this a company must balance variable capacity requirements with relatively invariable capacity resources", (pp. 73-74). This is analogous to service providers.

According to Lovelock (1992) a concern regarding capacity management is that during periods of high volume, service may be unavailable when needed, or quality may be poor during peak periods.

Likewise for computer systems, Lipner (1989) states, "The economic value of achieving the balance [between demand and supply for computer resources] comes from reducing the risk of a performance slowdown", (p. 51). He notes that the effects of a performance slowdown include lost productivity, late projects, manufacturing slowdown, lost business, loss of customer goodwill, lost customers, and failure to meet reporting requirements, among others.

As is evident in manufacturing, Towill, Davies and Naim (1989) state, "The correct amount of manufacturing capacity within a company is therefore usually a delicate balance. At any point in time the balance may be disturbed by too many orders and too little capacity or vice versa. The former results in poor delivery times to the customer and possibly a loss in further orders, the latter to likely receivership for a company which cannot exist indefinitely with a minimal order book and too much capacity", (p. 56).

Whether a manufacturing or service organization, in order to remain cost competitive, companies must use their resources in an optimal way. Proper planning avoids missed deadlines that result in disappointed and frustrated customers.

c. Critical Evaluation of the Literature

Notably absent are case studies of "what not to do", or problems experienced when trying to design or implement capacity plans. All of the case studies state how wonderful the models are and the good results obtained. There are several reasons why this may be true; 1) companies do not publish accounts of mistakes for fear of bad publicity, 2) the managers or consultants who tried to implement failed programs are not around any longer to write about them, 3) publishers do not think that accounts of failures are relevant topics for their audiences. It seems that information regarding potential pitfalls, and the trial and error process that is part of model development would provide valuable information for practitioners.

There are a number of definition issues inherent in the literature. One is the dichotomy between whether capacity planning determines potential output from designated resources, or whether capacity planning determines resources from projected output. The same term, "capacity planning" is used to refer to both. Other authors have designed pure

production planning models, place a constraint on a particular resource, and then consider it a "capacity plan".

The approach taken here is that capacity planning should start with a goal for output, or, in the case of a service organization, throughput. As previously defined, throughput is the number of items processed or customers served within a particular time period. Capacity planning acquires and arranges the resources needed to achieve the throughput goal. If the level of resources is unattainable, then the capacity plan should predict the effects, and offer information about how to best use the resources available.

Most present models are designed for a manufacturing environment. Models have been designed and adapted for many manufacturing applications. Much good research links capacity planning with other planning techniques, and integrates capacity models as part of the overall planning process. The focus of this paper, as discussed in the introduction, is to apply capacity planning models, principles, and concepts to the service industry. As noted by previous research, this has been successful in computer planning, health care, school lunches and maintenance/repair operations. The key is to choose the right model and adapt the model to the type of production or processing operation studied.

Although capacity planning models in banking are rare, other operations research techniques are presently used. Cheng (1990b) notes that forecasting, statistical analysis and simulation are the most frequently used operations research techniques used in banking, according to a study of commercial banks in the United States. However, the use of statistical techniques in banking seems to be relegated to particular functions. For example, McClure and Miller (1979) state, "Queuing models are essentially used for one problem, teller staffing", (p. 26).

Paperwork processing is a major function for all banks, insurance companies, and other service providers. However, there is a particular commonality in a paperwork process that must be reflected in order to develop an accurate model. One of the distinguishing aspects of a paperwork process is rework due to customer error. Typically, a customer fills out a form (whether to open an account, file an insurance claim, renew a car registration, etc.). If there is an error, (usually omitted or incorrect information), the item is either returned to the customer, or a letter sent to obtain the required information so that processing can resume.

During this stage, there is attrition, since only a percentage of customers respond to the request. Also, the resubmitted items have a variable return time, since some

customers mail the information promptly, and others wait days or even weeks to respond. The effects of both attrition and variable return time must be modeled in order to produce a capacity plan that accurately reflects a paperwork environment. To date, no model has been identified that deals with these two phenomena in a campaign demand environment.

In the literature, there are models that account for variable transport time. However, in these models, the transport operation is under the control of the company. In paperwork processing, whether the item is returned or not and how long the return takes is under the control of the customer. This can only be represented by a probabilistic distribution. To date, no capacity model has been identified that incorporates this return/rework phenomena.

Throughout the literature, where successful capacity planning exists in a non-manufacturing organization, the model's structure and variables are modified or adapted to the individual attributes of the situation. In order to develop and test a model for a paperwork process, the model must be extended to accommodate these unique characteristics.

TABLE 2-1. REVIEW OF LITERATURE MODELS

The legend for symbols follows the table.

	Author	Steady state	Variable transport	Attrition	* Variable service	** Variable arrival	*** Input	**** TBD
1	Afentakis 1985	N	N	N	Y	Y	P	R+,S,C
2	Askin & Mitwasi 1992	Y	N	N	N	N	R,P	C
3	Bahl & Ritzman 1984	N	N	N	N	YL	P	R+,C,S
4	Bain & Wilhelm 1983 (A)	N	N	N	Y	Y	R	O
5	Bain & Wilhelm 1983 (B)	Y	N	N	YE	YP	R	O
6	Bain & Wilhelm 1983 (C)	Y	N	N	YE	YP	R	O
7	Bain & Wilhelm 1983 (D)	Y	N	N	YE	YR	R	O
8	Berry, Schmitt et al 1982 (A)	N	N	N	N	Y,L	P	R,S
9	Berry, Schmitt et al 1982 (B)	N	N	N	N	Y,L	P	R,S
10	Berry, Schmitt et al 1982 (C)	N	N	N	N	Y,L	P	R,S
11	Berry, Schmitt et al 1982 (D)	N	N	N	N	Y,L	P	R,S
12	Blackburn & Millen 1984 (A)	Y	N	N	N	N	R,P	C
13	Blackburn & Millen 1984 (B)	N	N	N	N	Y	R,P	C
14	Burd & Kassicieh 1991 (A)	-	-	N	-	-	C	O,R
15	Burd & Kassicieh 1991 (B)	-	-	N	-	-	P	C,R
16	Burd & Kassicieh 1991 (C)	-	-	N	-	-	P	C,R
17	Chakravarty & Jain 1990	N	N	N	N	N	R,P	C
18	Cheng 1990a	N	N	N	YN	YL	P	R
19	Chow 1986	Y	Y	Y	N	YP	R,L	O
20	Deitch 1992	Y	N	N	YE	YP	P	R
21	Dervitsiotis 1981 (A)	N	N	Y	N	N	P	R
22	Dervitsiotis 1981 (B)	N	N	Y	N	YL	P	R,S
23	Dijkstra, Kroon et al 1991	N	N	N	Y	YL	P	R+,S,C
24	Dutta & Lim 1992	Y	-	N	YE	YP	L,P	C,R
25	Eppen, Martin et al 1989	Y	N	N	N	Y	R,P	C
26	Fandel & Hegeman 1989	Y	N	N	YE	YP	R	O
27	Finlay 1983	N	N	N	N	Y	P	O,C

TABLE 2-1. REVIEW OF LITERATURE MODELS (CONTINUED)

	Author	Steady state	Variable transport	Attrition	* Variable service	** Variable arrival	*** Input	**** TBD
28	Hax & Candea 1980 (A)	N	N	N	N	YL	P,R+	R,S
29	Hax & Candea 1980 (B)	N	N	N	N	YL	P,R	R,S
30	Hax & Candea 1980 (C)	N	N	N	N	Y	P,R+	C
31	Hax & Candea 1980 (D)	N	N	N	N	Y	P,R	C
32	Hax & Candea 1980 (E)	N	N	N	N	Y	P	O,S
33	Hax & Candea 1980 (F)	N	N	N	N	Y	P	O,S,R
34	Henderson, Krajewski, Showalter 1982	N	N	N	N	Y	P	R+,S,C
35	Holt, Modigliani & Simon 1955	N	N	N	N	Y	P,R	C
36	Hosni & Alsebaise 1987	N	N	N	N	YL	R,P	S
37	Lazowska 1984	Y	N	N	Y	YP	R,P	O
38	Lee, Park et.al. 1978	Y	N	N	YN	YM	L,P	R
39	Macairt & Perros 1982	Y	N	N	N	N	P	R,C
40	Martin 1989	N	Y	N	N	Y	R,P	S
41	Marucheck & McClelland 1992(A)	Y	N	N	YN	YN,YL	R,P,L	L,C
42	Marucheck & McClelland 1992(B)	Y	N	N	YN	YN,YL	R,P,L	L,C
43	Mole 1975	N	N	N	Y	YL	P	R
44	Randhawa & Pendakur 1990	N	N	N	N	Y	R,P	S,C
45	Ravindran, Foote et al 1989	Y	N	N	Y	Y	P	R
46	Sadowski, Waller & McNeely 1981	Y	N	N	Y	N	R	O
47	Solberg 1981 (A)	Y	N	N	N	N	R	O
48	Solberg 1981 (B)	Y	N	N	Y	YR	R	O
49	Srikar & Vinod 1989	N	Y	N	YE	YP	P	R
50	Tang 1990	Y	N	Y	-	N	P	R+,O,C
51	Thinnes & Kachitvichyanukul 1990	N	N	N	Y	Y	R	O,C
52	Trivedi & Wagner 1979	N	N	N	Y	YL	P,C	R+
53	Van Hees & Wijbrands 1988	Y	Y	N	N	YP	R	O
54	Walker 1991	N	N	N	N	Y,L	P	O,R,S

TABLE 2-1. REVIEW OF LITERATURE MODELS (CONTINUED)

	Author	Learn/ Efficiency	Batch/ lot size	Inventory/ safety stock	Variable Workforce	Optimize/prescriptive	Scenarios	FIFO
1	Afentakis 1985	N	N	Y	Y	N	N	N
2	Askin & Mitwasi 1992	N	N	N	N	Y	Y	Y
3	Bahl & Ritzman 1984	N	Y	Y	Y	N	N	-
4	Bain & Wilhelm 1983 (A)	N	N	N	N	N	Y	Y
5	Bain & Wilhelm 1983 (B)	N	N	N	N	N	Y	Y
6	Bain & Wilhelm 1983 (C)	N	N	N	N	N	Y	Y
7	Bain & Wilhelm 1983 (D)	N	N	N	N	N	Y	Y
8	Berry, Schmitt et al 1982 (A)	N	N	N	N	N	N	Y
9	Berry, Schmitt et al 1982 (B)	N	N	N	N	N	N	Y
10	Berry, Schmitt et al 1982 (C)	N	N	N	N	N	N	Y
11	Berry, Schmitt et al 1982 (D)	N	Y	Y	N	N	N	Y
12	Blackburn & Millen 1984 (A)	N	Y	Y	N	Y	Y	Y
13	Blackburn & Millen 1984 (B)	N	Y	Y	N	Y	Y	Y
14	Burd & Kassicieh 1991 (A)	Y	-	N	N	Y	Y	-
15	Burd & Kassicieh 1991 (B)	Y	-	N	N	Y	Y	-
16	Burd & Kassicieh 1991 (C)	Y	-	N	N	Y	Y	-
17	Chakravarty & Jain 1990	N	N	N	N	Y	Y	N
18	Cheng 1990a	N	Y	Y	N	N	Y	N
19	Chow 1986	N	N	N	Y	N	N	Y
20	Deitch 1992	N	N	N	N	N	Y	N
21	Dervitsiotis 1981 (A)	Y	N	N	N	N	N	Y
22	Dervitsiotis 1981 (B)	Y	N	N	N	N	N	Y
23	Dijkstra, Kroon et al 1991	N	N	N	Y	Y	Y	Y
24	Dutta & Lim 1992	N	-	N	N	Y	Y	-
25	Eppen, Martin et al 1989	N	N	N	Y	Y	Y	Y
26	Fandel & Hegeman 1989	N	N	N	N	N	N	Y
27	Finlay 1983	N	N	N	Y	Y	Y	Y
28	Hax & Candea 1980 (A)	N	N	Y	N	Y	N	-
29	Hax & Candea 1980 (B)	N	N	Y	Y	Y	N	-

TABLE 2-1. REVIEW OF LITERATURE MODELS (CONTINUED)

	Author	Learn/ Efficiency	Batch/ lot size	Inventory/ safety stock	Variable Workforce	Optimize/prescriptive	Scenarios	FIFO
30	Hax & Candea 1980 (C)	N	Y	Y	N	Y	N	-
31	Hax & Candea 1980 (D)	N	Y	Y	Y	N	N	-
32	Hax & Candea 1980 (E)	N	N	Y	Y	Y	N	-
33	Hax & Candea 1980 (F)	N	N	Y	Y	Y	N	-
34	Henderson, Krajewski, Showalter 1982	N	N	N	Y	Y	Y	Y
35	Holt, Modigliani & Simon 1955	N	N	Y	Y	Y	N	-
36	Hosni & Alsebaise 1987	Y	N	N	Y	Y	Y	N
37	Lazowska 1984	N	Y	N	N	N	Y	N
38	Lee, Park et.al. 1978	N	N	N	Y	Y	Y	-
39	Macairt & Perros 1982	N	Y	N	Y	Y	Y	Y
40	Martin 1989	N	Y	Y	N	Y	Y	N
41	Marucheck & McClelland 1992(A)	N	Y	N	N	N	Y	N
42	Marucheck & McClelland 1992(B)	N	Y	Y	N	N	Y	N
43	Mole 1975	N	N	N	N	Y	Y	-
44	Randhawa & Pendakur 1990	N	N	N	N	Y	N	N
45	Ravindran, Foote et al 1989	N	N	N	Y	N	Y	Y
46	Sadowski, Waller & McNeely 1981	Y	N	N	N	N	Y	Y
47	Solberg 1981 (A)	Y	Y	N	N	N	Y	Y
48	Solberg 1981 (B)	Y	Y	N	N	N	Y	Y
49	Srikar & Vinod 1989	N	N	N	Y	N	N	Y
50	Tang 1990	N	N	Y	Y	N	-	Y
51	Thinnes & Kachitvichyanukul 1990	Y	N	N	Y	N	N	Y
52	Trivedi & Wagner 1979	N	N	N	N	Y	Y	Y
53	Van Hees & Wijbrands 1988	N	N	N	N	N	Y	Y
54	Walker 1991	N	N	Y	Y	Y	Y	-

TABLE 2-1. REVIEW OF LITERATURE MODELS (CONTINUED)

	Multi product	Situation	Criteria/Measures	Solution Method
1	Y	Production/MRP	Cost	Machine Loading Heuristic/MRP
2	Y	Production	Profit	Mixed Integer Mathematical Programming
3	Y	Production/MRP	Cost	Mixed integer nonlinear programming iteration
4	Y	Hospital Beds	Utilization, p(not enough beds)	Cap Rate Method/ Normal Distribution
5	Y	Hospital Beds	Utilization, p(not enough beds)	Queuing Computation
6	Y	Hospital Beds	p(not enough beds)	Semi Markov process analysis/Erlang Loss
7	Y	Hospital Beds	# in queue, # serviced, wait/service time	CAN-Q
8	Y	Production	Allocate staff for time periods to work centers	CPOF (capacity planning using overall factors) computation
9	Y	Production/MRP	Allocate staff for time periods to work centers	Capacity bills, computation (change product mix)
10	Y	Production/MRP	Allocate staff for time periods to work centers	Resource profiles, computation
11	Y	Production/MRP	Allocate staff for time periods to work centers	Capacity requirements planning, computation
12	N	Production/MRP	Total Cost (holding and ordering)	Branch and Bound
13	N	Production/MRP	Total Cost	Lot Size Heuristics
14	N	Computer configuration	Maximize capacity	Integer programming
15	N	Computer configuration	Cost	Integer programming/ branch and bound
16	N	Computer configuration	Cost subject to budget increase percentage	Integer programming/branch and bound
17	Y	Distributed Systems	Minimum cost (process +switching + delay + penalty)	Linear programming
18	Y	Electronic/MRP	Load per unit, standard unit manufacturing time	Product load profile/ timing of demand, simulation
19	N	Production	Wait time, Utilization (queue)	Sequential Search
20	N	Computer Configuration	Volume of transactions, transaction time (queue)	Computation
21	N	Single stage production	Number of machines	Computation
22	N	Multi stage production	Number of machines	Computation
23	N	Airline Inspections	Labor Cost	Integer Programming, Lagrangian relaxation
24	N	Computer communications network	Cost, routing (queue)	Integer programming/ Lagrangian relaxation
25	Y	Auto manufacturing GM	Total cost	Stochastic mixed integer linear programming
26	Y	Hospital Patients	Patients waiting, time waiting	Queuing Computation
27	Y	Cigarette production UK	Total cost	Generation of multiple scenarios/ enumeration
28	Y	Production (OT allowed)	Cost	Linear programming

TABLE 2-1. REVIEW OF LITERATURE MODELS (CONTINUED)

	Multi product	Situation	Criteria/Measures	Solution Method
29	Y	Production	Minimum cost, minimum inventory, meet schedule	Goals Programming
30	Y	Production	Cost	Capacitated lot size model, fixed workforce
31	Y	Production	Cost	Capacitated lot size model, variable workforce, 2 stage
32	Y	Production	Accuracy of schedule	Bowman, regression past behavior heuristic
33	Y	Production	Cost	Heuristic followed by search
34	N	Post Office	Minimum cost subject to service levels	Goal Programming
35	N	Paint Factory	Total Cost (labor, inventory, backorder, set up)	Quadratic cost/Linear decision rule
36	Y	Production	Utilization, p(not enough beds)	Forward & backward machine loading
37	N	Computer systems	Throughput, # in system, response time	Queuing models
38	Y	Repair Navy aircraft	Cost	Analysis and simulation
39	N	School Lunches	Total Cost (Size ovens, # seatings, storage space)	Enumeration
40	Y	Chemical manufacture	Lead times	Backward scheduling, simulation
41	Y	Electronics production/MRP	Cycle time, average lateness, % on time	Simulation in MRP
42	Y	Electronics production/MRP	Cycle time, average lateness, % on time	Simulation in MRP
43	N	Fleet vehicle size	Cost	Dynamic programming/recursion
44	Y	Dental Equipment	Total Cost , early/late jobs, overtime	Scheduling, Workload Balancing
45	Y	Air Force Repair	Volume, flow time, Utilization	Simulation
46	Y	Autoparts/MRP	Output, Machine time required, key machine utilization	Forward & backward machine loading
47	Y	Production	Output, workload, mean time operation	Computation
48	Y	Production	Output, Workload, Server Utilization, p(k units at i)	Computation/Queuing/CAN-Q
49	Y	Landing Gear	Utilization, queue length, work time	Heuristic Search, network of queues
50	N	Production	Costs, decrease of variability	Inventory Model with Simulation
51	Y	Circuit Boards	Minimum cost to schedule all jobs	Simulation
52	N	Computer Configuration	Throughput	Lagrangian Multiplier, closed queuing network
53	Y	Container terminals (shipping)	Mean wait, utilization, throughput	Mean value analysis, DSS, queuing networks
54	Y	Production	Goals met using penalty function	Simulation, penalty functions

Legend for Literature Review Model Summary

General

Y = Named as an input or outcome

N = Not an input or outcome

\- = Cannot determine whether an input or outcome

(A),(B),... = Multiple models within the same reference

* = Variable Service Rate

YE = Exponential

YN = Normal

** = Variable Arrival Rate/Demand

YR = Replacement

YP = Poisson

YM = Monte Carlo Simulation

YN = Normal

YL = Predetermined List

*** = Input/Given

R = Resources (# machines, # workers, etc.)

R+ = Resource Constraints (# machines, # workers, etc.)

P = Production/Demand Level

C = Cost constraint for resources

L = Service level requirement

**** = TBD (To Be Determined by Model)

O = Output, Items Produced/Processed

R = Resources Required

R+ = Resources Required Subject to Constraints

C = Cost

S = Schedule of Activities

CHAPTER 3
CONCEPTUAL FRAMEWORK, GENERAL MODEL AND METHODOLOGY

In this chapter, a capacity planning model is presented for a general paperwork processing situation with variable customer returns. This chapter describes the conceptual framework, general model and methodology, including comparison and contrasts for the manufacturing vs. service environment, and a statement of purpose and objectives. Descriptions of the general capacity planning models (descriptive and prescriptive) include variables, parameters, assumptions, and equations.

To begin, it is important to understand the differences between manufacturing and service since variables, assumptions, and parameters may vary between types of models.

a. Comparison and Contrasts for the Manufacturing vs. Service Environment

The similarities between types of companies are examined first. Snyder, Cox and Jesse (1982) state that the identification of similarities between manufacturing and service permits the use of proven management techniques regardless of the organizational classification. According

to Ruch, Adam and Hershauer (1979), "Banks are organizations using people, machines and materials to deliver products and services to customers. They are subject to many of the same problems as other manufacturing or service organizations", (p. 47).

Like manufacturing, capacity plays a critical role in service organizations, as Lovelock (1992) notes, "Capacity planning is vital in capacity constrained service organizations which need to match productive resources to fluctuating demand levels. It helps to keep costs down by avoiding wasteful under-utilization of people, buildings and machines when demand is low. It also minimizes lost revenues from customers turned away during peak periods. Finally, it reduces the risks that staff and employees will become bored and sloppy as a result of having too little to do or burn out as a result of being overworked and under excessive pressure", (p. 26). Turnover or attrition rates may be impacted by poor planning.

Similar to manufacturing, demand can be altered via pricing. Smith (1979) notes that in the airline industry, when capacity is constrained, a customer can tradeoff a more popular travel time for a reduced fare ticket.

However strong the similarities are, the differences must be acknowledged. According to Henderson, Krajewski and Showalter (1982), service has more reliance on manpower

planning, "The importance of service-oriented organizations to both economic and socio-environmental stability has grown steadily in the last decade. Organizations such as governmental agencies, public utilities, and communications companies have had major influences on the efficient daily functioning of our economic system. As the size and scope of these service organizations grow, the problems of managing them take on added significance. Because most service systems are by their nature highly labor intensive, the manpower management problem is crucial to the economic survival of service organizations", (p. 62).

Faisst, Schneeweiss and Wolf (1991) note for medium term manpower capacity planning, "Two main strategies are available: one can change the number of workers or one can change the length of a shift" [the number of work hours], (p. 90).

According to Henderson, Krajewski and Showalter (1982), "Service organizations, however, have two unique characteristics that must be explicitly considered when approaching the manpower planning problem. First, service organizations cannot accumulate 'finished' services in advance of customer demand. The traditional approach to manpower planning has been to smooth the requirement for manpower by absorbing peaks in demand with finished goods inventory. Obviously, this is not practical for service

organizations. Secondly, the service sector, particularly service organizations that operate under public regulation, is characterized by multiple, conflicting goals regarding service level and costs of providing that service", (p. 62). Krajewski and Ritzman (1977) note that service organizations also have to contend with stringent response time characteristics and time dependent demand rates.

According to Whitt and Whitt (1988), "Capacity planning in manufacturing is primarily a function of machine capacity. In professional services, it is almost entirely a function of head count and how well that head count can be leveraged. Line balancing in manufacturing refers to optimizing the combination of machines so that their output is synchronized and bottlenecks and idle machines are minimized. Comparable planning in professional services would be the prioritizing of work so that those activities that have the highest payoff for the firm are done before those that are easy, interesting, or otherwise personally rewarding. Hiring policies and training in professional services firms would be comparable to materials requirements planning, purchasing, and inventory control. Instead of buying components for its inventory, the firm is stocking its inventory with expertise", (pp. 40-41). As noted previously, Begley, Kainen and Maggard (1983) note that in many service areas, "managers do not have the benefit [as in

manufacturing] of established traditions, long term industry experience or procedural applications from research to guide their efforts", (p. 220).

Berry, Zeithaml and Parasuraman (1985) add that there is a reversal of process, "Goods are manufactured in a factory, then sold, then consumed. For many services the sequence is reversed. First the service is sold, then produced, often in the presence of the customer", (p. 47). In a service environment, demand creates inputs to the system.

Because of the above differences, existing types of models cannot be used without including the types of variables and characteristics inherent in a paperwork process.

b. Statement of Model Purpose and Objectives

As stated in the introduction, if variables and assumptions inherent in a paperwork process are correctly modeled within the framework and structure of a capacity plan, then a model can be designed to:

1) Determine needed staffing levels to process forecasted volumes.
2) Identify where there exists an under capacity situation, indicating that without overtime or temporary help, throughput goals will not be met.
3) Determine where there exists an over capacity situation, indicating that there are excess

resources that may be redeployed for other job tasks.

4) Provide for scenario analysis. To provide information regarding how a change in productivity, an increase in volume, a routing change, etc., will impact volume, costs and resource requirements.

5) Put the capacity plan into a P.C. format to facilitate ease of use and ease of revision.

The model to be presented here is designed to 1) provide an analysis of the situation and, 2) predict the effect of implementing a particular course of action, or change in assumptions.

c. Description of the General Capacity Planning Model: A Descriptive Approach

This section describes the format of a general capacity planning model for paperwork processing with customer rework and attrition in a campaign demand environment, including variables, parameters, structure, transition matrix, and flowchart.

This general model can be implemented as a spreadsheet. A spreadsheet model was chosen for several reasons. Because of the nature of campaign demand (varying demand pattern), each day requires a different level of resources which can be represented by a column in the spreadsheet. Also, since the system will not reach a steady state and work arrivals

are not Poisson distributed, queuing analysis is not appropriate. Semi-Markov analyses are not appropriate since they assume that all states communicate (Ross 1989), however, in this model there are absorbing states. Rework loops, variable return time and attrition make the situation more complex than can be handled by inventory or MRP based models. For example, Karmarkar (1989) states that, "MRP must assume a fixed production environment with fixed lead times", (p. 125). A spreadsheet model can accommodate the best elements of simulation and decision support systems. A spreadsheet does not assume independence between time periods and backlogs from prior days can be modeled easily. As Marucheck and McClelland (1992) state, "However, given the dynamics of the manufacturing environment modeled, the simulation analysis was the preferred methodology as many analytic approaches cannot accommodate dynamic inter-relationships and contain overly restrictive assumptions which compromise reality", (p. 36).

Spreadsheets have the added benefit that many managers use them on personal computers at the home or office. This familiarity facilitates the understanding and application of the model at various levels in the organization. According to Plane (1994), "In a rather remarkable way, the spreadsheet provides a single modeling language, as well as a single computation platform for many analyses. And its

empowerment of the user to be intimately involved in the modeling process sets the stage to have better models that are more likely to be implemented", (p. 36).

For the general model, a simple six-stage processing workflow is used. Variables relevant to processing are included. Response time is defined as the number of days between the day a solicitation or letter is mailed to a customer, and the day the item is received back. Response times are assumed to be Normally distributed over the duration of the campaign; note this refers to the "area under the curve", as a probability or frequency distribution. A key component is that incomplete applications are returned to the customer for correction. At this stage, there is attrition, since only a portion of customers so-contacted eventually respond. There is also a variable return time that is not under the control of the company.

The variables and parameters for this model were chosen based on personal experience of important variables in the service industry, as well as those variables that are part of successful capacity models in the literature. Variable cost is comprised of labor and backlog cost. Backlog cost per day can be estimated by dividing the yearly profit per account by the days in the year, and then rounding the

resulting figure upward if the market is saturated and customers are likely to cancel orders when delays occur.

Other organizations do not realize profit or revenue for processing applications. Requests for insurance claim reimbursements would be one example. However, in these cases, there could still be costs associated with backlogs. The costs of backlogs can be analogous to the costs of poor quality, since timeliness is often a measure of customer service and quality in the service industry. According to Tschetter (1986), the internal costs of poor quality include the cost of customers contacting you, investigation cost, and the cost of contacting the customer. External costs could be that the customer quits doing business with the organization or that the customer tells friends and associates about the poor service received from your company (p. 117, paraphrased). As an example of internal backlog costs applied to the insurance industry, a customer waiting an excessive period of time for a reimbursement check will call, the claim status researched by the insurance company, and the customer notified of the progress regarding their claim. In addition, there may be costs associated with poor employee morale, as when employees feel pressured and overwhelmed by excessive volumes of work awaiting processing. Different costs would be associated with backlogs depending on the nature of the business involved.

SYSTEM STRUCTURE - This system is a general, theoretical system for processing applications resulting from a marketing campaign. Although not based on an actual system, it is a typical example of such operations. Please refer to Figure 3-1 for the flowchart of the general process. This general model assumes the following stages:

Stage 1 - Mail Area. This is the area at which new applications (as well corrected ones) enter the system. Envelopes are opened, new applications and letters are sorted into respective piles, and items are assigned a control number. All items from this stage go to Stage 2 the following day.

Stage 2 - Data Entry. Information from applications such as name, address, date of birth, phone number, etc., are input via computer terminals. From Stage 2, items can go to either Stage 3 Exception Processing, or to Stage 4 Finish/Accounts Booked.

Stage 3 - Exception Processing. The system "kicks out" as an exception any item that does not have all fields completed. Also, the system scans for certain types of errors. For example, a system scan could flag an account if the date of birth indicates that the applicant is under 18 years old. In Exception Processing, a percentage of the

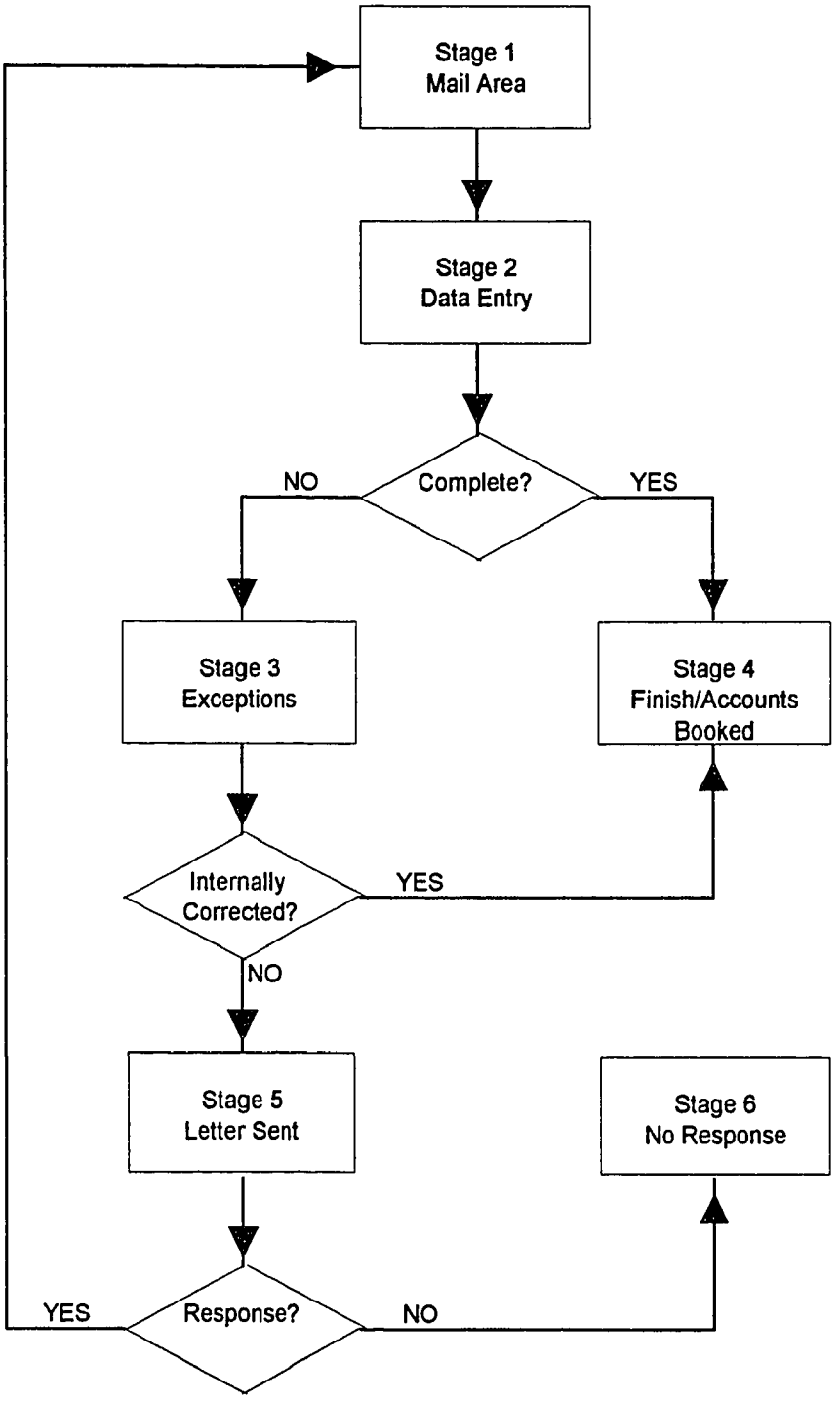
discrepancies are resolved internally (i.e., the data entry clerk made an error by omitting a field or miskeying an entry), but the rest must be resolved with customer intervention, (i.e., the field was truly omitted, or the customer wrote the information incorrectly). The latter results in a letter to the customer.

Stage 4 - Finish/Accounts Booked. This is an automated step, whereby an account becomes "live" on the books of the company, or, the request fulfilled. In this case, the system actually completes the final step. Accounts arrive either from Stage 2 (Data Entry) or Stage 3. (Exception Processing). This is a terminal state.

Stage 5 - Letters Sent. A form letter is generated explaining to the customer that additional information is needed in order to process the application. The customer is instructed to respond with the required information. From this stage, some will become Stage 6 (No Response), and the remainder will be returned to Stage 1 (Mail Area). These percentages are also input parameters.

Stage 6 - No Response. This is attrition; applicants decide they do not want the account after all, and

FIGURE 3-1. FLOWCHART FOR GENERAL PAPERWORK PROCESS



do not return the information. This is a terminal state.

ASSUMPTIONS - The assumptions are the following:

- Finite time horizon
- Campaign Demand
- FIFO processing
- Variable workforce between time periods using contract staff
- Proportion and timing of returned letters and incoming new work are represented by a distribution
- Lead time, or transport time between stages is fixed, (except for returned letters), but can be adjusted if the need arises

DECISION VARIABLES - Management decision variables:

- Paid hours per day per FTE (Full time employee), regular and overtime
- Number of FTEs hired or number of machines

PARAMETERS - Parameters can relate to productive work time, productivity, incoming work or costs. The following are parameters affecting productive work time:

- Break time per day
- Proportion of PFD (personal, fatigue and delay)
- Machine up time

Parameters affecting productivity:

- Proportion of time lost to system "slow time". If computer response time is slow, employees process less items per hour.
- Learning curve factors
- Items per hour processed per FTE, for the "goal", or "best case"

Incoming work parameters:

- Predicted incoming volume of work (number of solicitations * response rate)
- Type of distribution and parameters for incoming applications
- Type of distribution and parameters for returned letters
- Probability of going from stage i to stage j, P_{ij}

Cost parameters:

- Regular labor cost per hour
- Overtime labor cost per hour
- Unit cost per backlogged item per day

As a descriptive model, all of the above are inputs. The model's output is a description of workflow and costs:

- Daily volume expected to arrive at each department
- Amount of resources required to process the daily volume

- Daily throughput (items processed)
- Daily backlog (items that cannot be processed due to lack of resources)
- Daily idle time (areas where there exists an over capacity situation, indicating that resources can be redeployed elsewhere)
- Daily variable costs comprised of labor and backlog costs for each area
- Mean time in system

The values of all input variables and parameters can be changed to create additional scenarios. Please refer to Appendix A for examples of scenario analysis applications. Figure 3-2 illustrates how the incoming flow of work can vary from day to day. In this example 200,000 items will arrive over the designated time period. The arrival distribution for demand is assumed Normal with a mean arrival date of 25 and a standard deviation of 8. Other distributions such as Poisson can be used to model. Any realistic value can be chosen for any parameter, and expected volume of incoming work.

Figure 3-3 is a summary description of model inputs and outputs, and depicts the temporal workflow, with all parameters and transition matrix. Assumptions regarding the number of FTE's, use of overtime, items per hour, machine up

FIGURE 3-2. DAILY INCOMING WORK FOR THE GENERAL PLANNING MODEL

NEW INCOMING WORK

Normal : x = day of arrival	
Total Received	200,000
Number of Days to Receive NORMAL DISTRIBUTION	50
Mean Number of Days (Number of Days/ 2)	25
Standard Deviation	8.00
Increment	1

Day	1	2	3	4	5	6	7	8	9	10	11
Cumul %	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.9%	1.2%	1.7%	2.3%	3.0%
Raw %	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.5%	0.6%	0.8%
# Received	178	92	134	192	271	375	513	690	914	1191	1529

Day	12	13	14	15	16	17	18	19	20	21	22
Cumul %	4.0%	5.2%	6.7%	8.5%	10.6%	13.0%	15.9%	19.1%	22.7%	26.6%	30.9%
Raw %	1.0%	1.2%	1.5%	1.8%	2.1%	2.5%	2.8%	3.2%	3.6%	3.9%	4.3%
# Received	1933	2404	2945	3552	4217	4929	5672	6426	7168	7872	8510

Day	23	24	25	26	27	28	29	30	31	32	33
Cumul %	35.4%	40.1%	45.0%	50.0%	55.0%	59.9%	64.6%	69.1%	73.4%	77.3%	80.9%
Raw %	4.5%	4.7%	4.9%	5.0%	5.0%	4.9%	4.7%	4.5%	4.3%	3.9%	3.6%
# Received	9059	9493	9794	9948	9948	9794	9493	9059	8510	7872	7168

Day	34	35	36	37	38	39	40	41	42	43	44
Cumul %	84.1%	87.0%	89.4%	91.5%	93.3%	94.8%	96.0%	97.0%	97.7%	98.3%	98.8%
Raw %	3.2%	2.8%	2.5%	2.1%	1.8%	1.5%	1.2%	1.0%	0.8%	0.6%	0.5%
# Received	6426	5672	4929	4217	3552	2945	2404	1933	1529	1191	914

Day	45	46	47	48	49	50	51	52	53	54	55
Cumul %	99.1%	99.4%	99.6%	99.7%	99.8%	99.9%	99.9%	99.9%	100.0%	100.0%	100.0%
Raw %	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
# Received	690	513	375	271	192	134	92	62	42	27	18

Day	56	57	58	59	60	61	62	63	64	65	66
Cumul %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Raw %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# Received	11	7	4	3	2	1	1	0	0	0	0

Day	67	68	69	70	71	72	73	74	75	TOTAL
Cumul %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Raw %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
# Received	0	0	0	0	0	0	0	0	0	200000

FIGURE 3-3. DAILY WORKFLOW AND ASSUMPTIONS: DESCRIPTIVE MODEL - ASSUME NORMAL ARRIVALS

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

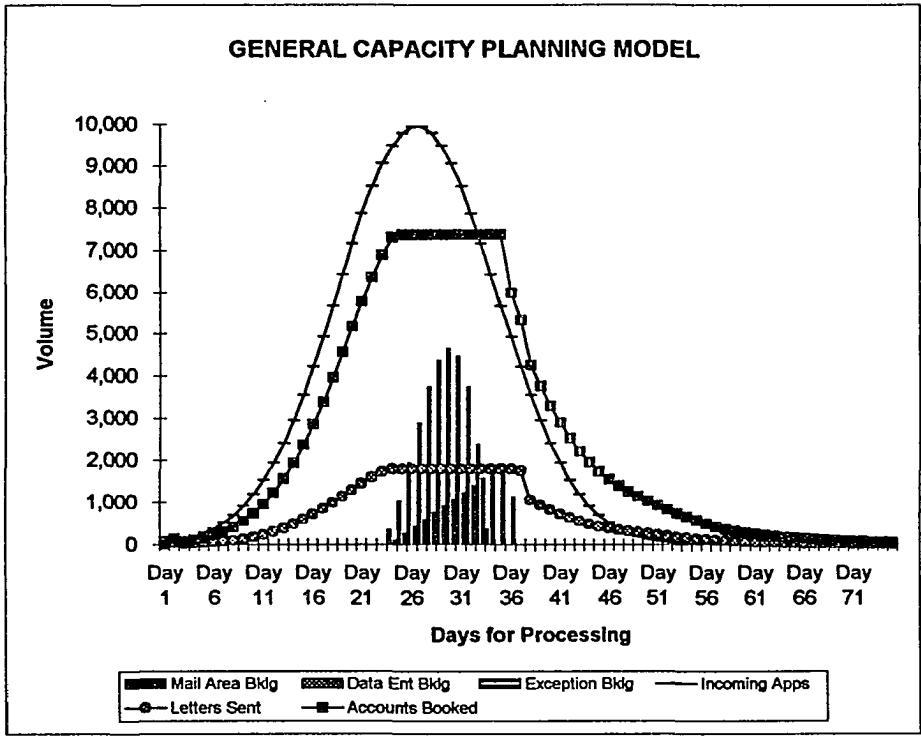
DATA ENTRY:

Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
15.5
MEAN TIME IN SYSTEM (DAYS):
4.345



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Except	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$70,405
Data Entry	$30,938
Exception Processing	$39,085
TOTAL	$140,427

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

* See also Appendix B, the General Capacity Planning Model.

time, and others are reflected in summary form. Included is the flow of work for incoming applications, letters sent, accounts booked, and backlogs for data entry, the mail area and exception processing. The entire model can be recalculated when any parameter listed on the exhibit is changed.

The capacity plan is unique in its treatment of returned letters. Table 3-1 calculates the manner in which outgoing letters are returned. Each day, a bundle of letters is mailed. Those letters that return, do so according to a distribution. In this case, a Poisson distribution is assumed. The "# received" represents the letters mailed per day that will eventually return. Each line takes the volume in "# received" and distributes letters horizontally, along a line in the table, over the appropriate period of time. The bottom line "total letters received per day" adds the letters that are expected to be received on a particular day, from the letters mailed over past days.

Figure 3-4 pictorially represents the returned letters. Each graph line shows how the letters from a particular day will be returned over future days. The effect is that letters arriving on any given day are a composite of letters mailed over many prior days. Figure 3-5 graphs the total expected letters received per day.

TABLE 3-1. RETURNED LETTER TABLE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
# REC	0	25	13	19	27	38	53	72	97	128	167	214	271	337	414	499	593	693	799	906	1012	1113	1206	1248	1248	1248	1248	1248	1248	1248	1248	1248	1248	1248	1248	1248	1227	743	656	576	504
SHIFT			3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	1	1	2	2	3	3	3	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
						0	0	0	0	0	0	0	1	1	2	2	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
							0	0	0	0	0	0	1	1	2	2	3	3	3	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
								0	0	0	0	0	0	1	2	2	3	4	4	4	4	3	3	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
									0	0	0	0	0	1	1	2	3	5	6	6	6	6	5	4	3	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
										0	0	0	0	0	1	2	3	5	6	8	8	8	8	6	5	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0
											0	0	0	0	1	1	2	4	6	8	10	11	11	10	9	7	5	4	2	2	1	1	0	0	0	0	0	0	0	0
												0	0	0	0	1	2	3	6	8	11	13	15	15	14	12	9	7	5	3	2	1	1	0	0	0	0	0	0	0
													0	0	0	0	1	2	4	7	11	15	18	19	19	18	15	12	9	6	4	3	2	1	1	0	0	0	0	0
														0	0	0	0	1	3	5	9	14	19	22	25	25	23	19	18	12	8	5	3	2	1	1	0	0	0	0
															0	0	0	0	1	3	7	12	18	24	28	31	31	29	25	20	15	10	7	4	3	1	1	0	0	0
																0	0	0	1	2	4	9	15	22	29	35	39	39	38	31	24	18	13	9	5	3	2	1	1	0	0
																	0	0	0	1	2	5	11	18	27	38	43	47	47	44	37	30	22	16	11	7	4	2	1	1	0
																		0	0	0	1	3	6	13	22	33	44	52	57	57	53	45	36	27	19	13	8	5	3	2	1
																			0	0	0	1	3	8	15	26	39	52	62	68	68	63	54	43	32	23	15	10	6	3	2
																				0	0	0	1	4	9	13	30	45	61	73	79	79	73	63	50	38	27	18	11	7	4
																					0	0	0	1	4	10	20	35	52	70	84	91	91	84	72	58	43	31	20	13	8
																						0	0	0	2	5	12	23	40	59	79	95	104	104	98	82	66	49	35	23	15
																							0	0	0	2	5	13	26	44	66	88	106	116	116	107	92	73	55	39	26
																								0	0	0	2	6	14	28	49	73	97	117	127	127	118	101	81	60	43
																									0	0	1	2	6	15	31	53	79	105	126	138	138	127	109	87	65
																										0	0	1	2	7	16	32	55	82	109	131	143	143	132	113	90
																											0	0	1	2	7	16	32	55	82	109	131	143	143	132	113
																												0	0	1	2	7	16	32	55	82	109	131	143	143	132
																													0	0	1	2	7	16	32	55	82	109	131	143	143
																														0	0	1	2	7	16	32	55	82	109	131	143
																															0	0	1	2	7	16	32	55	82	109	131
																																0	0	1	2	7	16	32	55	82	109
																																	0	0	1	2	7	16	32	55	82
																																		0	0	1	2	7	16	32	55
																																			0	0	1	2	7	16	32
																																				0	0	1	2	7	16
																																					0	0	1	2	7
																																						0	0	1	2
																																							0	0	1

TABLE 3-1. RETURNED LETTER TABLE (Continued)

																																						0	0
																																							0
Total Letters Recei	0	0	0	0	0	0	0	1	2	3	5	8	12	18	24	34	45	61	80	104	134	170	214	264	323	389	462	542	626	714	801	885	962	1031	1089	1136	1172	1199	1217

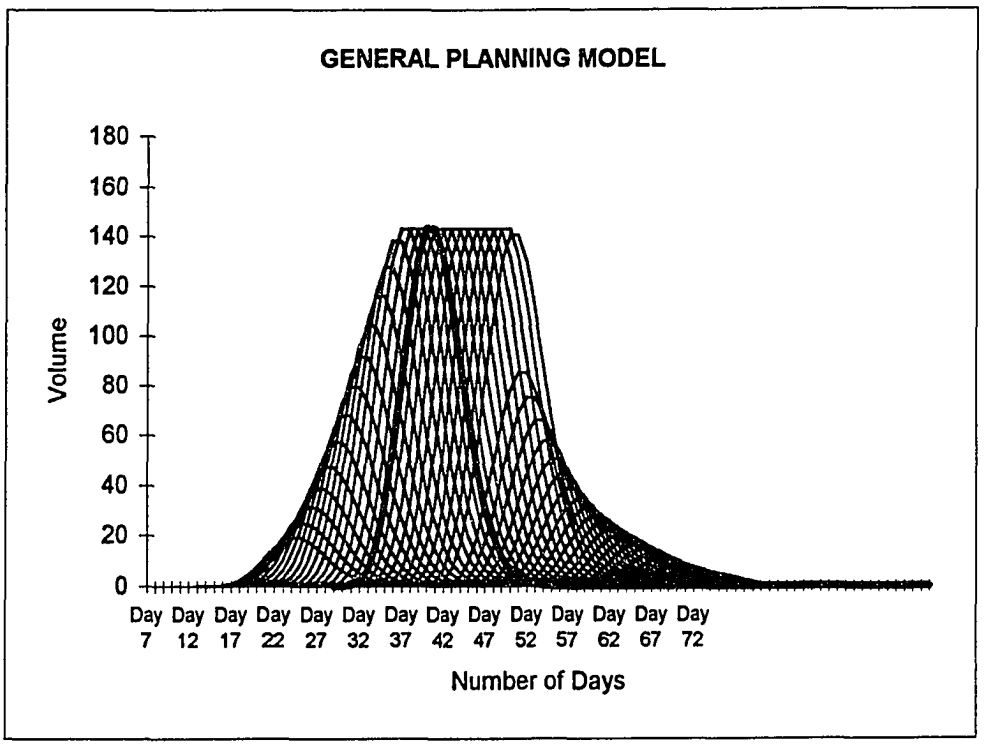
TABLE 3-1. RETURNED LETTER TABLE (Continued)

42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	
441	386	340	301	269	243	220	199	181	162	145	128	112	98	85	73	64	56	49	43	38	34	30	27	24	21	19	17	15	13	11	10	9	7	0	0	0	0	0	0	0	
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	Tot Row
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	97
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	214
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	271
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	337
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	414
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	499
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	593
2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	693
4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	799
9	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	906
16	10	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1012
28	18	11	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1113
48	31	19	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1206
68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
82	109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
55	82	109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
32	55	82	109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
16	32	55	82	109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
7	16	32	55	82	109	131	143	143	132	113	90	68	48	32	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1248
2	7	16	31	54	80	107	129	140	140	130	111	89	67	47	31	20	12	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1227

TABLE 3-1. RETURNED LETTER TABLE (Continued)

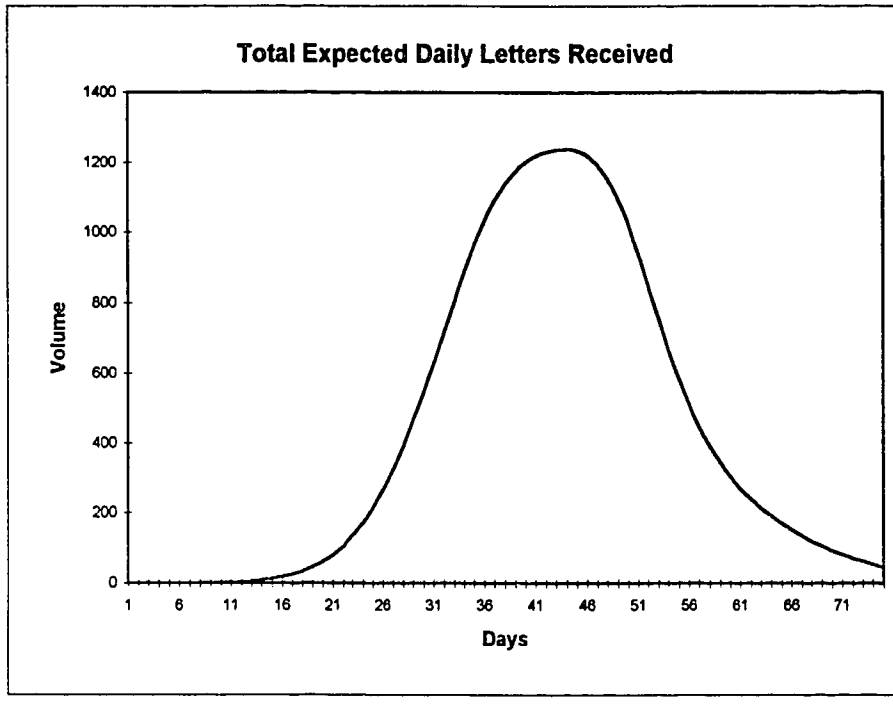
0	1	4	9	19	32	49	65	78	85	85	78	67	54	40	28	19	12	7	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	743
0	0	1	3	8	17	29	43	57	69	75	75	69	59	48	36	25	17	11	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	656
0	0	0	1	3	7	15	25	38	50	60	66	66	61	52	42	31	22	15	9	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	576
	0	0	0	1	3	6	13	22	33	44	53	58	58	53	46	37	27	19	13	8	5	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	504
		0	0	0	1	2	6	11	19	29	39	46	50	50	47	40	32	24	17	11	7	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	441
			0	0	0	1	2	5	10	17	25	34	40	44	44	41	35	28	21	15	10	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	386
				0	0	0	1	2	4	9	15	22	30	36	39	39	36	31	25	18	13	9	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	340
					0	0	0	1	2	4	8	13	20	26	32	34	34	32	27	22	16	12	8	5	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	301
						0	0	0	0	1	3	7	12	18	24	28	31	31	28	24	19	15	10	7	4	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	269
							0	0	0	0	1	3	6	11	16	21	25	28	28	26	22	18	13	9	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	243
								0	0	0	0	1	3	6	10	14	19	23	25	25	23	20	16	12	8	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	220
									0	0	0	0	1	3	5	9	13	17	21	23	23	21	18	14	11	8	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	199
										0	0	0	0	1	2	5	8	12	16	19	21	21	19	16	13	10	7	5	3	2	1	1	0	0	0	0	0	0	0	0	0	181
											0	0	0	0	1	2	4	7	11	14	17	19	19	17	15	12	9	6	4	3	2	1	0	0	0	0	0	0	0	0	0	162
												0	0	0	0	1	2	4	6	9	13	15	17	17	15	13	10	8	6	4	2	1	1	0	0	0	0	0	0	0	0	145
													0	0	0	0	1	2	3	6	8	11	13	15	15	14	12	9	7	5	3	2	1	1	0	0	0	0	0	0	128
														0	0	0	0	1	1	3	5	7	10	12	13	13	12	10	8	6	4	3	2	1	1	0	0	0	0	0	112
															0	0	0	0	1	1	2	4	6	9	10	11	11	10	9	7	5	4	2	2	1	1	0	0	0	0	98
																0	0	0	0	0	1	2	4	6	7	9	10	10	9	8	6	5	3	2	1	1	0	0	0	0	85
																	0	0	0	0	0	1	2	3	5	6	8	8	8	8	7	5	4	3	2	1	1	0	0	0	73
																		0	0	0	0	0	1	2	3	4	6	7	7	7	7	6	5	3	2	2	1	1	0	0	64
																			0	0	0	0	0	1	1	2	4	5	6	6	6	6	5	4	3	2	1	1	1	0	55
																				0	0	0	0	0	1	1	2	3	4	5	6	6	5	4	4	3	2	1	1	0	48
																					0	0	0	0	0	1	1	2	3	4	4	5	5	5	4	3	2	2	1	1	42
																						0	0	0	0	0	0	1	2	2	3	4	4	4	4	3	3	2	1	1	37
																							0	0	0	0	0	0	1	1	2	3	4	4	4	4	3	2	2	1	32
																								0	0	0	0	0	0	1	1	2	3	3	3	3	3	3	2	2	27
1229	1236	1238	1233	1220	1195	1154	1098	1026	942	852	780	670	587	513	448	393	345	305	270	241	215	192	171	152	135	120	106	93	82	71	62	53	45	37	30	23	17	13	9	6	32317

FIGURE 3-4. RETURNED LETTER DISTRIBUTION - DESCRIPTIVE MODEL



*Note: Each day's returned letters are represented by one curve on the chart. For example, the highlighted curve represents how the letters mailed on day 28 will return between day 32 and day 54.

FIGURE 3-5. TOTAL EXPECTED DAILY VOLUME OF RETURNED LETTERS



Please see Appendix B for the entire General Capacity Planning Model. Each stage of the capacity plan is comprised of the following:

- Volume or workload to be processed
- Resource requirements
- Available capacity
- Maximum capacity
- Resource overage or underage
- Items handled and items backlogged
- Variable costs

Following is an overview of the basic calculations in the capacity plan. Each line of the spreadsheet is numbered. For calculations, succeeding lines use data from preceding lines in formulas. In these cases, the line number and formula are listed in parentheses. A detail for Stage 1 is depicted in Table 3-2. A more detailed description of equations in mathematical form is in Appendix C.

d. Description of the General Capacity Planning Model: A Prescriptive Approach

The general model is not just a descriptive model, it can also be used as a prescriptive model. Descriptively, the model is given staff levels and volumes to determine workflow, backlogs and variable cost. Alternatively, (prescriptively), the model uses volume and constraints to

TABLE 3-2. EXAMPLE OF CAPACITY PLANNING FORMAT

6	**STAGE 1: MAIL AREA (OPEN, SORT, AND LOG APPLICATION)**
7	Incoming Applications (from Fig. 3-2)
8	Yesterday's Backlog (Line 31 with 1 Day Delay)
9	"Information Letters" Returned (from Fig. 3-5)
10	Total Incoming Work (Line 7+Line 8+Line 9)
11	
12	Resource Requirements:
13	Items Per Hour
14	Required Hours (Line 10/Line 13)
15	Required FTE (Line 14/Line 19)
16	
17	Capacity (available staff hours):
18	FTE's in Department
19	Regular Paid Hours in the Work Day Per FTE
20	Overtime Paid Hours in the Work Day Per FTE
21	Machine Uptime
22	Learning Curve Assumptions
23	Prod Hrs in Wk Day/FTE Inc OT (Line 19+Line 20)
24	Total Dept Productive hours per day (Line 18*Line 23)
25	Maximum Capacity to Process Items (Line 13*Line 24)
26	
27	Overage (Underage) in Hours (Line 24-Line 14)
28	Overage (Underage) in FTE (Line 27/Line 19)
29	
30	Items Handled ([MIN] Line 10,Line 25) to Data Entry
31	Tomorrow's Backlog (Line 10-Line 30)
32	
33	Unit Cost:
34	Regular Labor Cost Per Hour
35	Overtime Labor Cost Per Hour (Line 34*1.5)
36	Tot.Cost(Line18*Line19*Line34)+(Line18*Line20*Line35)
37	Labor Cost Per Item Processed (Line 36/Line30)
38	
39	Unit Cost per Backlogged item
40	Total Cost Backlog (Line 39*Line 31)
41	
42	Total Cost of Backlog and Processed (Line 36+Line 40)
43	Weighted Avg Costs:
	((Line37*Line30)+(Line31*Line39))/(Line30+Line31)

derive the optimal staff configuration to minimize total variable cost.

All system structure, parameters, variables and formulas are identical to the descriptive model. However, in this case, staff level is no longer an input variable, it is an output of the model. The model will calculate the least cost staffing configuration when staff level must be held constant. The objective function and constraints for the prescriptive version of the general model are detailed in Appendix C.

Of course, the best staffing configuration in a lumpy demand environment matches staffing levels to volume fluctuations through hiring, firing and use of overtime. When staff available equals staff required, there is no overcapacity or undercapacity. Excess labor costs and backlog costs are not incurred. The best staff configuration when staff level is permitted to vary is obtained from the Total Staff Requirement Summary in the General Model (see Appendix B).

However, union agreements, policies to only use permanent employees, or labor contracts, may restrict the ability to hire and fire freely. In these cases, a predetermined level of staff is required for the duration of the campaign. For the prescriptive model, and under the assumption of a constant staffing level, the SOLVER program

within EXCEL determines the level of staff to minimize variable costs associated with labor and backlogs. Note that for this study, all models were run using Microsoft EXCEL Version 5.0a software on an NCR 3180 Personal Computer.

Please review Figure 3-6. This figure depicts the best staff level when staff level must be held constant for the duration of the campaign. The optimal level of staff varies with the response rate. Here, the mailing is assumed to be 10,000,000 and the response rate varies between 1% and 3%. Figure 3-7 graphs the optimal staff (as per the EXCEL SOLVER Program) by response rate and also the least cost by response rate. These graphs demonstrate a linear relationship in both cases. Figure 3-8 plots variable cost vs. staff level for the three response rates of 1%, 2% and 3%. The optimal staff configurations for these response rates lie along the same line.

In addition, there may be cases when staffing levels are held constant and staff is limited. In a further refinement of the general model, a constraint of 14 FTEs is imposed and the model solved again. This model version provides the best staff allocation when resources are limited to a pre-defined level of staff.

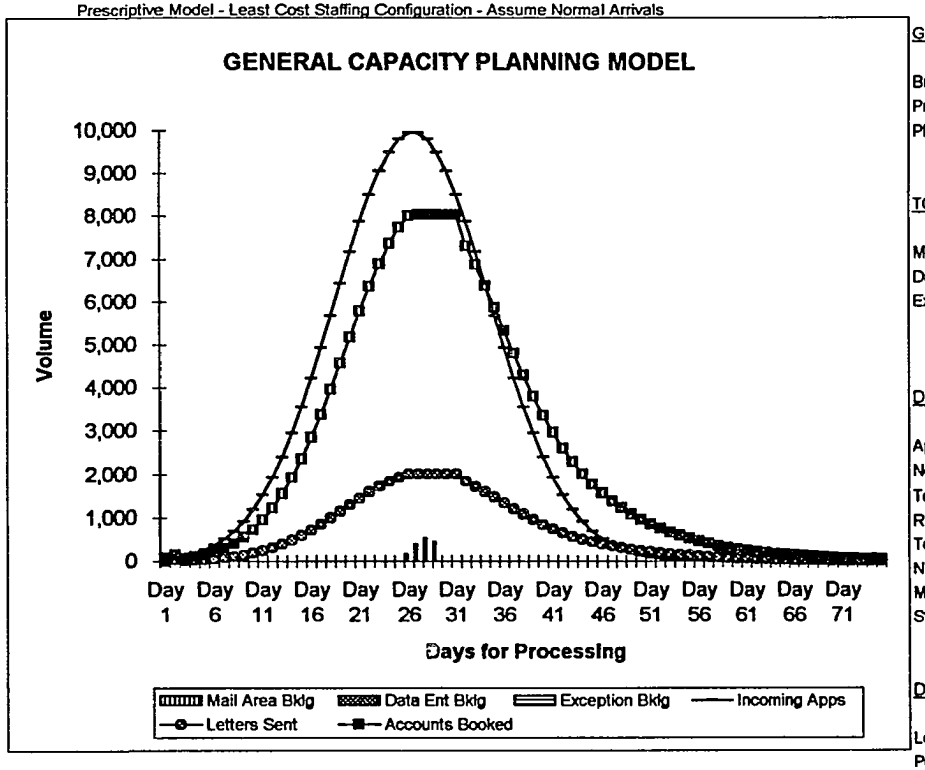
Figure 3-9 depicts the best staffing level, but with constraints added. In this example, total FTEs may not

exceed 14, and overtime may not exceed 1 hour per day per FTE. This is a variation of the general model and is a constrained capacity planning model, useful to determine optimal allocation when resources are limited.

The next chapter describes how the general model was applied to an actual processing environment.

FIGURE 3-6. DAILY WORKFLOW AND ASSUMPTIONS: PRESCRIPTIVE MODEL

Prescriptive Model - Least Cost Staffing Configuration - Assume Normal Arrivals



MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	7.4
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,045
Labor Cost Per Hour	$10.00
Backlog Cost per Ite	$1.00

DATA ENTRY:

Entered Per Hour	300
FTE's Available	4.9
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,045
Labor Cost Per Hour	$11.00
Backlog Cost per Ite	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	5.1
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	4,018
Labor Cost Per Hour	$12.00
Backlog Cost per Ite	$1.00

TOTAL STAFF (FTE):
17.4

MEAN TIME IN SYSTEM (DAYS):
4.081

MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$42,984
Data Entry	$30,395
Exception Processing	$29,276
TOTAL	$102,655

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	50
Mean Number of Days	25
Standard Deviation	8.0

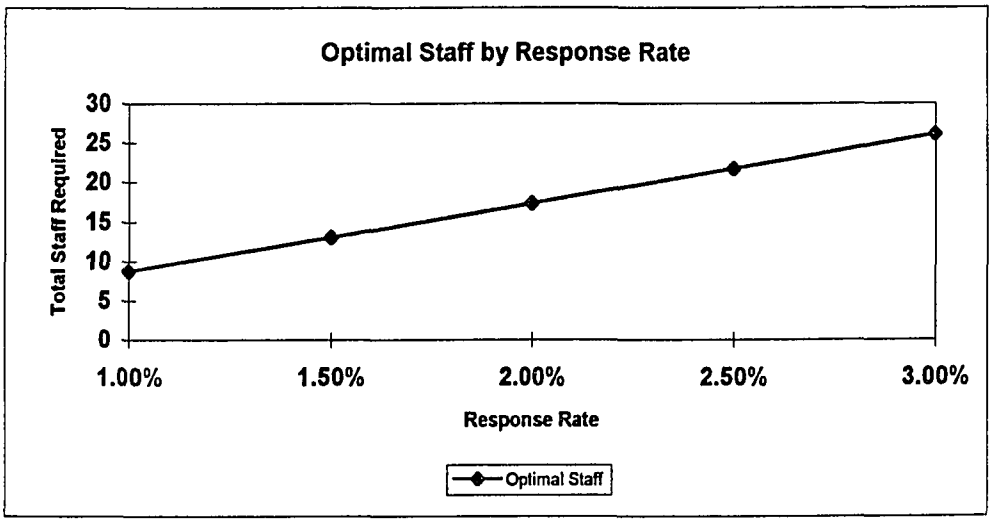
DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 3-7. OPTIMAL STAFF AND LEAST COST BY RESPONSE RATE



Percent	1.0%	1.5%	2.0%	2.5%	3.0%
Optimal Staff	8.7	13.0	17.4	21.7	26.1
Cost	$51,331	$76,991	$102,655	$128,318	$153,987

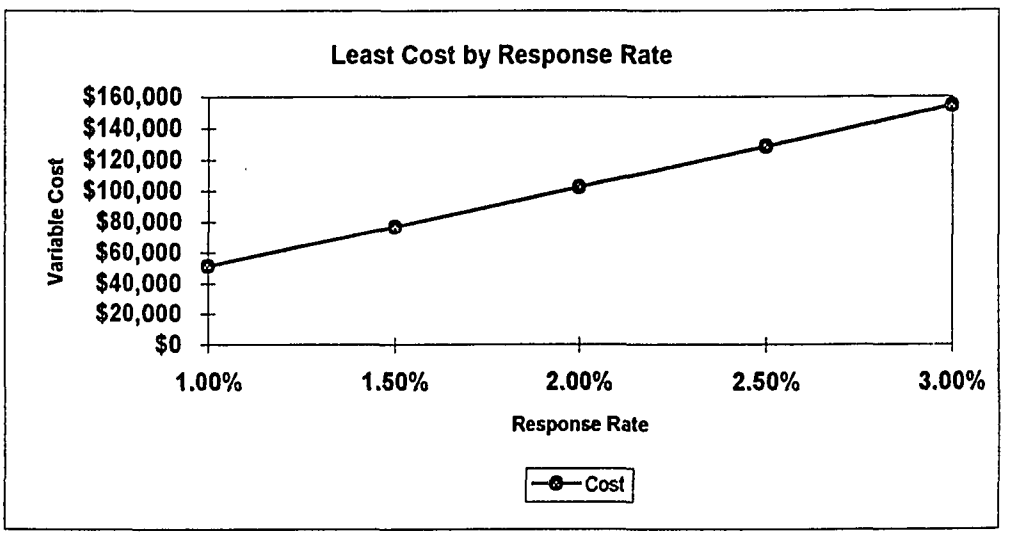
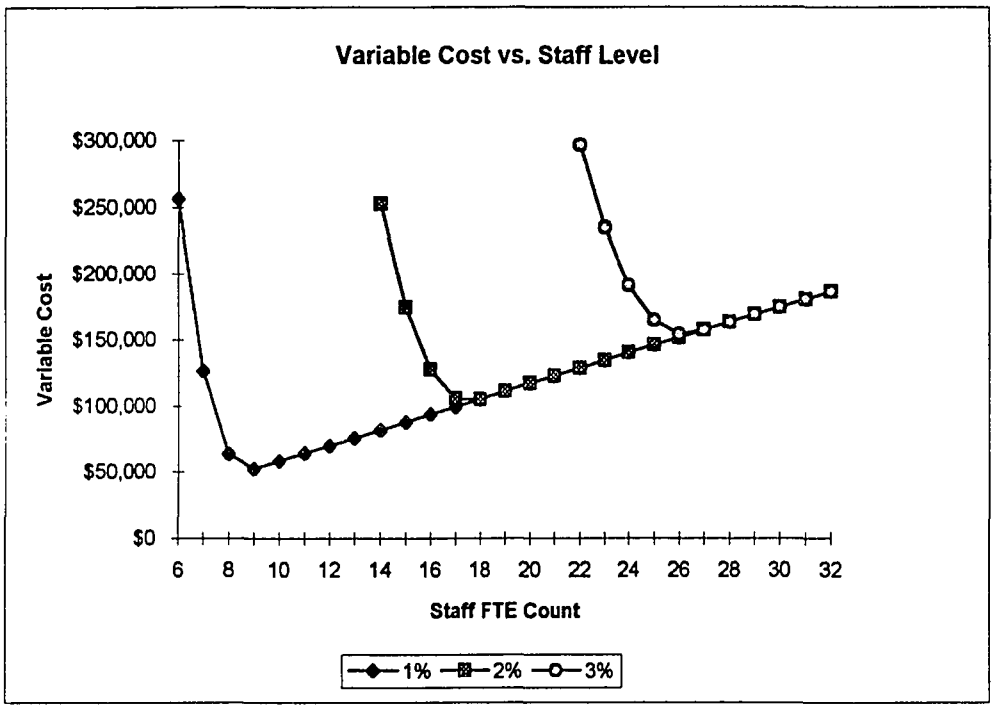


FIGURE 3-8. VARIABLE COST BY STAFF LEVEL



* Variable costs are labor and backlog costs

FIGURE 3-9. DAILY WORKFLOW AND ASSUMPTIONS: PRESCRIPTIVE MODEL WITH CONSTRAINTS

Prescriptive Model - Least Cost Staffing Configuration - Assume Normal Arrivals and Constraints

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,259
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

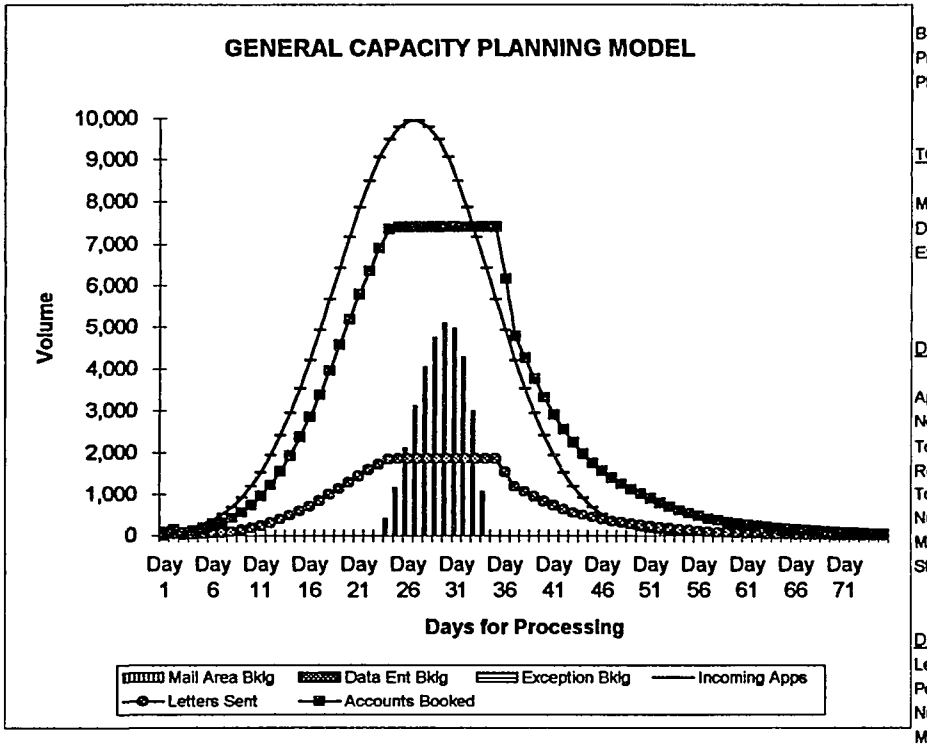
Entered Per Hour	300
FTE's Available	4.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,259
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.1
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,704
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
14.0

MEAN TIME IN SYSTEM (DAYS):
4.221



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost to Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$74,166
Data Entry	$29,507
Exception Processing	$28,499
TOTAL	$132,171

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

CONSTRAINTS:

Total Staff < or = to	14.0
Overtime < or = to	1.0

CHAPTER 4
MODEL DEVELOPMENT: EXPERIMENTAL DESIGN

a. Adapting the Model to an Actual Case Study

This chapter details the development of the model regarding experimental design, and adaptation to an actual case study. This chapter contains a description of the processing environment, types of data collected and methodology, and a description of the applied models.

During the case study, three applied models were developed; the historical, pre-campaign and applied/actual. The historical model depicted a prior campaign and determined that the general model could be adapted to a complex system. The pre-campaign model, completed four weeks before a marketing campaign, described the expected volumes and workflow for the duration of the campaign. The applied/actual model utilized the real volumes of incoming work and transition probabilities to determine how well the capacity plan predicted daily departmental volumes.

A model is valid if it accurately represents the actual system. The goal was to determine if the daily volumes estimated by the model were close to the actual realized daily volumes. Credibility is another goal for the applied

models. According to Law and Kelton (1991), "When a simulation model and its results are accepted by the manager/client as being valid and are used as an aid in making decisions, we call the model credible", (p. 299). The following describes the environment and how the general model was adapted to the case study.

1) Description of the processing environment. The general model was adapted and applied to a campaign demand situation for the credit card division of one of the largest financial services companies in the United States. The area of study focused on the response resulting from a nation-wide direct mail solicitation, where credit worthy consumers were sent applications for credit cards. These potential customers, if interested, fill out and return the required information by a pre-determined date. Campaigns such as these are typically run two to three times per year by the larger credit card issuers.

In this case study, much of the workflow is automated. Incoming work is "scanned" into an optical imaging system which captures and routes items to the appropriate workstations. Characteristics of the information provided can lead to exception processing, and, there are a total of 26 possible stages an item can pass through.

Optical imaging is a technology (also referred to as electronic image processing) that is being applied to an

increasing number of operations in the service industry. According to Friis (1989), "It involves the electronic scanning of entire documents relating to loans, trusts, electronic funds transfer, human resource, and other everyday bank operations - and conversion of images of those documents to digital form. This information is stored on, and retrieved from, optical disks that can be read by laser beams - much like compact disk recordings", (p. 61).

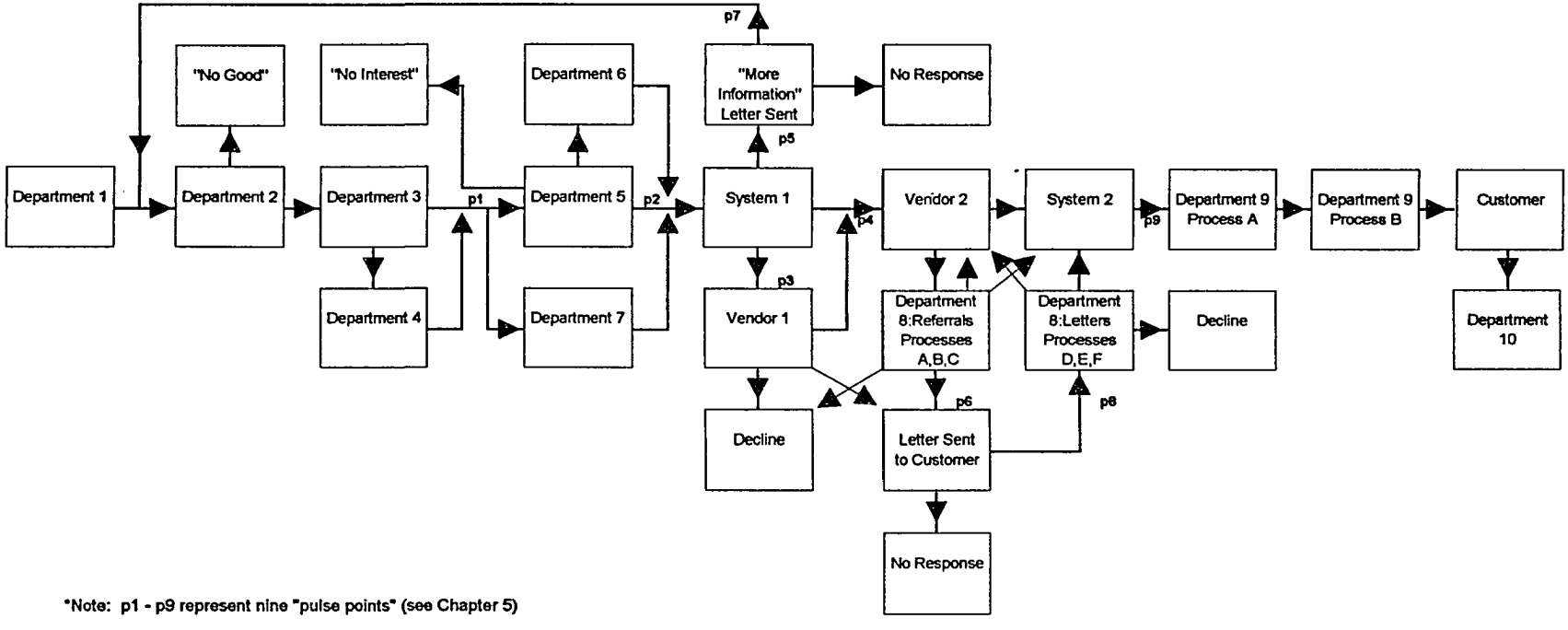
According to Marpe (1990), benefits of an optical imaging system include, "Documents spend less time in transit among personnel and departments because of automated routing, professionals spend less time finding and waiting for documents crucial to decision making, through work flow automation imaging processing can cut the number of personnel needed for document management, imaging drastically reduces required storage space,...Image management can reduce the time required to complete the credit process and initiate interest or fee generation", (p. 22).

2) Types of data collected, methodology. After the general model was completed, the next step was to adapt the model to an actual case study. The first adaptation took the form of modeling a past marketing campaign. The reason for this was two-fold; 1) Using historical data provided a preliminary test for the feasibility of designing a model of

this large scope. The historical data gave insights regarding workflows, types of variables and parameters, ranges for variable values and parameters, and probabilities, and, 2) The preliminary historical capacity plan set the stage for designing a true planning model (the pre-campaign model) that could be tested in a processing environment. The methodology of designing and testing a model using identical data is questionable, at best, and is always somewhat suspect. The historical model separated the development from the testing of the capacity planning model.

Developing the applied capacity planning models included the following steps. Managers were interviewed to determine their department's role in processing the work. Time was spent in each unit to document workflows, identify job functions, observe procedures and understand department organization. A flowchart was prepared to list all of the processes that can precede of succeed another process (see Figure 4-1). Individual areas were researched to determine relevant variables. Data was compiled on all relevant variables, assumptions and parameters. Sample data and reports were collected to determine the probability that one stage will follow another stage. This was represented by a transition matrix (see Figure 4-2). The historical model provided a prototype to determine the expected workload at each stage over the course of the prior campaign.

FIGURE 4-1. FLOWCHART FOR THE PRE-CAMPAIGN PLANNING MODEL



*Note: p1 - p9 represent nine "pulse points" (see Chapter 5)

FIGURE 4-2. TRANSITION MATRIX FOR THE PRE-CAMPAIGN MODEL

* States	Dept 1 1	Dept 2 2	No Good 3	Dept 3 4	Dept 4 5	No Int 6	Dept 5 7	Dept 6 8	More Info 9	Dept 7 10	System 1 11	Ven 1 12	Dept 8E 13	Ven 2 14	Dept 8D 15	Dept 8A 16	Dept 8B 17	Dept 8F 18	Dept 8C 19	System 2 20	Dept 9A 21	Dept 9B 22	Decline 23	No Resp 24	Custome 25	Dept 10 26
Dept 1	1		1.000																							
Dept 2	2			0.050	0.950																					
"No Good"	3			1.000																						
Dept 3	4					0.050		0.950			0.000															
Dept 4	5							1.000																		
"No Interest"	6						1.000																			
Dept 5	7						0.133		0.217			0.650														
Dept 6	8											1.000														
More Info Let	9		0.243																					0.757		
Dept 7	10											0.333								0.667						
System 1	11									0.113			0.130		0.757											
Vendor 1	12													0.450	0.380									0.170		
Dept 8 Proc E	13														0.248									0.052	0.700	
Vendor 2	14															0.080				0.920						
Dept 8 Proc D	15																			0.289				0.041	0.670	
Dept 8 Proc A	16														0.578					0.406				0.016		
Dept 8 Proc B	17													0.540	0.438									0.022		
Dept 8 Proc F	18														0.255									0.045	0.700	
Dept 8 Proc C	19														0.763									0.237		
System 2	20																				1.000					
Dept 9A	21																					1.000				
Dept 9B	22																								1.000	
Decline	23																						1.000			
No Resp	24																							1.000		
Customer	25																							0.550		0.450
Dept 10	26																									1.000

* Shaded units represent exception processing

While designing the historical and pre-campaign models, the author conducted three series of interviews with department managers up to and including the level of Vice President. Separate meetings were held with the managers of each major function. Holding a larger number of smaller meetings permitted more in-depth discussion of the capacity plan, and obtained more feedback from managers. It was crucial that managers understood the nature of capacity planning and the model development process. All managers were made aware of what data would be collected, how the information would be used, and how the model would help to make better decisions regarding staffing levels. It was also explained that the data collected, for example, on department productivity levels would be used to analyze workflow, and not to judge the performance of their department.

The first series of meetings described the concept of capacity planning. On a macro level, managers were asked how their department fits into the overall processing. At a more micro level, managers described the specific job functions in their area, where work comes from, and where it goes. The process was portrayed on a flowchart, and a transition matrix created. Historical data were collected from interviews, departmental reports, records and log sheets. Reports from computer systems and vendors were

obtained. Some data were collected through sampling of past records. Data collected included volume levels, volume patterns, FTEs, number of hours per shift, number of shifts, use of overtime, number of machines/computer terminals available, learning curve factors, estimates of machine downtime, PFD factors, number of items processed per hour, maximum daily capacity, and the probability that an item is routed from one stage to another. Each processing area was visited to directly observe the work processed, the types of decisions made, and other aspects regarding the nature and character of the tasks involved at the various workstations.

The historical information was molded into a capacity plan, using the general model as a guide. There are several notable differences between the general and actual models. The general model has only one type of letter. In the applied models, there are two distinct types of letters, each mailed from a different point in the process. The applied models have twenty-six possible states, rather than the general model's six. The applied models are more complex and accommodate additional parameters. Vendors and system stages are part of the actual model.

The historical model indicated, during which weeks of the prior campaign, there would have been idle time and backlogs. The historical model also indicated the

approximate amount of work that would have been processed during various time periods.

The second series of meetings reviewed the historical model. Summary sheets were prepared for each department by the author. Managers were asked to review a summary of the model's output for their department. Please refer to Figure 4-3 for a sample summary sheet for Department 5. The sheet described, for each day of the prior campaign, the maximum capacity to process work, items handled, and holdover (backlog). Agreement was good, since the weeks that the model indicated the existence of backlogs were the same weeks that backlogs actually occurred. There was agreement with the maximum daily capacities by department and volumes of work processed.

After this initial credibility was established, managers were asked if any variables, strategies or workflow would change from the prior campaign to the future campaign. As Law and Kelton (1991) note, "Regardless of the accuracy of a model's past predictions, a model should be carefully scrutinized before each new application, since a change in purpose or the passage of time may have invalidated some aspect of the existing model", (p. 314). All changes were noted and incorporated into the model. Based on manager interviews, variable values were changed to match the

FIGURE 4-3. SAMPLE SUMMARY SHEET FOR HISTORICAL CAPACITY PLAN

DEPARTMENT 5:		Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Staff	10	15	20	20	20
	Maximum Capacity	2664	3996	5328	5328	5328
	Items Handled	15	248	20	582	556
	Holdover	0	0	0	0	0
Week 2	Staff	30	30	30	30	30
	Maximum Capacity	7992	7992	7992	7992	7992
	Items Handled	3043	2193	1801	3194	4251
	Holdover	0	0	0	0	0
Week 3	Staff	30	30	30	30	30
	Maximum Capacity	7992	7992	7992	7992	7992
	Items Handled	7422	2475	2192	2627	2958
	Holdover	0	0	0	0	0
Week 4	Staff	Holiday	35	35	35	35
	Maximum Capacity	0	9324	9324	9324	9324
	Items Handled	0	6492	7154	9221	5320
	Holdover	0	0	0	0	0
Week 5	Staff	35	35	35	35	35
	Maximum Capacity	9324	9324	9324	9324	9324
	Items Handled	5167	8219	9281	6318	3511
	Holdover	0	0	0	0	0
Week 6	Staff	10	10	10	10	10
	Maximum Capacity	2664	2664	2664	2664	2664
	Items Handled	2059	2664	2664	2664	2664
	Holdover	0	3963	2655	3946	3539
Week 7	Staff	10	10	10	10	10
	Maximum Capacity	2664	2664	2664	2664	2664
	Items Handled	2664	2664	2664	2479	496
	Holdover	3713	2509	1430	0	0
Week 8	Staff	2	2	2	Holiday	2
	Maximum Capacity	533	533	533	0	533
	Items Handled	257	317	322	0	323
	Holdover	0	0	0	0	0
Week 9	Staff	2	2	2	2	2
	Maximum Capacity	533	533	533	533	533
	Items Handled	321	315	317	317	300
	Holdover	0	0	0	0	0
Week 10	Staff	2	2	2	Holiday	2
	Maximum Capacity	533	533	533	0	533
	Items Handled	89	34	39	0	40
	Holdover	0	0	0	0	0

prediction for the future marketing campaign. Please refer to the source column in Appendix D to determine the source of data. Workflow changes between campaigns were reflected. For example in one area, a two-step process was combined into one and another area added an evening shift. FTE counts were revised, as were estimates of machine downtime and transition probabilities. A revised flowchart and transition matrix with updated transition probabilities were developed. The Marketing Department provided estimates regarding predicted response rates, and the timing of responses. This pre-campaign model was a true capacity planning model, since it was used to make plans that were implemented.

The third series of meetings were planning sessions. Each manager was given the expected daily volume for the future campaign (based on model predictions) and recommendations were made regarding the amount and timing of resources, so as to avoid backlogs and idle time. Based on these meetings, managers revised resource allocations. The new allocations were input into the model and updated versions distributed. Additional resource adjustments were made based on this new information. In this sense, the resource allocation process was interactive. Changes in parameters led to revisions in staffing levels, and the new results (over and undercapacity situations) led to further

refinements in staff allocation. Senior management reviewed the plans which provided over one month's notice of potential bottlenecks. Contingency plans were developed to avoid anticipated backlogs. For example, workstations that were previously used for specific job functions during the day were reconfigured to enable the night shift to use them for additional functions.

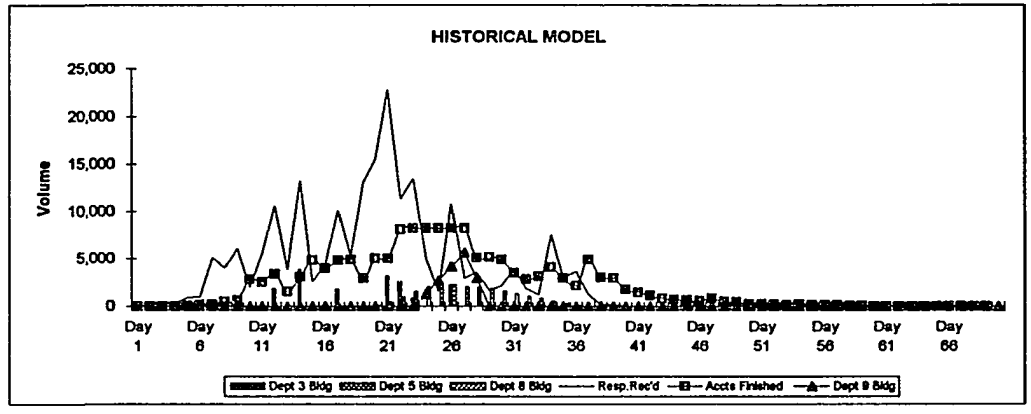
Managers were also asked what types of information and analyses could be provided in order to help them do a better job. Managers indicated the types of summaries that would be useful to document predicted volumes, and formats that would be easier to read. As an example, the capacity plan was extended to include the option of weekend overtime. Using the capacity plan, managers estimated the effect of alternative solutions when a potential bottleneck existed, for example, the effect of hiring additional staff vs. working a longer shift vs. working Saturdays.

b. Description of the Applied Models

1) Historical capacity planning model. Figure 4-4 is the historical capacity planning model, with all variables, assumptions, workflow and backlogs. In addition to the summaries contained in the general model, new summaries were included for total staff required to process all work, total variable costs and unit costs.

2) Pre-Campaign capacity planning model. For the pre-campaign model, Figure 4-1 is the flowchart and Figure 4-2 is the transition matrix. Figure 4-5 depicts the pre-campaign capacity planning model. This is a descriptive model, which permits the level of staff to vary during the campaign with regard to number of FTE's and overtime. For the pre-campaign model, additional summaries were added for average delay, weekend overtime, maximum daily capacity and backlogs. These summaries are also incorporated into the applied model in Appendix D.

FIGURE 4-4. HISTORICAL CAPACITY PLANNING MODEL



DEPARTMENT 1:		
Items Per Hour	7,000	
FTE's Available	0.27	
Hours In Work Day	7.5	Hr /day
Number of machines	1	Varies:
Est Mach downtime	0.0%	
Learning Curve	100.0%	
Max Daily Capacity	14,000	2
Max Daily Capacity	21,000	3

DEPARTMENT 2:		
Percent "No Good"	4.0%	
Items Per Hour	1,500	
FTE's Available	1	Varies:
Hours In Work Day	7.5	
Est Mach downtime	0.0%	
Learning Curve	100.0%	
Max Daily Capacity	10,540	1
Max Daily Capacity	21,080	2

DEPARTMENT 3:		
Percent to Dept 3	96.0%	
Items Per Hour	3990	
Machines Available	1.0	Varies:
Hours In Work Day	7.5	
Est Mach downtime	5.0%	
Learning Curve	100.0%	
Max Daily Capacity	26,634	1
Max Daily Capacity	26,634	1

DEPARTMENT 4:		
Percent to Dept 4	5.0%	
Items Per Hour	85.7	
FTE's Available	1.00	Varies:
Hours In Work Day	7.0	
Est Mach downtime	2.0%	
Learning Curve	100.0%	
Max Daily Capacity	590	1
Max Daily Capacity	1,770	3

DEPARTMENT 5:		
Percent "No Interest"	13.3%	
Items Per Hour	35	
FTE's Available	6.0	Varies:
Hours In Work Day	7.0	
Est Mach downtime	2.0%	
Learning Curve	100.0%	
Max Daily Capacity	1,345	6
Max Daily Capacity	3,363	15
Max Daily Capacity	6,726	30
Max Daily Capacity	11,210	50
Max Daily Capacity	13,452	60

DEPARTMENT 6:		
Percent Dept 6	25.0%	
Items Per Hour	80.0	
FTE's Available	1.0	Varies:
Hours In Work Day	7.0	
Est Mach downtime	2.0%	
Learning Curve	100.0%	
Max Daily Capacity	512	1
Max Daily Capacity	2,050	4
Max Daily Capacity	3,075	6

DEPARTMENT 7:		
%"More Info" to D7	2.2%	
Items Per Hour	20.0	
FTE's Available	0.5	Varies:
Hours In Work Day	7.0	
Percent Resolved	33.3%	
Percent to Dept 8	66.7%	
Est Mach downtime	2.0%	
Learning Curve	100.0%	
Max Daily Capacity	64	1
Max Daily Capacity	256	2
Max Daily Capacity	384	3

SYSTEM 1 DETERMINATION:		
% L1,L2,L4,L5,L6	17.05%	
% L1,L2,L4,L5	6.31%	
% L6 Letters	10.74%	
% to Ven 2	74.25%	
% to Ven1 from Ven2	13.90%	
% to Dept 8/Proc B	3.0%	
% Return Lets	66.1%	
% to Ven 1addchnge	2.54%	
Tot % to Ven 1	16.44%	

VENDOR 1 VERIFICATION:		
Ven 1 says OK	27.16%	
Ven 1 says Letter "V"	65.94%	
Ven 1 says Decline	6.90%	

INCOMING VENDOR 2:		
% Dept 8/Proc A	7.00%	
% to System 2	93.00%	

DEPARTMENT 8: REFERRALS		
Items Per Hour	3.0	
FTE's Available	29.0	
Hours In Work Day	7.5	
Proc A says OK	40.55%	
Proc A says Let "R"	57.83%	
Proc A says Decline	1.61%	
Proc B says OK	43.76%	
Proc B says Let "V"	54.04%	
Proc B says Decline	2.20%	
Proc C says OK	76.33%	
Proc C says Decline	23.66%	
System Downtime	2.00%	
Max Daily Capacity	599	29
Learning Curve	100.0%	

DEPARTMENT 9: LETTERS		
Items Per Hour	3.0	
FTE's Available	29.0	
Hours In Work Day	7.5	
% R letters returned	33.00%	
% Ven 1 "V" Let returned	30.00%	
% Proc B "V" Let returned	30.00%	
Proc D "R" says OK	87.59%	
Proc D "R" says Decline	12.41%	
Proc E "V" says OK	82.69%	
Proc E "V" says Decline	17.31%	
Proc F "V" says OK	84.93%	
Proc F "V" says Decline	15.07%	
System Downtime	2.0%	
Max Daily Capacity	599	
Learning Curve	100.0%	

DEPARTMENT 9A: DAY SHIFT		
Items Per Hour	600.0	
FTE's Available	4.0	
Hours In Work Day	7.5	
Number of Machines	4	Varies:
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	15,177	4
Max Shift Capacity	11,383	3
Max Shift Capacity	7,589	2

DEPARTMENT 9B: DAY SHIFT		
Items Per Hour	650	
FTE's Available	1.0	
Number of Machines	1	
Hours In Work Day	7.5	
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	4,111	

DEPARTMENT 9A: NIGHT SHIFT		
Items Per Hour	600.0	
FTE's Available	1.0	
Hours In Work Day	7.5	
Number of Machines	1	Varies:
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	11,383	3
Max Shift Capacity	7,589	2
Max Shift Capacity	3,794	1

DEPARTMENT 9B: NIGHT SHIFT		
Items Per Hour	650	
FTE's Available	1.0	
Number of Machines	1.0	
Hours In Work Day	7.5	
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	4,111	

DEPARTMENT 10:		
% Special handling	50.0%	
% Requests	90.0%	
Items Per Hour	24.0	
FTE's Available	2.0	Varies:
Hours In Work Day	7.5	
System Downtime	2.0%	
Learning Curve	100.0%	
Max Daily Capacity	331	2
Max Daily Capacity	1,322	8

FIGURE 4-5. PRE-CAMPAIGN CAPACITY PLANNING MODEL

DEPARTMENT 1:

Items Per Hour	7,000	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Number of machines	1	
Est Mach downtime	0.0%	Hr /day
Learning Curve	100.0%	Varies:
Max Daily Capacity	28,000	4
Max Daily Capacity	35,000	5

DEPARTMENT 2:

Percent "No Good"	5.0%	
Items Per Hour	1,500	
"Heavy" Env per hour	454	
Percent "Good"	80.0%	
Avg Items per hour	1290.8	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est Mach downtime	0.0%	FTE's
Learning Curve	100.0%	Varies:
Max Daily Capacity	10,540	1
Max Daily Capacity	42,160	4

DEPARTMENT 3:

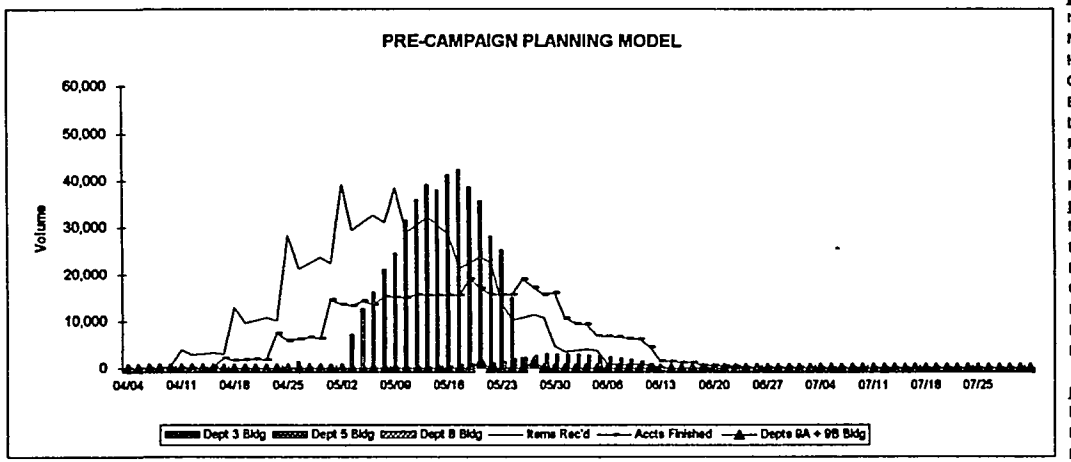
Percent to Dept 3	95.0%	
Items Per Hour	3990	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est Mach downtime	5.0%	Machin
Learning Curve	100.0%	Varies:
Max Daily Capacity	26,634	1
Max Daily Capacity	53,269	2

DEPARTMENT 4:

Percent to Dept 4	5.0%	
Items per hour	85.7	
Hours In Work Day	7.0	
Overtime Per Day	0.0	
Est Mach downtime	2.0%	FTE's
Learning Curve	100.0%	Varies:
Max Daily Capacity	590	1
Max Daily Capacity	1,180	2

DEPARTMENT 5:

Percent "No Interest"	13.3%	
Items per hour	35	
Hours In Work Day	7.0	
Overtime Per Day	1.0	
Est Mach downtime	2.0%	FTE's
Learning Curve	100.0%	Varies:
Max Daily Capacity	4,484	20
Max Daily Capacity	11,210	50
Max Daily Capacity	18,833	84



DEPARTMENT 6:

Percent Dept 6	25.0%	
Items Per Hour	80.0	
Hours In Work Day	7.0	
Overtime Per Day	0.0	
Est Mach downtime	2.0%	FTE's
Learning Curve	100.0%	Varies:
Max Daily Capacity	512	1
Max Daily Capacity	2,050	4
Max Daily Capacity	4,100	8

DEPARTMENT 7:

%"More Info" to D7	2.6%	
Items Per Hour	20.0	
Hours In Work Day	7.0	
Overtime Per Day	0.0	
Percent Resolved	33.3%	
Percent to Dept 8C	66.7%	
Est Mach downtime	2.0%	FTE's
Learning Curve	100.0%	Varies:
Max Daily Capacity	64	0.5
Max Daily Capacity	256	2
Max Daily Capacity	64	0.5

SYSTEM 1 DETERMINATION:

% L1 Letter	3.36%
% L2,L4,L5,L6	18.93%
% L2,L4,L5	7.89%
% L5 Letters	11.04%
% to Vendor 2	75.75%
% to Dept 8B	0.0%
% Return Letters	24.3%
Tot % to Vendor 1	13.00%

VENDOR 1 VERIFICATION:

Ven 1 says OK	38.00%
Ven 1 says "V"Letter	45.00%
Ven 1 says Decline	17.00%

INCOMING VENDOR 2:

% Dept 8/Proc A	8.00%
% to System 2	92.00%

GLOBAL ASSUMPTIONS:

Breaktime Per Day In Hours	0.33
PFD Percentage	2.00%
Sys Down/Slow Resp Time	0.00%

DEPARTMENT 8: REFERRALS

Items Per Hour	3.0	
Hours In Work Day	7.5	
Overtime Per Day	1.0	
Proc A says OK	40.55%	
Proc A says Letter	57.83%	
Proc A says Decline	1.61%	
Proc B says OK	43.76%	
Proc B says Letter	54.04%	
Proc B says Decline	2.20%	
Proc C says OK	76.33%	
Proc C says Decline	23.66%	
		FTE's
System Downtime	2.00%	Varies:
Max Daily Capacity	413	20
Max Daily Capacity	826	40
Max Daily Capacity	1,239	60
Learning Curve	100.0%	
Dept 8 TOTAL FTE	60	

DEPARTMENT 8: LETTERS

Items Per Hour	3.0	
Hours In Work Day	7.5	
Overtime Per Day	1.0	
% "R" letters returned	33.00%	
% Vendor 1 "V" let ret	30.00%	
% PO Box "V" let ret	30.00%	
Proc D "R" let OK	87.59%	
Proc D "R" let Decline	12.41%	
Proc E "V" let OK	82.69%	
Proc E "V" let Decline	17.31%	
Proc F "V" let OK	84.93%	
Proc F "V" let Decline	15.07%	
		FTE's
System Downtime	2.0%	Varies:
Max Daily Capacity	413	20
Max Daily Capacity	826	40
Max Daily Capacity	1,239	60
Learning Curve	100.0%	
Max Total Delays All Areas	19.3	

DEPARTMENT 9A: DAY SHIFT

Items Per Hour	600.0	
Number of Machines	5	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est Mach downtime	10.0%	FTE's
Learning Curve	100.0%	Varies:
Max Shift Capacity	18,972	5
Max Shift Capacity	11,383	3
Max Shift Capacity	7,589	2

DEPARTMENT 9B: DAY SHIFT

Items Per Hour	700
Number of Machines	2
Hours In Work Day	7.5
Overtime Per Day	1.0
Est Mach downtime	10.0%
Learning Curve	100.0%
Max Shift Capacity	8,854

DEPARTMENT 9A: NIGHT SHIFT

Items Per Hour	600.0	
Number of Machines	1	Varies:
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est Mach downtime	10.0%	
Learning Curve	100.0%	Varies:
Max Shift Capacity	11,383	3
Max Shift Capacity	7,589	2
Max Shift Capacity	3,794	1

DEPARTMENT 9B: NIGHT SHIFT

Items Per Hour	700	
Number of Machines	2.0	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	8,854	

DEPARTMENT 10:

% Special Handling	50.0%	
% Requests	90.0%	
% Calls handled by VRU	40.0%	
Items Per Hour	24.0	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
System Downtime	2.0%	
Learning Curve	100.0%	Varies:
Max Daily Capacity	331	2
Max Daily Capacity	992	6
Max Daily Capacity	3,966	24

CHAPTER 5
MODEL IMPLEMENTATION: ANALYSIS OF THE DATA

This chapter discusses model implementation, data collection, data analysis and model validation. Topics covered also include a comparison of planned to actual and an assessment of the strengths and weaknesses of the model.

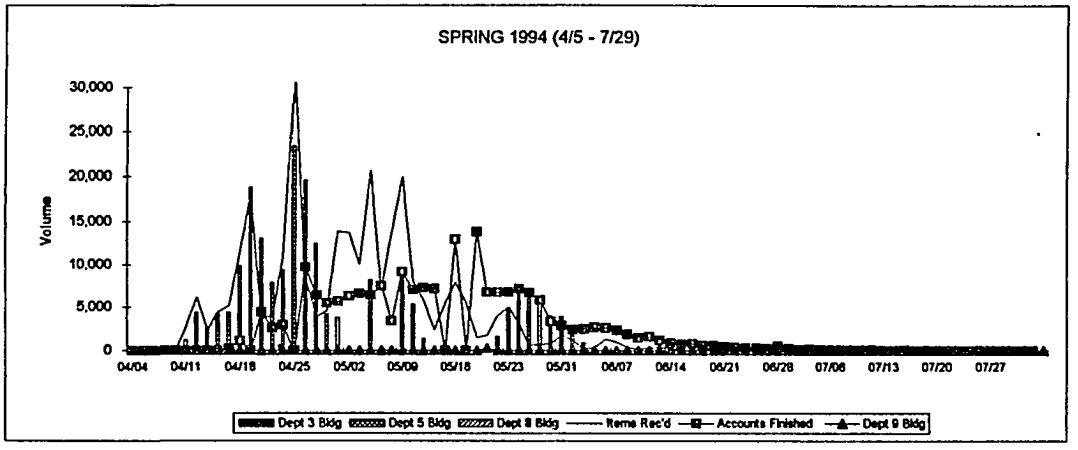
a. Applied/Actual Capacity Planning Model

Figure 5-1 is the applied capacity planning model for the actual event. Appendix D is the applied capacity planning spreadsheet model.

1) Data Collection. During a period of four months, over 250,000 responses to an actual marketing campaign were tracked. In addition, letters mailed to customers and letters returned were monitored to determine the nature of the return/rework phenomena common to service organizations. The goal was to determine if the model reflected actual processing. Nine points were designated as "pulse points". At these nine points, actual daily work was tracked and compared to what the model expected volume to be. For each day in the campaign, actual volumes were recorded at each of these nine points.

Also, the number of days between "letter sent date" and "letter received date" was documented for 20,000 letters to conclude whether the magnitude and timing of incoming items

FIGURE 5-1. APPLIED /ACTUAL CAPACITY PLANNING MODEL



DEPARTMENT 1:

Items Per Hour	7000
Hours In Work Day	7.5
Overtime Per Day	0.0
Number of machines	1
Est Machine downtime	0.0%
Learning Curve	100.0%
Max Daily Capacity	28000
Max Daily Capacity	35000

DEPARTMENT 2:

Percent "No Good"	5.1%
Items Per Hour	1500
"Heavy" Env per hour	454
Percent "Good"	80.0%
Avg Items per hour	1291
Hours In Work Day	7.5
Overtime Per Day	0.0
Est Machine downtime	0.0%
Learning Curve	100.0%
Max Daily Capacity	9255
Max Daily Capacity	27765

DEPARTMENT 3:

Percent to Dept 3	94.9%		
Items Per Hour	4095		
Hours In Work Day	7.5		
Overtime Per Day	0.0		
Est Machine downtime	5.0%		
Learning Curve	100.0%	Varies:	
Max Daily Capacity	27893	1	

DEPARTMENT 4:

Percent to Dept 4	8.0%		
Items per hour	100		
Hours In Work Day	7.0		
Overtime Per Day	0.0		
Est Machine downtime	2.0%	FTE's	
Learning Curve	100.0%	Varies:	
Max Daily Capacity	116	0	
Max Daily Capacity	1605	2	

DEPARTMENT 5:

Percent "No Interest"	7.6%		
Items per hour	35		
Hours In Work Day	7.0		
Overtime Per Day	0.0		
Est Machine downtime	2.0%	FTE's	
Learning Curve	100.0%	Varies:	
Max Daily Capacity	389	2	
Max Daily Capacity	4576	20	
Max Daily Capacity	11439	50	
Max Daily Capacity	16379	72	

DEPARTMENT 6:

Percent Dept 6	100.0%		
Items Per Hour	100		
Hours In Work Day	7.0		
Overtime Per Day	0.0		
Est Machine downtime	2.0%	FTE's	
Learning Curve	100.0%	Varies:	
Max Daily Capacity	196	0.3	
Max Daily Capacity	654	1	
Max Daily Capacity	9949	15	

DEPARTMENT 7:

% "More Info" to D7	6.1%		
Items Per Hour	20		
Hours In Work Day	7.0		
Overtime Per Day	0.0		
Percent Resolved	33.3%		
Percent to Dept 8C	66.7%		
Est Machine downtime	2.0%	FTE's	
Learning Curve	100.0%	Varies:	
Max Daily Capacity	131	1	
Max Daily Capacity	261	2	
Max Daily Capacity	65	0.5	

SYSTEM 1 DETERMINATION:

% L1 Letter	3.9%
% L2,L4,L5,L6	9.8%
% L2,L4,L5	9.8%
% L5 Letters	0.0%
% to Vendor 2	66.6%
% to Dept 8B	0.0%
% Return Letters	44.0%
Tot % to Vendor 1	19.7%

VENDOR 1 VERIFICATION:

Ven 1 says OK	61.1%
Ven 1 says "V"Letter	28.3%
Ven 1 says Decline	10.6%

INCOMING VENDOR 2:

% Dept 8/Proc A	9.9%
% to System 2	90.1%

GLOBAL ASSUMPTIONS:

Breaktime Per Day In Hours	0.33
PFD Percentage	0.0%
Sys Down/Slow Resp Time	0.0%

DEPARTMENT 8: REFERRALS

Items Per Hour			3.5
Hours In Work Day			7.5
Overtime Per Day			0.0
Proc A says OK			53.8%
Proc A says Letter			40.7%
Proc A says Decline			5.5%
Proc B says OK			0.0%
Proc B says Letter			0.0%
Proc B says Decline			0.0%
Proc C says OK			58.4%
Proc C says Decline			41.6%
			FTE's
System Downti		2.0%	Varies:
Max Daily Capa		492	20
Max Daily Capa		984	40
Max Daily Capa		787	32
Learning Curve	100.0%		
Dept 8 TOTAL FTE		32	
		58	
		60	

DEPARTMENT 8: LETTERS

Items Per Hour			3.5
Hours In Work Day			7.5
Overtime Per Day			0.0
% "R" letters returned			26.4%
% Vendor 1 "V" let ret			21.3%
% PO Box "V" let ret			0.0%
Proc D "R" let OK			84.7%
Proc D "R" let Decline			15.3%
Proc E "V" let OK			77.4%
Proc E "V" let Decline			22.6%
Proc F "V" let OK			0.0%
Proc F "V" let Decline			0.0%
			FTE's
System Downti		2.0%	Varies:
Max Daily Cap		492	20
Max Daily Cap		984	40
Max Daily Cap		787	32
Learning Curve	100.0%		
Max Tot Delays All Areas			159

DEPARTMENT 9A: DAY SHIFT

Items Per Hour	600	
Number of Machines	5	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est of Mach downtime	10.0%	FTE's
Learning Curve	100.0%	Varies:
Max Shift Capacity	30974	8
Max Shift Capacity	11615	3
Max Shift Capacity	15487	4

DEPARTMENT 9B: DAY SHIFT

Ratio Items:Accts	1.6	
Items Per Hour	1000	
Number of Machines	1	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	6453	

DEPARTMENT 9A: NIGHT SHIFT

Items Per Hour	600	
Number of Machines	1	Varies:
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est of Mach downtime	10.0%	
Learning Curve	100.0%	Varies:
Max Shift Capacity	11615	3
Max Shift Capacity	7744	2
Max Shift Capacity	3872	1

DEPARTMENT 9B: NIGHT SHIFT

Items Per Hour	1000	
Number of Machines	1	
Hours In Work Day	7.5	
Overtime Per Day	0.0	
Est of Mach downtime	10.0%	
Learning Curve	100.0%	
Max Shift Capacity	6453	

DEPARTMENT 10:

% Special Handling	60.0%
% Requests	85.0%
% Calls automated	60.0%
Items Per Hour	24
Hours In Work Day	7.5
Overtime Per Day	0.0
System Downtime	2.0%
Learning Curve	100.0% Varies:
Max Daily Capacity	337 2
Max Daily Capacity	1012 6

could be determined and whether the pattern can be approximated by a standard distribution.

Actual production data were collected for the volume of incoming work, productivity, amount of staff available to process work, number of items routed between departments and to vendors, and other daily processing factors. In addition, a number of unexpected events occurred that impacted processing. The model was recalibrated to reflect these situations. As an example, near the expected peak of incoming volume from the campaign, a former president of the United States died, and mail delivery was impacted for two days. A flood after a particularly severe rainstorm disabled twenty computer terminals causing staff and work to be rerouted. A temporary anomaly in the letter system resulted in several days letters being produced and mailed on one day, and occasionally a vendor's anticipated work was received late, among other unusual circumstances.

2) Data Analysis and Model Validation. Validation determines whether the model accurately represents the actual processing system. There are different types of validity. Face validity means that the model appears to act like the system under study. If a model has predictive validity, then model predictions reflect actual future occurrences. According to Law and Kelton (1991), "The most definitive test of a simulation model's validity is

establishing that its output data closely resemble the output data that would be expected from the actual system", (p. 311).

To relate the actual system data to model output, Law and Kelton (1991) recommend a "correlated inspection approach". In this approach, the same input variables experienced by the system are entered into the model and the results compared. Likewise, Kleijnen (1974) states, "Reading in historical data ... we recommend for 'validation' of the model. When validating a model we read in the historical data, have these data processed by the simulation program, obtain simulation output, and decide whether the model is realistic or not", (p. 68).

The above approach is followed in this study. Actual daily volume of incoming work, FTEs, transition probabilities and unusual circumstances were inputs to the model. Model output were the daily volume of items routed from one state to another at the nine designated pulse points. The points were chosen from letters, vendors, systems and operational areas. These points are designated as p1-p9 on Exhibit 4-1.

Four measures focus on letters since modeling the nature of the return/rework characteristic is a key objective of this study. There is an outgoing volume and an incoming volume for each of the two letter types. Two measures are

from operational areas. These operational areas were chosen because they drive the volume received by all other areas. They are key to overall processing since all work passes through these areas. Two measures are from vendors. These vendors were chosen since the work processed by them fuels many of the exception processing areas. The system chosen actually books the account and puts it on-line. It is a measure of the actual number of new accounts realized by the marketing campaign. In this step, an application becomes a customer. Please note that work output from one state is the input to another state. The following are the nine points:

- Point 1 - Combined work processed by Departments 3 and 4
- Point 2 - Work processed by Department 5
- Point 3 - Volume of items sent to Vendor 1
- Point 4 - Volume of items sent to Vendor 2
- Point 5 - Volume of outgoing more information letters
- Point 6 - Volume of outgoing Dept 8 letters
- Point 7 - Volume of incoming more information letters
- Point 8 - Volume of incoming Dept 8 letters
- Point 9 - Volume of items sent to System 2 (accounts booked)

A number of the more commonly used validation tests were not applicable to this study. Most of the established tests assume a steady state, underlying queuing properties, and/or independence between intervals. None of these assumptions hold true for the situation under study. Work processed as a result of a marketing campaign does not reach steady state. Work arrivals and processing times do not fulfill standard queuing system requirements, since work is received in large batches as deliveries from the post office. The intervals are not independent since the amount of work arriving on one day is more like the amount of work arriving on the day before or after by the nature of campaign demand. Inman and Leon (1993) note that mechanical failures in one time interval can effect production in other intervals. They also note that the presence of rework loops affect production counts in different time periods.

Butterfield and Thomas (1986) note the lack of empirical validation for transient models in engineering applications, "Clearly, a comparison with empirical data from rig or plant is needed, but we note that hitherto, in practice, the test process has relied almost entirely on visual comparison between the recorded transients and the corresponding model predictions. Hence, the assessed merit of the model has been all too frequently subjective opinion", (p. 187).

Also, Law and Kelton (1991) state with regard to statistical validity tests, "Since the model is only an approximation to the actual system, a null hypothesis that the system and model are the 'same' is clearly false. We believe that it is more useful to ask whether or not the differences between the system and the model are significant enough to affect any conclusions derived from the model", (p. 312). Law and Kelton (1991) also note, "The accuracy required from the model will depend on its intended use and the utility function of the manager", (p. 311). Similarly, Gresham, Meyer and Gray (1985) acknowledge that there will be differences between the actual circumstance and the simulation. They note with regard to validation, "It is first verified that the deviations do not cause the operator to take any action that would not otherwise be taken or to fail to take a required action", (p. 5). Holt, Modigliani and Simon (1955) mirror the idea that decisions based on models are relative, "A decision is not good or bad in itself, but only relative to the state of the world during the time in which the influence of the decision is being felt", (p. 5).

As noted previously, the model was run using actual incoming volume of new work, actual transition probabilities and available staff. The model calculated, day by day, the expected volume of work passing through each of the nine

points. Data on actual volume were collected at each of these nine points for each day of the study, 78 days in all. Comparisons of expected daily volume to actual daily volume were viewed by several methods. Please refer to Figures 5-2 to 5-10 to view the comparison graphs and measures that are described below for each of the nine points. Note that each exhibit, 5-2 through 5-10, has either five or six sections, depending on whether FTEs process work at that stage.

- Exhibit Section 1 - Control charts determine if the difference falls within acceptable limits. This exhibit compares the expected-actual volume and uses +3 and -3 standards deviations as control limits.
- Exhibit Section 2 - This exhibit compares the absolute value of the ratio of actual volume to expected volume, with standard deviations depicted as control limits.
- Exhibit Section 3 - To measure a type of forecast error, the absolute value of (expected-actual)/expected is plotted, again with standard deviations as control limits.
- Exhibit Section 4 - A scatter diagram plots expected vs. actual volumes. A correlation is calculated to the left of the exhibit.

- Exhibit Section 5 - This exhibit graphs the expected vs. actual volume. The mean average deviation and mean squared error are listed to the left of the exhibit.
- Exhibit Section 6 - For processing units, FTE's must be available to process work. Points within the control limits indicate that the model correctly indicated the number of FTE's needed to process the work. Note that not all nine pulse points have this exhibit, only those that for which an FTE comparison is relevant.

b. Comparison of Planned to Actual

Note that the correlations degrade at the points in the model that are more remote, or further downstream in processing. This may indicate entropy or the difficulty of modeling a complex system. Also, the maximum value of a correlation may be constrained by the magnitude of the correlation of the measure before it. For example, correlations for pulse points in the regular process flow (vs. exception processing), from the closest to further downstream, are .99, .93, .91, and .77. For exception processing, correlations from earliest to those near the end of the process flow are .72, .65, .64, .60 and .45.

Regarding staffing levels, on most days model predictions were within control limits. This indicates that

Figure 5-2. Comparison Expected to Actual at Point 1

Exhibit 5-2.1:

Mean
0.0
Std Deviation
840.8

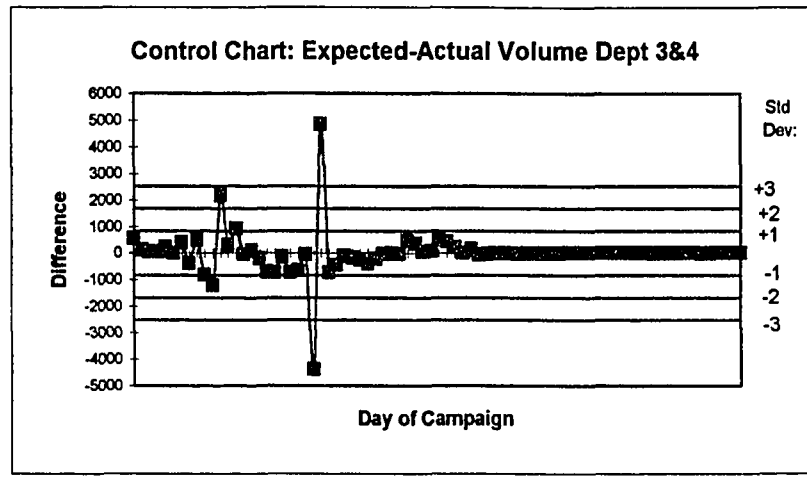


Exhibit 5-2.2:

Mean
0.9
Std Deviation
0.5

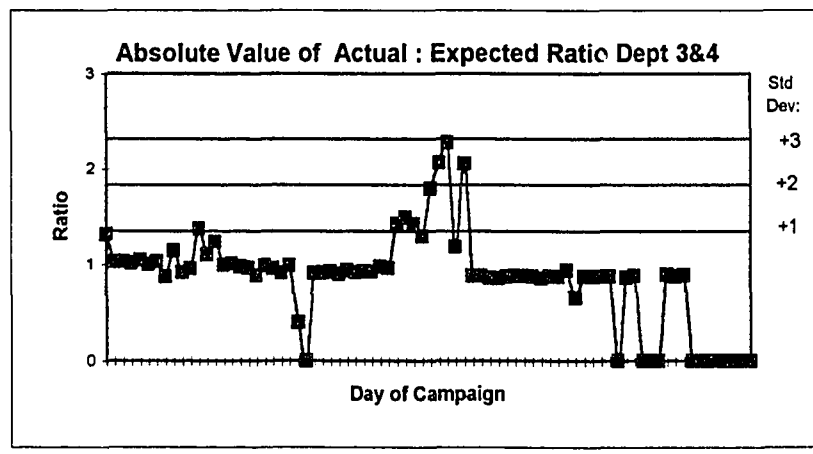


Exhibit 5-2.3:

Mean
0.1
Std Deviation
0.2

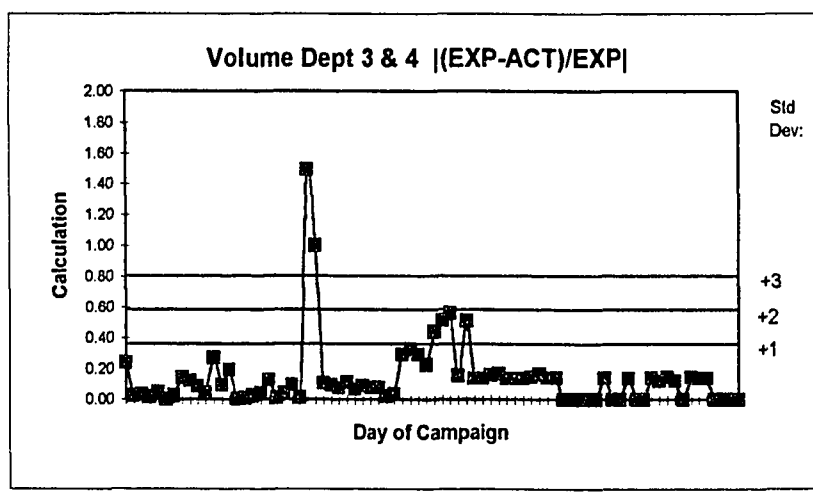


Figure 5-2. Comparison Expected to Actual at Point 1 (Continued)

Exhibit 5-2.4:

Correlation
0.99

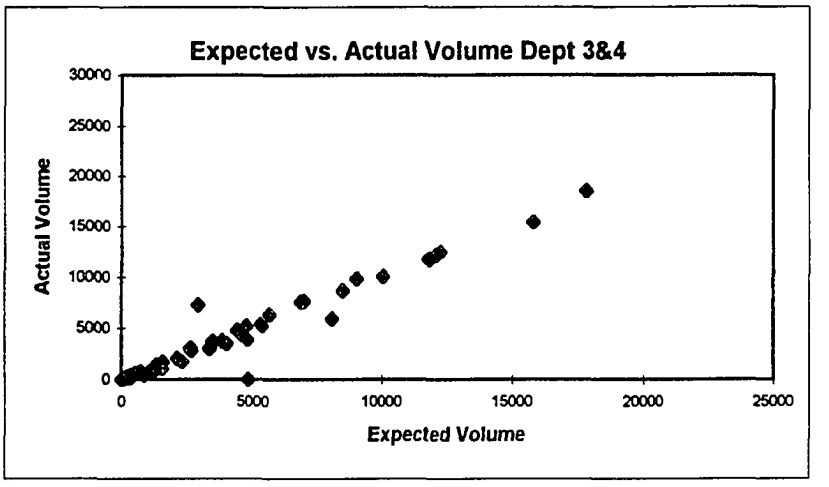


Exhibit 5-2.5:

Mean Avg Deviation
321.7

Mean Square Error
706994.5

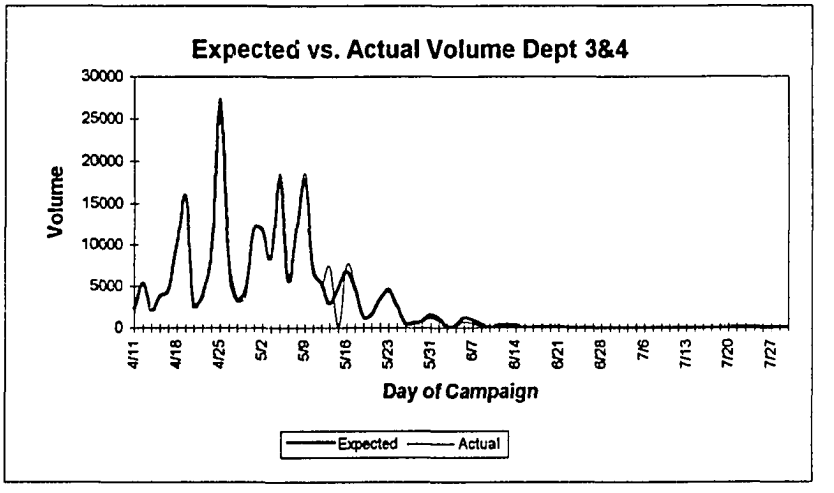


Exhibit 5-2.6:

Items/Hour
35.0
Hours in work day
7.0
Items per day
245.0

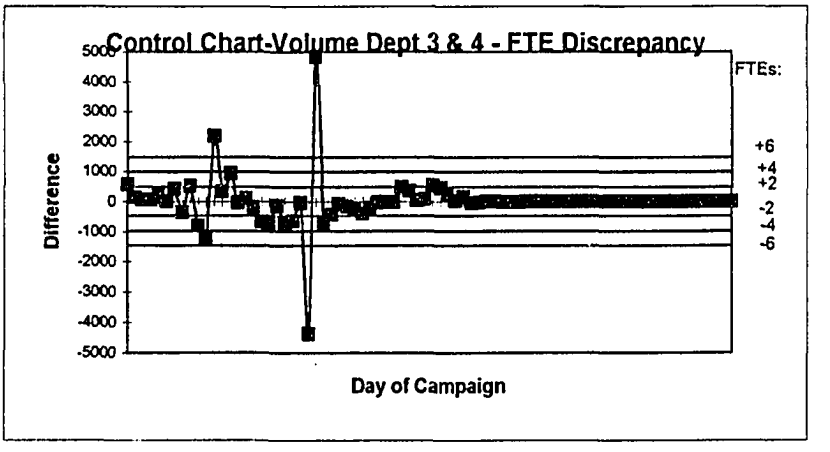


Figure 5-3. Comparison Expected to Actual at Point 2

Exhibit 5-3.1:

Mean
4.61
Std Deviation
1585.17

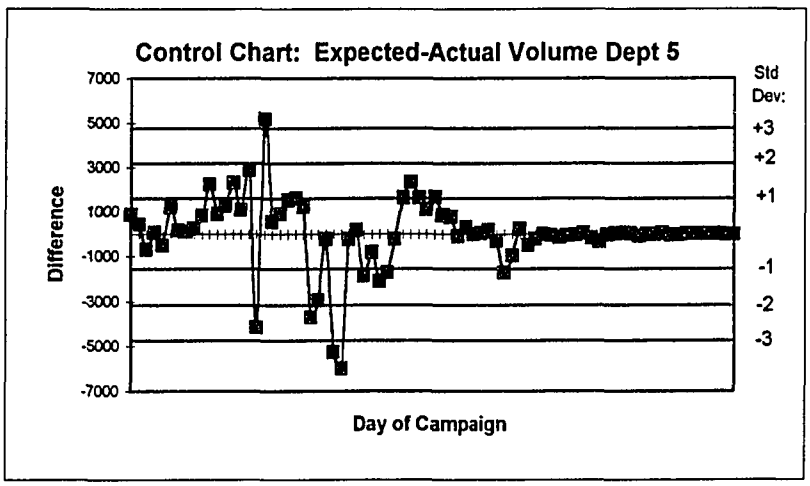


Exhibit 5-3.2:

Mean
1.77
Std Deviation
3.90

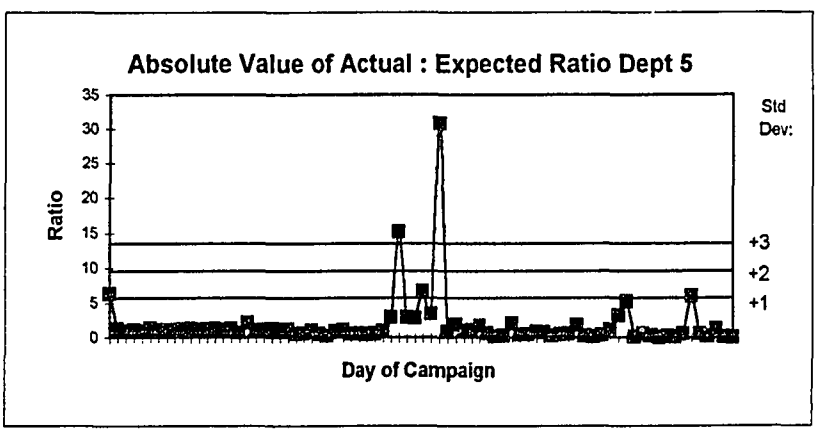


Exhibit 5-3.3:

Mean
1.31
Std Deviation
2.43

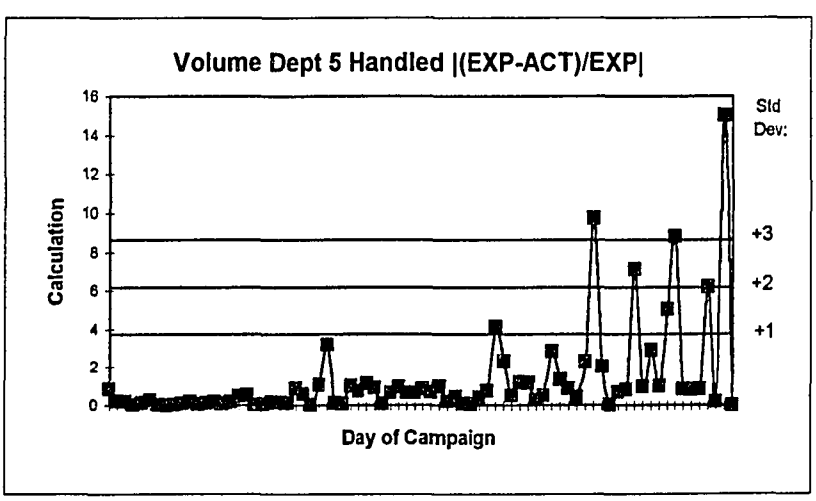


Figure 5-3. Comparison Expected to Actual at Point 2 (Continued)

Exhibit 5-3.4:

Correlation
0.93

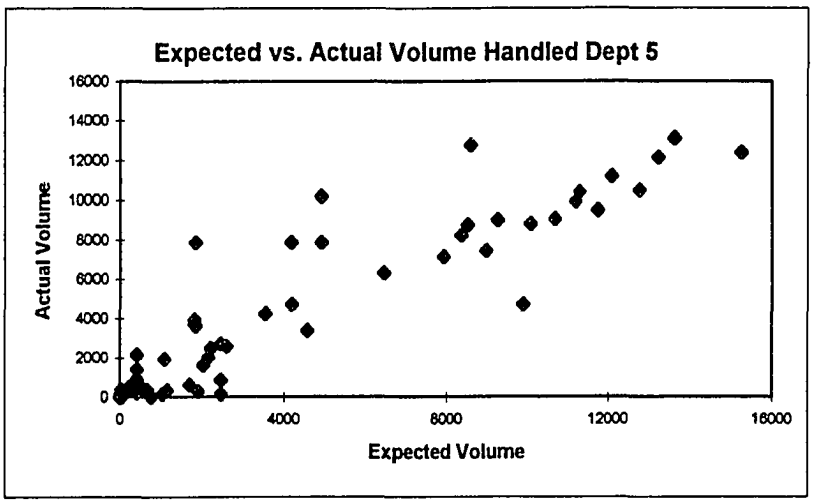


Exhibit 5-3.5:

Mean Avg Deviation
924.49

Mean Square Error
2512789.71

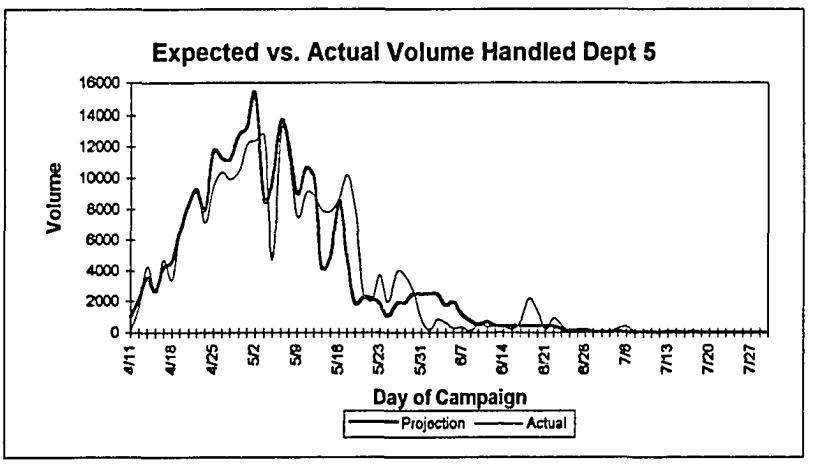


Exhibit 5-3.6:

Items/Hour
100.00
Hours in work day
7.00
Items per day
700.00

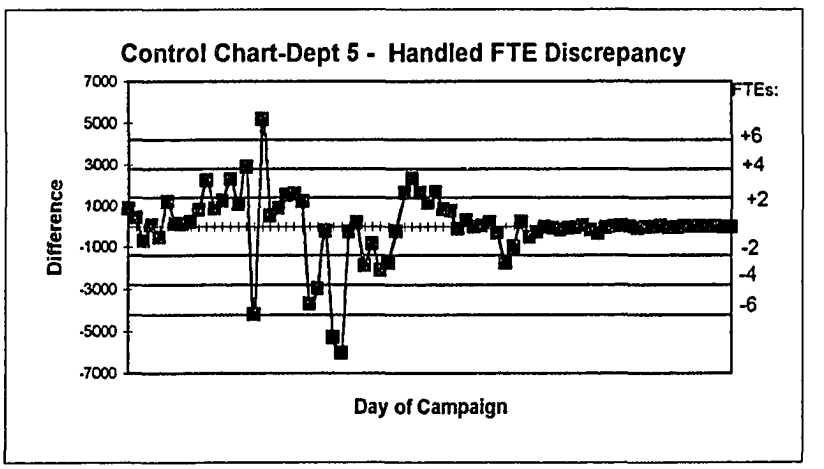


Figure 5-4. Comparison Expected to Actual at Point 3

Exhibit 5-4.1:

Mean
-0.01
Std Deviation
917.95

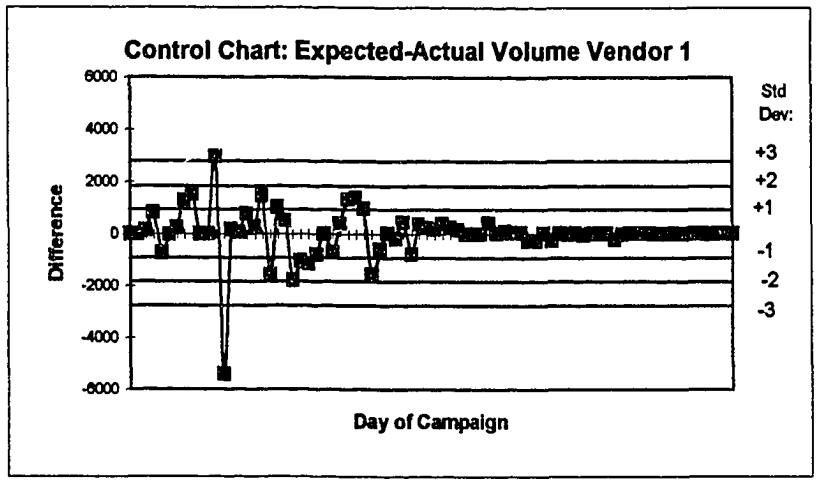


Exhibit 5-4.2:

Mean
5.36
Std Deviation
18.67

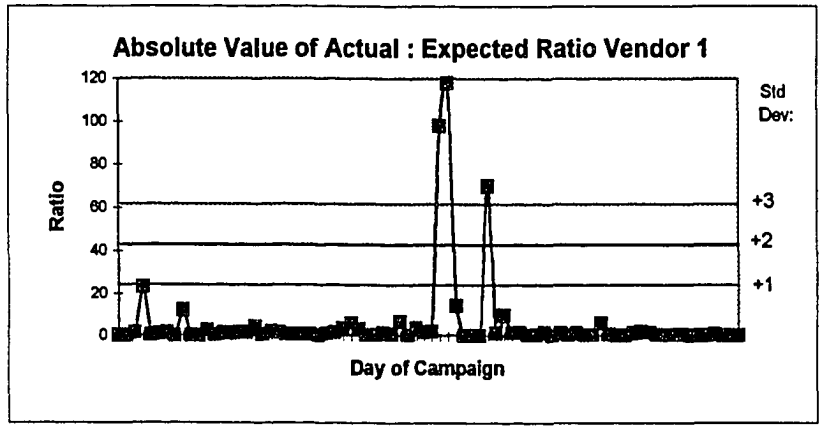


Exhibit 5-4.3:

Mean
1.64
Std Deviation
4.28

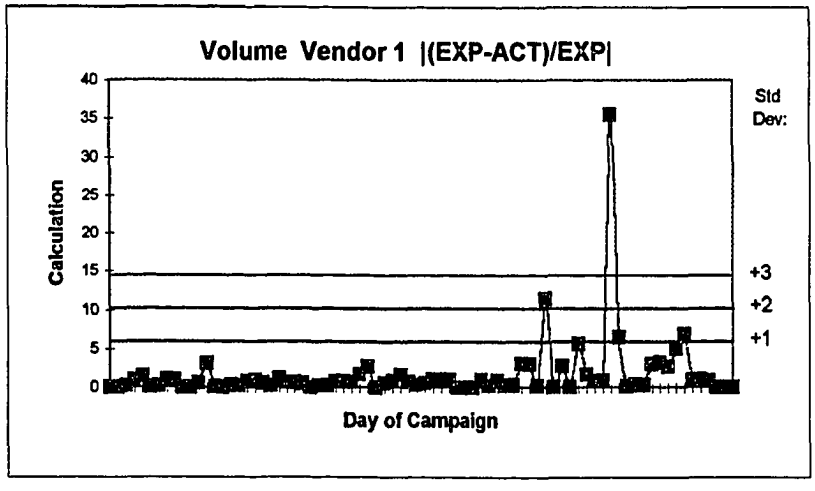


Figure 5-4. Comparison Expected to Actual at Point 3 (Continued)

Exhibit 5-4.4:

Correlation
0.65

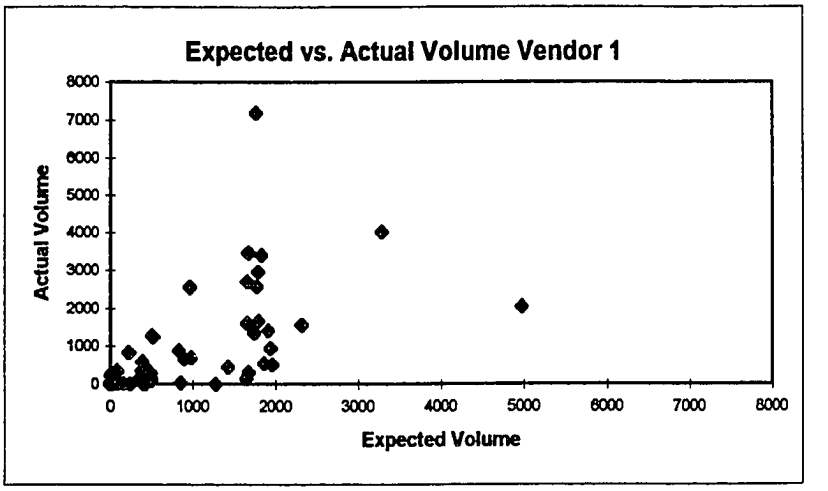


Exhibit 5-4.5:

Mean Avg Deviation
452.8

Mean Square Error
842633.3

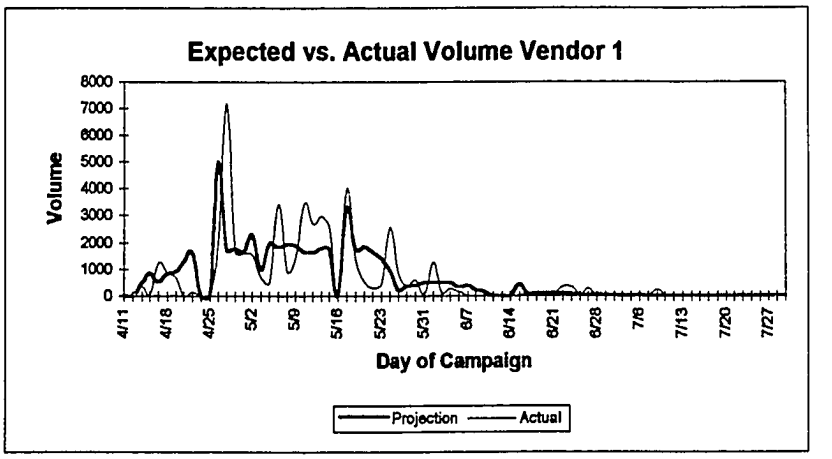


Figure 5-5. Comparison Expected to Actual at Point 4

Exhibit 5-5.1:

Mean
25.69
Std Deviation
840.83

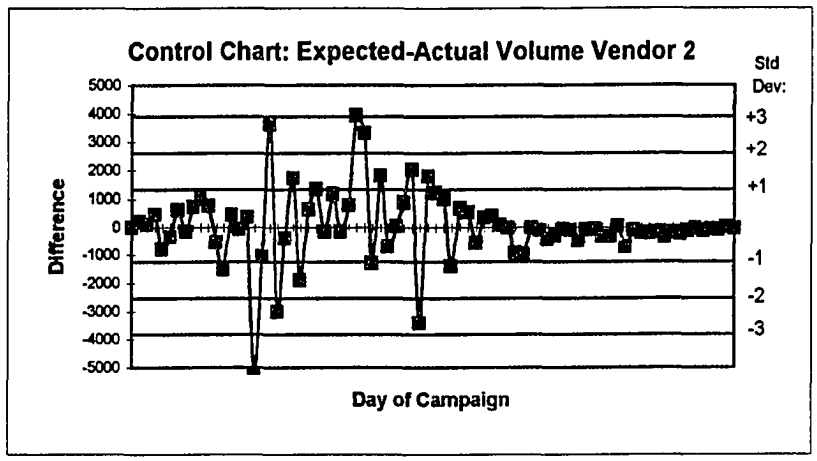


Exhibit 5-5.2:

Mean
0.87
Std Deviation
0.48

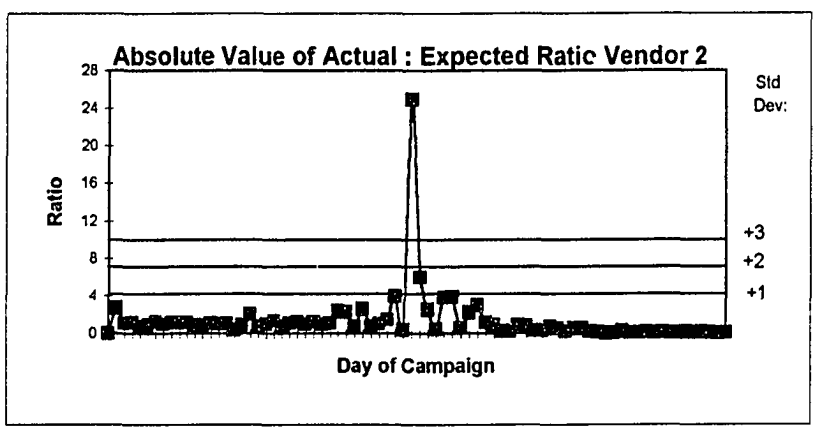


Exhibit 5-5.3:

Mean
3.08
Std Deviation
5.90

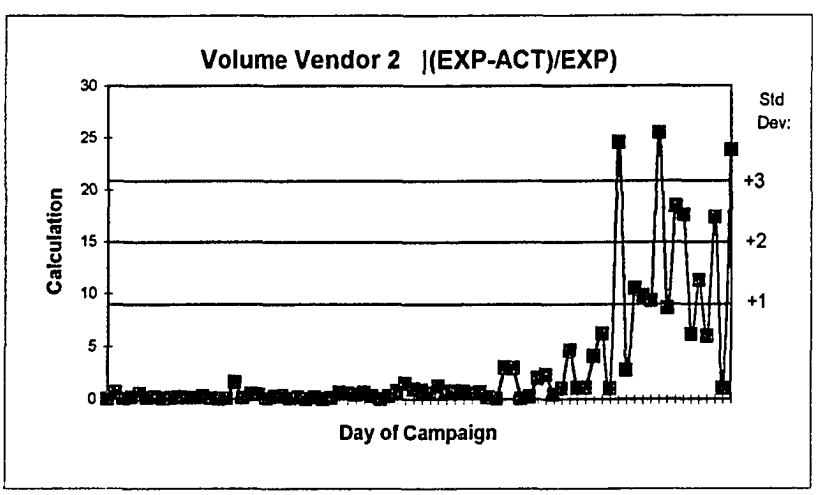


Figure 5-5. Comparison Expected to Actual at Point 4 (Continued)

Exhibit 5-5.4:

Correlation
0.91

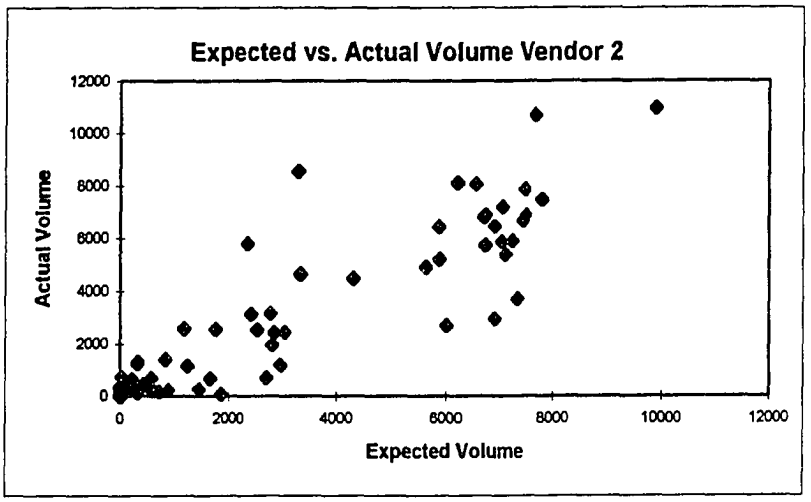


Exhibit 5-5.5:

Mean Avg Deviation
791.8

Mean Square Error
1651847.1

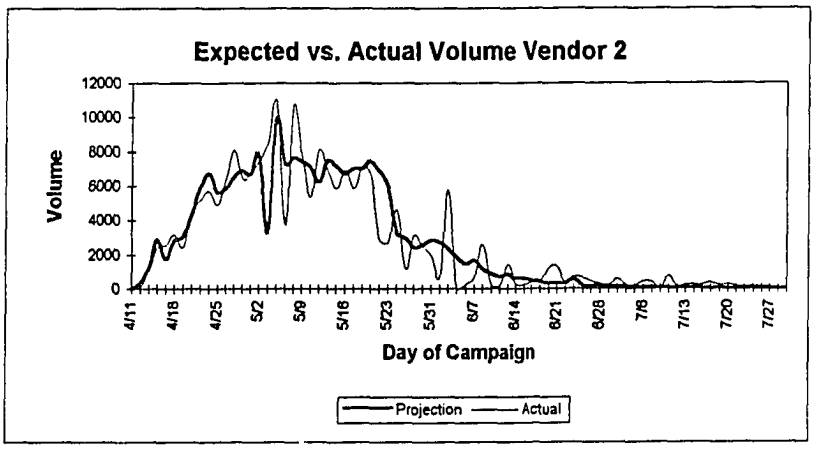


Figure 5-6. Comparison Expected to Actual at Point 5

Exhibit 5-6.1:

Mean
0.02
Std Deviation
592.11

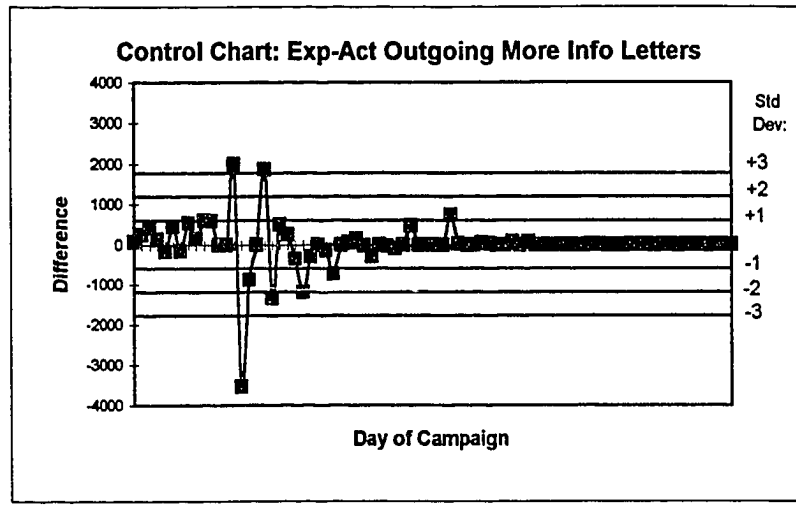


Exhibit 5-6.2:

Mean
1.91
Std Deviation
5.12

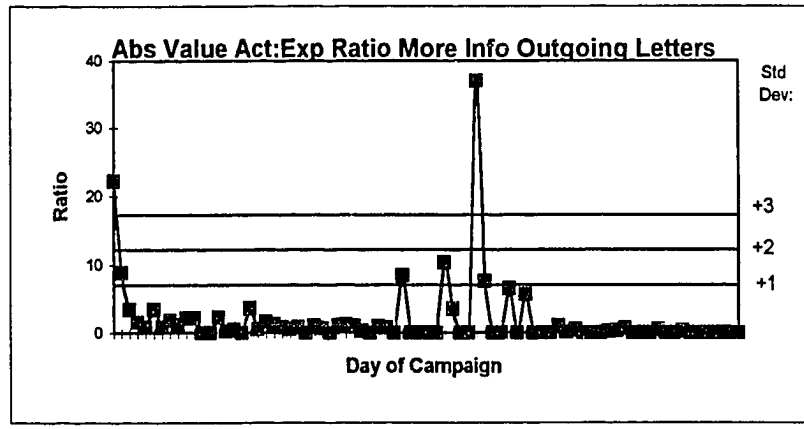


Exhibit 5-6.3:

Mean
0.36
Std Deviation
0.53

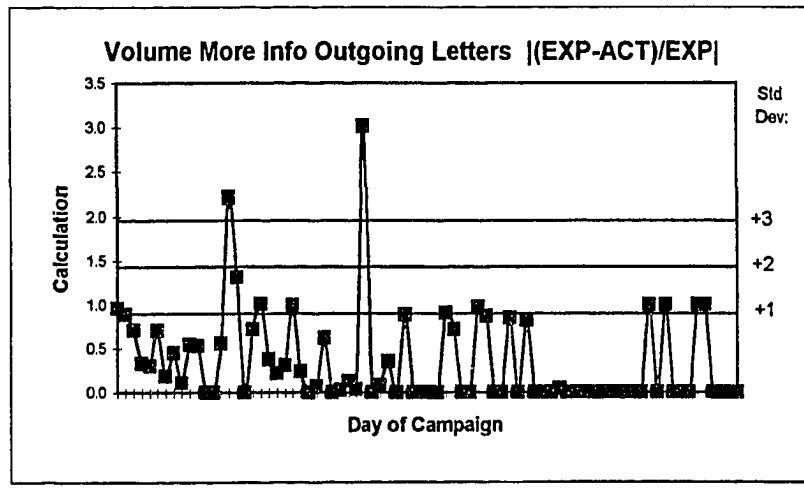


Figure 5-6. Comparison Expected to Actual at Point 5 (Continued)

Exhibit 5-6.4:

Correlation
0.72

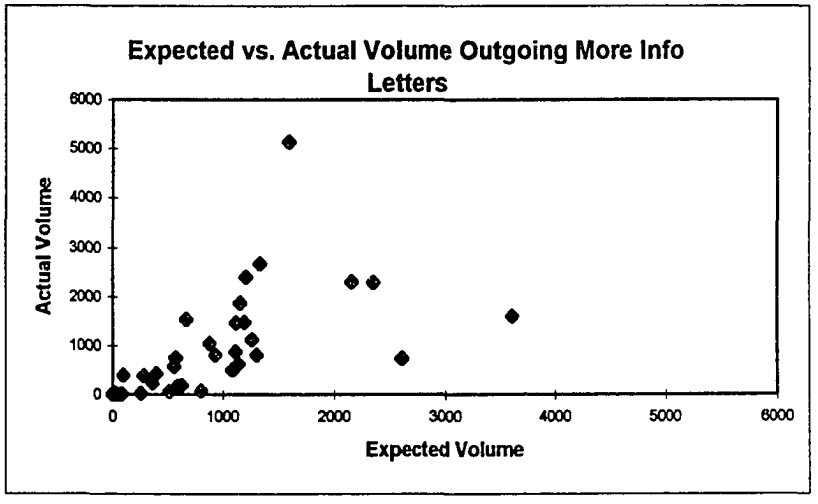


Exhibit 5-6.5:

Mean Avg Deviation
237.30

Mean Square Error
350598.55

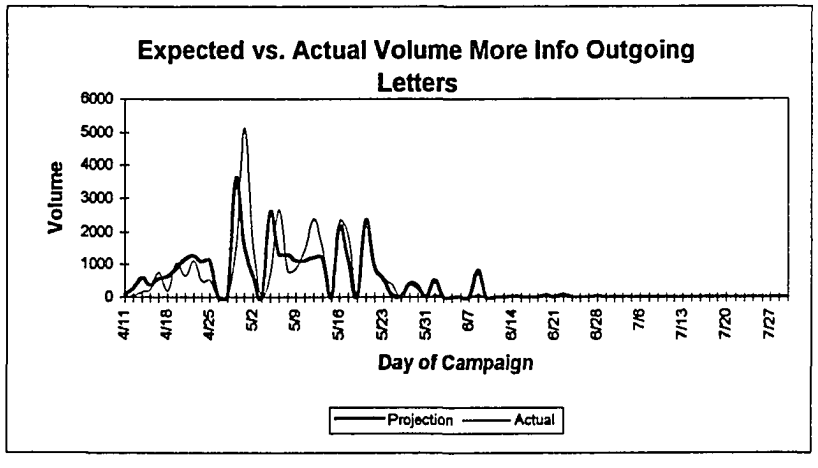


Figure 5-7. Comparison Expected to Actual at Point 6

Exhibit 5-7.1:

Mean
0.51
Std Deviation
568.15

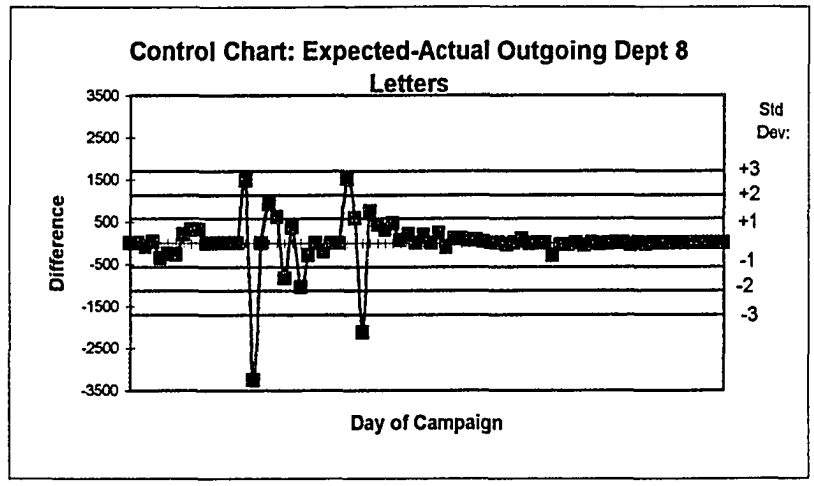


Exhibit 5-7.2:

Mean
1.07
Std Deviation
1.45

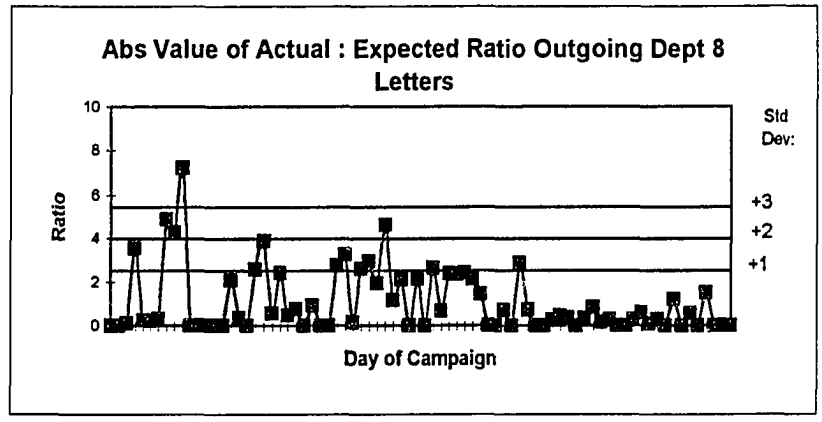


Exhibit 5-7.3:

Mean
0.99
Std Deviation
1.72

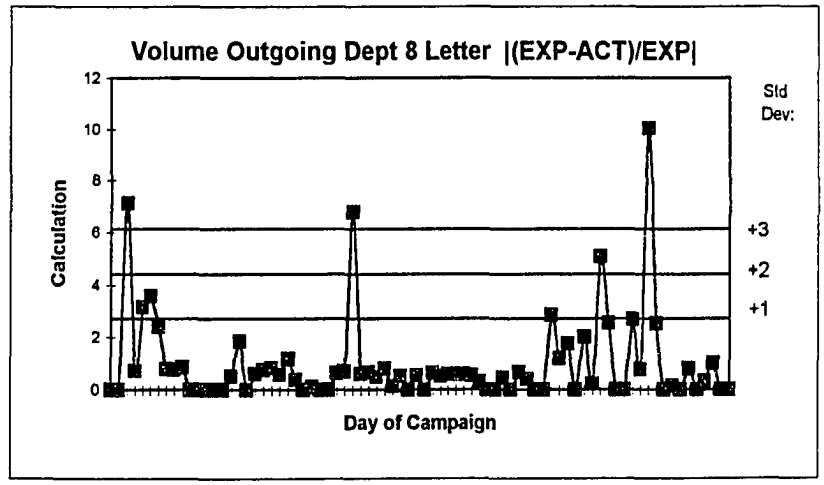


Figure 5-7. Comparison Expected to Actual at Point 6 (Continued)

Exhibit 5-7.4:

Correlation
0.64

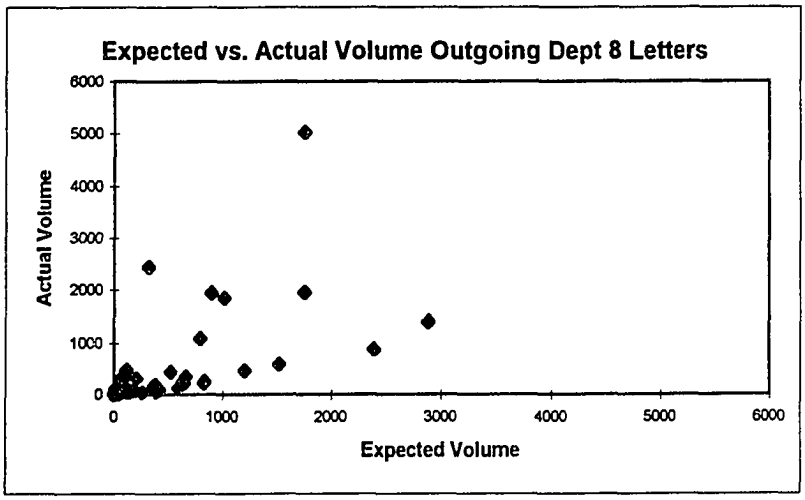


Exhibit 5-7.5:

Mean Avg Deviation
243.02

Mean Square Error
322794.31

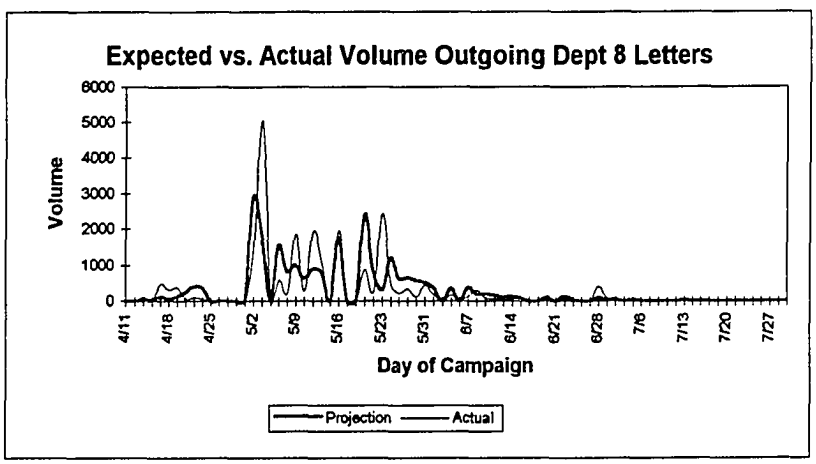


Figure 5-8. Comparison Expected to Actual at Point 7

Exhibit 5-8.1:

Mean
-0.06
Std Deviation
212.56

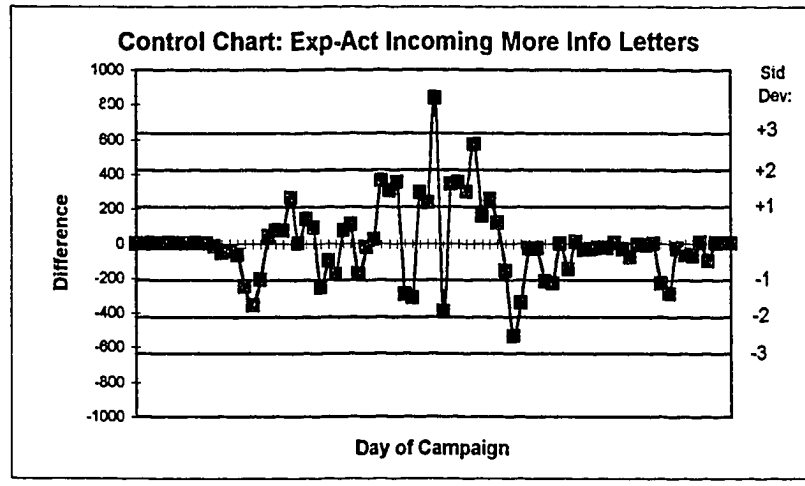


Exhibit 5-8.2:

Mean
1.27
Std Deviation
1.95

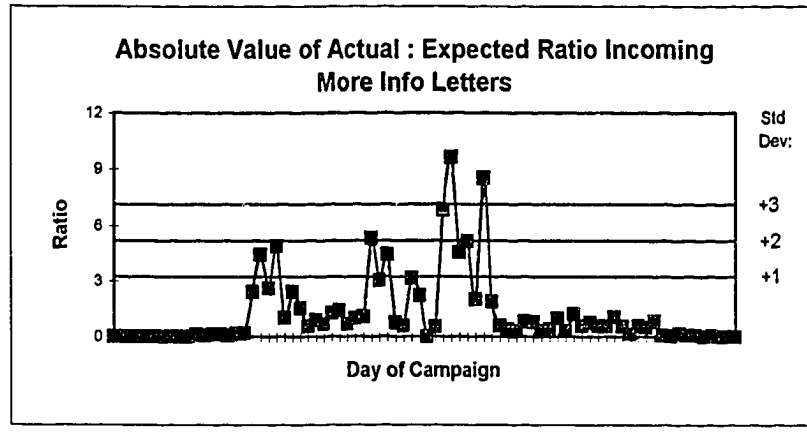


Exhibit 5-8.3:

Mean
2.94
Std Deviation
7.07

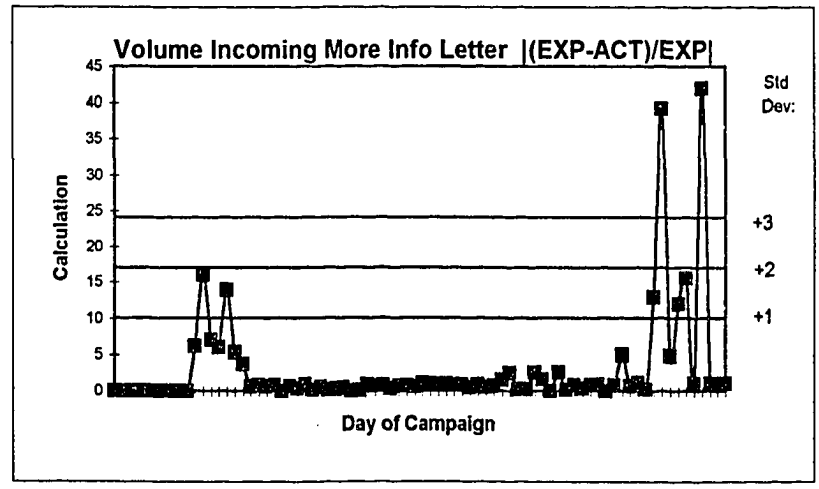


Figure 5-8. Comparison Expected to Actual at Point 7 (Continued)

Exhibit 5-8.4:

Correlation
0.60

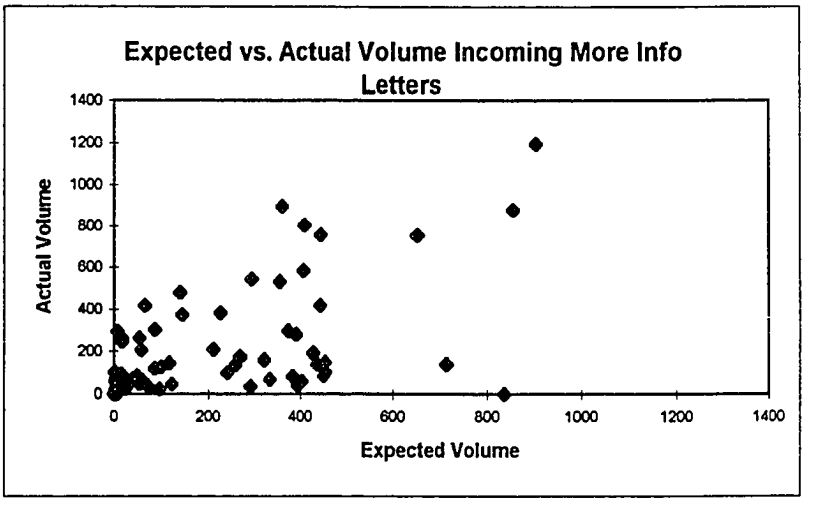


Exhibit 5-8.5:

Mean Average Deviation
139.31

Mean Square Error
45179.64

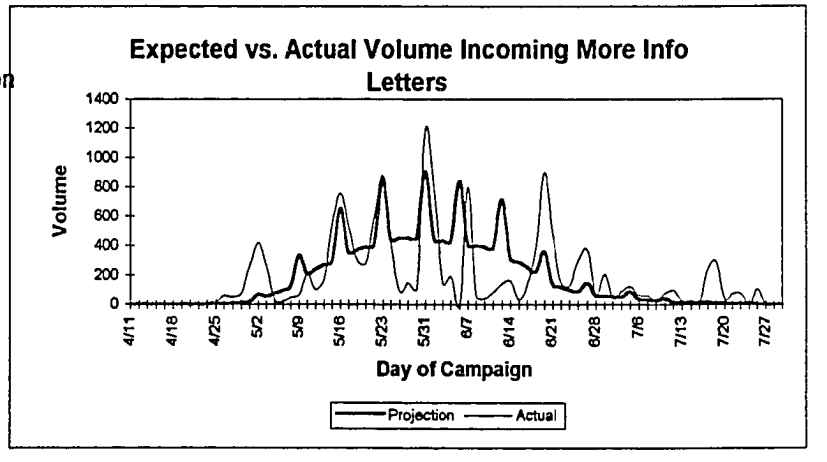


Exhibit 5-8.6:

Items/Hour
1290.80
Hours in work day
7.50
Items per day
9681.00

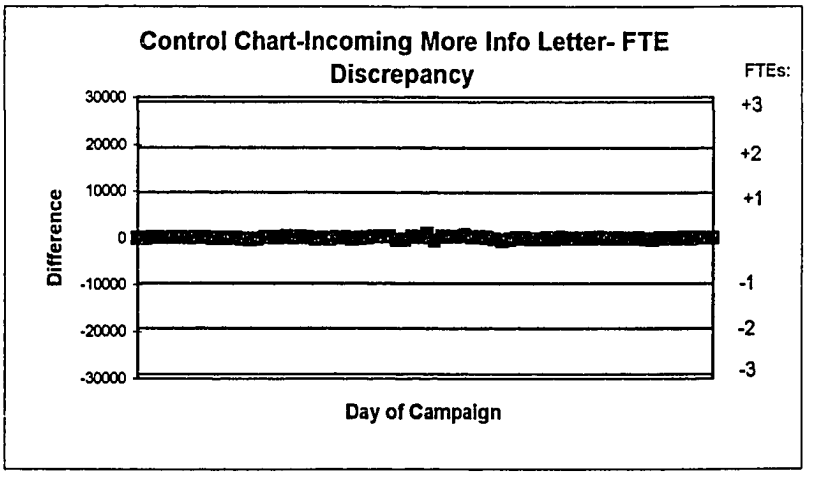


Figure 5-9. Comparison Expected to Actual at Point 8

Exhibit 5-9.1:

Mean
-0.15
Std Deviation
93.73

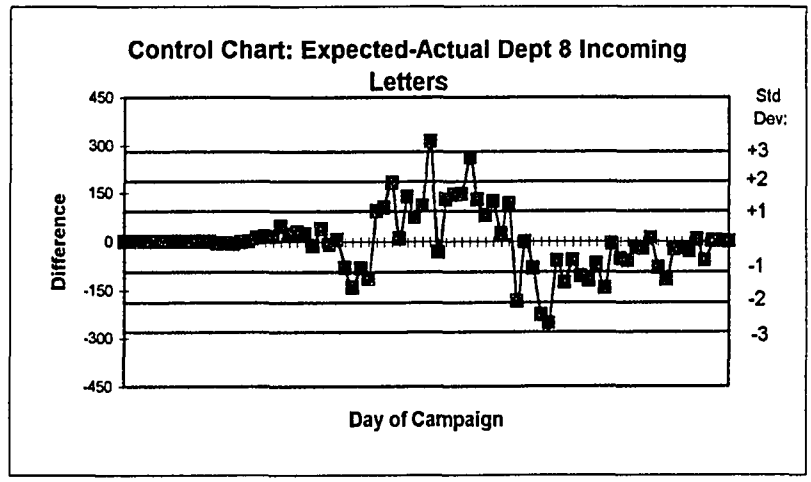


Exhibit 5-9.2:

Mean
1.93
Std Deviation
3.64

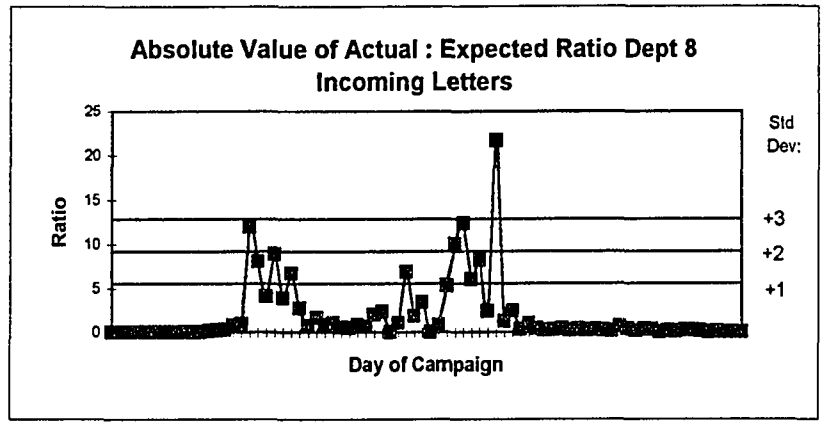


Exhibit 5-9.3:

Mean
1.80
Std Deviation
3.66

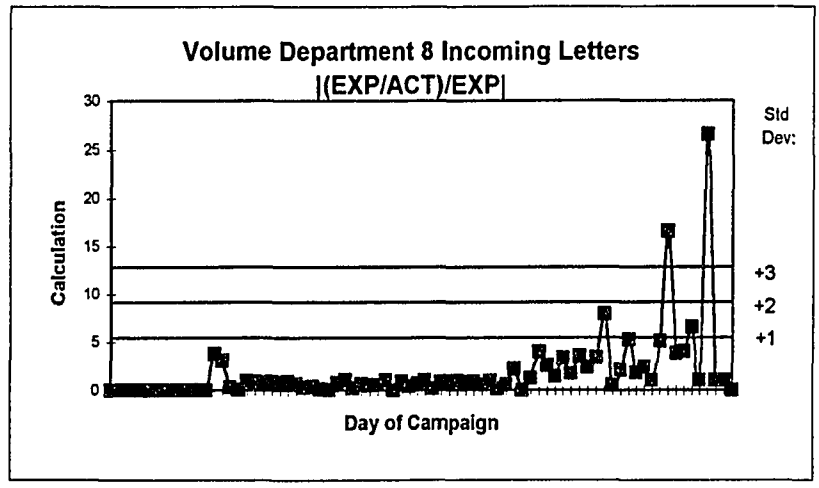


Figure 5-9. Comparison Expected to Actual at Point 8 (Continued)

Exhibit 5-9.4:

Correlation
0.45

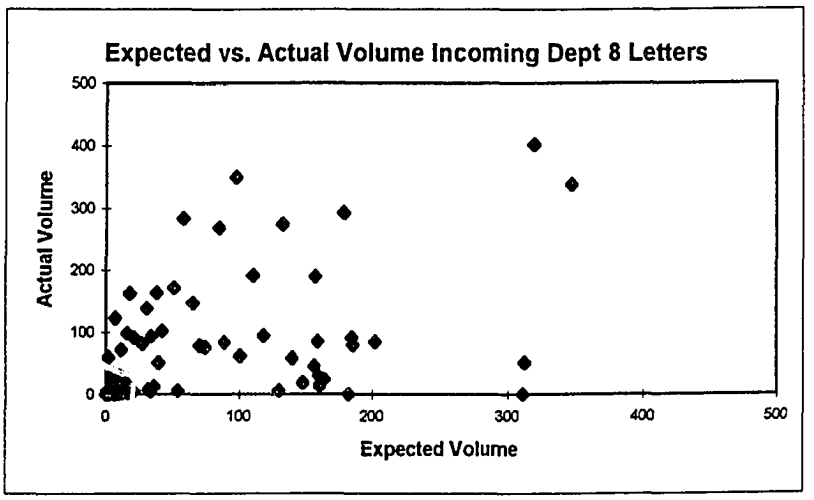


Exhibit 5-9.5:

Mean Avg Deviation
62.01

Mean Square Error
8785.90

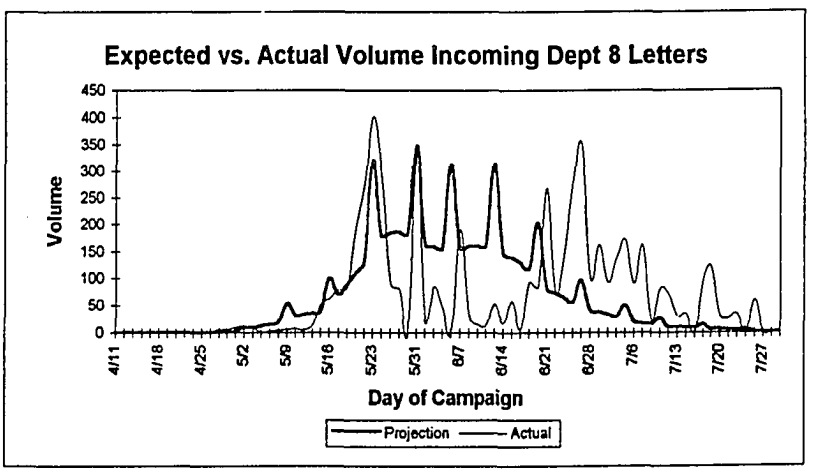


Exhibit 5-9.6:

Items/Hour
1290.80
Hours in work day
7.50
Items per day
9681.00

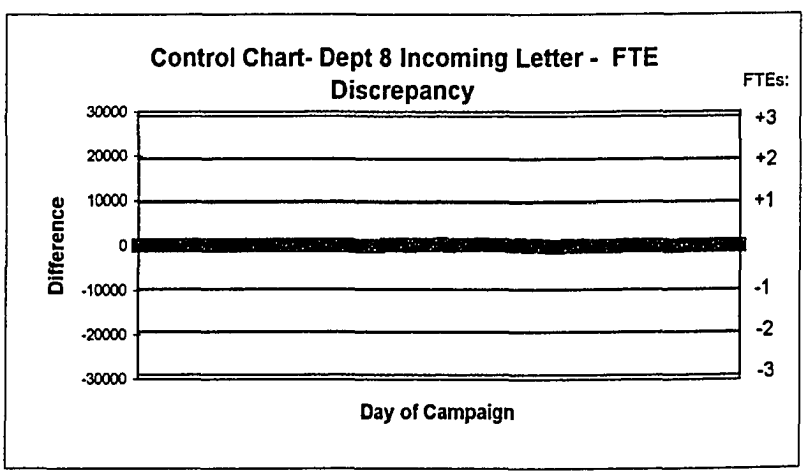


Figure 5-10. Comparison Expected to Actual at Point 9

Exhibit 5-10.1:

Mean
18.30
Std Deviation
2269.53

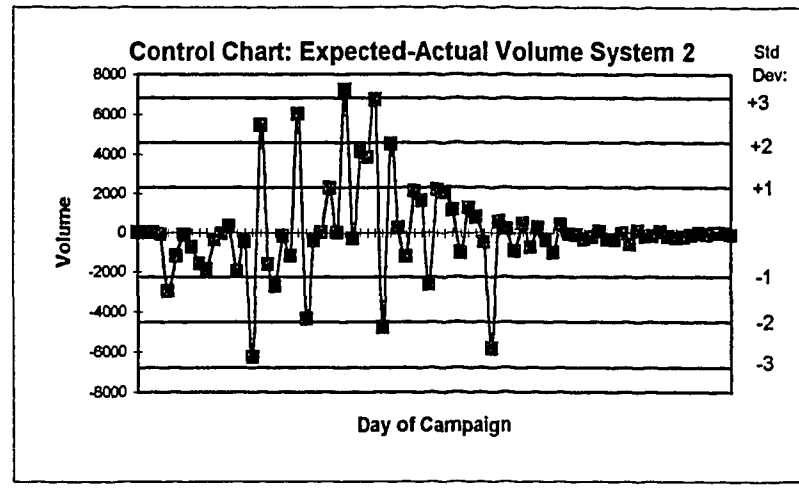


Exhibit 5-10.2:

Mean
2.03
Std Deviation
3.69

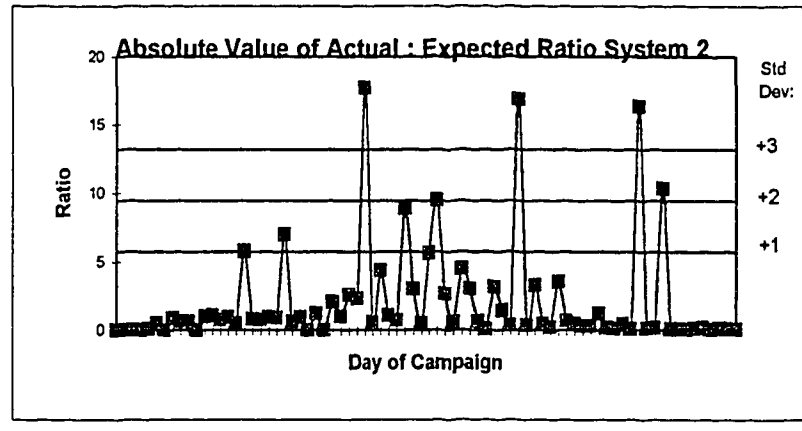


Exhibit 5-10.3:

Mean
2.47
Std Deviation
4.10

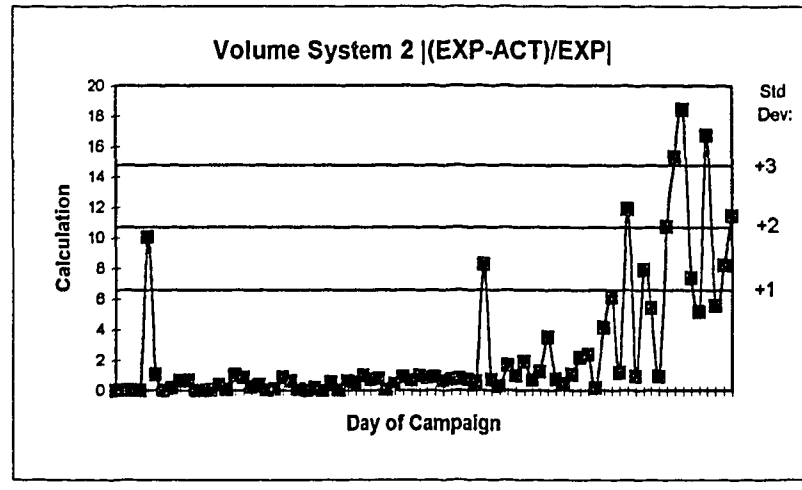


Figure 5-10. Comparison Expected to Actual at Point 9 (Continued)

Exhibit 5-10.4:

Correlation
0.77

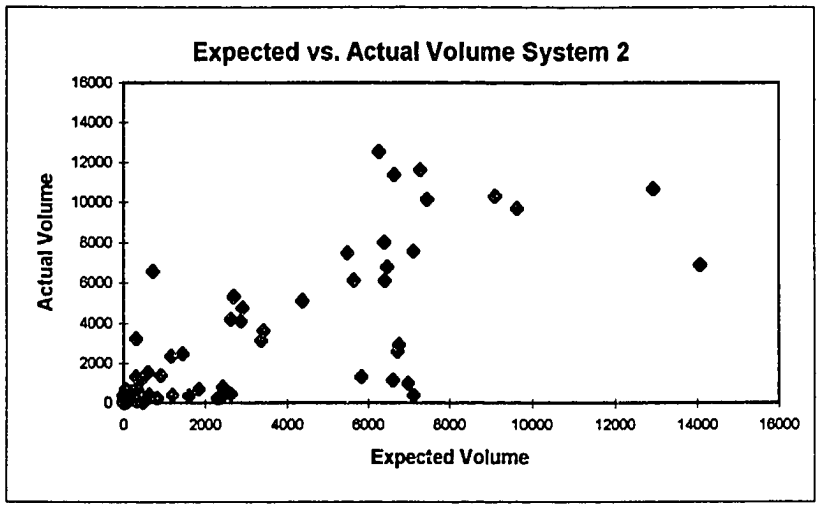


Exhibit 5-10.5:

Mean Avg Deviation
1354.94

Mean Square Error
5151118.88

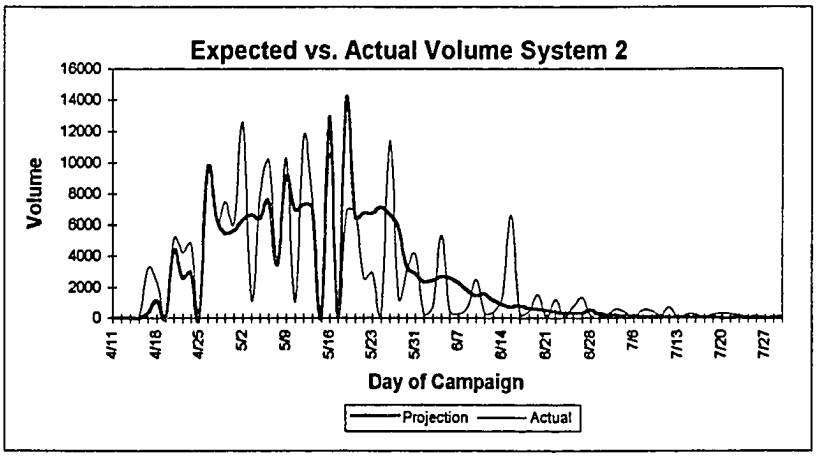
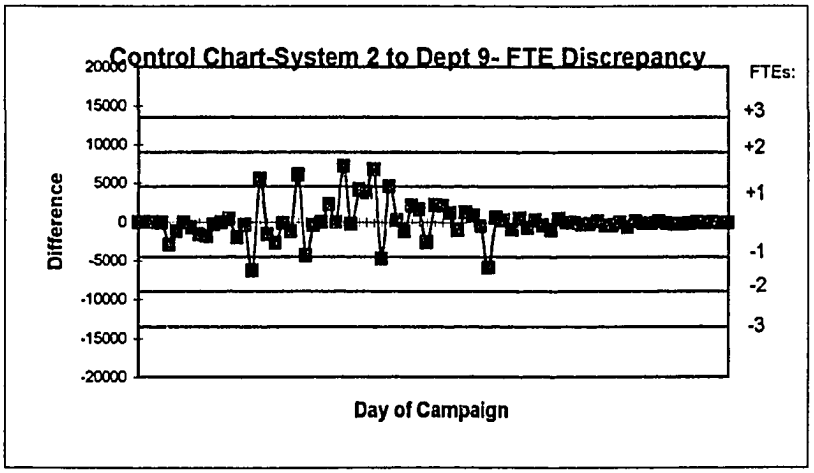


Exhibit 5-10.6:

Items/Hour
600.00
Hours in work day
7.00
Items per day
4200.00



the model made reasonably correct decisions most of the time. The difference control chart (exhibit section 1), FTE discrepancy (exhibit section 6), scatter diagram (exhibit section 4) and line graph (exhibit section 5) provide the clearest information regarding discrepancies. The actual ratio (exhibit section 2) and error forecast of |Expected-Actual|/Expected (exhibit section 3) do not address the magnitude of discrepancy in a useful way. As an example, for the ratio, if the model predicted 16 items, but only 1 actually arrived, the calculation would be 16. This point would be outside the control limits, although the actual magnitude of difference is only 15 items, and a difference of 15 items on any given day would not change staffing decisions.

Analysis of the letter distribution revealed that returned letters do not neatly fall into known distributions such as the Normal or Poisson distributions. Before reviewing the return/rework patterns, the following is a discussion of alternative methods of calculating time. The time to return a letter is calculated between the "letter sent date" and "letter received date". This can be calculated in three ways. Three different assumptions were made to see if different patterns result depending on the manner in which days are counted:

- Calendar days - This is a straightforward calculation between the letter sent and letter received dates. A letter mailed on the first of the month and arriving on the fifteenth would have a calculation of 15-1=14 days to return.
- Monday volume halved - This counts post office days. Saturdays are counted but Sundays are not. Assuming the first of the month is a Monday, the number of days to return would get a value of 15-1-2=12. The above attempts to reflect the situation that approximately half of Monday's work actually arrived on Saturday.
- Business Days - This calculates business days only, assuming a five day work week. Holidays are not counted. The number of days to return would be 15-1-2-2=10 since neither Saturdays nor Sundays are counted.

Figures 5-11 to 5-13 depict the number of days for letters to return for the "more information letters" and "Department 8 letters". Figure 5-11 plots the number of days to return letters under the three assumptions. Figure 5-12 displays this same information cumulatively. Figure 5-13 illustrates how each bundle of letters mailed on each day was returned over the following business days. Figure 5-14 aggregates the number of days into groups of five. It is

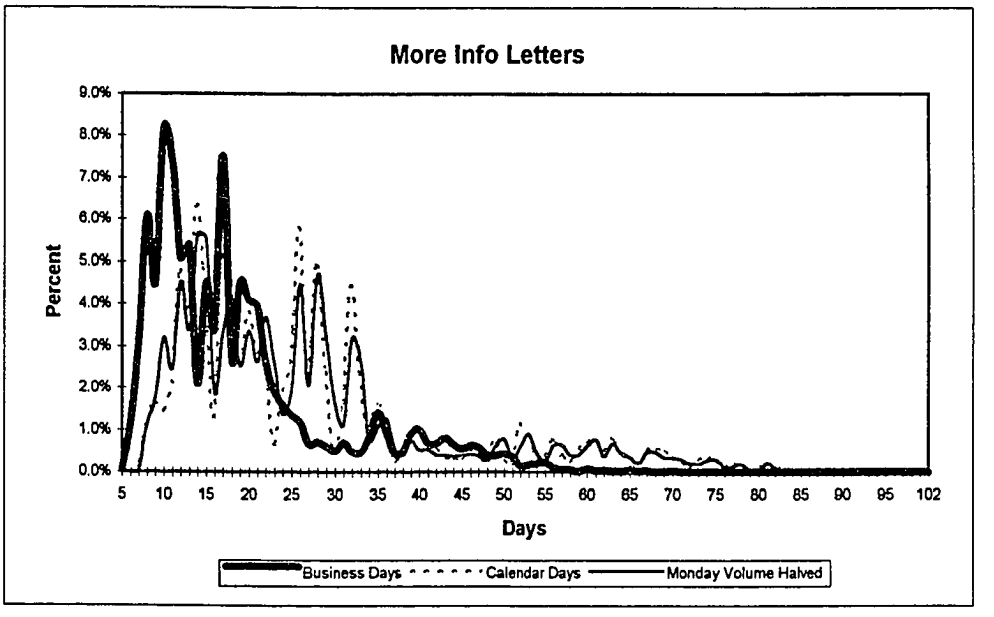
apparent that how the days are counted makes a difference. In this study, since the departments actually work a five day week, the number of days to return a letter was counted in terms of business days. However, the issue that double work is available for processing on Mondays remained. Using a regular return distribution, correlations of .51 and .40 were obtained for incoming "more information letters" and "Department 8 letters" respectively. Modeling double work on Mondays increased the correlations to .60 and .45 respectively. Although the increase is small in magnitude, the improvement in predicted volume indicates that it is useful for businesses to build "double work on Monday" into their capacity planning models.

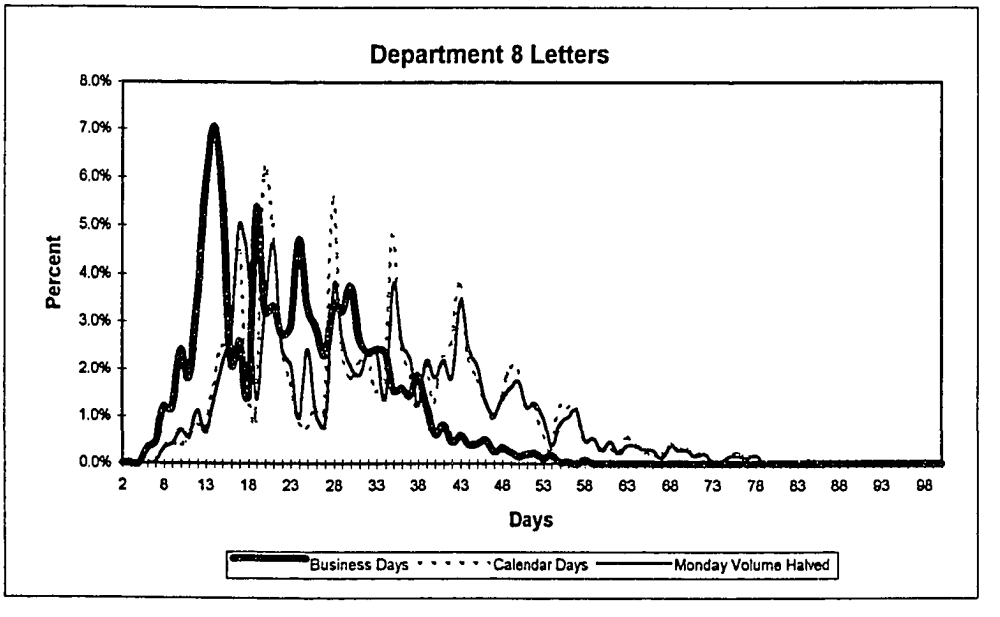
Comparing "mean time to book an account" from a systems journal to the model's calculations revealed the model to be correct within .5 days.

c. Alternative Input Data

The model is dependent on the accuracy of the prediction of incoming work. To determine how well a campaign demand curve fit the actual input data, the actual data was correlated with the best fit Normal curve. The correlation was .77. Input values were taken similarly from a Normal curve, but allowed for weekend mail. This improved the correlation with actual data to .86. The implication is that capacity plans for organizations that receive mail six

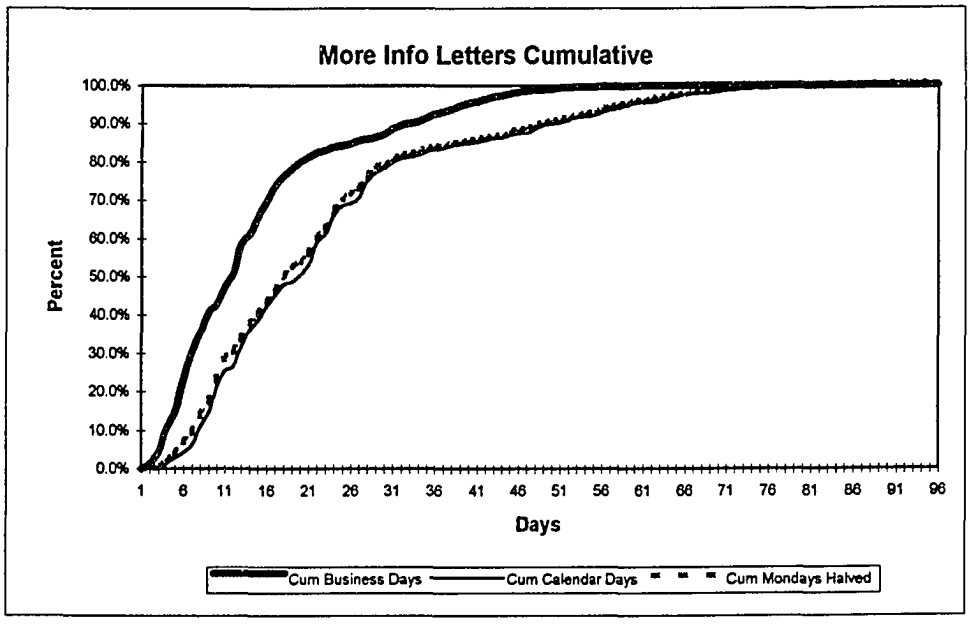
FIGURE 5-11. NUMBER OF DAYS TO RETURN LETTERS





* Note: This represents the percentage of outgoing letters that were received "x days" after mailing.

FIGURE 5-12. CUMULATIVE DAYS TO RETURN LETTERS



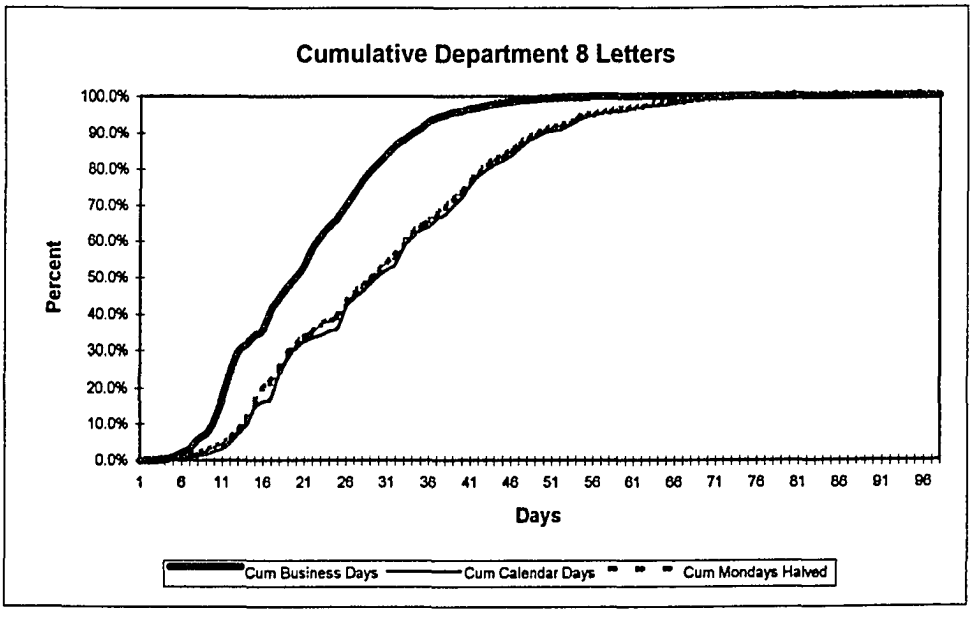
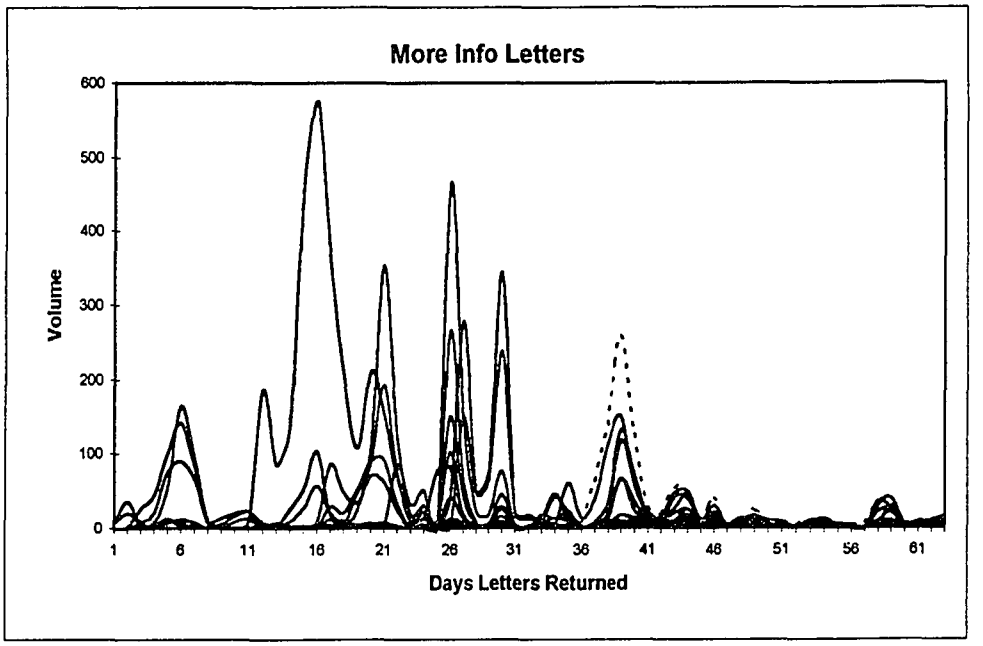
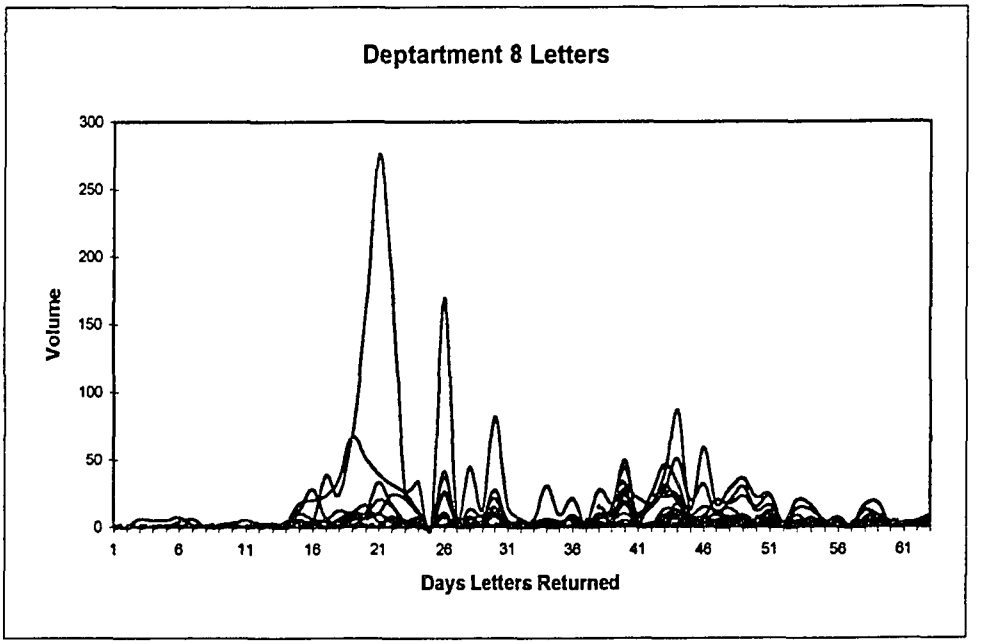


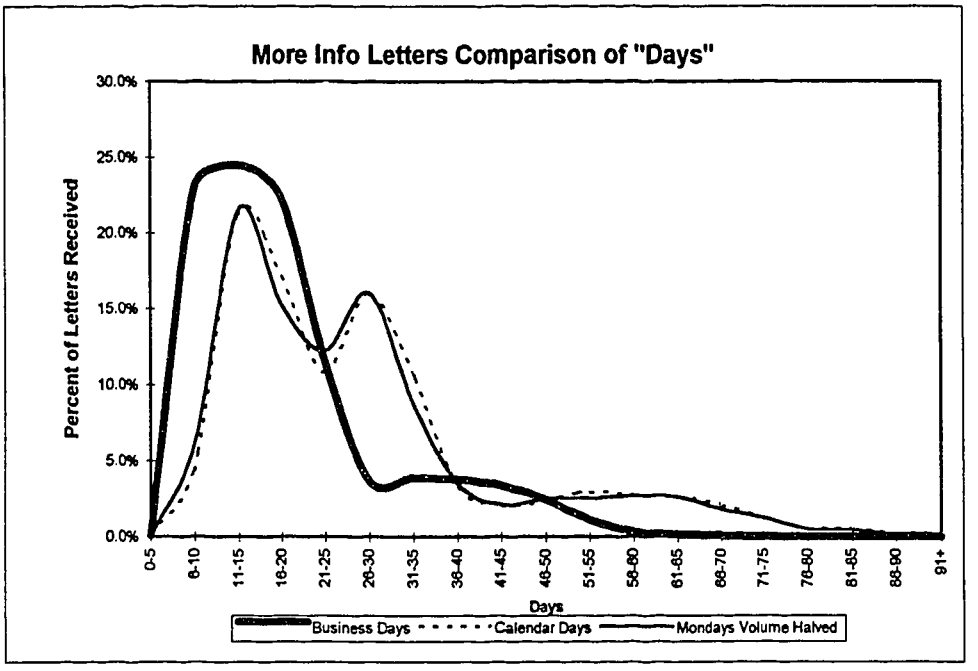
FIGURE 5-13. RETURNED LETTER DISTRIBUTION

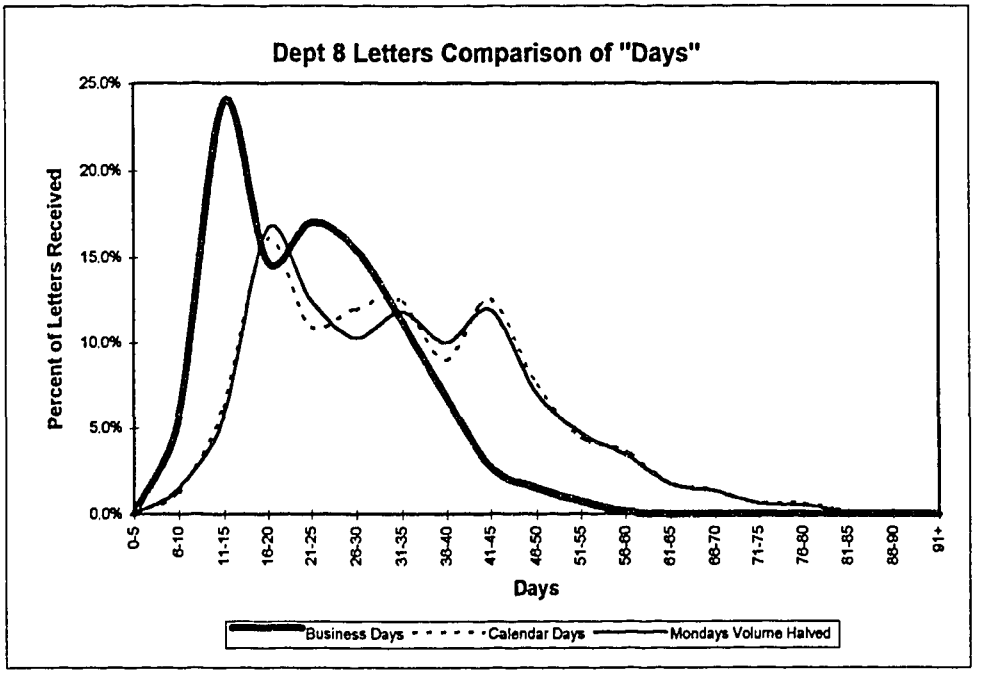




* Note: Each line represents how each day's outgoing letters were actually returned. For example, the dotted lines indicate the return pattern of letters mailed on Day 33.

FIGURE 5-14. NUMBER OF DAYS TO RETURN LETTERS GROUPED





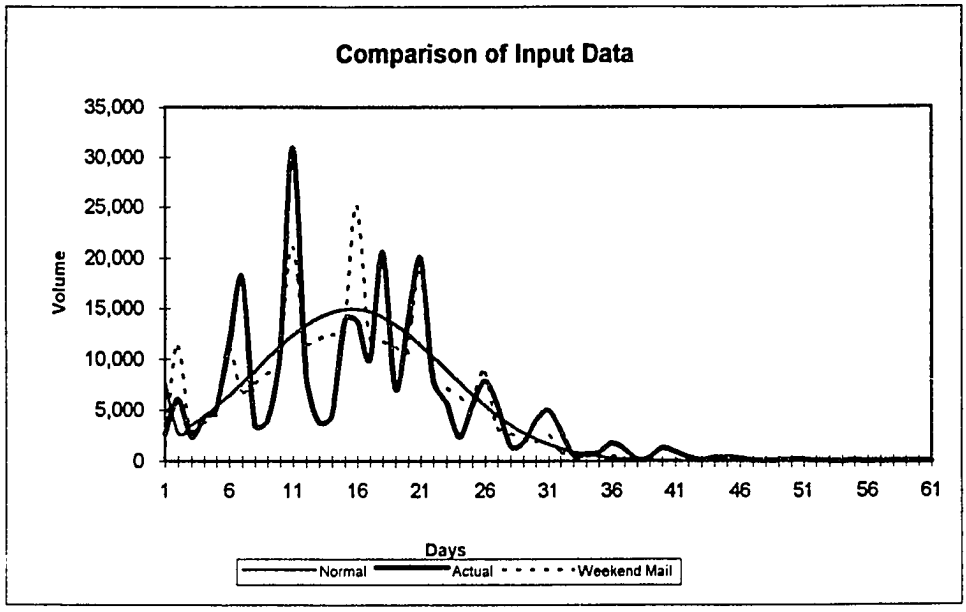
days per week but that only process five days per week should build this type of seasonality adjustment into the model.

Viewing correlations at the nine pulse points, three cases were reviewed: actual input data, a Normal distribution over the course of the marketing campaign, and a Normal distribution but allowing for weekend mail. Figure 5-15 depicts three alternative input streams for incoming work. In the model, all other variables and parameters were held constant. At each of the nine points, each day's expected volume (as determined by the model) and each day's actual volume is compared. The following are the results:

TABLE 5-1: ALTERNATIVE INPUT DATA

Point	Actual Input	Normal	Weekend Mail
Point 1	.99	.77	.85
Point 2	.93	.95	.95
Point 3	.65	.66	.66
Point 4	.91	.90	.90
Point 5	.72	.73	.73
Point 6	.64	.63	.63
Point 7	.60	.61	.61
Point 8	.45	.45	.46
Point 9	.77	.77	.77

FIGURE 5-15. COMPARISON OF INPUT DATA FOR ACTUAL/APPLIED MODEL



The correlations are essentially the same in every case but point 1. This was a surprising finding. Upon closer inspection however, the results are readily explained. Backlogs regulate the amount of work released to other areas. Analogous to a manufacturing environment, the backlog provided a buffer, or safety stock to succeeding departments. Units downstream in the processing flow receive the same amount of work every day regardless of the volume of new incoming work arriving at Department 1. Note that all productivity levels and staff allocations were held constant between these tests, only the input values at Department 1 changed. This demonstrates that departments cannot allocate resources in isolation. For a particular department, resource allocation must consider the resources of other areas and anticipate bottlenecks. It may be more important for a manager determining staff levels to know the maximum capacity of a prior department than the overall pattern of the expected responses to a marketing campaign.

d. Calculating the Overall Volume of Work

The capacity planning model is designed to predict the magnitude and timing of work. The model also calculates "volume factors" which can be used to determine the total volume a department can expect to process as a result of a marketing campaign.

Due to attrition and exception processing, some departments process less than 100% of the incoming applications. Due to return mailings and rework loops, other departments process more than 100% since some items will be processed more than once. Also, if there are multiple individuals per account, some processes must be performed more than once for a single application. Volume factors for the actual case study are listed in Table 5-2.

TABLE 5-2: VOLUME FACTORS FOR THE ACTUAL CASE STUDY

Department	Factor
Department 1	100.0%
Department 2	108.5%
Department 3	108.5%
Department 4	8.0%
Department 5	105.9%
Department 6	105.9%
Department 7	0.4%
Department 8a	8.6%
Department 8b	2.2%
Department 9a	129.7%
Department 9b	80.5%
Department 10	43.8%

As an example, if 100,000 responses were received, Department 2 could expect their workload to increase by

108,500 items (100,000 * 108.5%). Likewise, Department 8b could expect their workload to increase by 2,200 (100,000 * 2.2%). Multiplying the volume factors by the number of consumers expected to respond to a marketing solicitation indicates the total increase in workload during a marketing campaign. Note that the volume factors are a result of the transition probabilities, and will change accordingly if transition probabilities vary between campaigns.

Although designed for a campaign demand environment, the present model can also be used for a steady volume environment by holding incoming work constant. This will be discussed in Chapter 6.

e. Assessment of model strengths and weaknesses

Overall, the model evaluates current operations, and facilitates the planning and scheduling of resources. The benefits of using the model are the following:

1) Alternative scenarios are produced in seconds which is a great time savings.
2) The model enables managers to evaluate, test and compare a wide range of strategy and policy alternatives with regard to scheduling resources (as noted previously, alternatives such as hiring additional staff, working longer shifts and requesting weekend overtime were compared).

3) A "snapshot" of the total picture is provided, since a wide range of variables are viewed simultaneously.
4) The model accurately projects the effect that a change in one department will have on other departments. For example, new equipment in Department 2 nearly doubled capacity which had great impact on Departments 3 and 4.
5) In the event of an unforeseen disaster or crisis (i.e., systems crash, snowstorm, etc.), recovery options can be tested. For example, after the interrupted mail delivery, the effects of alternative strategies were compared such as redeploying staff cross-trained for other job duties.
6) The model predicted potential backlogs weeks in advance, enabling managers to acquire additional resources, thereby avoiding backlogs. As noted previously, a night shift was added in one department and some terminals were reconfigured to handle additional job tasks.

Aside from the benefits of using the model, the process of developing the capacity model had many benefits; 1) The flowcharting and data collection phase facilitated the re-engineering of workflow and streamlined operations. Dissecting and analyzing the process identified

opportunities for improvement and enhanced understanding and agreement regarding how processes work, 2) In the context of developing the capacity plan, managers discussed the types of information that were readily available, information available but only with great effort to collect, and types of information not available. From this type of research, new automated reports were designed to provide managers with additional actionable information, 3) Inter-departmental interfaces improved since managers could more directly observe how their areas impacted other areas. A process view was reinforced for functions that cross divisional lines. Some meetings were attended by managers from multiple departments who offered to cross train staff for additional job functions. This enabled staff to be redeployed more readily in the event of a backlog situation.

This model is a planning model for decision making. The model depicts workflow and resource requirements under normal or expected circumstances. By inputting different levels of resource availability, machine downtime, etc., this model provides an excellent tool for sensitivity analysis.

CHAPTER 6
SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

This chapter is a summary and contains suggestions for future research. Here are conclusions with respect to model validation, extensions and further applications.

a. Conclusions With Respect to Model Validation

Although the relationship of predicted to actual is weaker at the departments closer to the end of the processing workflow, the model gave actionable information regarding volumes and required staffing levels. In most cases, one overall transition probability was used for the duration of the campaign. It is expected that discrepancies between predicted and actual will be greater when actual transition probabilities vary during the course of a campaign. This may occur if workflow changes or new procedures are implemented during a campaign. In these cases, it is necessary to revise probabilities on a more frequent basis, such as weekly. For future marketing campaigns, to further refine the model, transition probabilities will be permitted to vary if evidence indicates change. This is expected to increase the correspondence between actual and expected volumes.

Another enhancement will be the additional use of forecasting tools for adjusting predictions of incoming work. For example, response rates are estimated prior to a campaign, and the capacity plan recommends resource allocations accordingly. However, if the actual response rate is higher or lower than predicted, the magnitude of the discrepancy can be used to revise forecasts for the remainder of the campaign.

The capacity plan was deemed successful enough by management to be used during the succeeding campaign, and there are plans to adapt the model to other areas within the division.

According to Butterfield and Thomas (1986), "Each successful test will give confidence that we may continue to use the generic model to predict process behavior. Failure of any fair test, on the other hand, will indicate that the model is in some way defective, and needs correcting. At first sight, it may seem paradoxical that it is not the successes but the failures that give us further information, and that spur us on to improve our generic models!", (p. 187).

While the above is generally true, and discrepancies between expected and actual volumes did indicate methods to improve the model, a bank manager involved in the actual case study noted that a low correlation between predicted

and actual volumes may not be due to a deficiency in the model. Since the model assumes a stable environment, it is possible that a low correlation indicates that a department's processing is not stable and opportunities for operational improvement exist.

According to Stevens (1991), "We must remember that the fundamental purpose of performance and capacity management is not the acquisition of information about our micro environment, but the development of a level of understanding that will facilitate the timely deployment of necessary resources", (p. 6). In this sense, the model is a definite success, the insights gained from this planning process enabled more efficient planning and allocation of resources.

b. Extensions of the Model and Further Applications

The model can be modified to handle various variations in the flow of incoming work. This section describes the appropriate circumstances for each variation. In addition to service companies, these models have relevance to service departments within manufacturing firms. In all cases, there is a return/rework distribution for errors and omissions that cause items to be returned to the customer. This is a unique feature of this model.

1) Normal Arrivals. The general model is appropriate for the backoffice processing resulting from a marketing

campaign for any company that works 6 days per week and receives responses via mail.

Alternatively, this could also be applied to a business that receives incoming work orders via telephone, and is not dependent on mail for new business. Some categories (for example telephone responses to solicitations) include charities that take MasterCard/Visa via phone, and companies that advertise with mail flyers to encourage individuals to take advantage of promotions for chimney cleanings, home alarm systems, lawn care, carpet cleanings and home improvements, as well companies that advertise with catalogues such as toy companies at Christmas time. The return/rework would be customers whose credit cards are declined, customers who aren't home for their scheduled appointments and must be rescheduled, and customers who change their mind after receiving merchandise and order other items. Attrition occurs when a potential customer decides not to accept the service after the company has invested time and effort to recruit that individual. Please refer back to Figures 3-3, 3-6 and 3-9.

2) Normal Arrivals/Weekend Mail. Another possible extension reflects the realistic situation that occurs on Mondays since the post office delivers six days per week, but most businesses work five. Although the post office receives mail according to a smooth distribution, the

FIGURE 6-1A. NORMAL ARRIVALS/WEEKEND MAIL - DESCRIPTIVE MODEL

MAIL AREA (OPEN,SORT & LOG):

Descriptive Model - Assume Normal Arrivals, but "Saturday Mail" also arrives on Monday

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

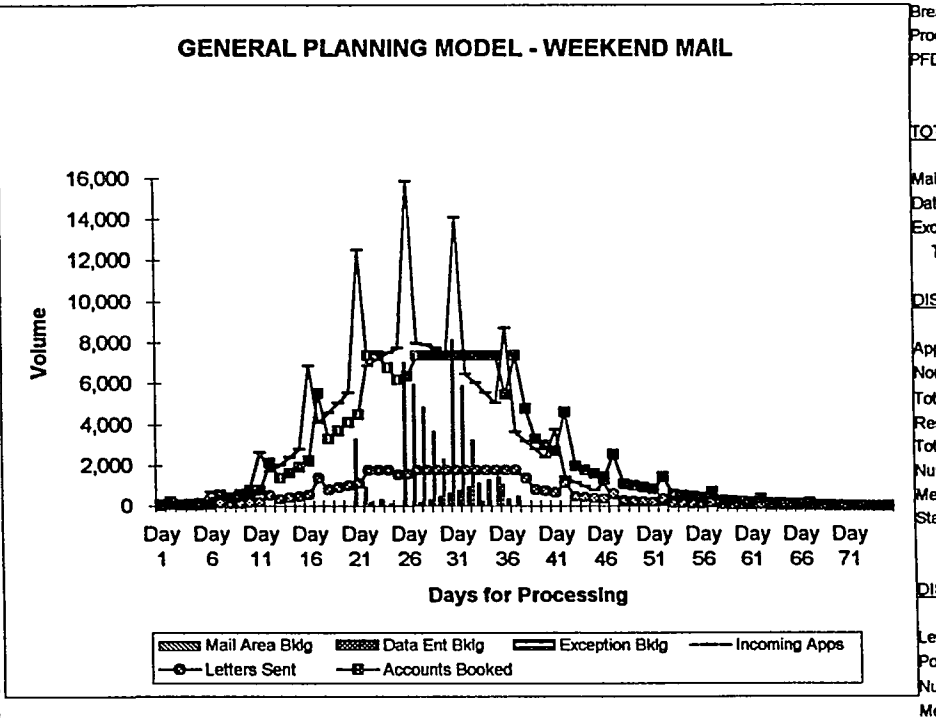
Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
15.5

MEAN TIME IN SYSTEM (DAYS):
4.277



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost to Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$87,309
Data Entry	$30,938
Exception Processing	$34,632
TOTAL	$152,879

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	60
Mean Number of Days	30
Standard Deviation	10.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	28
Mean Number of Days	14
Standard Deviation	14

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 6-1B. NORMAL ARRIVALS/WEEKEND MAIL - PRESCRIPTIVE MODEL

Prescriptive Model - Least Cost Staffing Configuration - Assume Normal Arrivals but "Saturday" Mail Also Arrives on Monday

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	7.8
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,577
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

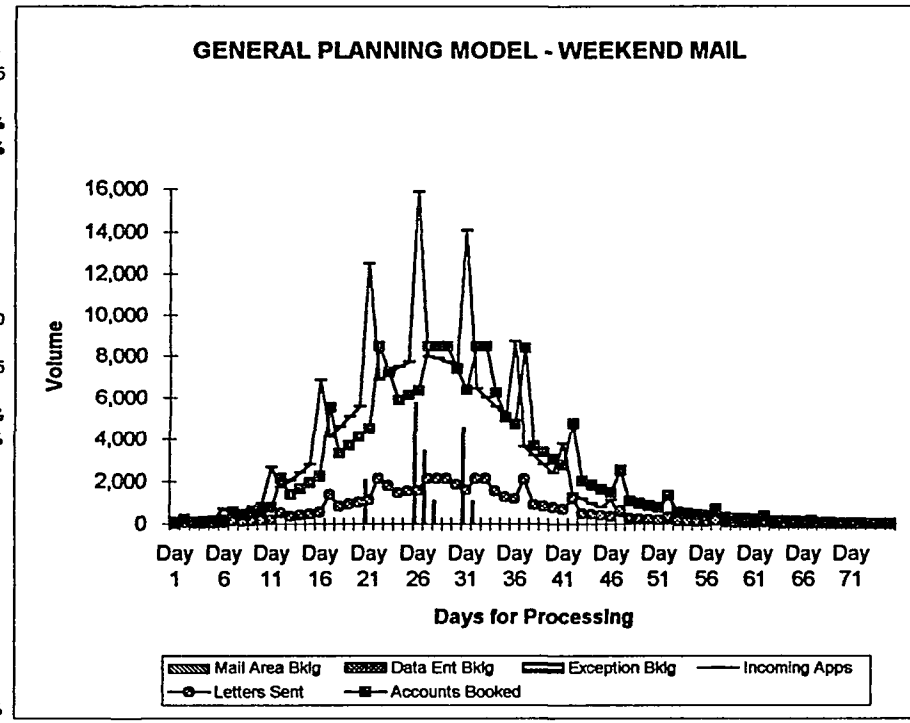
Entered Per Hour	300
FTE's Available	5.2
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,579
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	5.3
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maxi Daily Capacity	4,231
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
18.3

MEAN TIME IN SYSTEM (DAYS):
4.153



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Productivity Lost to Slow Res	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$61,662
Data Entry	$32,012
Exception Processing	$30,827
TOTAL	$124,502

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	60
Mean Number of Days	30
Standard Deviation	10.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	28
Mean Number of Days	14
Standard Deviation	14

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 6-1C. NORMAL ARRIVALS/WEEKEND MAIL - PRESCRIPTIVE MODEL WITH CONSTRAINTS

Prescriptive Model - Least Cost Staffing Configuration - Assume Normal Arrivals but "Saturday" Mail also arrives on Monday, and Constraints

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	5.9
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,237
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

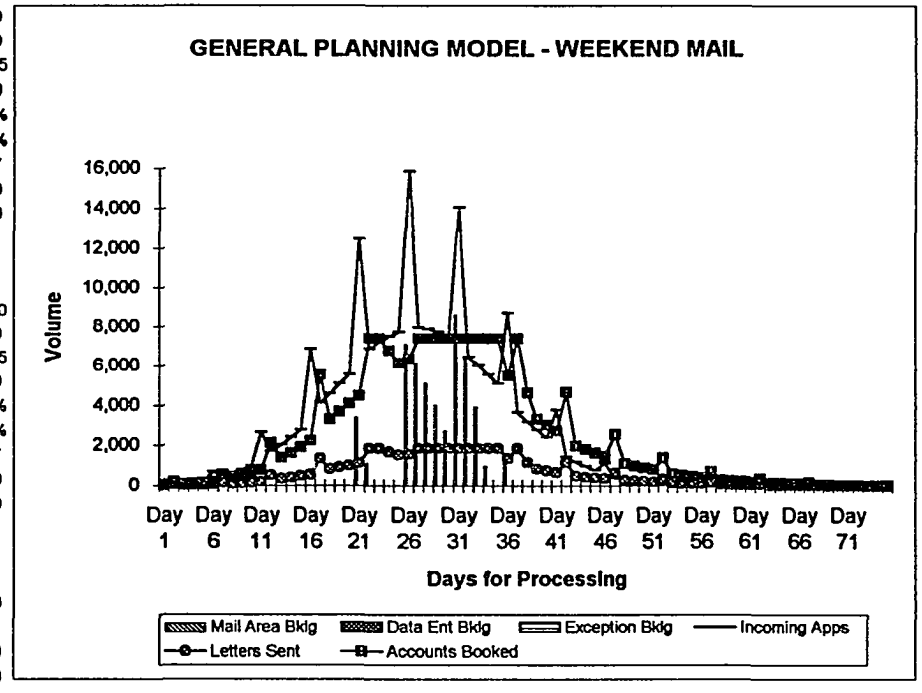
Entered Per Hour	300
FTE's Available	4.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,237
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.1
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,695
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
14.0

MEAN TIME IN SYSTEM (DAYS):
4.294



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost to Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$91,035
Data Entry	$29,438
Exception Processing	$28,431
TOTAL	$148,903

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	60
Mean Number of Days	30
Standard Deviation	10.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	28
Mean Number of Days	14
Standard Deviation	14

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

CONSTRAINTS:

Total Staff < or =	14.0
Overtime < or = to	1.0

business receives double work on Monday, since on Monday, the business is also receiving work processed by the post office on Saturday. Please refer to Figures 6-1a to 6-1c, which illustrate the following models respectively; descriptive model, prescriptive and prescriptive with constraints.

The weekend mail model is appropriate for the backoffice processing resulting from a marketing campaign including charities that process checks, credit card companies offering pre-approved cards, insurance companies who offer free estimates to individuals who fill out personal information on forms included with advertisements, sweepstakes companies, offers for magazine subscriptions, and employers advertising for available jobs that require the applicant to mail a resume. The return/rework would be customers who fill out information incorrectly. Attrition occurs when the company requests additional information and the applicant does not respond.

3) Steady Arrivals. One other extension to the general model would be to consider steady or uniform arrivals, for businesses receiving a steady level of incoming work. This use is appropriate for a phone area that has a steady customer base and stable probability of customers mailing or calling, such as a customer service

FIGURE 6-2A. STEADY ARRIVALS - DESCRIPTIVE MODEL

Descriptive Model - Steady Arrivals

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

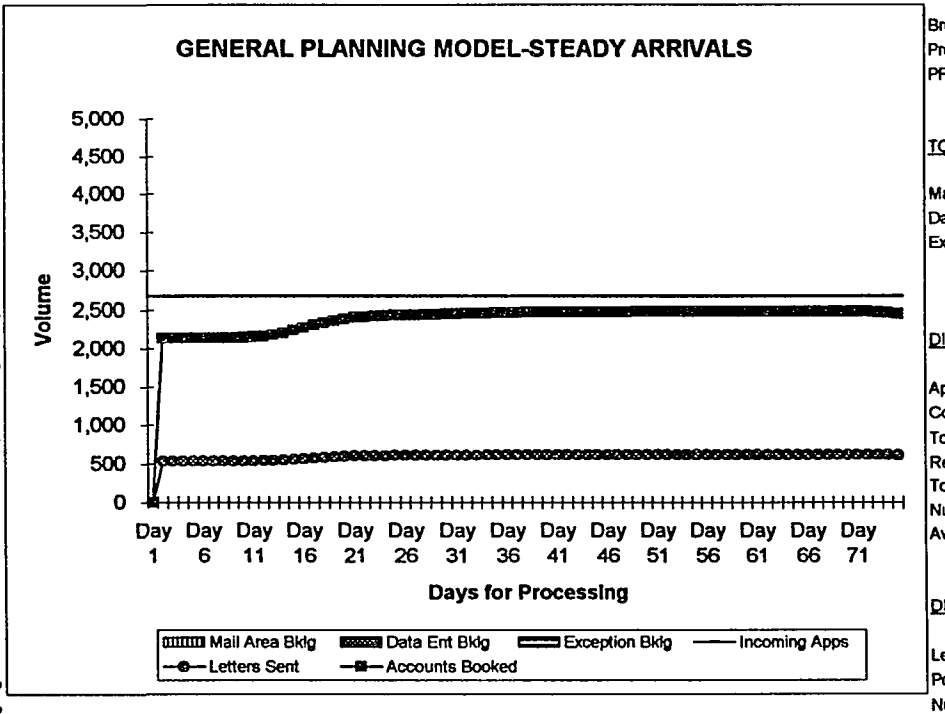
Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
15.5

MEAN TIME IN SYSTEM (DAYS):
4.075



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$40,500
Data Entry	$30,938
Exception Processing	$25,988
TOTAL	$97,425

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Constant Daily Volume of Arrivals	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	75
Average per Day	2,667

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 6-2B. STEADY ARRIVALS - PRESCRIPTIVE MODEL

Prescriptive Model - Least Cost Staffing Configuration

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	2.3
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,100
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

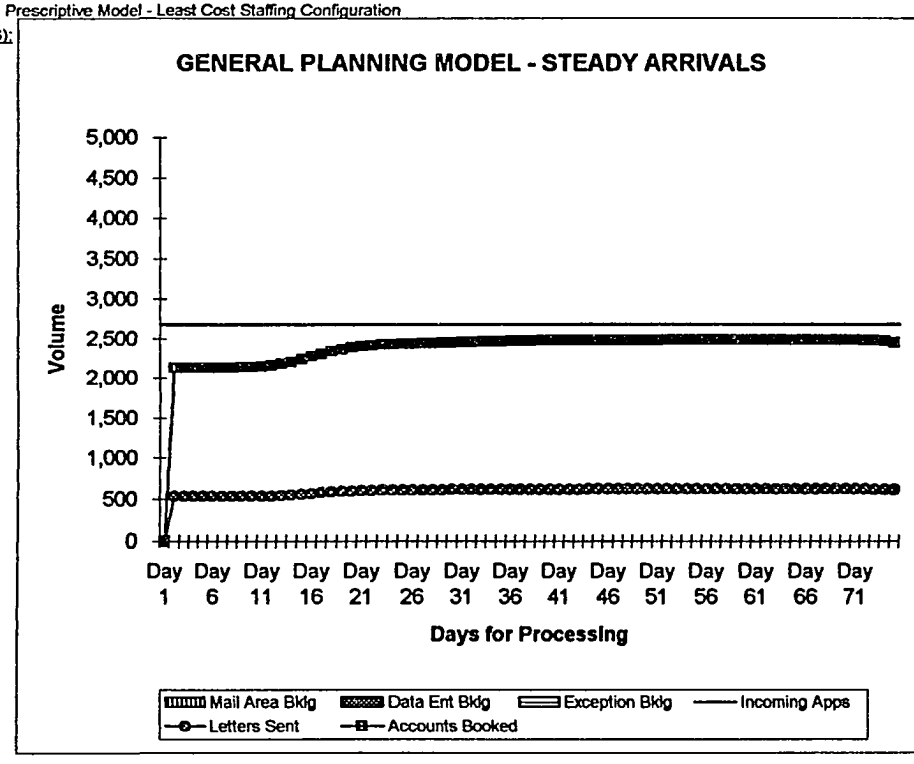
Entered Per Hour	300
FTE's Available	1.5
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	3,100
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	1.6
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	1,240
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
5.4

MEAN TIME IN SYSTEM (DAYS):
4.075



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Productivity Lost to Slow Res	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$12,794
Data Entry	$9,382
Exception Processing	$9,036
TOTAL	$31,212

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Constant Daily Volume of Arrivals	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	75
Average per Day	2,667

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 6-3A. STEADY ARRIVALS/WEEKEND MAIL - DESCRIPTIVE MODEL

Descriptive Model - Steady Arrivals but "Saturday Mail" also arrives on Monday

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

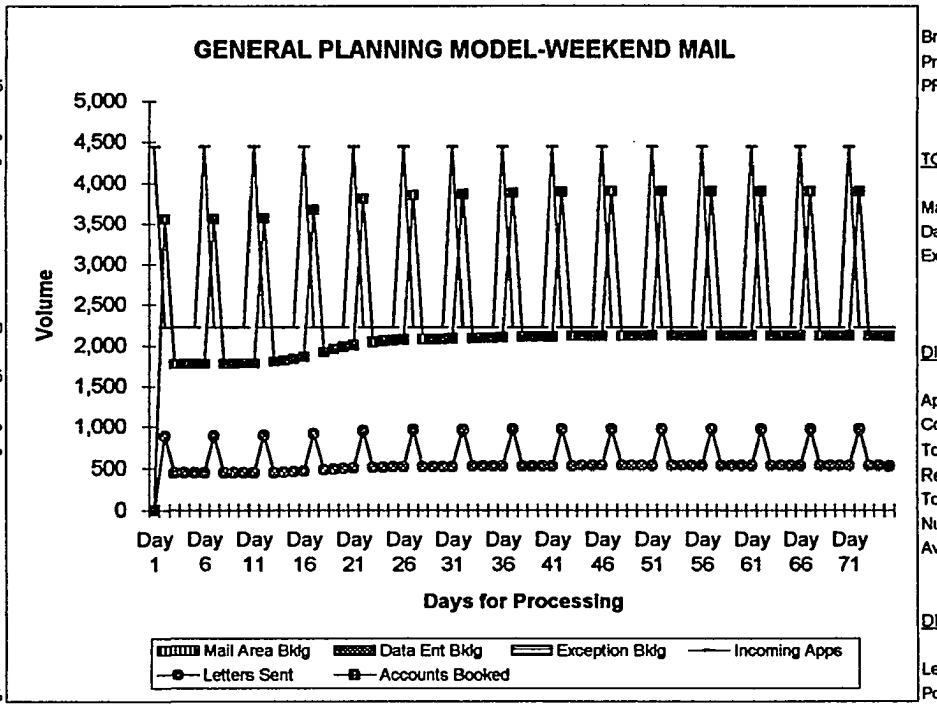
Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maxd Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
15.5

MEAN TIME IN SYSTEM (DAYS):
4.075



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost to Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$40,500
Data Entry	$30,938
Exception Processing	$25,988
TOTAL	$97,425

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Constant Daily Volume of Arrivals	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	90
Average per Day at Post Offic	2,222

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	28
Mean Number of Days	14
Standard Deviation	14

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE 6-3B. STEADY ARRIVALS/WEEKEND MAIL - PRESCRIPTIVE MODEL

Prescriptive Model - Least Cost Staffing Configuration - Steady Arrivals but "Saturday Mail" also arrives on Monday

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	3.5
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maxi Daily Capacity	4,780
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

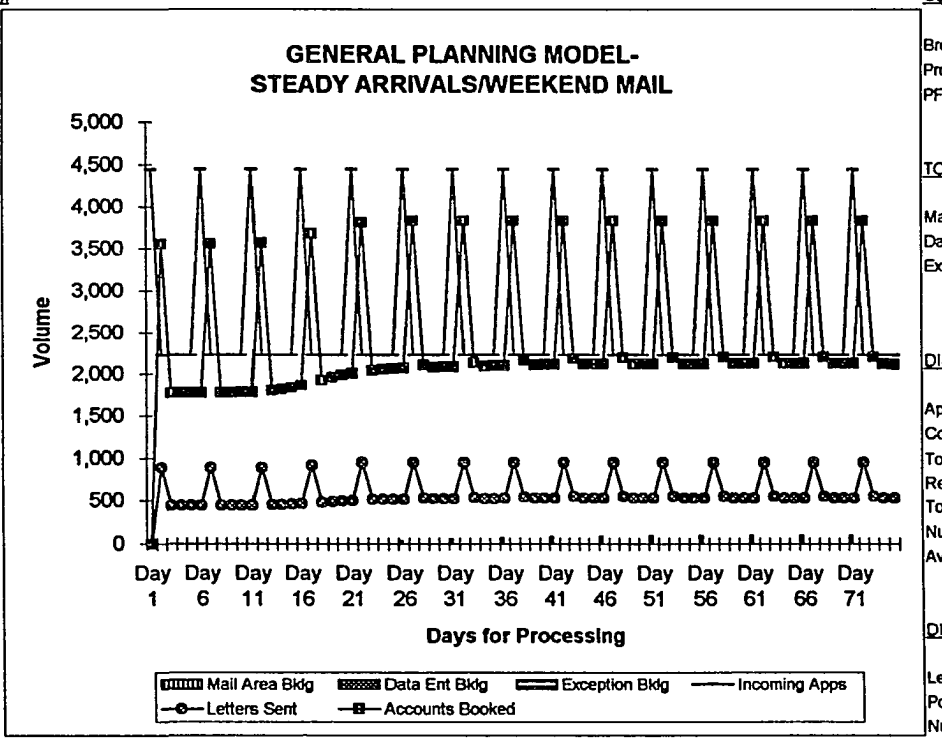
Entered Per Hour	300
FTE's Available	2.3
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	4,780
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	2.4
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Max Daily Capacity	1,912
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE):
8.3

MEAN TIME IN SYSTEM (DAYS):
4.078



MATRIX	States	Mail Area 0	Data Ent 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Ent	1	0.00	0.00	0.40	0.60	0.00	0.00
Exceptio	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost to Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$20,539
Data Entry	$14,465
Exception Processing	$13,932
TOTAL	$48,937

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Constant Daily Volume of Arrivals	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	90
Average per Day at Post Office	2,222

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	28
Mean Number of Days	14
Standard Deviation	14

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

center. The paper work generated by the phone area includes research, adjustments, copies of statements, and other requests. Attrition occurs when the customer makes an error, the company requests additional information and the customer does not respond. Please refer to Figures 6-2a and 6-2b, which illustrate the descriptive and prescriptive model versions.

4) Steady Arrivals/Weekend Mail. This model is appropriate for an area that works 5 days per week, serving customers via mail, with a steady customer base and stable probability of customers arriving. An example would be an insurance claims processing area, or motor vehicle department, as when individuals renew car registrations by mail. Return/rework occurs when the customer forgets to sign the application, or omits required documentation. Attrition occurs when the customer makes an error, the company requests additional information and the customer does not respond. Please refer to Figures 6-3a and 6-3b, which illustrate the descriptive and prescriptive model versions.

c. Discussion of Possible Model Implications

Return/rework is expensive and time consuming for service organizations. There are expenses associated with sending out a letter, receiving a letter (especially if a postage paid business reply envelope is enclosed), and

processing exceptions. In addition, there is the risk of losing a potential customer, after effort has been expended to solicit and partially process the customer.

One solution is to simplify forms. Additional instructions can decrease the amount of incorrect or incomplete work. A toll free telephone number for consumers to call if they have questions is another alternative.

One major focus is prevention, to eliminate the causes of incomplete or omitted information by simplifying processing, educating consumers by including additional instructions, (perhaps in additional languages), and offering assistance. Another focus is to minimize the disruption that takes place when there is an error, by facilitating the repair process. Perhaps customers can be persuaded to respond in a timely manner to requests for more information with small gifts such as mugs or pens.

d. Suggested Areas for Future Research

Areas for future research include adapting the model to other types of organizations that have marketing, or solicitation campaigns such as charitable organizations, and phone/mail order merchandising companies. Manufacturing companies that periodically have large increases in orders can benefit from this model.

Research on response curves would be valuable to determine the magnitude of customer response to various

types of advertising or solicitations. Another direction for future research would be to determine customer tolerance for turnaround time, or fulfillment time. Since backlogs provide insurance against wasting resources (idle time), knowing how long customers are willing to wait before canceling orders provides information to manage backlogs by timing resources. "Customer annoyance" or "customer dissatisfaction" curves would quantify the trade-off between avoiding idle time and losing customers.

e. Overall Summary

In this research study, a general capacity planning model for a campaign demand environment was developed. Unique features include customer attrition and the return/rework situation that occurs when customers do part of the processing. The model was adapted and applied to a paperwork process in a major US Bank. The model was deemed successful by the managers who used it, and is now an ongoing part of the planning process.

The following is an overall review of this research study. Chapter 1, the introduction, contains a definition of key terms, states goals and objectives, and explains why the changing environment for banking increased the need for sophisticated management tools. In Chapter 2, the existing literature is reviewed, including a summary of various approaches to capacity planning, applied models and case

studies, success factors for models, applications to quality control and customer service, and a critical evaluation of literature. Chapter 3 reviews the conceptual framework, general model and methodology, including comparison and contrasts for the manufacturing vs. service environment, and a description of the general capacity planning model. Chapter 4 details the development of the model regarding experimental design, and adaptation to an actual case study. Chapter 5 discusses model implementation, data collection, data analysis and model validation. Chapter 6 is a summary and provides suggestions for future research.

APPENDIX A
SCENARIO ANALYSIS APPLICATIONS

FIGURE A-1. SAMPLE SCENARIO - TWO DAY SYSTEM FAILURE

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

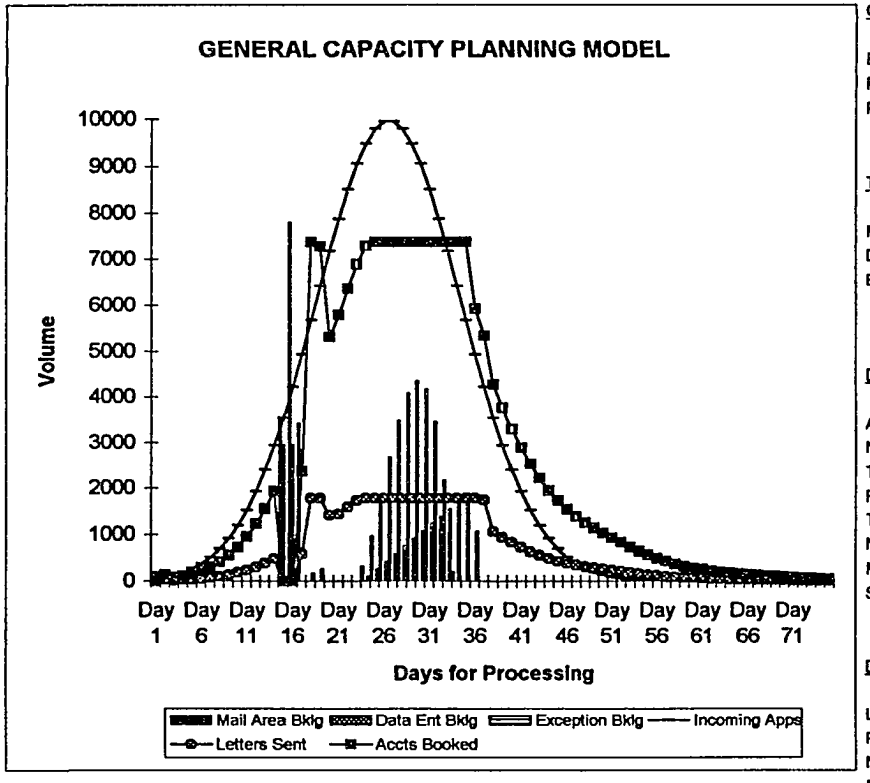
Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE): 15.5

MEAN TIME IN SYSTEM (DAYS):
4.427
* Two day system failure on days 15 and 16



MATRIX	States	Mail Area 0	Data Entry 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Entry	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$82,959
Data Entry	$36,844
Exception Processing	$39,361
TOTAL	$159,164

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	
Cost Per Letter Returned	$0.35

FIGURE A-2. SAMPLE SCENARIO - INTERRUPTED MAIL DELIVERY DAY 25 - NO ADDITIONAL OVERTIME

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

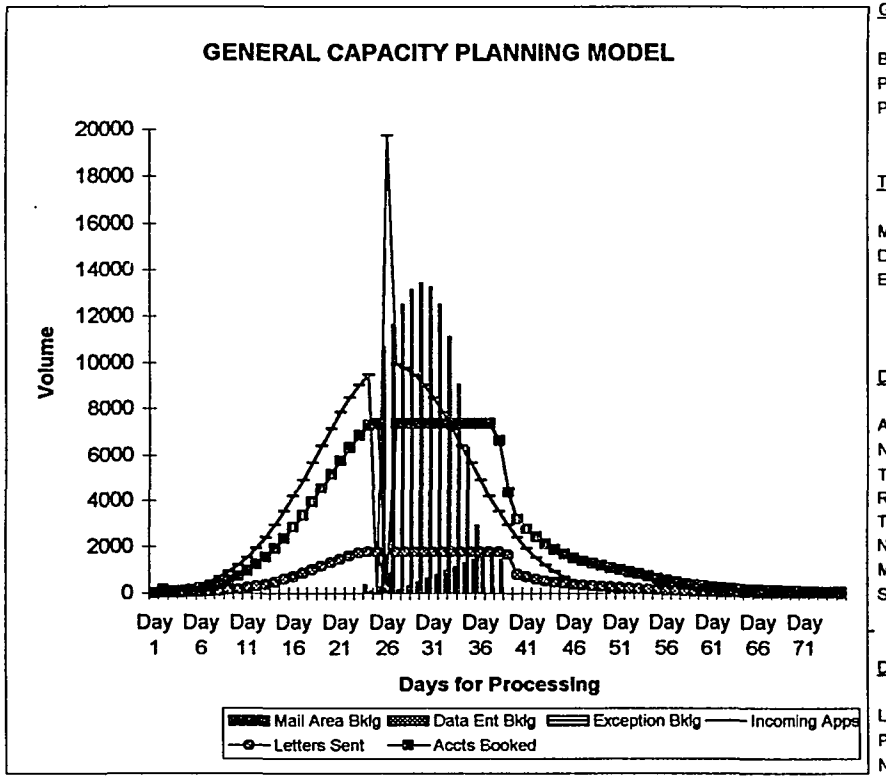
EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE): 15.5

MEAN TIME IN SYSTEM (DAYS):
4.713

**No mail delivery on day 25, double work received on day 26.*



MATRIX	States	Mail Area 0	Data Entry 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Entry	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$157,438
Data Entry	$30,938
Exception Processing	$38,482
TOTAL	$226,858

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	$1.00
Cost Per Letter Returned	$0.35

FIGURE A-3. SAMPLE SCENARIO - INTERRUPTED MAIL DELIVERY DAY 25 WITH ADDITIONAL OVERTIME

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	11,601
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

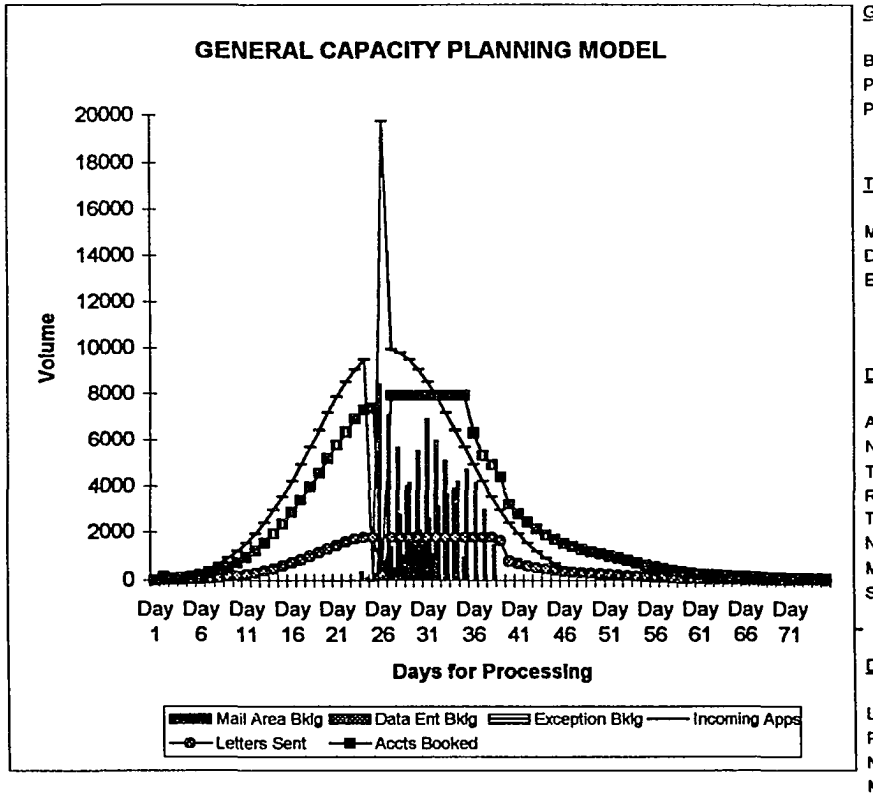
EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE): 15.5

MEAN TIME IN SYSTEM (DAYS):
4.713

*No mail delivery on day 25, double work received on day 26. Mail Area staff asked for 2 additional hours overtime on days 26-30.



MATRIX	States	Mail Area 0	Data Entry 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Entry	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$71,802
Data Entry	$67,508
Exception Processing	$58,468
TOTAL	$197,779

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.0%
Total Received	200,000
Number of Days to Receive (8 wks	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	
Cost Per Letter Returned	$0.35

FIGURE A-4. SAMPLE SCENARIO - 2.2% RESPONSE RATE

MAIL AREA (OPEN,SORT & LOG):

Applications Per Hour	200
FTE's Available	6.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	1.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	9,320
Labor Cost Per Hour	$10.00
Backlog Cost per Item	$1.00

DATA ENTRY:

Entered Per Hour	300
FTE's Available	5.0
Reg Hrs in Work Day	7.5
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	10,224
Labor Cost Per Hour	$11.00
Backlog Cost per Item	$1.00

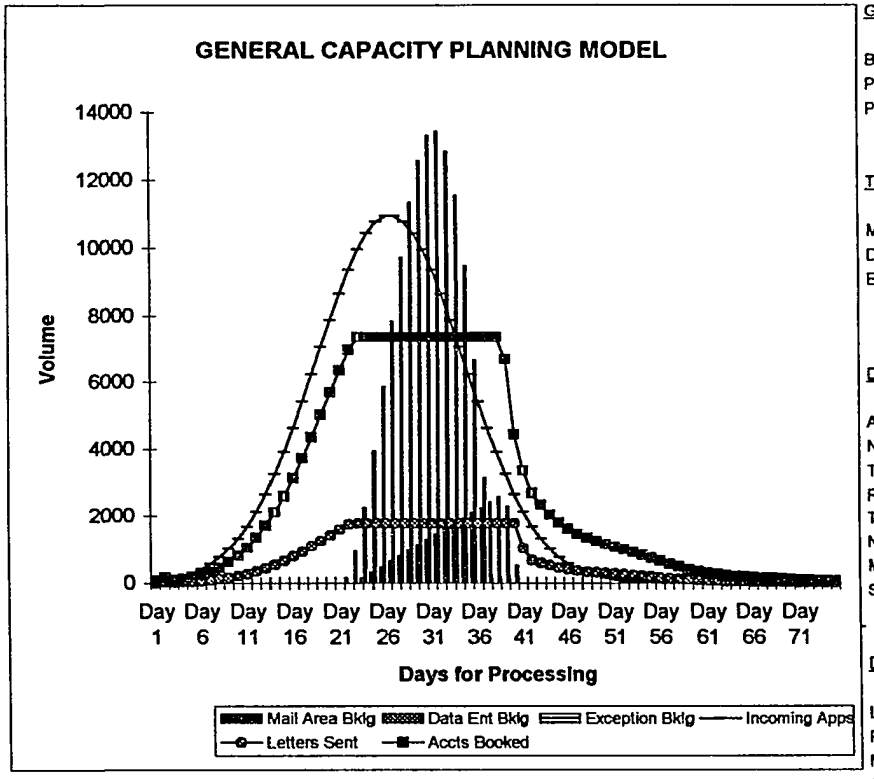
EXCEPTION PROCESSING:

Items Per Hour	125.0
FTE's Available	4.5
Reg Hrs in Work Day	7.0
OT Hrs in Work Day	0.0
Machine Uptime	100.0%
Learning Curve	100.0%
Maximum Daily Capacity	3,567
Labor Cost Per Hour	$12.00
Backlog Cost per Item	$1.00

TOTAL STAFF (FTE): 15.5

MEAN TIME IN SYSTEM (DAYS):
4.807

*Response rate is 2.2%, and staffing level remains the same.



MATRIX	States	Mail Area 0	Data Entry 1	Exception 2	Finish 3	Letter 4	No Resp 5
Mail Area	0	0.00	1.00	0.00	0.00	0.00	0.00
Data Entry	1	0.00	0.00	0.40	0.60	0.00	0.00
Exception	2	0.00	0.00	0.00	0.50	0.50	0.00
Finish	3	0.00	0.00	0.00	1.00	0.00	0.00
Letter	4	0.70	0.00	0.00	0.00	0.00	0.30
No Resp	5	0.00	0.00	0.00	0.00	0.00	1.00

GLOBAL ASSUMPTIONS:

Breaktime per day in hours	0.33
Prod Lost Slow Resp Time	2.0%
PFD Percentage	3.0%

TOTAL VARIABLE COST OF STRATEGY:

Mail Area	$165,626
Data Entry	$30,938
Exception Processing	$50,732
TOTAL	$247,296

DISTRIBUTION ASSUMPTIONS:

Applications Received	
Normal : x = day of arrival	
Total Solicitations Mailed	10,000,000
Response Rate	2.2%
Total Received	220,000
Number of Days to Receive (8 wks	50
Mean Number of Days	25
Standard Deviation	8.0

DISTRIBUTION ASSUMPTIONS:

Letters Returned	
Poisson: x = day of arrival	
Number of Days to Receive	24
Mean Number of Days	12
Standard Deviation	12

LETTERS:

Cost Per Letter Sent	
Cost Per Letter Returned	$0.35

APPENDIX B
GENERAL CAPACITY PLANNING MODEL

Line#	GENERAL CAPACITY MODEL - MARKETING CAMPAIGN	Source	Assumptions
1	**Global Staffing Assumptions:**		
2	-Breaktime Per Day in Hours		
3	-PFD Percentage		
4	-Productivity Lost to Slow Response Time		
5			
6	**STAGE 1: MAIL AREA (OPEN, SORT, AND LOG APPLICATION)**		
7	Incoming Applications (from Figure 3-2)	Projected	
8	Yesterday's Backlog (Line 31 With 1 Day Delay)	Copy Line	
9	"Information Letters" Returned From Applicants (Line 146)	Copy Line	
10	Total Incoming Work (Line 7 + Line 8 + Line 9)	Calculation	
11			
12	Resource Requirements:		
13	Items Per Hour (Items per hour * Line 22 * (1- Line 4))	Dept Records	200.0
14	Required Hours (Line 10 / Line 13)	Calculation	
15	Required FTE (Line 14/(Line 19 - Line 2 - (Line 19 * Line 3)))	Calculation	
16			
17	Capacity (available staff hours):		
18	FTE's in Department	Dept Records	6.0
19	Regular Paid Hours in the Work Day Per FTE	Dept Policy	7.5
20	Overtime Paid Hours in the Work Day Per FTE	Dept Records	1.0
21	Machine Uptime	Dept Records	100.0%
22	Learning Curve Assumptions	Dept Records	100.0%
23	Prod Hrs in Wk Day/FTE Inc OT (Line 19+Line 20-Line 2)*(Line 21)*(1-Line	Calculation	
24	Total Departmental Productive hours per day (Line 18 * Line 23)	Calculation	
25	Maximum Capacity to Process Items (Line 13 * Line 24)	Calculation	
26			
27	Overage (Underage) in Hours (Line 24 - Line 14)	Calculation	
28	Overage (Underage) in FTE (Line 27/ (Line 19+Line 20-Line2-(Line 19*Line 3))	Calculation	
29			
30	Items Handled ([MIN] Line 10, Line 25) to Data Entry	Calculation	
31	Tomorrow's Backlog (Line 10 - Line 30)	Calculation	0.0
32			
33	Unit Cost:		
34	Regular Labor Cost Per Hour	Dept Records	$10.00
35	Overtime Labor Cost Per Hour (Line 34 * 1.5)	Dept Records	$15.00
36	Total Labor Cost (Line 18*Line 19*Line 34)+(Line 18*Line 20*Line35)	Calculation	$540
37	Labor Cost Per Item Processed (Line 36/Line30)	Calculation	
38			
39	Unit Cost per Backlogged item	Dept Records	$1.00
40	Total Cost Backlog (Line 39 * Line 31)	Calculation	$0
41			
42	Total Cost of Backlog and Processed (Line 36 + Line 40)	Calculation	$540
43	Weighted Avg costs ((Line37*Line30)+(Line31*Line39))/ (Line30+Line31)	Calculation	
44			
45			
46	**STAGE 2: DATA ENTRY**		
47	Volume Received from Mail Area (Line 30 with 1 day delay)	Copy Line	
48	Yesterday's Backlog (Line 70 With Delay)	Copy Line	
49	Total Volume (Line 47 + Line 48) For Data Entry	Calculation	
50			
51	Resource Requirements:		
52	Items Per Hour (Items per hour * Line 61 * (1- Line 4))	Dept Records	300.0
53	Required Hours (Line 49 / Line 52)	Calculation	
54	Required FTE (Line 53/(Line 58 - Line 2-(Line 58*Line 3)))	Calculation	
55			
56	Capacity (available staff hours):		
57	FTE's in Department	Dept Records	5.0
58	Regular Paid Hours in the Work Day Per FTE	Dept Policy	7.5
59	Overtime Paid Hours in the Work Day Per FTE	Dept Records	0.0

Line#	GENERAL CAPACITY MODEL - MARKETING CAMPAIGN	Source	Assumptions
60	Machine Uptime	Dept Records	100.0%
61	Learning Curve Assumptions	Dept Records	100.0%
62	Prod Hrs in Wk Day/FTE Inc OT (Line 58+Line 59-Line 2)*(Line 60)*(1-Line	Calculation	
63	Total Departmental Productive hours per day (Line 57 * Line 62)	Calculation	
64	Maximum Capacity to Process Items (Line 52 * Line 63)	Calculation	
65			
66	Overage (Underage) in Hours (Line 63 - Line 53)	Calculation	
67	Overage (Underage) in FTE (Line 66/ (Line 58+Line 59-Line2-(Line 58* Line 3))	Calculation	0.0
68			
69	Items Handled ([MIN] Line 49, Line 64) to Exception Processing	Calculation	
70	Tomorrow's Backlog (Line 49 - Line 69)	Calculation	0.0
71			
72	Unit Cost:		
73	Regular Labor Cost Per Hour	Dept Records	$11.00
74	Overtime Labor Cost Per Hour (Line 73 * 1.5)	Dept Records	$16.50
75	Total Labor Cost (Line 57*Line 58*Line 73)+(Line 57*Line 59*Line74)	Calculation	$413
76	Labor Cost Per Item Processed (Line 75/Line 69)	Calculation	
77			
78	Unit Cost per Backlogged item	Dept Records	$1.00
79	Total Cost Backlog (Line 78 * Line 70)	Calculation	$0
80			
81	Total Cost of Backlog and Processed (line 75 + Line 79)	Calculation	$413
82	Weighted Avg costs ((Line76* Line69)+(Line70* Line78))/ (Line69+Line70)	Calculation	
83			
84			
85	**STAGE 3: EXCEPTION PROCESSING**		
86	Percent Exceptions (Mismatch/Omitted Information) from Data Entry	Dept Records	40.0%
87	Items from Data Entry to Exception Processing (Line 69 * Line 86)	Calculation	
88	Yesterday's Backlog (Line 110 With Delay)	Copy Line	
89	Total Volume Exceptions (Line 87 + Line 88)	Calculation	
90			
91	Resource Requirements:		
92	Items Per Hour (Items per hour * Line 101 * (1- Line 4))	Dept Records	125.0
93	Required Hours (Line 89 / Line 92)	Calculation	
94	Required FTE (Line 93/(Line 98 - Line 2-(Line 98*Line 3)))	Calculation	
95			
96	Capacity (available staff hours):		
97	FTE's in Department	Dept Records	4.5
98	Regular Paid Hours in the Work Day Per FTE	Dept Policy	7.00
99	Overtime Paid Hours in the Work Day Per FTE	Dept Records	0.00
100	Machine Uptime	Dept Records	100.0%
101	Learning Curve Assumptions	Dept Records	100.0%
102	Prod Hrs in Wk Day/FTE (Line 98+Line99-Line 2)*(Line 100)*(1-Line 3)	Calculation	7.0
103	Total Departmental Productive hours per day (Line 97 * Line 102)	Calculation	
104	Maximum Capacity to Process Items (Line 92 * Line 103)	Calculation	
105			
106	Overage (Underage) in Hours (Line 103 - Line 93)	Calculation	
107	Overage (Underage) in FTE (Line 106/ (Line 98+Line 99-Line2-(Line 98* Line 3))	Calculation	0.0
108			
109	Items Handled ([MIN] Line 89, Line 104) Exception Processing	Calculation	
110	Tomorrow's Backlog (Line 89 - Line 109)	Calculation	0.0
111			
112	Unit Cost:		
113	Regular Labor Cost Per Hour	Dept Records	$11.00
114	Overtime Labor Cost Per Hour (Line 113 * 1.5)	Dept Records	$16.50
115	Total Labor Cost (Line 97*Line 98*Line 113)+(Line 97*Line 99*Line114)	Calculation	$347
116	Labor Cost Per Item Processed (Line 115/Line 109)	Calculation	
117			
118	Unit Cost per Backlogged item	Dept Records	$1.00
119	Total Cost Backlog (Line 110*Line 118)	Calculation	$0
120			

Line#	GENERAL CAPACITY MODEL - MARKETING CAMPAIGN	Source	Assumptions
121	Total Cost of Backlog and Processed (Line 115 + Line 119)	Calculation	$347
122	Weighted Avg cost((Line116*Line109)+(Line110*Line118))/(Line109+Line110	Calculation	
123			
124	Percent Items Resolved (To Finish)	Dept Records	50.0%
125	Volume Items to Finish (Line 109 * Line 124)	Calculation	
126			
127	Percent Items Needing Letters (Letters Sent) (1 - Line 124)	Calculation	50.0%
128	Volume Items Needing Letters (Letters Sent) (Line 109 * Line 127) to Letters	Calculation	
129			
130			
131	**STAGE 4: FINISH (ACCOUNTS BOOKED)**		
132	Accounts Booked from Data Entry (Line 69 - Line 87)	Calculation	0
133	Accounts Booked from Exception Processing (Line 125)	Copy Line	0
134	Total Volume (Line 132 + Line 133)	Calculation	0
135			
136			
137	**STAGE 5: LETTERS**		
138	Letters Sent (Line 128)	Copy Line	0
139			
140	Percent Letters No Response (Stage 6)	Dept Records	30.0%
141	Volume Letters No Response (Stage 6) (Line 138 * Line 140)	Calculation	0
142			
143	Percent Letters Returned (1 - Line 140)	Calculation	70.0%
144	Raw Volume Letters Expected to Return (Line 138 * Line 143)	Calculation	0
145			
146	Volume Letters Returned Distributed (From Return Letter Table, Figure 3-5)	Copy Line	0
147			
148	Cost Per Letter Sent	Materials Cost	$1.00
149	Total Cost of Letters Sent (Line 138 * Line 148)	Calculation	$0
150			
151	Cost Per Letter Returned	Materials Cost	$0.35
152	Total Cost of Letters Returned (Line 146 * Line 151)	Calculation	$0
153			
154	Total Cost All Letters (Line 149 + Line 152)	Calculation	$0
155			
156	**Total Staff Requirement (In Hours)**		
157	STAGE 1: Mail Area (Line 14)		
158	STAGE 2: Data Entry (Line 53)		
159	STAGE 3: Exception Processing (Line 93)		
160	STAGE 4: Finish (Accounts Booked)		
161	STAGE 5: Letters Sent to Customer		
162	STAGE 6: No Response		
163	**Total Staff Required to Process Applications (Assumes Backlogs are Possible)**		
164	**Total Staff Requirement (In Hours)**		
165	STAGE 1: Mail Area ((Line 7 + Line 9)/ Line13)		
166	STAGE 2: Data Entry (Line 47/Line 52)		
167	STAGE 3: Exception Processing (Line 87/Line 92)		
168	STAGE 4: Finish (Accounts Booked)		
169	STAGE 5: Letters Sent to Customer		
170	STAGE 6: No Response		
171	**Total Staff Required to All work on a Daily Basis**		
172	**Total Costs**		
173	STAGE 1: Mail Area (Line 42)		
174	STAGE 2: Data Entry (Line 81)		
175	STAGE 3: Exception Processing (Line 121)		
176	STAGE 4: Finish (Accounts Booked)		
177	STAGE 5: Letters Sent to Customer (Line 154)		
178	STAGE 6: No Response		
179	**Total Cost of Processed and Backlogged Items**		

Line#	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	0.0	177.8	92.2	134.0	191.9	270.5	375.4	513.0	690.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
10	0.0	177.8	92.2	134.0	191.9	270.5	375.5	513.0	690.2
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	0.0	0.9	0.5	0.7	1.0	1.4	1.9	2.6	3.5
15	0.0	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.5
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	47.5	46.6	47.1	46.9	46.6	46.2	45.6	44.9	44.0
28	6.0	5.9	5.9	5.9	5.9	5.8	5.7	5.7	5.5
29									
30	0	178	92	134	192	271	375	513	690
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37		$3.04	$5.86	$4.03	$2.81	$2.00	$1.44	$1.05	$0.78
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43		$3.04	$5.86	$4.03	$2.81	$2.00	$1.44	$1.05	$0.78
44									
45									
46									
47	0.0	0.0	177.8	92.2	134.0	191.9	270.5	375.5	513.0
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	0.0	177.8	92.2	134.0	191.9	270.5	375.5	513.0
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	0.0	0.0	0.6	0.3	0.5	0.7	0.9	1.3	1.7
54	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.3
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	34.8	34.8	34.2	34.5	34.3	34.1	33.9	33.5	33.0
67	5.0	5.0	4.9	5.0	4.9	4.9	4.9	4.8	4.8
68									
69	0	0	178	92	134	192	271	375	513
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76		$412.50	$2.32	$4.48	$3.08	$2.15	$1.52	$1.10	$0.80
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82			$2.32	$4.48	$3.08	$2.15	$1.52	$1.10	$0.80
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	0.0	0.0	71.1	36.9	53.6	76.8	108.2	150.2	205.2
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	0.0	0.0	71.1	36.9	53.6	76.8	108.2	150.2	205.2
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	0.0	0.0	0.6	0.3	0.4	0.6	0.9	1.2	1.7
94	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.3
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	29.1	29.1	28.5	28.8	28.7	28.5	28.2	27.9	27.4
107	4.5	4.5	4.4	4.5	4.4	4.4	4.4	4.3	4.2
108									
109	0	0	71	37	54	77	108	150	205
110	0	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116		$346.50	$4.87	$9.40	$6.46	$4.51	$3.20	$2.31	$1.69
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
121	$347	$347	$347	$347	$347	$347	$347	$347	$347
122			$4.87	$9.40	$6.46	$4.51	$3.20	$2.31	$1.69
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	0	0	36	18	27	38	54	75	103
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	0	0	36	18	27	38	54	75	103
129									
130									
131									
132	0	0	107	55	80	115	162	225	308
133	0	0	36	18	27	38	54	75	103
134	0	0	142	74	107	154	216	300	410
135									
136									
137									
138	0	0	36	18	27	38	54	75	103
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	0	0	11	6	8	12	16	23	31
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	0	0	25	13	19	27	38	53	72
145									
146	0	0	0	0	0	0	0	0	0
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$0	$0	$36	$18	$27	$38	$54	$75	$103
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$0	$0	$0	$0	$0	$0	$0	$0	$0
153									
154	$0	$0	$36	$18	$27	$38	$54	$75	$103
155									
156									
157	0.0	0.9	0.5	0.7	1.0	1.4	1.9	2.6	3.5
158	0.0	0.0	0.6	0.3	0.5	0.7	0.9	1.3	1.7
159	0.0	0.0	0.6	0.3	0.4	0.6	0.9	1.2	1.7
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	0.0	0.9	1.7	1.3	1.9	2.7	3.7	5.1	6.9
164									
165	0.0	0.9	0.5	0.7	1.0	1.4	1.9	2.6	3.5
166	0.0	0.0	0.6	0.3	0.5	0.7	0.9	1.3	1.7
167	0.0	0.0	0.6	0.3	0.4	0.6	0.9	1.2	1.7
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	0.0	0.9	1.7	1.3	1.9	2.7	3.7	5.1	6.9
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$0.00	$0.00	$35.56	$18.43	$26.81	$38.39	$54.11	$75.11	$102.66
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$1,299.00	$1,299.00	$1,334.56	$1,317.43	$1,325.81	$1,337.39	$1,353.11	$1,374.11	$1,401.66

Line#	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	913.8	1,191.4	1,529.2	1,932.6	2,404.4	2,945.2	3,551.7	4,216.8	4,928.9
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.4	1.0	1.9	3.3	5.5	8.4	12.3	17.6	24.5
10	914.2	1,192.3	1,531.1	1,935.9	2,409.9	2,953.6	3,564.0	4,234.4	4,953.4
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	4.7	6.1	7.8	9.9	12.3	15.1	18.2	21.6	25.3
15	0.7	0.9	1.1	1.4	1.8	2.2	2.6	3.1	3.6
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	42.9	41.5	39.7	37.7	35.3	32.5	29.4	25.9	22.3
28	5.4	5.2	5.0	4.7	4.4	4.1	3.7	3.3	2.8
29									
30	914	1,192	1,531	1,936	2,410	2,954	3,564	4,234	4,953
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.59	$0.45	$0.35	$0.28	$0.22	$0.18	$0.15	$0.13	$0.11
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43	$0.59	$0.45	$0.35	$0.28	$0.22	$0.18	$0.15	$0.13	$0.11
44									
45									
46									
47	690.2	914.2	1,192.3	1,531.1	1,935.9	2,409.9	2,953.6	3,564.0	4,234.4
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	690.2	914.2	1,192.3	1,531.1	1,935.9	2,409.9	2,953.6	3,564.0	4,234.4
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	2.3	3.1	4.1	5.2	6.6	8.2	10.0	12.1	14.4
54	0.3	0.4	0.6	0.7	0.9	1.2	1.4	1.7	2.1
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	32.4	31.7	30.7	29.6	28.2	26.6	24.7	22.7	20.4
67	4.7	4.6	4.4	4.3	4.1	3.8	3.6	3.3	2.9
68									
69	690	914	1,192	1,531	1,936	2,410	2,954	3,564	4,234
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.60	$0.45	$0.35	$0.27	$0.21	$0.17	$0.14	$0.12	$0.10
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.60	$0.45	$0.35	$0.27	$0.21	$0.17	$0.14	$0.12	$0.10
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	276.1	365.7	476.9	612.5	774.4	964.0	1,181.4	1,425.6	1,693.8
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	276.1	365.7	476.9	612.5	774.4	964.0	1,181.4	1,425.6	1,693.8
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	2.3	3.0	3.9	5.0	6.3	7.9	9.6	11.6	13.8
94	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.8	2.1
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	26.9	26.1	25.2	24.1	22.8	21.2	19.5	17.5	15.3
107	4.2	4.0	3.9	3.7	3.5	3.3	3.0	2.7	2.4
108									
109	276	366	477	612	774	964	1,181	1,426	1,694
110	0	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$1.26	$0.95	$0.73	$0.57	$0.45	$0.36	$0.29	$0.24	$0.20
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
121	$347	$347	$347	$347	$347	$347	$347	$347	$347
122	$1.26	$0.95	$0.73	$0.57	$0.45	$0.36	$0.29	$0.24	$0.20
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	138	183	238	306	387	482	591	713	847
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	138	183	238	306	387	482	591	713	847
129									
130									
131									
132	414	549	715	919	1,162	1,446	1,772	2,138	2,541
133	138	183	238	306	387	482	591	713	847
134	552	731	954	1,225	1,549	1,928	2,363	2,851	3,388
135									
136									
137									
138	138	183	238	306	387	482	591	713	847
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	41	55	72	92	116	145	177	214	254
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	97	128	167	214	271	337	414	499	593
145									
146	0	1	2	3	5	8	12	18	24
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$138	$183	$238	$306	$387	$482	$591	$713	$847
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$0	$0	$1	$1	$2	$3	$4	$6	$9
153									
154	$138	$183	$239	$307	$389	$485	$595	$719	$855
155									
156									
157	4.7	6.1	7.8	9.9	12.3	15.1	18.2	21.6	25.3
158	2.3	3.1	4.1	5.2	6.6	8.2	10.0	12.1	14.4
159	2.3	3.0	3.9	5.0	6.3	7.9	9.6	11.6	13.8
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	9.3	12.2	15.8	20.1	25.2	31.1	37.9	45.4	53.5
164									
165	4.7	6.1	7.8	9.9	12.3	15.1	18.2	21.6	25.3
166	2.3	3.1	4.1	5.2	6.6	8.2	10.0	12.1	14.4
167	2.3	3.0	3.9	5.0	6.3	7.9	9.6	11.6	13.8
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	9.3	12.2	15.8	20.1	25.2	31.1	37.9	45.4	53.5
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$138.18	$183.18	$239.13	$307.40	$389.10	$484.92	$595.04	$718.96	$855.44
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$1,437.18	$1,482.18	$1,538.13	$1,606.40	$1,688.10	$1,783.92	$1,894.04	$2,017.96	$2,154.44

Line#	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	5,672.1	6,426.3	7,168.1	7,871.6	8,510.4	9,058.6	9,492.7	9,793.6	9,947.7
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	343.4	1,031.1
9	33.5	45.3	60.5	79.9	104.2	134.1	170.4	213.7	264.5
10	5,705.7	6,471.6	7,228.6	7,951.5	8,614.6	9,192.6	9,663.1	10,350.7	11,243.2
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	29.1	33.0	36.9	40.6	44.0	46.9	49.3	52.8	57.4
15	4.2	4.8	5.3	5.8	6.3	6.8	7.1	7.6	8.3
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	18.4	14.5	10.7	7.0	3.6	0.6	(1.8)	(5.3)	(9.8)
28	2.3	1.8	1.3	0.9	0.5	0.1	(0.2)	(0.7)	(1.2)
29									
30	5,706	6,472	7,229	7,952	8,615	9,193	9,320	9,320	9,320
31	0	0	0	0	0	0	343	1,031	1,924
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.09	$0.08	$0.07	$0.07	$0.06	$0.06	$0.06	$0.06	$0.06
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$343	$1,031	$1,924
41									
42	$540	$540	$540	$540	$540	$540	$883	$1,571	$2,464
43	$0.09	$0.08	$0.07	$0.07	$0.06	$0.06	$0.09	$0.15	$0.22
44									
45									
46									
47	4,953.4	5,705.7	6,471.6	7,228.6	7,951.5	8,614.6	9,192.6	9,319.7	9,319.7
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	4,953.4	5,705.7	6,471.6	7,228.6	7,951.5	8,614.6	9,192.6	9,319.7	9,319.7
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	16.8	19.4	22.0	24.6	27.0	29.3	31.3	31.7	31.7
54	2.4	2.8	3.2	3.5	3.9	4.2	4.5	4.6	4.6
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	17.9	15.4	12.8	10.2	7.7	5.5	3.5	3.1	3.1
67	2.6	2.2	1.8	1.5	1.1	0.8	0.5	0.4	0.4
68									
69	4,953	5,706	6,472	7,229	7,952	8,615	9,193	9,320	9,320
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.08	$0.07	$0.06	$0.06	$0.05	$0.05	$0.04	$0.04	$0.04
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.08	$0.07	$0.06	$0.06	$0.05	$0.05	$0.04	$0.04	$0.04
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	1,981.4	2,282.3	2,588.7	2,891.4	3,180.6	3,445.8	3,677.1	3,727.9	3,727.9
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.5	271.9
89	1,981.4	2,282.3	2,588.7	2,891.4	3,180.6	3,445.8	3,677.1	3,838.4	3,999.7
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	16.2	18.6	21.1	23.6	26.0	28.1	30.0	31.3	32.7
94	2.5	2.9	3.3	3.7	4.0	4.4	4.6	4.9	5.1
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	12.9	10.5	8.0	5.5	3.2	1.0	(0.9)	(2.2)	(3.5)
107	2.0	1.6	1.2	0.9	0.5	0.2	(0.1)	(0.3)	(0.5)
108									
109	1,981	2,282	2,589	2,891	3,181	3,446	3,567	3,567	3,567
110	0	0	0	0	0	0	111	272	433
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$0.17	$0.15	$0.13	$0.12	$0.11	$0.10	$0.10	$0.10	$0.10
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$111	$272	$433
120									

Line#	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26
121	$347	$347	$347	$347	$347	$347	$457	$618	$780
122	$0.17	$0.15	$0.13	$0.12	$0.11	$0.10	$0.12	$0.16	$0.19
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	991	1,141	1,294	1,446	1,590	1,723	1,783	1,783	1,783
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	991	1,141	1,294	1,446	1,590	1,723	1,783	1,783	1,783
129									
130									
131									
132	2,972	3,423	3,883	4,337	4,771	5,169	5,516	5,592	5,592
133	991	1,141	1,294	1,446	1,590	1,723	1,783	1,783	1,783
134	3,963	4,565	5,177	5,783	6,361	6,892	7,299	7,375	7,375
135									
136									
137									
138	991	1,141	1,294	1,446	1,590	1,723	1,783	1,783	1,783
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	297	342	388	434	477	517	535	535	535
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	693	799	906	1,012	1,113	1,206	1,248	1,248	1,248
145									
146	34	45	61	80	104	134	170	214	264
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$991	$1,141	$1,294	$1,446	$1,590	$1,723	$1,783	$1,783	$1,783
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$12	$16	$21	$28	$36	$47	$60	$75	$93
153									
154	$1,002	$1,157	$1,316	$1,474	$1,627	$1,770	$1,843	$1,858	$1,876
155									
156									
157	29.1	33.0	36.9	40.6	44.0	46.9	49.3	52.8	57.4
158	16.8	19.4	22.0	24.6	27.0	29.3	31.3	31.7	31.7
159	16.2	18.6	21.1	23.6	26.0	28.1	30.0	31.3	32.7
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	62.1	71.1	80.0	88.8	97.0	104.3	110.6	115.8	121.7
164									
165	29.1	33.0	36.9	40.6	44.0	46.9	49.3	51.1	52.1
166	16.8	19.4	22.0	24.6	27.0	29.3	31.3	31.7	31.7
167	16.2	18.6	21.1	23.6	26.0	28.1	30.0	30.4	30.4
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	62.1	71.1	80.0	88.8	97.0	104.3	110.6	113.2	114.2
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$883.42	$1,571.06	$2,463.50
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$457.03	$618.37	$779.71
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$1,002.41	$1,156.99	$1,315.51	$1,473.68	$1,626.76	$1,769.85	$1,842.91	$1,858.07	$1,875.83
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$2,301.41	$2,455.99	$2,614.51	$2,772.68	$2,925.76	$3,068.85	$3,595.86	$4,459.99	$5,531.55

Line#	Day 27	Day 28	Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	9,947.7	9,793.6	9,492.7	9,058.6	8,510.4	7,871.6	7,168.1	6,426.3	5,672.1
8	1,923.5	2,874.4	3,737.4	4,372.7	4,653.6	4,470.7	3,736.2	2,385.2	376.4
9	322.9	389.0	462.3	542.0	626.4	713.6	800.6	884.5	962.2
10	12,194.1	13,057.0	13,692.4	13,973.2	13,790.4	13,055.9	11,704.9	9,696.0	7,010.7
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	62.2	66.6	69.9	71.3	70.4	66.6	59.7	49.5	35.8
15	9.0	9.6	10.1	10.3	10.1	9.6	8.6	7.1	5.2
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	(14.7)	(19.1)	(22.3)	(23.7)	(22.8)	(19.1)	(12.2)	(1.9)	11.8
28	(1.8)	(2.4)	(2.8)	(3.0)	(2.9)	(2.4)	(1.5)	(0.2)	1.5
29									
30	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	7,011
31	2,874	3,737	4,373	4,654	4,471	3,736	2,385	376	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.08
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$2,874	$3,737	$4,373	$4,654	$4,471	$3,736	$2,385	$376	$0
41									
42	$3,414	$4,277	$4,913	$5,194	$5,011	$4,276	$2,925	$916	$540
43	$0.28	$0.33	$0.36	$0.37	$0.36	$0.33	$0.25	$0.09	$0.08
44									
45									
46									
47	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7	9,319.7
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7
54	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 27	Day 28	Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
67	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
68									
69	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	3,727.9	3,727.9	3,727.9	3,727.9	3,727.9	3,727.9	3,727.9	3,727.9	3,727.9
88	433.2	594.5	755.9	917.2	1,078.6	1,239.9	1,401.3	1,562.6	1,723.9
89	4,161.1	4,322.4	4,483.8	4,645.1	4,806.4	4,967.8	5,129.1	5,290.5	5,451.8
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	34.0	35.3	36.6	37.9	39.2	40.6	41.9	43.2	44.5
94	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	(4.9)	(6.2)	(7.5)	(8.8)	(10.1)	(11.4)	(12.8)	(14.1)	(15.4)
107	(0.8)	(1.0)	(1.2)	(1.4)	(1.6)	(1.8)	(2.0)	(2.2)	(2.4)
108									
109	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
110	595	756	917	1,079	1,240	1,401	1,563	1,724	1,885
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$595	$756	$917	$1,079	$1,240	$1,401	$1,563	$1,724	$1,885
120									

Line#	Day 27	Day 28	Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35
121	$941	$1,102	$1,264	$1,425	$1,586	$1,748	$1,909	$2,070	$2,232
122	$0.23	$0.26	$0.28	$0.31	$0.33	$0.35	$0.37	$0.39	$0.41
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783
129									
130									
131									
132	5,592	5,592	5,592	5,592	5,592	5,592	5,592	5,592	5,592
133	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783
134	7,375	7,375	7,375	7,375	7,375	7,375	7,375	7,375	7,375
135									
136									
137									
138	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783	1,783
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	535	535	535	535	535	535	535	535	535
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	1,248	1,248	1,248	1,248	1,248	1,248	1,248	1,248	1,248
145									
146	323	389	462	542	626	714	801	885	962
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$1,783	$1,783	$1,783	$1,783	$1,783	$1,783	$1,783	$1,783	$1,783
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$113	$136	$162	$190	$219	$250	$280	$310	$337
153									
154	$1,896	$1,919	$1,945	$1,973	$2,003	$2,033	$2,063	$2,093	$2,120
155									
156									
157	62.2	66.6	69.9	71.3	70.4	66.6	59.7	49.5	35.8
158	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7
159	34.0	35.3	36.6	37.9	39.2	40.6	41.9	43.2	44.5
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	127.9	133.6	138.2	140.9	141.3	138.9	133.3	124.4	112.0
164									
165	52.4	52.0	50.8	49.0	46.6	43.8	40.7	37.3	33.8
166	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7
167	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	114.5	114.1	112.9	111.1	108.7	105.9	102.8	99.4	96.0
172									
173	$3,414.40	$4,277.35	$4,912.70	$5,193.55	$5,010.71	$4,276.22	$2,925.22	$916.37	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$941.05	$1,102.39	$1,263.73	$1,425.07	$1,586.41	$1,747.75	$1,909.09	$2,070.43	$2,231.77
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$1,896.29	$1,919.43	$1,945.09	$1,972.96	$2,002.52	$2,033.01	$2,063.48	$2,092.84	$2,120.02
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$6,664.24	$7,711.67	$8,534.02	$9,004.08	$9,012.14	$8,469.48	$7,310.29	$5,492.14	$5,304.29

Line#	Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42	Day 43	Day 44
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	4,928.9	4,216.8	3,551.7	2,945.2	2,404.4	1,932.6	1,529.2	1,191.4	913.8
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1,031.0	1,089.2	1,136.2	1,172.4	1,198.8	1,217.3	1,229.4	1,236.2	1,238.0
10	5,959.9	5,306.0	4,687.9	4,117.5	3,603.3	3,149.9	2,758.6	2,427.6	2,151.7
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	30.4	27.1	23.9	21.0	18.4	16.1	14.1	12.4	11.0
15	4.4	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	17.1	20.5	23.6	26.5	29.2	31.5	33.5	35.2	36.6
28	2.2	2.6	3.0	3.3	3.7	4.0	4.2	4.4	4.6
29									
30	5,960	5,306	4,688	4,118	3,603	3,150	2,759	2,428	2,152
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.09	$0.10	$0.12	$0.13	$0.15	$0.17	$0.20	$0.22	$0.25
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43	$0.09	$0.10	$0.12	$0.13	$0.15	$0.17	$0.20	$0.22	$0.25
44									
45									
46									
47	7,010.7	5,959.9	5,306.0	4,687.9	4,117.5	3,603.3	3,149.9	2,758.6	2,427.6
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	7,010.7	5,959.9	5,306.0	4,687.9	4,117.5	3,603.3	3,149.9	2,758.6	2,427.6
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	23.8	20.3	18.0	15.9	14.0	12.3	10.7	9.4	8.3
54	3.4	2.9	2.6	2.3	2.0	1.8	1.5	1.4	1.2
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42	Day 43	Day 44
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	10.9	14.5	16.7	18.8	20.8	22.5	24.1	25.4	26.5
67	1.6	2.1	2.4	2.7	3.0	3.2	3.5	3.7	3.8
68									
69	7,011	5,960	5,306	4,688	4,118	3,603	3,150	2,759	2,428
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.06	$0.07	$0.08	$0.09	$0.10	$0.11	$0.13	$0.15	$0.17
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.06	$0.07	$0.08	$0.09	$0.10	$0.11	$0.13	$0.15	$0.17
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	2,804.3	2,384.0	2,122.4	1,875.2	1,647.0	1,441.3	1,260.0	1,103.5	971.0
88	1,885.3	1,123.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	4,689.5	3,507.0	2,122.4	1,875.2	1,647.0	1,441.3	1,260.0	1,103.5	971.0
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	38.3	28.6	17.3	15.3	13.4	11.8	10.3	9.0	7.9
94	5.9	4.4	2.7	2.4	2.1	1.8	1.6	1.4	1.2
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	(9.2)	0.5	11.8	13.8	15.7	17.3	18.8	20.1	21.2
107	(1.4)	0.1	1.8	2.1	2.4	2.7	2.9	3.1	3.3
108									
109	3,567	3,507	2,122	1,875	1,647	1,441	1,260	1,103	971
110	1,123	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$0.10	$0.10	$0.16	$0.18	$0.21	$0.24	$0.28	$0.31	$0.36
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$1,123	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42	Day 43	Day 44
121	$1,470	$347	$347	$347	$347	$347	$347	$347	$347
122	$0.31	$0.10	$0.16	$0.18	$0.21	$0.24	$0.28	$0.31	$0.36
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	1,783	1,753	1,061	938	824	721	630	552	486
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	1,783	1,753	1,061	938	824	721	630	552	486
129									
130									
131									
132	4,206	3,576	3,184	2,813	2,471	2,162	1,890	1,655	1,457
133	1,783	1,753	1,061	938	824	721	630	552	486
134	5,990	5,329	4,245	3,750	3,294	2,883	2,520	2,207	1,942
135									
136									
137									
138	1,783	1,753	1,061	938	824	721	630	552	486
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	535	526	318	281	247	216	189	166	146
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	1,248	1,227	743	656	576	504	441	386	340
145									
146	1031	1089	1136	1172	1199	1217	1229	1236	1238
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$1,783	$1,753	$1,061	$938	$824	$721	$630	$552	$486
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$361	$381	$398	$410	$420	$426	$430	$433	$433
153									
154	$2,144	$2,135	$1,459	$1,348	$1,243	$1,147	$1,060	$984	$919
155									
156									
157	30.4	27.1	23.9	21.0	18.4	16.1	14.1	12.4	11.0
158	23.8	20.3	18.0	15.9	14.0	12.3	10.7	9.4	8.3
159	38.3	28.6	17.3	15.3	13.4	11.8	10.3	9.0	7.9
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	92.5	76.0	59.3	52.3	45.8	40.1	35.1	30.8	27.2
164									
165	30.4	27.1	23.9	21.0	18.4	16.1	14.1	12.4	11.0
166	23.8	20.3	18.0	15.9	14.0	12.3	10.7	9.4	8.3
167	22.9	19.5	17.3	15.3	13.4	11.8	10.3	9.0	7.9
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	77.1	66.8	59.3	52.3	45.8	40.1	35.1	30.8	27.2
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$1,469.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$2,144.10	$2,134.70	$1,458.87	$1,347.91	$1,243.11	$1,146.72	$1,060.26	$984.41	$918.80
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$4,566.11	$3,433.70	$2,757.87	$2,646.91	$2,542.11	$2,445.72	$2,359.26	$2,283.41	$2,217.80

Line#	Day 45	Day 46	Day 47	Day 48	Day 49	Day 50	Day 51	Day 52	Day 53
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	690.0	513.0	375.4	270.5	191.9	134.0	92.2	62.4	41.6
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1,233.4	1,220.0	1,194.5	1,154.2	1,097.7	1,026.0	942.5	851.9	759.5
10	1,923.4	1,733.0	1,570.0	1,424.7	1,289.6	1,160.1	1,034.6	914.3	801.1
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	9.8	8.8	8.0	7.3	6.6	5.9	5.3	4.7	4.1
15	1.4	1.3	1.2	1.0	0.9	0.9	0.8	0.7	0.6
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	37.7	38.7	39.5	40.3	41.0	41.6	42.3	42.9	43.5
28	4.7	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.5
29									
30	1,923	1,733	1,570	1,425	1,290	1,160	1,035	914	801
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.28	$0.31	$0.34	$0.38	$0.42	$0.47	$0.52	$0.59	$0.67
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43	$0.28	$0.31	$0.34	$0.38	$0.42	$0.47	$0.52	$0.59	$0.67
44									
45									
46									
47	2,151.7	1,923.4	1,733.0	1,570.0	1,424.7	1,289.6	1,160.1	1,034.6	914.3
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	2,151.7	1,923.4	1,733.0	1,570.0	1,424.7	1,289.6	1,160.1	1,034.6	914.3
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	7.3	6.5	5.9	5.3	4.8	4.4	3.9	3.5	3.1
54	1.1	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.4
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 45	Day 46	Day 47	Day 48	Day 49	Day 50	Day 51	Day 52	Day 53
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	27.5	28.2	28.9	29.4	29.9	30.4	30.8	31.3	31.7
67	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6
68									
69	2,152	1,923	1,733	1,570	1,425	1,290	1,160	1,035	914
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.19	$0.21	$0.24	$0.26	$0.29	$0.32	$0.36	$0.40	$0.45
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.19	$0.21	$0.24	$0.26	$0.29	$0.32	$0.36	$0.40	$0.45
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	860.7	769.4	693.2	628.0	569.9	515.9	464.0	413.9	365.7
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	860.7	769.4	693.2	628.0	569.9	515.9	464.0	413.9	365.7
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	7.0	6.3	5.7	5.1	4.7	4.2	3.8	3.4	3.0
94	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	22.1	22.8	23.5	24.0	24.5	24.9	25.3	25.7	26.1
107	3.4	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.0
108									
109	861	769	693	628	570	516	464	414	366
110	0	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$0.40	$0.45	$0.50	$0.55	$0.61	$0.67	$0.75	$0.84	$0.95
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 45	Day 46	Day 47	Day 48	Day 49	Day 50	Day 51	Day 52	Day 53
121	$347	$347	$347	$347	$347	$347	$347	$347	$347
122	$0.40	$0.45	$0.50	$0.55	$0.61	$0.67	$0.75	$0.84	$0.95
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	430	385	347	314	285	258	232	207	183
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	430	385	347	314	285	258	232	207	183
129									
130									
131									
132	1,291	1,154	1,040	942	855	774	696	621	549
133	430	385	347	314	285	258	232	207	183
134	1,721	1,539	1,386	1,256	1,140	1,032	928	828	731
135									
136									
137									
138	430	385	347	314	285	258	232	207	183
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	129	115	104	94	85	77	70	62	55
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	301	269	243	220	199	181	162	145	128
145									
146	1233	1220	1195	1154	1098	1026	942	852	760
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$430	$385	$347	$314	$285	$258	$232	$207	$183
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$432	$427	$418	$404	$384	$359	$330	$298	$266
153									
154	$862	$812	$765	$718	$669	$617	$562	$505	$449
155									
156									
157	9.8	8.8	8.0	7.3	6.6	5.9	5.3	4.7	4.1
158	7.3	6.5	5.9	5.3	4.8	4.4	3.9	3.5	3.1
159	7.0	6.3	5.7	5.1	4.7	4.2	3.8	3.4	3.0
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	24.2	21.7	19.6	17.7	16.1	14.5	13.0	11.6	10.2
164									
165	9.8	8.8	8.0	7.3	6.6	5.9	5.3	4.7	4.1
166	7.3	6.5	5.9	5.3	4.8	4.4	3.9	3.5	3.1
167	7.0	6.3	5.7	5.1	4.7	4.2	3.8	3.4	3.0
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	24.2	21.7	19.6	17.7	16.1	14.5	13.0	11.6	10.2
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$862.03	$811.68	$764.68	$717.97	$669.15	$617.04	$561.88	$505.08	$448.68
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$2,161.03	$2,110.68	$2,063.68	$2,016.97	$1,968.15	$1,916.04	$1,860.88	$1,804.08	$1,747.68

Line#	Day 54	Day 55	Day 56	Day 57	Day 58	Day 59	Day 60	Day 61	Day 62
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	27.3	17.6	11.2	7.0	4.3	2.6	1.6	0.9	0.5
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	670.2	587.4	513.2	448.3	392.6	345.1	304.7	270.3	240.5
10	697.5	605.0	524.4	455.3	396.9	347.7	306.3	271.2	241.1
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	3.6	3.1	2.7	2.3	2.0	1.8	1.6	1.4	1.2
15	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	44.0	44.5	44.9	45.2	45.5	45.8	46.0	46.2	46.3
28	5.5	5.6	5.6	5.7	5.7	5.8	5.8	5.8	5.8
29									
30	697	605	524	455	397	348	306	271	241
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$0.77	$0.89	$1.03	$1.19	$1.36	$1.55	$1.76	$1.99	$2.24
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43	$0.77	$0.89	$1.03	$1.19	$1.36	$1.55	$1.76	$1.99	$2.24
44									
45									
46									
47	801.1	697.5	605.0	524.4	455.3	396.9	347.7	306.3	271.2
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	801.1	697.5	605.0	524.4	455.3	396.9	347.7	306.3	271.2
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	2.7	2.4	2.1	1.8	1.5	1.4	1.2	1.0	0.9
54	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 54	Day 55	Day 56	Day 57	Day 58	Day 59	Day 60	Day 61	Day 62
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	32.0	32.4	32.7	33.0	33.2	33.4	33.6	33.7	33.9
67	4.6	4.7	4.7	4.8	4.8	4.8	4.8	4.9	4.9
68									
69	801	697	605	524	455	397	348	306	271
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$0.51	$0.59	$0.68	$0.79	$0.91	$1.04	$1.19	$1.35	$1.52
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$0.51	$0.59	$0.68	$0.79	$0.91	$1.04	$1.19	$1.35	$1.52
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	320.4	279.0	242.0	209.7	182.1	158.8	139.1	122.5	108.5
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	320.4	279.0	242.0	209.7	182.1	158.8	139.1	122.5	108.5
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9
94	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	26.5	26.8	27.1	27.4	27.6	27.8	28.0	28.1	28.2
107	4.1	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4
108									
109	320	279	242	210	182	159	139	123	108
110	0	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$1.08	$1.24	$1.43	$1.65	$1.90	$2.18	$2.49	$2.83	$3.19
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 54	Day 55	Day 56	Day 57	Day 58	Day 59	Day 60	Day 61	Day 62
121	$347	$347	$347	$347	$347	$347	$347	$347	$347
122	$1.08	$1.24	$1.43	$1.65	$1.90	$2.18	$2.49	$2.83	$3.19
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	160	139	121	105	91	79	70	61	54
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	160	139	121	105	91	79	70	61	54
129									
130									
131									
132	481	418	363	315	273	238	209	184	163
133	160	139	121	105	91	79	70	61	54
134	641	558	484	419	364	318	278	245	217
135									
136									
137									
138	160	139	121	105	91	79	70	61	54
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	48	42	36	31	27	24	21	18	16
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	112	98	85	73	64	56	49	43	38
145									
146	670	587	513	448	393	345	305	270	241
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$160	$139	$121	$105	$91	$79	$70	$61	$54
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$235	$206	$180	$157	$137	$121	$107	$95	$84
153									
154	$395	$345	$301	$262	$228	$200	$176	$156	$138
155									
156									
157	3.6	3.1	2.7	2.3	2.0	1.8	1.6	1.4	1.2
158	2.7	2.4	2.1	1.8	1.5	1.4	1.2	1.0	0.9
159	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	8.9	7.7	6.7	5.8	5.1	4.4	3.9	3.4	3.0
164									
165	3.6	3.1	2.7	2.3	2.0	1.8	1.6	1.4	1.2
166	2.7	2.4	2.1	1.8	1.5	1.4	1.2	1.0	0.9
167	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	8.9	7.7	6.7	5.8	5.1	4.4	3.9	3.4	3.0
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$394.77	$345.06	$300.60	$261.78	$228.47	$200.17	$176.20	$155.85	$138.42
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$1,693.77	$1,644.06	$1,599.60	$1,560.78	$1,527.47	$1,499.17	$1,475.20	$1,454.85	$1,437.42

Line#	Day 63	Day 64	Day 65	Day 66	Day 67	Day 68	Day 69	Day 70	Day 71
1									
2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
3	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
4	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
5									
6									
7	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	214.6	191.6	171.0	152.4	135.4	120.0	105.9	93.2	81.7
10	214.9	191.8	171.1	152.4	135.4	120.0	105.9	93.2	81.7
11									
12									
13	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0	196.0
14	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4
15	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
16									
17									
18	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
22	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
23	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
24	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
25	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320	9,320
26									
27	46.5	46.6	46.7	46.8	46.9	46.9	47.0	47.1	47.1
28	5.8	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
29									
30	215	192	171	152	135	120	106	93	82
31	0	0	0	0	0	0	0	0	0
32									
33									
34	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
35	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
36	$540	$540	$540	$540	$540	$540	$540	$540	$540
37	$2.51	$2.82	$3.16	$3.54	$3.99	$4.50	$5.10	$5.79	$6.61
38									
39	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
40	$0	$0	$0	$0	$0	$0	$0	$0	$0
41									
42	$540	$540	$540	$540	$540	$540	$540	$540	$540
43	$2.51	$2.82	$3.16	$3.54	$3.99	$4.50	$5.10	$5.79	$6.61
44									
45									
46									
47	241.1	214.9	191.8	171.1	152.4	135.4	120.0	105.9	93.2
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	241.1	214.9	191.8	171.1	152.4	135.4	120.0	105.9	93.2
50									
51									
52	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0	294.0
53	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3
54	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
55									
56									
57	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
58	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Line#	Day 63	Day 64	Day 65	Day 66	Day 67	Day 68	Day 69	Day 70	Day 71
60	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
61	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
62	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
63	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
64	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224	10,224
65									
66	34.0	34.0	34.1	34.2	34.3	34.3	34.4	34.4	34.5
67	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5.0	5.0
68									
69	241	215	192	171	152	135	120	106	93
70	0	0	0	0	0	0	0	0	0
71									
72									
73	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
74	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
75	$413	$413	$413	$413	$413	$413	$413	$413	$413
76	$1.71	$1.92	$2.15	$2.41	$2.71	$3.05	$3.44	$3.89	$4.43
77									
78	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
79	$0	$0	$0	$0	$0	$0	$0	$0	$0
80									
81	$413	$413	$413	$413	$413	$413	$413	$413	$413
82	$1.71	$1.92	$2.15	$2.41	$2.71	$3.05	$3.44	$3.89	$4.43
83									
84									
85									
86	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
87	96.4	86.0	76.7	68.4	61.0	54.2	48.0	42.4	37.3
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	96.4	86.0	76.7	68.4	61.0	54.2	48.0	42.4	37.3
90									
91									
92	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5	122.5
93	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3
94	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
95									
96									
97	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
98	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
102	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
103	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
104	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
105									
106	28.3	28.4	28.5	28.6	28.6	28.7	28.7	28.8	28.8
107	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.5	4.5
108									
109	96	86	77	68	61	54	48	42	37
110	0	0	0	0	0	0	0	0	0
111									
112									
113	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00
114	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50
115	$347	$347	$347	$347	$347	$347	$347	$347	$347
116	$3.59	$4.03	$4.52	$5.06	$5.68	$6.40	$7.22	$8.18	$9.29
117									
118	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
119	$0	$0	$0	$0	$0	$0	$0	$0	$0
120									

Line#	Day 63	Day 64	Day 65	Day 66	Day 67	Day 68	Day 69	Day 70	Day 71
121	$347	$347	$347	$347	$347	$347	$347	$347	$347
122	$3.59	$4.00	$4.52	$5.06	$5.68	$6.40	$7.22	$8.18	$9.29
123									
124	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
125	48	43	38	34	30	27	24	21	19
126									
127	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
128	48	43	38	34	30	27	24	21	19
129									
130									
131									
132	145	129	115	103	91	81	72	64	56
133	48	43	38	34	30	27	24	21	19
134	193	172	153	137	122	108	96	85	75
135									
136									
137									
138	48	43	38	34	30	27	24	21	19
139									
140	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
141	14	13	12	10	9	8	7	6	6
142									
143	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
144	34	30	27	24	21	19	17	15	13
145									
146	215	192	171	152	135	120	106	93	82
147									
148	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
149	$48	$43	$38	$34	$30	$27	$24	$21	$19
150									
151	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
152	$75	$67	$60	$53	$47	$42	$37	$33	$29
153									
154	$123	$110	$98	$88	$78	$69	$61	$54	$47
155									
156									
157	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4
158	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3
159	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
163	2.7	2.4	2.2	1.9	1.7	1.5	1.3	1.2	1.0
164									
165	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4
166	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3
167	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3
168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	2.7	2.4	2.2	1.9	1.7	1.5	1.3	1.2	1.0
172									
173	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00	$540.00
174	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50	$412.50
175	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50	$346.50
176	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
177	$123.32	$110.04	$98.22	$87.56	$77.88	$69.07	$61.06	$53.81	$47.25
178	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
179	$1,422.32	$1,409.04	$1,397.22	$1,386.56	$1,376.88	$1,368.07	$1,360.06	$1,352.81	$1,346.25

Line#	Day 72	Day 73	Day 74	Day 75	Total
1					
2	0.33	0.33	0.33	0.33	
3	3.0%	3.0%	3.0%	3.0%	
4	2.0%	2.0%	2.0%	2.0%	
5					
6					
7	0.0	0.0	0.0	0.0	200,000
8	0.0	0.0	0.0	0.0	29,905
9	71.4	61.9	53.1	44.9	32,182
10	71.4	61.9	53.1	44.9	262,087
11					
12					
13	196.0	196.0	196.0	196.0	
14	0.4	0.3	0.3	0.2	
15	0.1	0.0	0.0	0.0	
16					
17					
18	6.0	6.0	6.0	6.0	
19	7.5	7.5	7.5	7.5	
20	1.0	1.0	1.0	1.0	
21	100.0%	100.0%	100.0%	100.0%	
22	100.0%	100.0%	100.0%	100.0%	
23	7.9	7.9	7.9	7.9	
24	47.5	47.5	47.5	47.5	
25	9,320	9,320	9,320	9,320	
26					
27	47.2	47.2	47.3	47.3	
28	5.9	5.9	6.0	6.0	
29					
30	71	62	53	45	232,182
31	0	0	0	0	29,905
32					
33					
34	$10.00	$10.00	$10.00	$10.00	
35	$15.00	$15.00	$15.00	$15.00	
36	$540	$540	$540	$540	
37	$7.57	$8.73	$10.17	$12.04	
38					
39	$1.00	$1.00	$1.00	$1.00	
40	$0	$0	$0	$0	$29,905
41					
42	$540	$540	$540	$540	$70,405
43	$7.57	$8.73	$10.17	$12.04	
44					
45					
46					
47	81.7	71.4	61.9	53.1	232,137
48	0.0	0.0	0.0	0.0	0
49	81.7	71.4	61.9	53.1	
50					
51					
52	294.0	294.0	294.0	294.0	
53	0.3	0.2	0.2	0.2	
54	0.0	0.0	0.0	0.0	
55					
56					
57	5.0	5.0	5.0	5.0	
58	7.5	7.5	7.5	7.5	
59	0.0	0.0	0.0	0.0	

Line#	Day 72	Day 73	Day 74	Day 75	Total
60	100.0%	100.0%	100.0%	100.0%	
61	100.0%	100.0%	100.0%	100.0%	
62	7.0	7.0	7.0	7.0	
63	34.8	34.8	34.8	34.8	
64	10,224	10,224	10,224	10,224	
65					
66	34.5	34.5	34.6	34.6	
67	5.0	5.0	5.0	5.0	
68					
69	82	71	62	53	232,137
70	0	0	0	0	0
71					
72					
73	$11.00	$11.00	$11.00	$11.00	
74	$16.50	$16.50	$16.50	$16.50	
75	$413	$413	$413	$413	
76	$5.05	$5.78	$6.67	$7.77	
77					
78	$1.00	$1.00	$1.00	$1.00	
79	$0	$0	$0	$0	
80					
81	$413	$413	$413	$413	$30,938
82	$5.05	$5.78	$6.67	$7.77	
83					
84					
85					
86	40.0%	40.0%	40.0%	40.0%	
87	32.7	28.5	24.8	21.2	92,855
88	0.0	0.0	0.0	0.0	13,098
89	32.7	28.5	24.8	21.2	
90					
91					
92	122.5	122.5	122.5	122.5	
93	0.3	0.2	0.2	0.2	
94	0.0	0.0	0.0	0.0	
95					
96					
97	4.5	4.5	4.5	4.5	
98	7.0	7.0	7.0	7.0	
99	0.0	0.0	0.0	0.0	
100	100.0%	100.0%	100.0%	100.0%	
101	100.0%	100.0%	100.0%	100.0%	
102	6.5	6.5	6.5	6.5	
103	29.1	29.1	29.1	29.1	
104	3,567	3,567	3,567	3,567	
105					
106	28.8	28.9	28.9	28.9	
107	4.5	4.5	4.5	4.5	
108					
109	33	29	25	21	92,855
110	0	0	0	0	13,098
111					
112					
113	$11.00	$11.00	$11.00	$11.00	
114	$16.50	$16.50	$16.50	$16.50	
115	$347	$347	$347	$347	
116	$10.60	$12.14	$14.00	$16.31	
117					
118	$1.00	$1.00	$1.00	$1.00	
119	$0	$0	$0	$0	
120					

Line#	Day 72	Day 73	Day 74	Day 75	Total
121	$347	$347	$347	$347	$39,085
122	$10.60	$12.14	$14.00	$16.31	
123					
124	50.0%	50.0%	50.0%	50.0%	
125	16	14	12	11	
126					
127	50.0%	50.0%	50.0%	50.0%	
128	16	14	12	11	
129					
130					
131					
132	49	43	37	32	
133	16	14	12	11	
134	65	57	50	42	185,710
135					
136					
137					
138	16	14	12	11	46,427
139					
140	30.0%	30.0%	30.0%	30.0%	
141	5	4	4	3	13,928
142					
143	70.0%	70.0%	70.0%	70.0%	
144	11	10	9	7	32,499
145					
146	71	62	53	45	
147					
148	$1.00	$1.00	$1.00	$1.00	
149	$16	$14	$12	$11	$46,427
150					
151	$0.35	$0.35	$0.35	$0.35	
152	$25	$22	$19	$16	$11,264
153					
154	$41	$36	$31	$26	$57,691
155					
156					
157	0.4	0.3	0.3	0.2	
158	0.3	0.2	0.2	0.2	
159	0.3	0.2	0.2	0.2	
160	0.0	0.0	0.0	0.0	
161	0.0	0.0	0.0	0.0	
162	0.0	0.0	0.0	0.0	
163	0.9	0.8	0.7	0.6	2,991.7
164					
165	0.4	0.3	0.3	0.2	
166	0.3	0.2	0.2	0.2	
167	0.3	0.2	0.2	0.2	
168	0.0	0.0	0.0	0.0	
169	0.0	0.0	0.0	0.0	
170	0.0	0.0	0.0	0.0	
171	0.9	0.8	0.7	0.6	2,732.2
172					
173	$540.00	$540.00	$540.00	$540.00	
174	$412.50	$412.50	$412.50	$412.50	
175	$346.50	$346.50	$346.50	$346.50	
176	$0.00	$0.00	$0.00	$0.00	
177	$41.33	$35.93	$30.97	$26.33	
178	$0.00	$0.00	$0.00	$0.00	
179	$1,340.33	$1,334.93	$1,329.97	$1,325.33	$198,118.52

APPENDIX C
NOTATION AND EQUATIONS FOR THE GENERAL CAPACITY PLANNING MODEL

In this section, notation and sample equations are provided for the capacity planning models. Note that all calculations are depicted in column 2 of both the General Capacity Planning Model and the Actual/Applied Model. Please refer to Appendices B and D.

TABLE C-1. MODEL NOTATION AND DEFINITIONS

Notation	Definition
T =	Planning horizon in days (t=1,2,.....T)
I =	Number of states, or departments (i=1,2,...I)
J =	Another department other than dept i that can feed work to dept i (j=1,2,...I)
Pr_{jit}=	Probability that an item is routed from dept j to dept i during time t
x =	The number of days to return a rework letter from date mailed t. This is calculated from the date the letter is mailed to the date returned
λ =	The mean and standard deviation for the returned letter distribution (assumes Poisson)
μ =	The mean of the new incoming work distribution (assumes Normal)
σ =	The standard deviation of the new incoming work distribution (assumes Normal)
TEV =	Total expected volume of work arriving over T

TABLE C-1. MODEL NOTATION AND DEFINITIONS (CONTINUED)

Notation	Definition
BR_{it} =	Amount of time for rest/break time per day per FTE during time t in dept i
D_{it} =	Proportion of time lost due to PFD (personal, fatigue and delay) during time t in dept i
S_{it} =	Proportion of productivity lost due to system slow response during time t in dept i
N_{it} =	Number of items new work arriving during time t in dept i
B_{it-1} =	Number of items yesterday's backlog that become "today's" work during time t in dept i
R_{it} =	Number of items return/rework arriving during time t in dept i
V_{it} =	Total volume of items available for processing during time t in dept i
A_{it} =	Actual items per hour processed during time t in dept i
HR_{it} =	Number of hours required during time t in dept i
FR_{it} =	Number of FTEs (full time equivalent employees) required during time t in dept i
F_{it} =	Number of FTEs (full time equivalent employees) available during time t in dept i
H_{it} =	Number of regular hours paid per FTE during time t in dept i
O_{it} =	Number of overtime hours paid per FTE during time t in dept i
M_{it} =	Machine uptime during time t in dept i
LC_{it} =	Level of efficiency accounting for learning curve effects during time t in dept i
HP_{it} =	Number of productive hours per FTE during time t in dept i

TABLE C-1. MODEL NOTATION AND DEFINITIONS (CONTINUED)

Notation	Definition
THP_{it} =	Total number of departmental productive hours during time t in dept i
C_{it} =	Maximum capacity to process items during time t in dept i
H+ or H- =	Number of actual hours over or under required hours
F+ or F- =	Number of FTEs over or under required FTEs
P_{it} =	Number of items processed during time t in dept i
B_{it} =	Number of items backlogged during time t in dept i
h_{it} =	Cost per regular hour during time t in dept i
o_{it} =	Cost per overtime hour during time t in dept i
L_{it} =	Total labor cost during time t in dept i
p_{it} =	Cost to process one item during time t in dept i
b_{it} =	Cost to backlog one item during time t in dept i
Tb_{it} =	Total cost to backlog all items during time t in dept i
G_{it} =	Goal for items per hour processed during time t in dept i (best case number of items)
TC_{it} =	Total cost of all items processed and backlogged during time t in dept i
W_{it} =	Weighted average unit cost for all items processed and backlogged during time t in dept i
RM_{it} =	Letters mailed during time t from dept i
RR_{it} =	Letters returned that were originally sent during time t from dept i (mailed at time t that will eventually return)

OBJECTIVE FUNCTION AND CONSTRAINTS: The following details the objective function and constraints for the prescriptive version of the general model.

Objective:

Minimize Total Cost: $\text{Min } Z = \sum_{t=1}^{T} (P_{it}p_{it} + B_{it}b_{it})$

Subject to:

$0 \leq D_{it}, LC_{it}, M_{it}, PR_{jit}, S_{it} \leq 1 \quad (i = 1,..,I;\ j = 1,...,J;\ t = 1,...,T)$

$0 \leq$ all parameters and variables

EQUATIONS: The following is a description of sample equations in mathematical notation. For clarification purposes, the line on which the variable or the equation first appears on the General Spreadsheet Model (in Appendix B, beginning on page 161) is listed to the left of the description. A less complex set of equations, that does not explicitly deal with breaktime, PFD factors, system slow time and learning curves are presented first, in Table C-2. These are meant to simplify the model. Relevant equations are expressed in a more complex form in Table C-3. Note that N_{1t} is a special case of N_{it}.

TABLE C-2. SIMPLIFIED EQUATION DEFINITIONS

Line #	Notation	Equations for workload or volume	Explanation
7	N_{1t}	$[P(x<t)-P(x<t-1)] * TEV$ Where $x = N(\mu, \sigma)$	Items arriving in Dept 1 = % area under the curve between t and t-1 * total vol. received
9	R_{it}	$\sum_{x=1}^{T-3} \sum_{t=1}^{T} [P(x=x \mid t=t) * RR_{it}]$	*Letters arriving at time t = total letters mailed on previous days accounting for attrition, and distributed
10	V_{it}	$(N_{it} + B_{it-1} + R_{it})$	Total volume = new items + yesterday's backlog + returned letters
47	N_{it}	$\sum_{j=1}^{J} (PR_{jit} * P_{jt})$	New work in dept i = amount of work processed in dept j * % of dept j work routed to dept i

* Assumes 3 days is the minimum time from mailing to return. x is the number of days to return. As an example, the number of letters received by Department 1 on Day 9 is R_{19}. RR_{56} = the number of letters mailed by Department 5 on Day 6 that are "destined to return". The following example demonstrates that letters received on Day 9 are from the batches of letters mailed on Days 1 through 6.

$$R_{19} = P(x=1|t=9) * RR_{51} + P(x=2|t=9) * RR_{52}$$
$$+ P(x=3|t=9) * RR_{53} + P(x=4|t=9) * RR_{54}$$
$$+ P(x=5|t=9) * RR_{55} + P(x=6|t=9) * RR_{56}$$

TABLE C-2. SIMPLIFIED EQUATION DEFINITIONS (CONTINUED)

Line #	Notation	Equations for resource requirements	Explanation
14	HR_{it}	V_{it}/A_{it}	Required hours = volume/actual items per hour
15	FR_{it}	HR_{it}/H_{it}	# FTEs = required hours/reg hours per FTE

Line #	Notation	Equations for available capacity	Explanation
23	HP_{it}	$(H_{it} + O_{it}) * M_{it}$	Productive hours per FTE = (reg hrs+ OT hrs)* Proportion of machine uptime
24	THPit	HPit * Fit	Total productive hours = productive hrs per FTE * #FTEs
25	C_{it}	$THP_{it} * A_{it}$	Max Capacity = productive hours * actual items per hr

Line #	Notation	Equations for resource overage/underage	Explanation
27	H+ or H-	$THP_{it} - HR_{it}$	Hour overage or underage = hours available - hours required
28	F+ or F-	$(H+ \text{ or } H-)/(H_{it} + O_{it})$	FTE overage or underage = hours over or under/(reg hrs + OT hours)

Line #	Notation	Equations for items handled vs. not handled	Explanation
30	P_{it}	MIN [V_{it}, C_{it}]	Actual processed = minimum of: maximum capacity or volume available to process
31	B_{it-1}	$V_{it} - P_{it}$	Tomorrow's backlog = total volume - processed

TABLE C-2. SIMPLIFIED EQUATION DEFINITIONS (CONTINUED)

Line #	Notation	Cost Equations	Explanation
36	L_{it}	$F_{it} * [(H_{it} * h_{it}) + (O_{it} * o_{it})]$	Labor cost = FTEs*[reg hours* cost reg hour + OT hrs * cost OT hour]
37	p_{it}	L_{it}/P_{it}	Cost to process one item = labor cost/items processed
42	TC_{it}	$L_{it} + Tb_{it}$	Total cost of all items processed and backlogged = total labor cost + total backlog cost
43	W_{it}	$(P_{it}p_{it} + B_{it}b_{it})/(P_{it} + B_{it})$	Weighted average cost of all items = cost to process * # processed + cost to backlog * total backlogged/(items processed + backlogged)

Line #	Notation	Letter Equations	Explanation
128	RM_{it}	$(P_{it} * PR_{i5t})$	Letters mailed = volume processed * % that needs a letter
144	RR_{it}	$(RM_{it} * PR_{51t})$	Letters that will return = number of letters mailed * % that will return

TABLE C-3. MORE COMPLEX EQUATION DEFINITIONS

The following equations presented in Table C-3 are the more complex versions. They account for additional parameters such as PFD, system slow time, the effect of a learning curve, and breaktime.

Line #	Notation	Equation	Explanation
13	A_{it}	$G_{it} * LC_{it} * (1 - S_{it})$	Actual items per hour processed = goal * learning curve * (1- productivity lost to system slow time)
15	FR_{it}	$HR_{it}/(H_{it} - Br_{it} - (H_{it} * D_{it}))$	# FTEs = required hours/(reg hours per FTE - Break time - (hours * PFD))
23	HP_{it}	$(H_{it} + O_{it} - BR_{it}) * (M_{it} * (1- D_{it}))$	Productive hours per FTE = (reg hrs+ OT hrs - break) * Machine uptime * (1-PFD)
28	F+ or F-	$(H+ \text{ or } H-)/(H_{it} + O_{it} - BR_{it} - (H_{it} * D_{it}))$	FTE overage or underage = hrs over or under/(reg hrs + OT hours - break - (reg hrs * PFD))

APPENDIX D
APPLIED/ACTUAL CAPACITY PLANNING MODEL

Line	ACTUAL MARKETING CAMPAIGN	Source
1	**Global Staffing Assumptions:**	
2	-Breaktime Per Day in Hours	Company Policy
3	-PFD Percentage	Area Estimate
4	-System Downtime/Slow Response Time (Percent Productivity Lost)	Area Estimate
5		
6	**DEPT 1**	
7	Incoming Items	A=Actual Spring 1994
8	Yesterday's Backlog (Line 31 With 1 Day Delay)	Copy Line With Delay
9	Total Incoming Items + Backlog (Line 7 + Line 8)	Calculation
10		
11	Resource Requirements:	
12	Items Per Hour (Goal Items per hour * Line 13)	Department Records
13	Learning Curve Assumptions	Department Estimate
14	Required Hours (Line 9 / Line 12)	Calculation
15	Required FTE (Line 14/(Line 19-Line2-(Line19*Line 3)))	Calculation
16		
17	Capacity (available staff hours):	
18	FTE's in Department (Varies)	Department Records
19	Regular paid hours in the work day per FTE	Department Policy
20	Overtime paid hours in the work day per FTE	Department Policy
21	Productive hours in Work Day per FTE(Line 24*(Line 19+Line 20))	Calculation
22	Total department productive hours per day(Line 18*Line 21)	Calculation
23	Number of Machines	Department Records
24	Machine Uptime	Department Records
25	Maximum Capacity to Process Items (Line 12*Line 22*Line 23)	Calculation
26		
27	Overage (Underage) in Hours (Line 22 - Line 14)	Calculation
28	Overage (Underage) in FTE (Line 18 - Line 15)	Calculation
29		
30	Items Handled ([MIN] Line 9, Line 25) to DEPT 2	Calculation
31	Tomorrow's Backlog (Line 9 - Line 30)	Calculation
32		
33	Average Delay (Line 31/Line 25)	Calculation
34		
35		
36	**DEPT 2**	
37	Volume from DEPT 1 (Line 30)	Copy Line
38	Yesterday's Backlog (Line 66 With 1 Day Delay)	Copy Line With Delay
39	Total Incoming Items + Backlog (Line 37 + Line 38)	Calculation
40	Percent no good	Historical Data
41	Volume no good (Line 37 * Line 40)	Calculation
42	Incoming Items With Backlog Less no good (Line 39 - Line 41)	Calculation
43	Volume of Incoming Dept 8 Letters (Poisson Distribution)	Letter Table
44	Volume of Incoming more info letters (Poisson Distribution)	Letter Table
45	Processable Today's Volume (Line 42 + Line 43 + Line 44)	Calculation
46		
47	Resource Requirements:	
48	Items Per Hour (Goal Items per hour*Line 49)	Department Records
49	Learning Curve Assumptions	Department Estimate
50	Required Hours (Line 45 / Line 48)	Calculation
51	Required FTE (Line 50/(Line 55-Line2-(Line55*Line 3)))	Calculation
52		
53	Capacity (available staff hours):	
54	FTE's in Department (Varies)	Department Records
55	Regular paid hours in the work day per FTE	Department Policy
56	Overtime paid hours in the work day per FTE	Department Policy
57	Productive hours in Work Day per FTE(Line 59*(Line 55+Line 56-Line 2)*(1-Line 3))	Calculation
58	Total department productive hours per day(Line 54 * Line 57)	Calculation
59	Machine Uptime	Department Records
60	Maximum Capacity to Process Items (Line 48 * Line 58)	Calculation
61		
62	Overage (Underage) in Hours (Line 57 - Line 50)	Calculation
63	Overage (Underage) in FTE (Line 54 - Line 51)	Calculation
64		
65	Items Handled ([MIN] Line 45, Line 60) to DEPT 3	Calculation
66	Tomorrow's Backlog (Line 45 - Line 65)	Calculation
67		
68	Average Delay (Line 66/Line 60)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
69		
70		
71	**DEPT 3:**	
72	Percent to DEPT 3 (1 - Line 40) from DEPT 2	Calculation
73	From DEPT 2 (Line 65)	Copy Line
74	Yesterday's Backlog (Line 96 With 1 Day Delay)	Copy Line With Delay
75	Total Volume of Items (Line 73 + Line 74)	Calculation
76		
77	Resource Requirements:	
78	Items Per Hour (Goal items per hour * Line 79 * (1- Line 4))	Department Records
79	Learning Curve Assumptions	Department Estimate
80	Required Hours (Line 75 / Line 78)	Calculation
81	Required Machines (Line 80/(Line 85-Line2-(Line85*Line 3)))	Calculation
82		
83	Capacity (available staff hours):	
84	Machines in Department (It takes 2 employees to run one machine)	Department Records
85	Regular paid hours in the work day per Machine	Department Policy
86	Overtime paid hours in the work day per Machine	Department Policy
87	Productive hours in Work Day per FTE(Line 89*(Line 85+Line 86-Line 2)*(1-Line 3))	Calculation
88	Total department productive hours per day(Line 84 * Line 87)	Calculation
89	Machine Uptime	Department Records
90	Maximum Capacity to Process Items (Line 78 * Line 88)	Calculation
91		
92	Overage (Underage) in Hours (Line 88 - Line 80)	Calculation
93	Overage (Underage) in FTE/Machines (Line 84 - Line 81)	Calculation
94		
95	Items Handled ([MIN] Line 75, Line 90) to DEPT 5 or DEPT 4	Calculation
96	Tomorrow's Backlog (Line 75 - Line 95)	Calculation
97		
98	Average Delay (Line 96/Line 90)	Calculation
99		
100	Dept 8 Letters to DEPT 8 (Line 43)	Copy Line
101	% Returned Letters L1 and L5 (to DEPT 8)	Historical Data
102	Volume L1, L5 Letters to DEPT 8 (Line 44 * Line 101)	Calculation
103	% Returned Letters L2 (to DEPT 5)	Historical Data
104	Volume L2 Letters to DEPT 5 (Line 44 * Line 103)	Calculation
105	% Returned Letters L4 Letters (to DEPT 7)	Historical Data
106	Volume L4 Letters to DEPT 7 (Line 44 * Line 105)	Calculation
107	% Returned Letters L6 Letters (to File)	Historical Data
108	Volume L6 Letters to File (Line 44* Line 107)	Calculation
109		
110	Scan Items Handled Less Letters (Line95- Line100-Line102-Line104-Line106-Line108)	Calculation
111		
112	**DEPT 4:**	
113	DEPT 3 Items Handled Less Letters (Line 110) 1 Day Delay	Copy Line With Delay
114	Percent From DEPT 3 to DEPT 4	Department Estimate
115	DEPT 4 Volume (Line 113 * Line 114)	Calculation
116	Yesterday's Backlog (Line 138 With 1 Day Delay)	Copy Line With Delay
117	Total Volume of Items (Line 115 + Line 116)	Calculation
118		
119	Resource Requirements:	
120	Items Per Hour (Goal items per hour * Line 121* (1- Line 4))	Department Records
121	Learning Curve Assumptions	Department Estimate
122	Required Hours (Line 117 / Line 120)	Calculation
123	Required FTE (Line 122/(Line 127-Line 2-(Line 127*Line 3)))	Calculation
124		
125	Capacity (available staff hours):	
126	FTE's in Department (Varies)	Department Records
127	Regular paid hours in the work day per FTE	Department Policy
128	Overtime paid hours in the work day per FTE	Department Policy
129	Productive hours in Work Day per FTE(Line 131*(Line 127+Line 128-Line 2)*(1-Line 3))	Calculation
130	Total department productive hours per day(Line 126* Line 129)	Calculation
131	Machine Uptime	*Department Records*
132	Maximum Capacity to Process Items (Line 130 * Line 120)	Calculation
133		
134	Overage (Underage) in Hours (Line 130 - Line 122)	Calculation
135	Overage (Underage) in FTE (Line 126 - Line 123)	Calculation
136		
137	Items Handled ([MIN] Line 117, Line 132) to DEPT 5	Calculation
138	Tomorrow's Backlog (Line 117 - Line 137)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
139		
140	Average Delay (Line 138/Line 132)	Calculation
141		
142		
143	**DEPT 5:**	
144	Volume Items Received from DEPT 3 (Line 110 - Line 115) 1 Day Delay	Calculation With Delay
145	Volume Received from DEPT 4 (1 Day Delay Line 137)	Copy Line With Delay
146	Volume of Letters to DEPT 5 (L2 Letters) (Line 104)	Copy Line
147	Total Volume (Line 144 + Line 145 + Line 146)	Calculation
148	Percent no interest	Historical Data
149	Volume of no interests ((Line 144+Line 145) * Line 148)	Calculation
150	DEPT 5 Volume Less no interest (Line 147 - Line 149)	Calculation
151		
152	Yesterday's Backlog (Line 174 With Delay)	Copy Line With Delay
153	Total Daily Work (Line 150 + Line 152)	Calculation
154		
155	Resource Requirements:	
156	Items Per Hour (Goal items per hour * Line 157* (1- Line 4))	Department Records
157	Learning Curve Assumptions	Department Estimate
158	Required Hours (Line 153 / Line 156)	Calculation
159	Required FTE (Line 158/(Line 163-Line 2-(Line 163*Line 3)))	Calculation
160		
161	Capacity (available staff hours):	
162	FTE's in Department (Varies)	Department Records
163	Regular paid hours in the work day per FTE	Department Policy
164	Overtime paid hours in the work day per FTE	Department Policy
165	Productive hours in Work Day per FTE(Line 167*(Line 163+Line 164-Line 2)*(1-Line 3))	Calculation
166	Total department productive hours per day(Line 162 * Line 165)	Calculation
167	Machine Uptime	Department Records
168	Maximum Capacity to Process Items (Line 156 * Line 166)	Calculation
169		
170	Overage (Underage) in Hours (Line 166 - Line 158)	Calculation
171	Overage (Underage) in FTE (Line 162 - Line 159)	Calculation
172		
173	Items Handled ([MIN] Line 153, Line 168) to System 1	Calculation
174	Tomorrow's Backlog (Line 153 - Line 173)	Calculation
175		
176	Average Delay (Line 174/Line 168)	Calculation
177		
178		
179	**DEPT 6:**	
180	Percent DEPT 6 from DEPT 5	Department Policy
181	Items from DEPT 5 to DEPT 6 (Line 173 * Line 180)	Calculation
182	Volume Not DEPT 6 From DEPT 5 (to System 1)(Line 173*(1-Line 180))	Calculation
183	Yesterday's Backlog (Line 205 With Delay)	Copy Line With Delay
184	Total Volume DEPT 6 (Line 181 + Line 183)	Calculation
185		
186	Resource Requirements:	
187	Items Per Hour (Goal items per hour * Line 188 * (1- Line 4))	Department Records
188	Learning Curve Assumptions	Department Estimate
189	Required Hours (Line 184 / Line 187)	Calculation
190	Required FTE (Line 189/(Line 194-Line 2-(Line 194*Line 3)))	Calculation
191		
192	Capacity (available staff hours):	
193	FTE's in Department (Varies)	Department Records
194	Regular paid hours in the work day per FTE	Department Policy
195	Overtime paid hours in the work day per FTE	Department Policy
196	Productive hours in Work Day per FTE(Line 198*(Line 194+Line 195-Line 2)*(1-Line 3))	Calculation
197	Total department productive hours per day(Line 193* Line 196)	Calculation
198	Machine Uptime	Department Records
199	Maximum Capacity to Process Items (Line 187 * Line 197)	Calculation
200		
201	Overage (Underage) in Hours (Line 197 - Line 189)	Calculation
202	Overage (Underage) in FTE (Line 193 - Line 190)	Calculation
203		
204	Items Handled ([MIN] Line 184, Line 199) to System 1	Calculation
205	Tomorrow's Backlog (Line 184 - Line 204)	Calculation
206		
207	Average Delay (Line 205/Line 199)	Calculation
208		

Line	ACTUAL MARKETING CAMPAIGN	Source
209		
210	**DEPT 7**	
211	Incoming Letters (L4) (Line 106 with delay)	Copy Line With Delay
212	Yesterday's Backlog (Line 234 With Delay)	Copy Line With Delay
213	Total Volume (Line 211 + Line 212)	Calculation
214		
215	Resource Requirements:	
216	Items Per Hour (Goal items per hour * Line 217 * (1- Line 4))	Department Records
217	Learning Curve Assumptions	Department Estimate
218	Required Hours (Line 213 / Line 216)	Calculation
219	Required FTE (Line 218/(Line 223-Line 2-(Line 223*Line 3)))	Calculation
220		
221	Capacity (available staff hours):	
222	FTE's in Department (Varies)	Department Records
223	Regular paid hours in the work day per FTE	Department Policy
224	Overtime paid hours in the work day per FTE	Department Policy
225	Productive hours in Work Day per FTE(Line 227*(Line 223+Line 224-Line 2)*(1-Line 3))	Calculation
226	Total department productive hours per day(Line 222 * Line 225)	Calculation
227	Machine Uptime	Department Records
228	Maximum Capacity to Process Items (Line 216* Line 226)	Calculation
229		
230	Overage (Underage) in Hours (Line 226 - Line 218)	Calculation
231	Overage (Underage) in FTE (Line 222 - Line 219)	Calculation
232		
233	Items Handled ([MIN] Line 213, Line 228)	Calculation
234	Tomorrow's Backlog (Line 213 - Line 233)	Calculation
235		
236	Average Delay (Line 234/Line 228)	Calculation
237		
238	Percent Incoming L4 letters Resolved by DEPT 7 to System 1 Determination	Department Estimate
239	Volume Incoming L4 letters Resolved by DEPT 7 (Line 233 * Line 238)	Calculation
240	Percent Incoming L4 letters Referred to DEPT 8 (1-Line 238)	Department Estimate
241	Volume Incoming L4 letters Referred to DEPT 8 (Line 240 * Line 233)	Calculation
242		
243		
244	**SYSTEM 1 DECISION**	
245	From DEPT 5 (Line 182)	Copy Line
246	From DEPT 6 (Line 204)	Copy Line
247	From DEPT 7 (Line 239)	Copy Line
248	L2 letters (Line 146)	Copy Line
249	Total System 1 Decision (Line 245 + Line 246 -Line 248)	Calculation
250		
251	Letter Decisioning (Line 247 + Line 248)	Copy Line
252	% Receive second Missing Info letter	Historical Data
253	Volume Second Letters (Line 251 * Line 252)	Calculation
254	% To Vendor 1	Historical Data
255	Volume to Vendor 1 (Line 251 * Line 254)	Calculation
256	% to Vendor 2	Historical Data
257	Volume to Vendor 2 (Line 251 * Line 256)	Calculation
258		
259	% Good Items Needing Missing Info Letters (L1, L2, L4, L5)	Historical Data
260	To: Volume Missing Info Letters (L1, L2 ,L4 ,L5) (Line249*Line259+Line 253)	Calculation
261	L1,L2,L4,L5 Letters Corrected for Mail Dates	Historical Data
262	% Needing Missing Info Letters L6	Historical Data
263	To: Volume Needing Missing Info Letters L6 (Line 249 * Line 262)	Calculation
264	% Missing Info Letters Returned (more info received/sent)(L1,L2,L4,L5,L6)	Historical Data
265	Volume Missing Info Letters Ret'd ((Line 261+Line 263)*Line 264)	Calculation
266		
267	% Vendor 2 (L6 Letters are not removed from processing)	Calculation
268	To: Volume Vendor 2 (Line 249 * Line 267 + Line 257)	Calculation
269	% Percent to Vendor 1	Historical Data
270	To: Volume Vendor 1(Line 249 * Line 269 + Line 255)	Calculation
271	%Percent DEPT 8/Process B	Historical Data
272	To: Volume DEPT 8/Process B (Line 249 * Line 271)	Calculation
273		
274		
275	**VENDOR 1 VERIFICATION:**	
276	From System 1 Determination to Vendor 1 day delay (Line 270)	Copy Line With Delay
277	From Vendor 1 Back to Processing 7 day delay: (Line 276 with delay)	Copy Line With Delay
278	Percent Vendor 1 says OK (To Vendor 2)	Historical Data

Line	ACTUAL MARKETING CAMPAIGN	Source
279	Volume Vendor 1 says OK (To Vendor 2) (Line 277 * Line 278)	Calculation
280	Percent No contact ("V" letter to cust-Returned to DEPT 8)	Historical Data
281	Volume No contact (Line 277 * Line 280)	Calculation
282	Percent Vendor 1 says Not OK/Decline	Historical Data
283	Volume Vendor 1 says Not OK/Decline (Line 277 * Line 282)	Calculation
284		
285		
286	**TO VENDOR 2:**	
287	From System 1 Determination (Line 268)	Copy Line
288	From Vendor 1 (Line 279)	Copy Line
289	From DEPT 8 - Process B Approvals (Line 346)	Copy Line
290	From DEPT 8 - Dept 7 Referrals (Line 354)	Copy Line
291	From DEPT 8 - Vendor 1 "V" Letters Approved (Line 411)	Copy Line
292	From DEPT 8 - Process B "V" Letters Approved (Line 417)	Copy Line
293	Outgoing Vendor 2 Volume (Total) (Line 287 +...+ Line 292)	Calculation
294		
295	**FROM VENDOR 2:**	
296	Outgoing volume (with delay) (Line 293 With 1 Day Delay)	Copy Line With Delay
297	Percent Process A - to DEPT 8	Historical Data
298	Volume Process A - to DEPT 8 (Line 296 * Line 297)	Calculation
299	Percent OK - Percent to System 2	Historical Data
300	Volume OK - Volume to System 2 (Line 296 * Line 299)	Calculation
301		
302		
303	**DEPT 8: REFERRALS**	
304	Incoming Vendor 2 Process A (with 1 day delay) (Line 298)	Copy Line With Delay
305	Process B Verification Referrals (Line 272 With 1 Day Delay)	Copy Line With Delay
306	Process C, L4, L1, L5 Letters (Line 241+ Line 102) with 1 Day Delay	Copy Line With Delay
307	Tot Ref Vol: Process B,Vendor 2 Process A(Line 304+Line 305+Line 306)	Calculation
308	Yesterday's Backlog (Line 330 With Delay)	Copy Line With Delay
309	Total Volume (Line 307 + Line 308)	Calculation
310		
311	Resource Requirements:	
312	Items Per Hour (Goal items per hour * Line 313 * (1- Line 4))	Department Records
313	Learning Curve Assumptions	Department Estimate
314	Required Hours (Line 309 / Line 312)	Calculation
315	Required FTE (Line 314/(Line 319-Line 2-(Line 319*Line 3)))	Calculation
316		
317	Capacity (available staff hours):	
318	FTE's in Department (Varies) (If Line 315<FTE,FTE,Line 315)	Department Records
319	Regular paid hours in the work day per FTE	Department Policy
320	Overtime paid hours in the work day per FTE	Department Policy
321	Productive hours in Work Day per FTE(Line 323*(Line 319+Line 320-Line 2)*(1-Line 3))	Calculation
322	Total department productive hours per day(Line 318 * Line 321)	Calculation
323	Machine Uptime	Department Records
324	Maximum Capacity to Process Items (Line 322*Line 312)	Calculation
325		
326	Overage (Underage) in Hours (Line 322 - Line 314)	Calculation
327	Overage (Underage) in FTE (Line 318 - Line 315)	Calculation
328		
329	Items Handled ([MIN] Line 309, Line 324)	Calculation
330	Tomorrow's Backlog (Line 309 - Line 329)	Calculation
331		
332	Average Delay (If Line 324=0,0,Line 330/Line 324)	Calculation
333		
334	Incoming Vendor 2 Process A (If Line 329=0,0,Line 304/Line 307 * Line 329)	Calculation
335	Percent Declined/Blocked	Historical Data
336	Volume Declined/Blocked (Line 334 * Line 335)	Calculation
337	Percent Approved (To System 2)	Historical Data
338	Volume Approved (To System 2) (Line 334 * Line 337)	Calculation
339	Percent Process D Letter Sent	Historical Data
340	Volume Process D Letter Sent (Line 334 * Line 339)	Calculation
341		
342	Process B Ver Referrals(If Line 329=0,0,Line 305/Line 307*Line 329)	Calculation
343	Percent Declined/Blocked	Historical Data
344	Volume Declined/Blocked (Line 342 * Line 343)	Calculation
345	Percent Approved (To Vendor 2)	Historical Data
346	Volume Approved (To Vendor 2) (Line 342 * Line 345)	Calculation
347	Percent "V" Letter Sent	Historical Data
348	Volume "V" Letter Sent (Line 342 * Line 347)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
349		
350	Dept 7 Referrals L4, L1 ,L5 Letters (If 329=0,0,Line 306/Line 307*Line 329)	Calculation
351	Percent Declined/Blocked	Historical Data
352	Volume Declined/Blocked (Line 350 * Line 351)	Calculation
353	Percent Approved (To Vendor 2)	Historical Data
354	Volume Approved (To Vendor 2) (Line 350 * Line 353)	Calculation
355		
356	**DEPT 8: LETTERS**	
357	DEPT 8 Letters Mailed (Process D Letters) (Line 340)	Copy Line
358	Percent of Letters Received	Historical Data
359	Total Volume of Letters to be Received (Line 357 * Line 358)	Calculation
360		
361	Vendor 1 Letters Mailed ("V" Letters) (Line 281)	Copy Line
362	Percent Letters Received	Historical Data
363	Volume Letters to be Received (Line 361 * Line 362)	Calculation
364		
365	Process B Letters Mailed ("V" Letters) (Line 348)	Copy Line
366	Percent Letters Received	Historical Data
367	Volume Letters Received (Line 365 * Line 366)	Calculation
368		
369	Total Outgoing "Dept 8" Letters (Line 357+Line 361 + Line 365)	Calculation
370	Outgoing Letters adjusted for actual mail dates	Department Records
371	Outgoing Letters that will return (Line 359+ Line363+ Line367)	Calculation
372	Outgoing Letters that will return adjusted for mail dates	Department Records
373		
374	Total DEPT 8 Letter Volume Incoming "V" & Process D (Poisson staggered distribution)	Letter Table
375	Yesterday's Backlog (Line 397 With Delay)	Copy Line With Delay
376	Total Volume (Line 374 + Line 375)	Calculation
377		
378	Resource Requirements:	
379	Items Per Hour (Goal Items per hour * Line 380 * (1- Line 4))	Department Records
380	Learning Curve Assumptions	Department Estimate
381	Required Hours (Line 376 / Line 379)	Calculation
382	Required FTE (Line 381/(Line 386-Line 2-(Line 386*Line 3))	Calculation
383		
384	*Capacity (available staff hours):*	
385	FTE's in Department (FTE - Line 318)	Dept Records/Calc
386	Regular paid hours in the work day per FTE	Department Policy
387	Overtime paid hours in the work day per FTE	Department Policy
388	Productive hours in Work Day per FTE(Line 390*(Line 386+Line 387-Line 2)*(1-Line 3))	Calculation
389	Total department productive hours per day (Line 385 * Line 388)	Calculation
390	Machine Uptime	Department Records
391	Maximum Capacity to Process Items (Line 379 * Line 389)	Calculation
392		
393	Overage (Underage) in Hours (Line 389 - Line 381)	Calculation
394	Overage (Underage) in FTE (Line 385 - Line 382)	Calculation
395		
396	Items Handled ([MIN] Line 376, Line 391)	Calculation
397	Tomorrow's Backlog (Line 376 - Line 396)	Calculation
398		
399	Average Delay (If Line 391=0,0,Line 397/Line 391)	Calculation
400		
401	DEPT 8 Letters Handled (Process D Letters) (If Line 396=0,0,Line 359/Line 374*Line 396)	Calculation
402	Percent Declined/Blocked	Historical Data
403	Volume Declined/Blocked (Line 401 * Line 402)	Calculation
404	Percent Approved (To System 2)	Historical Data
405	Volume Approved (To System 2) (Line 401 * Line 404)	Calculation
406		
407	Vendor 1 Letters Handled ("V" Letters) (If Line 396=0,0,Line 363/Line 374*Line 396)	Calculation
408	Percent Declined/Blocked	Historical Data
409	Volume Declined/Blocked (Line 407 * Line 408)	Calculation
410	Percent Approved (To Vendor 2)	Historical Data
411	Volume Approved (To Vendor 2) (Line 407 * Line 410)	Calculation
412		
413	Process B Letters Handled ("V" Letters)(If Line 396=0,0Line 367/Line 374*Line 396)	Calculation
414	Percent Declined/Blocked	Historical Data
415	Volume Declined/Blocked (Line 413 * Line 414)	Calculation
416	Percent Approved (To Vendor 2)	Historical Data
417	Volume Approved (To Vendor 2) (Line 413 * Line 416)	Calculation
418		

Line	ACTUAL MARKETING CAMPAIGN	Source
419	GRAND TOTAL DEPT 8 Volume (Referrals+Letters)(Line 307+Line 374)	Calculation
420	Total DEPT 8 Backlog (Line 330 + Line 397)	Calculation
421		
422		
423	**SYSTEM 2:**	
424	Incoming from Vendor 2 - OK (Line 300 with one day delay)	Copy Line With Delay
425	Incoming from DEPT 8 (Line 338 + Line 405)	Calculation
426	Outgoing System 2 Volume (to DEPT 9) (Line 424+Line 425)	Calculation
427		
428		
429	**DEPT 9 DAY SHIFT:**	
430	Incoming from System 2 (2 Day delay from Outgoing)(Line 426 With 2 Day Delay)	Copy Line With Delay
431	Ratio of Items : Accounts	Department Records
432	**Process A(From Incoming System 2) (Line 430*Line 431)**	Copy Line
433	Yesterday's Evening Shift Backlog (Line 504 With Delay)	Copy Line With Delay
434	Total Volume (Line 432 + Line 433)	Calculation
435		
436	Resource Requirements:	
437	Items Per Hour (Goal items per hour * Line 438)	Department Records
438	Learning Curve Assumptions	Department Estimate
439	Required Hours (Line 434 / Line 437)	Calculation
440	Required FTE (Line 439/(Line 444-Line 2-(Line 444*Line 3)))	Calculation
441		
442	Capacity (available staff hours):	
443	FTE's in Department (Varies)	Department Records
444	Regular paid hours in the work day per FTE	Department Policy
445	Overtime paid hours in the work day per FTE	Department Policy
446	Productive hours in Work Day per FTE(Line 448*(Line 444+Line 445-Line 2)*(1-Line 3))	Calculation
447	Total department productive hours per day(Line 443 * Line 446)	Calculation
448	Machine Uptime	Department Records
449	Maximum Capacity to Process Items (Line 437*Line 447)	Calculation
450		
451	Overage (Underage) in Hours (Line 447 - Line 439)	Calculation
452	Overage (Underage) in FTE (Line 443 - Line 440)	Calculation
453		
454	Items Handled ([MIN] Line 434, Line 449)	Calculation
455	Backlog For the Evening Shift (Line 434 - Line 454)	Calculation
456		
457	**Process B (From Process A Day Shift) (Line 454/Line 431)**	Calculation
458	Yesterday's Evening Shift Backlog (Line 529 With Delay)	Copy Line With Delay
459	Total Volume (Line 457 + Line 458)	Calculation
460		
461	Resource Requirements:	
462	Items Per Hour (Goal items per hour * Line 463)	Department Records
463	Learning Curve Assumptions	Department Estimate
464	Required Hours (Line 459 / Line 462)	Calculation
465	Required FTE (Line 464/(Line 469-Line 2-(Line 469*Line 3)))	Calculation
466		
467	Capacity (available staff hours):	
468	FTE's in Department (Varies)	Department Records
469	Regular paid hours in the work day per FTE	Department Policy
470	Overtime paid hours in the work day per FTE	Department Policy
471	Productive hours in Work Day per FTE(Line 473*(Line 469+Line 470-Line 2)*(1-Line 3))	Calculation
472	Total department productive hours per day(Line 468 * Line 471)	Calculation
473	Machine Uptime	Department Records
474	Maximum Capacity to Process Items (Line 462*Line 472)	Calculation
475		
476	Overage (Underage) in Hours (Line 472 - Line 464)	Calculation
477	Overage (Underage) in FTE (Line 468 - Line 465)	Calculation
478		
479	Items Handled ([MIN] Line 459, Line 474)	Calculation
480	Backlog For the Evening Shift (Line 459 - Line 479)	Calculation
481		
482	**DEPT 9 EVENING SHIFT:**	
483	**Process A (From Incoming DAY SHIFT) (Line 455)**	Copy Line
484		
485	Resource Requirements:	
486	Items Per Hour (Goal items per hour * Line 487)	Department Records
487	Learning Curve Assumptions	Department Estimate
488	Required Hours (Line 483 / Line 486)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
489	Required FTE (Line 488/(Line 493-Line 2-(Line 493*Line 3)))	Calculation
490		
491	Capacity (available staff hours):	
492	FTE's in Department (Varies)	Department Records
493	Regular paid hours in the work day per FTE	Department Policy
494	Overtime paid hours in the work day per FTE	Department Policy
495	Productive hours in Work Day per FTE(Line 497*(Line 493+Line 494-Line 2)*(1-Line 3))	Calculation
496	Total department productive hours per day(Line 492 * Line 495)	Calculation
497	Machine Uptime	Department Records
498	Maximum Capacity to Process Items (Line 486*Line 496)	Calculation
499		
500	Overage (Underage) in Hours (Line 496 - Line 488)	Calculation
501	Overage (Underage) in FTE (Line 492 - Line 489)	Calculation
502		
503	Items Handled ([MIN] Line 483, Line 498)	Calculation
504	Tomorrow's Backlog (Line 483 - Line 503)	Calculation
505		
506	Average Delay (Line 504/Line 498)	Calculation
507		
508	**Process B (From Evening Proc A + Day Proc B Backlog)(Line 480+ Line 503/Line 431)**	Copy Line With Delay
509		
510	Resource Requirements:	
511	Items Per Hour (Goal items per hour * Line 512)	Department Records
512	Learning Curve Assumptions	Department Estimate
513	Required Hours (Line 508 / Line 511)	Calculation
514	Required FTE (Line 513/(Line 518-Line 2-(Line 518*Line 3)))	Calculation
515		
516	Capacity (available staff hours):	
517	FTE's in Department (Varies)	Department Records
518	Regular paid hours in the work day per FTE	Department Policy
519	Overtime paid hours in the work day per FTE	Department Policy
520	Productive hours in Work Day per FTE(Line 522*(Line 518+Line 519-Line 2)*(1-Line 3))	Calculation
521	Total department productive hours per day(Line 517 * Line 520)	Calculation
522	Machine Uptime	Department Records
523	Maximum Capacity to Process Items (Line 511 * Line 521)	Calculation
524		
525	Overage (Underage) in Hours (Line 521 - Line 513)	Calculation
526	Overage (Underage) in FTE (Line 517 - Line 514)	Calculation
527		
528	Items Handled ([MIN] Line 508, Line 523)	Calculation
529	Tomorrow's Backlog (Line 508 - Line 528)	Calculation
530		
531	Average Delay (Line 529/Line 523)	Calculation
532		
533	Total Handled Process A (Day+Evening) (Line 454 + Line 503)	Calculation
534	Total Handled Process B (Day+Evening) (Line 479 + Line 528)	Calculation
535	TOTAL BACKLOG FOR TOMORROW DAY SHIFT (Line 504 + Line 529)	Calculation
536		
537	**DEPT 10:**	
538	Total Completed Sent (Line 534)	Copy Line
539	Percent "Special Situation"	Department Policy
540	Volume "Special Sit" (Line 538 * Line 539)	Calculation
541	Percent Incoming DEPT 10 Calls	Department Estimate
542	Volume Incoming DEPT 10 Calls (Line 540 * Line 541)	Calculation
543	Volume Incoming DEPT 10 Calls (Line 542 With 5 Day Delay)	Copy Line With Delay
544	Percent DEPT 10 Calls Handled by the VRU	Department Estimate
545	Volume Handled by DEPT 10 (Line 543 *(1-Line 544))	Calculation
546	Yesterday's Backlog (Line 568 With Delay)	Copy Line With Delay
547	Total Volume (Line 545 + Line 546)	Calculation
548		
549	Resource Requirements:	
550	Items Per Hour (Goal items per hour * Line 551)	Department Records
551	Learning Curve Assumptions	Department Estimate
552	Required Hours (Line 547 / Line 550)	Calculation
553	Required FTE (Line 552/(Line 557-Line 2-(Line 557*Line 3)))	Calculation
554		
555	Capacity (available staff hours):	
556	FTE's in Department	Department Records
557	Regular paid hours in the work day per FTE	Department Policy
558	Overtime paid hours in the work day per FTE	Department Policy

Line	ACTUAL MARKETING CAMPAIGN	Source
559	Productive hours in Work Day per FTE(Line 561*(Line 557+Line 558-Line 2)*(1-Line 3))	Calculation
560	Total department productive hours per day(Line 556* Line 559)	Calculation
561	Machine Uptime	Department Records
562	Maximum Capacity to Process Items (Line 550*Line 560)	Calculation
563		
564	Overage (Underage) in Hours (Line 560 - Line 552)	Calculation
565	Overage (Underage) in FTE (Line 556 - Line 553)	Calculation
566		
567	Items Handled ([MIN] Line 547, Line 562)	Calculation
568	Tomorrow's Backlog (Line 547 - Line 567)	Calculation
569		
570	Average Delay (Line 568/Line 562)	Calculation
571		
572	**Tot All Avg Delays (Line33+Line68+Line98+Line140+Line176+**	
573	**Line207+Line236+Line332+Line 399+Line506+Line531+Line570)**	Calculation
574		
575	**Total Allocated Staff / Machines**	
576	DEPT 1 (Line 18)	Copy Line
577	DEPT 2 (Line 54)	Copy Line
578	DEPT 3 (Line 84)	Copy Line
579	DEPT 4 (Line 126)	Copy Line
580	DEPT 5 (Line 162)	Copy Line
581	DEPT 6 (Line 193)	Copy Line
582	DEPT 7 (Line 222)	Copy Line
583	DEPT 8 Referrals (Line 318)	Copy Line
584	DEPT 8 Letters (Line 385)	Copy Line
585	DEPT 9 Process A(Day) (Line 443)	Copy Line
586	DEPT 9 Process A(Evening) (Line 492)	Copy Line
587	DEPT 9 Process B (Day) (Line 468)	Copy Line
588	DEPT 9 Process B (Evening) (Line 517)	Copy Line
589	DEPT 10 (Line 556)	Copy Line
590	**Total Allocated Staff for DMRP**	
591		
592	**Friday Box (Input Information)**	
593	DEPT 1	
594	DEPT 2	
595	DEPT 3	
596	DEPT 4	
597	DEPT 5	
598	DEPT 6	
599	DEPT 7	
600	DEPT 8 Referrals	
601	DEPT 8 Letters	
602	DEPT 9 Process A(Day)	
603	DEPT 9 Process A(Evening)	
604	DEPT 9 Process B (Day)	
605	DEPT 9 Process B (Evening)	
606	DEPT 10	
607	**Total Staff Requirement (In Hours)**	
608	DEPT 1 (Line 14)	Copy Line
609	DEPT 2 (Line 50)	Copy Line
610	DEPT 3 (Line 80)	Copy Line
611	DEPT 4 (Line 122)	Copy Line
612	DEPT 5 (Line 158)	Copy Line
613	DEPT 6 (Line 189)	Copy Line
614	DEPT 7 (Line 218)	Copy Line
615	DEPT 8 Referrals (Line 314)	Copy Line
616	DEPT 8 Letters (Line 381)	Copy Line
617	DEPT 9 Process A(Day) (Line 439)	Copy Line
618	DEPT 9 Process A(Evening) (Line 488)	Copy Line
619	DEPT 9 Process B (Day) (Line 464)	Copy Line
620	DEPT 9 Process B (Evening) (Line 513)	Copy Line
621	DEPT 10 (Line 552)	Copy Line
622	**Tot Staff Required (Assumes Backlogs are Possible)(Line 608..Line 621)**	
623	DEPT 1 (Line 7/Line 12)	Calculation
624	DEPT 2 (Line 37-Line 41+Line43+Line 44)/Line 48))	Calculation
625	DEPT 3 (Line 73/Line 78)	Calculation
626	DEPT 4 (Line 115/Line 120)	Calculation
627	DEPT 5 (Line 150/Line 156)	Calculation
628	DEPT 6 (Line 181/Line 187)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
629	DEPT 7 (Line 211/Line 216)	Calculation
630	DEPT 8 Referrals (Line 307/Line 312)	Calculation
631	DEPT 8 Letters (Line 374/Line 379)	Calculation
632	DEPT 9 Process A(Day) (Line 430/Line 437)	Calculation
633	DEPT 9 Process A(Evening) (Line 483/Line 486)	Calculation
634	DEPT 9 Process B (Day) (Line 457/Line 462)	Calculation
635	DEPT 9 Process B (Evening) (Line 508/Line 511)	Calculation
636	DEPT 10 (Line 545/Line 550)	Calculation
637	Tot Staff Required to Process all Work Same Day(Line 623..Line 636)	Calculation
638		
639	Staff/Capacity/Holdover Summary	
640	DEPT 1	
641	Machines/Staff (Line 576)	Copy Line
642	Maximum Capacity (Line 25)	Copy Line
643	Items Handled (Line 30)	Copy Line
644	Holdover/Backlog (Line 31)	Copy Line
645		
646	DEPT 2	
647	Staff (Line 577)	Copy Line
648	Maximum Capacity (Line 60)	Copy Line
649	Items Handled (Line 65)	Copy Line
650	Holdover/Backlog (Line 66)	Copy Line
651		
652	DEPT 3	
653	Staff (Line 578)	Copy Line
654	Maximum Capacity (Line 90)	Copy Line
655	Items Handled (Line 95)	Copy Line
656	Holdover/Backlog (Line 96)	Copy Line
657		
658	DEPT 4	
659	Staff (Line 579)	Copy Line
660	Maximum Capacity (Line 132)	Copy Line
661	Items Handled (Line 137)	Copy Line
662	Holdover/Backlog (Line 138)	Copy Line
663		
664	DEPT 5	
665	Staff (Line 580)	Copy Line
666	Maximum Capacity (Line 168)	Copy Line
667	Items Handled (Line 173)	Copy Line
668	Holdover/Backlog (Line 174)	Copy Line
669		
670	DEPT 6	
671	Staff (Line 581)	Copy Line
672	Maximum Capacity (Line 199)	Copy Line
673	Items Handled (Line 204)	Copy Line
674	Holdover/Backlog (Line 205)	Copy Line
675		
676	DEPT 7	
677	Staff (Line 582)	Copy Line
678	Maximum Capacity (Line 228)	Copy Line
679	Items Handled (Line 233)	Copy Line
680	Holdover/Backlog (Line 234)	Copy Line
681		
682	DEPT 8 Referrals	
683	Staff (Line 583)	Copy Line
684	Maximum Capacity (Line 324)	Copy Line
685	Items Handled (Line 329)	Copy Line
686	Holdover/Backlog (Line 330)	Copy Line
687		
688	DEPT 8 Letters	Copy Line
689	Staff (Line 584)	Copy Line
690	Maximum Capacity (Line 391)	Copy Line
691	Items Handled (Line 396)	Copy Line
692	Holdover/Backlog (Line 397)	Copy Line
693		
694	DEPT 9 Process A (Day)	
695	Machines/Staff (Line 585)	Copy Line
696	Maximum Capacity (Line 449)	Copy Line
697	Items Handled (Line 454)	Copy Line
698	Holdover/Backlog (Line 455)	Copy Line

Line	ACTUAL MARKETING CAMPAIGN	Source
699		
700	DEPT 9 Process A (Evening)	
701	Machines/Staff (Line 586)	Copy Line
702	Maximum Capacity (Line 498)	Copy Line
703	Items Handled (Line 503)	Copy Line
704	Holdover/Backlog (Line 504)	Copy Line
705		
706	DEPT 9 Process B (Day)	
707	Machines/Staff (Line 587)	Copy Line
708	Maximum Capacity (Line 474)	Copy Line
709	Items Handled (Line 479)	Copy Line
710	Holdover/Backlog (Line 480)	Copy Line
711		
712	DEPT 9 Process B (Evening)	
713	Machines/Staff (Line 588)	Copy Line
714	Maximum Capacity (Line 523)	Copy Line
715	Items Handled (Line 528)	Copy Line
716	Holdover/Backlog (Line 529)	Copy Line
717		
718	DEPT 10	
719	Staff (Line 589)	Copy Line
720	Maximum Capacity (Line 562)	Copy Line
721	Items Handled (Line 567)	Copy Line
722	Holdover/Backlog (Line 568)	Copy Line
723		
724	**Unit Costs**	
725	DEPT 1 Unit Cost:	
726	Regular Labor Cost Per Hour	Department Records
727	Overtime Labor Cost Per Hour (Line 726 * 1.5)	Calculation
728	Total Labor Cost (Line18*((Line19*Line726)+(Line20*Line727)))	Calculation
729	Unit Cost Per Item Processed (If Line 30<1,Line 728,Line 728/Line30)	Calculation
730	Unit Cost per Backlogged item	Department Records
731	Total Cost (Line 728+(Line 31*Line 730))	Calculation
732	Weighted Avg costs (If Line30<1,Line729,(Line729*Line30)+(Line31*Line730))/ (Line30+Line31)	Calculation
733		
734	DEPT 2:	
735	Regular Labor Cost Per Hour	Department Records
736	Overtime Labor Cost Per Hour (Line 735 * 1.5)	Calculation
737	Total Labor Cost (Line54*((Line55*Line735)+(Line56*Line736)))	Calculation
738	Unit Cost Per Item Processed (If Line 65<1,Line 737,Line 737/Line65)	Calculation
739	Unit Cost per Backlogged item	Department Records
740	Total Cost (Line 737+(Line 66*Line 739))	Calculation
741	Weighted Avg costs (If Line65<1,Line738,(Line738*Line65)+(Line66*Line739))/ (Line65+Line66)	Calculation
742		
743	DEPT 3:	
744	Regular Labor Cost Per Hour (2 FTE per Machine)	Department Records
745	Overtime Labor Cost Per Hour (Line 744 * 1.5)	Calculation
746	Total Labor Cost (Line84*((Line85*Line744)+(Line86*Line745)))	Calculation
747	Unit Cost Per Item Processed (If Line 95<1,Line 746,Line 746/Line95)	Calculation
748	Unit Cost per Backlogged item	Department Records
749	Total Cost (Line 746+(Line96*Line 748))	Calculation
750	Weighted Avg costs (If Line95<1,Line747,(Line747*Line95)+(Line96*Line748))/ (Line95+Line96)	Calculation
751		
752	DEPT 4:	
753	Regular Labor Cost Per Hour	Department Records
754	Overtime Labor Cost Per Hour (Line 753 * 1.5)	Calculation
755	Total Labor Cost (Line126*((Line127*Line753)+(Line128*Line754)))	Calculation
756	Unit Cost Per Item Processed (If Line 137<1,Line 755,Line 755/Line137)	Calculation
757	Unit Cost per Backlogged item	Department Records
758	Total Cost (Line 755+(Line 138*Line 757))	Calculation
759	Weighted Avg costs (If Line137<1,Line755,(Line756*Line137)+(Line138*Line757))/ (Line137+Line138)	Calculation
760		
761	DEPT 5:	
762	Regular Labor Cost Per Hour	Department Records
763	Overtime Labor Cost Per Hour (Line 762 * 1.5)	Calculation
764	Total Labor Cost (Line162*((Line163*Line762)+(Line164*Line763)))	Calculation
765	Unit Cost Per Item Processed (If Line 173<1,Line 764,Line 764/Line173)	Calculation
766	Unit Cost per Backlogged item	Department Records
767	Total Cost (Line 764+(Line 174*Line 766))	Calculation
768	Weighted Avg costs (If Line173<1,Line765,(Line765*Line173)+(Line174*Line766))/ (Line173+Line174)	Calculation

Line	ACTUAL MARKETING CAMPAIGN	Source
769		
770	DEPT 6:	
771	Regular Labor Cost Per Hour	Department Records
772	Overtime Labor Cost Per Hour (Line 771 * 1.5)	Calculation
773	Total Labor Cost (Line193*((Line194*Line771)+(Line195*Line772)))	Calculation
774	Unit Cost Per Item Processed (If Line 204<1,Line 773,Line 773/Line204)	Calculation
775	Unit Cost per Backlogged item	Department Records
776	Total Cost (Line 773+(Line 205*Line 775))	Calculation
777	Weighted Avg costs (If Line204<1,Line774,(Line774*Line204)+(Line205*Line775))/ (Line204+Line205)	Calculation
778		
779	DEPT 7:	
780	Regular Labor Cost Per Hour	Department Records
781	Overtime Labor Cost Per Hour (Line 780 * 1.5)	Calculation
782	Total Labor Cost (Line222*((Line223*Line780)+(Line224*Line781)))	Calculation
783	Unit Cost Per Item Processed (If Line 233<1,Line 782,Line 782/Line233)	Calculation
784	Unit Cost per Backlogged item	Department Records
785	Total Cost (Line 782+(Line 234*Line 784))	Calculation
786	Weighted Avg costs (If Line233<1,Line783,(Line783*Line233)+(Line234*Line784))/ (Line233+Line234)	Calculation
787		
788	DEPT 8 Referrals:	
789	Regular Labor Cost Per Hour	Department Records
790	Overtime Labor Cost Per Hour (Line 789 * 1.5)	Calculation
791	Total Labor Cost (Line318*((Line319*Line789)+(Line320*Line790)))	Calculation
792	Unit Cost Per Item Processed (If Line 329<1,Line 791,Line 791/Line329)	Calculation
793	Unit Cost per Backlogged item	Department Records
794	Total Cost (Line 791+(Line 330*Line 793))	Calculation
795	Weighted Avg costs (If Line329<1,Line792,(Line792*Line329)+(Line330*Line793))/ (Line329+Line330)	Calculation
796		
797	DEPT 8 Letters:	
798	Regular Labor Cost Per Hour	Department Records
799	Overtime Labor Cost Per Hour (Line 798 * 1.5)	Calculation
800	Total Labor Cost (Line385*((Line386*Line798)+(Line387*Line799)))	Calculation
801	Unit Cost Per Item Processed (If Line 396<1,Line 800,Line 800/Line396)	Calculation
802	Unit Cost per Backlogged item	Department Records
803	Total Cost (Line 800+(Line 397*Line 802))	Calculation
804	Weighted Avg costs (If Line396<1,Line801,(Line801*Line396)+(Line397*Line802))/ (Line396+Line397)	Calculation
805		
806	DEPT 9 Process A: (Proc Day+Evening,Backlog=Evening)	
807	Regular Labor Cost Per Hour	Department Records
808	Overtime Labor Cost Per Hour (Line 807 * 1.5)	Calculation
809	Tot Labor (Line443*((Line444*Line807)+(Line445*Line808))+(Line492*((Line493*Line807)+(Line494*Line808)))	Calculation
810	Unit Cost Per Item Processed (If Line 533<1,Line 809,Line 809/Line533)	Calculation
811	Unit Cost per Backlogged item	Department Records
812	Total Cost (Line 809+(Line 504*Line 811))	Calculation
813	Weighted Avg costs (If Line533<1,Line810,(Line810*Line533)+(Line504*Line811))/ (Line533+Line504)	Calculation
814		
815	DEPT 9 Process B:(proc=Day+Evening,Backlog=Evening)	
816	Regular Labor Cost Per Hour	Department Records
817	Overtime Labor Cost Per Hour (Line 816 * 1.5)	Calculation
818	Tot Labor (Line468*((Line469*Line816)+(Line470*Line817))+(Line517*((Line518*Line816)+(Line519*Line817)))	Calculation
819	Unit Cost Per Item Processed (If Line 534<1,Line 818,Line 818/Line534)	Calculation
820	Unit Cost per Backlogged item	Department Records
821	Total Cost (Line 818+(Line 529*Line 820))	Calculation
822	Weighted Avg costs (If Line534<1,Line819,(Line819*Line534)+(Line529*Line820))/ (Line529+Line534)	Calculation
823		
824	DEPT 10:	
825	Regular Labor Cost Per Hour	Department Records
826	Overtime Labor Cost Per Hour (Line 825 * 1.5)	Calculation
827	Total Labor Cost (Line556*((Line557*Line825)+(Line558*Line826)))	Calculation
828	Unit Cost Per Item Processed (If Line 567<1,Line 827,Line 827/Line567)	Calculation
829	Unit Cost per Backlogged item	Department Records
830	Total Cost (Line 827+(Line 568*Line 829))	Calculation
831	Weighted Avg costs (If Line567<1,Line828,(Line828*Line567)+(Line568*Line829))/ (Line568+Line567)	Calculation
832	**Total Cost (Line 731+Line 740+Line 749+Line 758+Line 767+Line 776+Line 785**	
833	**+Line 794+Line 803+Line 812+Line 821+Line 830)**	Calculation

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