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THESIS

RE-ENGINEERING THE ENROLLMENT MANAGEMENT SYSTEM AT THE MONTEREY PENINSULA UNIFIED SCHOOL DISTRICT (MPUSD)

by

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June 2001

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This thesis establishes a Forecasting Enrollment Management (FEM) system within the Monterey Peninsula Unified School District (MPUSD). In particular, it examines the effect the forecasting of student enrollment since the untimely departure of the Deputy Superintendent (DepSup) who had performed the function as Chief Enrollment Official for over two decades. The closure of the Fort Ord Army Facility had a significant impact on the accuracy of enrollment projections and inadvertently affected the funding for special program allocations and staffing. The MPUSD has within its control twenty-three schools that service over 12,000 students each year using public funds. Four schools are located within military housing communities and typically service the school-age military dependents residing nearby. Each year's funding is determined by an estimate projected from the previous year's enrollment. The District is required to provide a budget request by April 15th of each school operating year. The school district currently has no computational model adequate for projecting student enrollment; MPUSD uses a working group process to achieve its objective. A model that can more precisely project the number of students in each future year is developed; it can provide a more efficient enrollment management process and provide the necessary checks and balances for the current method. The thesis considers independent community related variables and historical data, and shows that prior-year enrollment figures can forecast future-year enrollment projections with smaller variance than the current working group method.

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RE-ENGINEERING THE ENROLLMENT MANAGEMENT SYSTEM AT THE MONTEREY PENINSULA UNIFIED SCHOOL DISTRICT (MPUSD)

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Submitted in partial fulfillment of the
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ABSTRACT

This thesis establishes a Forecasting Enrollment Management (FEM) system within the Monterey Peninsula Unified School District (MPUSD). In particular, it examines the effect the forecasting of student enrollment since the untimely departure of the Deputy Superintendent (DepSup) who had performed the function as Chief Enrollment Official for over two decades. The closure of the Fort Ord Army Facility had a significant impact on the accuracy of enrollment projections and inadvertently affected the funding for special program allocations and staffing. The MPUSD has within its control twenty-three schools that service over 12,000 students each year using public funds. Four schools are located within military housing communities and typically service the school-age military dependents residing nearby. Each year's funding is determined by an estimate projected from the previous year's enrollment. The District is required to provide a budget request by April 15th of each school operating year. The school district currently has no computational model adequate for projecting student enrollment; MPUSD uses a working group process to achieve its objective. A model that can more precisely project the number of students in each future year is developed; it can provide a more efficient enrollment management process and provide the necessary checks and balances for the current method. The thesis considers independent community related variables and historical data, and shows that prior-year enrollment figures can forecast future-year enrollment projections with smaller variance than the current working group method.

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To Dr. Robert Infelise and Mrs. Irene Hufford for having the professional courage to ask for assistance on matters that pertained to the welfare and stability of the school district. They put their responsibilities to the community before self and as a result the MPUSD is on track to becoming one of America's success stories in public school financial reform and community-based dedication. It has been said that it takes a village to raise a child, but the committed school district leadership team that guarantees that child's quality education is often overlooked.

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DEDICATION

To my four wonderful blessings, Fentrice, Nia, Naomi and Niles who often questioned why Daddy had so much schoolwork to do, you are my joy and I love you all more than you can realize. To my Mother and family who have supported me my entire life and continue to do so, once again I humbly say I am glad God put me in this family and I will never forget your support and love. To Jesus Christ, my Lord and Savior, I will continue to endure the trials and tribulations, as long as you continue to walk beside me. Thanks for the long walks through the halls of the Naval Postgraduate School Department of Operations Research. Amen!

To Brother Robert Holmes, the first African-American United States Navy Supply Corps Officer to nearly complete the Operations Analysis 360 curriculum thanks for paving the way for others to pursue this noteworthy endeavor.

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EXECUTIVE SUMMARY

Fort Ord was slated for base closure in 1991 and eventually closed three years later around September 30, 1994. The military retained part of the base for housing staff and students at the Defense language Institute and the Naval Postgraduate School. About 15 percent of the military and civilian personnel lived off base, primarily in the adjoining cities of Marina, Monterey, Salinas, Seaside, and Pacific Grove.

The ability to accurately estimate the projected enrollment and the Average Daily Attendance (ADA) for the ensuing school year at the Monterey Peninsula Unified School District's (MPUSD) is an annual challenge to be faced. The major source of revenue to the district is the base revenue limit per ADA. The revenue limit per ADA is the equivalent to the amount of funds provided by public sources to educate one child for one school year. The major expenditure of the district is the salary and benefit costs for staffing. Consequently, estimates of income and expenditures depend on the accuracy of the enrollment projections and accurate projections are vital to the on-going financial well-being of the school district. The fragmented departure of Fort Ord personnel and families during the school year instead of during the summer months as planned caused a dramatic deficit for the MPUSD from which it has not properly recovered.

This thesis establishes a Forecasting Enrollment Management (FEM) system within the Monterey Peninsula Unified School District (MPUSD). In particular, it examines the effect the forecasting of student enrollment since the untimely departure of the Deputy Superintendent (DepSup) who had performed the function as Chief Enrollment Official for over two decades. The closure of the Fort Ord Army Facility had a significant impact on the accuracy of enrollment projections and inadvertently affected the funding for special program allocations and staffing. The MPUSD has within its control twenty-three schools that service over 12,000 students each year using public funds. Four schools are located within military housing communities and typically service the school-age military dependents residing nearby. Each year's funding is determined by an estimate projected from the previous year's enrollment. The District is required to provide a budget request by April 15th of each school operating year. The school district currently has no computational model adequate for projecting student enrollment; MPUSD uses a working group process to achieve its objective. A model that can more precisely project the number of students in each future year is developed; it can provide a more efficient enrollment management process and provide the necessary checks and balances for the current method. The thesis considers independent community related variables and historical data, and shows that prior-year enrollment figures can forecast future-year enrollment projections with smaller variance than the current working group method.

In addition, this thesis is to provide a low-cost scientific model (mathematical, computational, and programmable) for analysis and forecasting enrollment projections. This output will then be used to project the student enrollment and the level of personnel staffing for the ensuing school year. The user will be able to simply compute the required enrollment figures for each school by grade using the Forecasting and Enrollment Management (FEM) Model program, the newly established FEM database and an existing Commercial Off The Shelf (COTS) software program named FORECAST.XLA that will calculate the next twelve data points in the forecast. This information will support the District's efforts to maintain solvency by incorporating current forecasting technology into their management decision process.

I. INTRODUCTION

A. RESEARCH PROBLEM

The purpose of this thesis was to use basic operations research techniques to reverse engineer the unrecorded enrollment management process used by the late Deputy Superintendent (DepSup) at Monterey Peninsula Unified School District (MPUSD) or to establish a process within the guidelines of the California Association of School Business Officer (CASBO) regulations. In addition, a computational model was to be developed to perform the enrollment forecasting procedures necessary to provide increased accuracy and reduced variance within the process.

In the summer of 2000, a blue ribbon commission was established by the Monterey School Board of Education to investigate allocations of insolvency at the MPUSD. Several commission members came from the academia of Monterey including the Naval Postgraduate School (NPS). The Operations Research Department's Curricular Officer was contacted regarding a forecast modeling project. The author was selected to solve the problem by the Curricular Officer and began work. The MPUSD required a forecasting model that was multi-functional. The model needed to be able to provide the following services:

- Project student enrollment for any grade at any school for at least one year (twelve periods) in the future
- Provide the necessary staffing assignments by school and grade
- Use existing hardware and software systems
- Provide a scalable and portable database management system with the following attributes:

- Low-cost or no-cost
- Easy to train existing personnel for use
- Developed, tested and operational before the 15th April deadline for submission of budget requests to the California Department of Education

What MPUSD was truly requesting was an enrollment management system. Since the current process did not include any computer-readable historical records, a database was created from volumes of data of written reports stored since the 1994 base closure of Fort Ord.

The ability to accurately estimate the projected enrollment and the Average Daily Attendance (ADA) for the ensuing school year at the Monterey Peninsula Unified School District (MPUSD) is an annual challenge to be faced. The major source of revenue to the district is the base revenue limit per ADA. The base revenue limit per ADA is the equivalent to the amount of funds provided by the state authorities to educate one child for one school year. The major expenditure of the district is the salary and benefit costs for staffing. Consequently, a suitable estimate for budgeting depends on the accuracy of the enrollment projections and is vital to the on-going financial well-being of the school district. The accuracy of the proposed budget is based on the level of accuracy of the prior year's projected enrollment estimates.

The base closure of Fort Ord in 1994 removed from the District's coffers vital supplemental Federal dollars that previously had substantially subsidized the thriving District's fiscal operations. In 1999, the unexpected retirement and death of the Deputy Superintendent (DepSup) who had served as the Chief Financial, Enrollment and Business Officer created a void in the level of corporate knowledge for forecasting and budgeting processes. Since the DepSup had worked independently for nearly twenty-seven years, the new learning curve for enrollment management was very steep. As a result, the attempted forecast was much too low enrollment for school year 2000-2001 was significantly under-forecasted. Because of the level of communication between the MPUSD staff and the DepSup, short-term analysis revealed that the management team at MPUSD had an understanding of the term "forecasting" as it pertained to student enrollment different from the mathematical denotation. At MPUSD, the enrollment management process included and was responsible for projections related to student enrollment, staff manning levels and initial budget formulation, but it was simply referred to as enrollment forecasting. As a result, the thesis was expanded to include the reengineering of the enrollment management process that included developmental training, auditing, process controls and new technology implementation.

B. BACKGROUND

Enrollment projections determine both the revenue and staffing patterns of the district. As any projection is based on analyzing historical data and determining trends in that data, the consistent and timely gathering of base data is essential. Selecting a particular month of the school year for comparison purposes is critical to the accuracy of the projection. Enrollment data for a specific month (e.g., the second school month) plus the resulting First Period (P-1, day 71 of 180 days) and Second Period (P-2, day 131 of 180 days) attendance figures are used to project the estimated ADA as a percent of enrollment for the upcoming year (CASBO, 1998). The monthly attendance values are used as indicators for trend analysis.

The enrollment projections need to be made early in the budget planning cycle to allow for staffing flexibility. Preliminary estimates made in December or January are reviewed in April or May and again during the summer to be sure that adequate staffing has been provided and that the estimated ADA for revenue purposes provides an accurate projection of income for the district for the coming year. (CASBO, 1998) MPUSD reviews are in December and April.

Forecasting is the prediction, projection, or estimation of the occurrences of uncertain future events or levels of activity. (Tersine, 1994) The staff responsible for projecting enrollment should take into consideration the following key points relative to forecasting:

- That which has happened in the past should be considered likely to recur
- By searching past occurrences, one may find regularities that can be used to predict the future
- By analyzing variables, the district can discover what relationship these variables will have on the forecast

After the enrollment data has been collected and the historical data has been arranged by such factors as "years," "school month," "grade level," "date of birth" of entering student, and so on, a time series analysis may be used to examine the data.

A time series analysis considers the following components:

- Secular Trend (Long-Term Movement) – refers to the general direction or trend of enrollments over a long period of time
- Seasonal Variation – refers to those patterns that appear at regular intervals in a series, such as a comparison of "School Month Two" to "School Month Ten" of each year. These movements are generally recurring annual events (CASBO, 1998).
- Cyclical Variation – refers to relatively long-term patterns around the trend line. Cycles may or may not follow regular patterns and are described as cycles only if they are repeated (Savage, 1998).

- Irregular or Random Variation – refers to small random movements or large variations in an enrollment pattern due to chance events that will likely not recur, such as strikes, weather conditions, and school closure (these affect the school-by-school historical comparisons.) These events cannot be systematically analyzed; however, they must be accounted for in the future projections, and allowances must be made for possible future recurrence (CASBO, 1998).

C. RESEARCH OBJECTIVE

The objective of this thesis is to provide a low-cost scientific model (mathematical, computational, or programmable) for analyzing and forecasting enrollment projections as they relate to the enrollment management process. This output will then be used to project the student enrollment and the level of personnel staffing for the ensuing school year which completes the forecasting and enrollment process. The user will be able to simply compute the required enrollment figures for each school by grade using the Forecasting and Enrollment Management (FEM) Model program, the newly established FEM database and an existing Commercial Off The Shelf (COTS) software program named FORECAST.XLA that will calculate the next twelve data points in the forecast. This decision support information will support the District's efforts to maintain solvency by implementing technology into their management decision process. In addition, the reengineered enrollment management process will provide the level of accuracy required to maintain fiscal controls and optimal operational efficiency. By using management science techniques, the MPUSD will maximize efficiency with its operations. Though there was no internal budget for this project, this thesis action was formally requested by the School Board appointed Blue Ribbon Commission and funded in part by a local community service organization Alpha Phi Alpha Fraternity of the Monterey Peninsula.

Chapter II contains a literature review of the nature of the problem. In Chapter III, the methodology used to study this problem is discussed. Chapter IV presents the results of this study in detail. Lastly, Chapter V's conclusions include findings and recommendations.

II. LITERATURE REVIEW

A. OVERVIEW

One of the most politically contentious adjustments to the decline in defense spending after the end of the Cold War has been the subject of military base closures. While the decline in military force structure and in weapons procurement has largely been a matter for the Department of Defense to decide, the question of which military bases to close was deemed too sensitive to be left to traditional legislative decision channels (Schmitt, 1993). Instead, the Base Realignment and Adjustment Commission (BRAC) was established in order to shield the process from political influences (Dardia, 1996).

Much of this sensitivity is due to concern for the fate of the communities surrounding the closed bases; such concerns are understandable in light of the fact that in many of these communities the base personnel – both military and civilian – represent a significant share of local employment and population. Even communities with promising alternative uses for the local base seem wary of the immediate effects of the closures, with its loss of civilian jobs and service members' local purchases. While the long-run experience with closed bases seems benign (Office of Economic Adjustment, 1993), little is known about the size or distribution of the more immediate impacts of base closures. If the effects are adverse, they should be most severe immediately after the closure, before there is time for labor markets to adjust and for the compensatory effects of base reuse to come into play. One such community is the one surrounding Fort Ord.

Fort Ord was located in Monterey County, adjacent to Monterey Bay, on California's Central Coast. It was the home of the Army's 7th Infantry Division and was designated as a major training center. It was used extensively during the Vietnam War for training infantrymen. Fort Ord also provided support and administrative services to other military facilities in the region, including Fort Hunter Liggett, the Presidio of Monterey (which houses the Defense Language Institute (DLI)), the Naval Postgraduate School (NPS), and a Coast Guard station.

Fort Ord was slated for base closure in 1991 and eventually closed three years later around September 30, 1994. The military retained part of the base for housing staff and students at the Defense language Institute and the Naval Postgraduate School. About 15 percent of the military and civilian personnel lived off base, primarily in the adjoining cities of Marina, Monterey, Salinas, Seaside, and Pacific Grove (Dardia, 1996).

Fort Ord's presence in Monterey County added another element to what was already one of the most disparate counties in the state, combining the affluent retirement and recreation centers of Carmel and the Monterey peninsula, the increasingly professional population of Monterey, the more blue-collar communities of Seaside and Marina, and the growing agricultural center of Salinas. Since the closure of Fort Ord, the surrounding housing prices have climbed dramatically, especially for the Seaside Community; unemployment is virtually non-existent; and the number of housing units is insufficient to meet current demand. Economic impact studies projected the only actual decline to be found in the K–12th grade student enrollment within the MPUSD (RKG Associates, 1992). K–12th grade student enrollments were projected to decrease by as much as 32% (Dardia, 1996). The actual decrease was 30% in the first year alone. In the

2001 school year, the financial impacts generated by that substantial decrease in enrollment are still evident.

Sections B through H will highlight some major contributing variables to the overall calculations within the forecasting enrollment management process and their ancillary impact on the community and the decision makers at MPUSD.

B. MPUSD

In the Summer of 2000, the MPUSD reported a possible budgeting deficit estimated to be in the millions of dollars. In August of 2000, the *Monterey Herald* newspaper released a three-part series that highlighted the issues that led to the potential financial insolvency position of the MPUSD. The story explained in vivid detail how the solvency issue began and its relationship to the Fort Ord base closure. An estimated funding deficit of an estimated $6.5 million, approximately 10 percent of the total budget, was reported. The problem had its roots years earlier, when the district income shrank by tens of millions of dollars with the closing of Fort Ord, but spending continued relatively unabated (Friedrich, 2000). The shrinking income was due to a lost of Federal Impact Aid (PL 874), a subsidy paid by the federal government to local school districts for the burden of educating the children of military and civil services children. Details on Public Law 874 and Federal Impact Aid will be discussed later in Section C. The deficit forced the district to lay off more than 100 personnel, including more than 70 teachers, and instantly dropped millions of dollars of programs including MAGNET, GATE (Gifted and Talented Education), music and alternative teen parenting. Enrollment and staffing are among the most critical elements in a school district budget. Accurately projecting how many students will enroll in the district is the key to calculating state revenue - the bulk of a district's income. Additionally, keeping unbudgeted employees off the payroll is the key to keeping costs down, because salaries make up about 85 percent of a district's expenses. (Freidrich, 2000) When Fort Ord closed in 1994, 25 percent of the district's revenue went with it in the form of lost ADA and Federal Impact Aid. In addition, the district lost approximately 3,400 students and 322 employees. Four schools on post were closed. To cushion the impact of the drastic decrease in income, the district requested an $11 million loan under a provision of state AB 160, which was a program designed to assist districts suffering because of military base closures. The repayment of the loan coupled with the vastly decreased enrollment and associated loss of ADA and Impact Aid income nearly put the district in an insolvent condition six years after the base closure of Fort Ord.

The program closures that affected the military communities of La Mesa and Old Fort Ord military communities the most were the loss of the GATE and MAGNET programs. The GATE program allowed gifted students, identified through testing and recommended by a teacher, to go beyond the basic curriculum and develop higher-level thinking skills. Without funding for the GATE programs, affected schools have searched for alternatives. One military community school, Fitch Middle School, has developed a program called "Great Explorations" that allows seventh- and eighth-graders of all abilities to learn about county history through poetry, reading, art and drama. But educators are concerned that the substitute program is not challenging enough for the brighter students (Duman, 2000).

The loss of the MAGNET programs at La Mesa and Ord Terrace Elementary Schools left the district with no program that specializes in advanced exposure to math, science, and computers. The MAGNET math, science and technology programs not only broadened diversity at the two schools by bringing in children from other schools, but they also gave students at La Mesa and Ord Terrace Elementary in Seaside a chance to immerse themselves in science and technology (Duman, 2000). The majority of the students in the program were military dependents. Military parents who can afford the additional expense may well engage their bright children with extracurricular activities, or by sending their children to private schools. But those families which cannot afford the extended financial burden will not receive any financial assistance to ensure that their gifted children are challenged. As more military parents shift their children to private or home schooling, the result will be fewer candidates for Federal Impact Aid (PL 874). The result will be a public school system funded at lower levels. This problem places the quality of military children's education at the economic level of the military member. This dilemma may pose an unfair advantage for those members forced to rely on the local public school system while stationed on the Peninsula in the future.

C. FEDERAL IMPACT AID (PL 81-874 & PL 81-815)

Monitoring Federal Impact Aid eligibility and disbursements can give advanced insight into funding shortages within the district. One of the highest priorities for a military family when moving to a new installation is the quality of education that is available to its children. Congress recognized that federal military activities were having an adverse effect on some local school districts' ability to raise revenue by executing federal employees local tax exemption rights. In addition, Congress was concerned that the children of military personnel should have adequate funds for their education. In 1950, Congress passed PL-81-874 (Impact Aid for Operating Expenses) and PL 81-815

(Impact Aid for Construction) in order to assist local schools affected by federal activities. These two laws were designed to make up for the financial losses of having a federal installation nearby may have caused many local schools. Later, other types of federal students were added to the program. These students included Indian Land students, Low Rent Housing students, and students whose parents work on federal property. In 1994, Congress reauthorized these Impact Aid laws as Title VIII of PL 103-382. In doing so, PL 81-874 and PL 81-815 were repealed. Federal Impact Aid was amended again in October 2000.

Federal Impact Aid is one of the only federal education programs where funds are sent directly to the school district, and thus there is almost no bureaucracy or regulatory oversight. As a result, the funds are used for the education of all students, and there is no "rake-off" by states or federal government to fund bureaucrats. In addition, these funds go into the general fund, and may be used as the local school district decides. There are "no strings attached" to the funds, and they may be used for any purpose within the guidelines of state law (NMISA, 2001).

Impact Aid is necessary because of the uncollectible tax revenue or opportunity loss for the area by federal exemptions. A non-federally impacted school has three main sources of revenue for each student. In theory, state aid amounts to about 50% of the total revenue, and local taxes account for the other 50%. The local portion of school revenue is made up of two main parts: (1) taxes on local businesses amount to about 25% of the total, and (2) local property taxes on homes account for the remaining 25%. When businesses are located on federal land, they are exempt from local taxes. In the case of the military, in addition to the services and commercial activities provided on federal property, the Soldiers and Sailors Relief Act exempts those personnel from local personal property taxes and any state income taxes. In theory, the result is that 25% of the school district's revenue is lost when a base closes. In cases where homes are located on federal property, residents are exempted from local taxes. As a result, the school district has lost 25% of its revenue that would otherwise have been collectable. Sometimes, both students' homes and the place of business of their parents are located on federal property. Both are exempt from local taxation. In theory, the school district loses all the local sources of revenue for these children, and only state aid (50% of the normal total revenue) is available (NMISA, 2001). For example, since the closing of Fort Ord, MPUSD has suffered a 90 percent decrease in PL874 funding from 1994 to 2000 amounting to loss revenue of an average $4.7 million dollars per year.

Department of Defense Supplemental Impact Aid Funding, which is different from the Federal Impact Aid, began in FY'91. The funding was established to help school districts with significant concentrations in military students to compensate for (1) a lack of adequate funding for over a decade, (2) challenges associated with base closures, and (3) realignments, deteriorating facilities, and reduced support for Impact Aid. Less than 40% of the Federal Impact Aid program funds go to military children (NMISA, 2001).

The Department of Defense Supplemental Impact Aid Funding is intended to address quality of life, readiness, and retention issues in an all-volunteer service. MPUSD may qualify for Supplemental Impact Aid Funding.

D. BIRTH RATES

One would assume that the rate of births within the MPUSD area of responsibility would be vital to the accurate projection of student enrollment. Birth rates could be used to forecast student enrollment for kindergarten five years later using correlation or regression analysis. Since the closure of Fort Ord, the gradual inflow of new residents, mostly Hispanic, has slowly and only partially replaced some of the void left by the military families (Moore, 2001). In addition, the lagging reutilization process developed and managed by the Fort Ord Reuse Authority (FORA) for the availability of low-income housing that was projected by the economic impact survey before the base closure has not produced a population influx. It was hypothesized that these new families would bring in additional population growth, revenue and jobs. In past MPUSD predictions, projections of any variables using birth rates were made using county-wide birth rates rather than using birth rates for the relevant zip codes (see Appendix F) which are more germane to the MPUSD. Higher accuracy should be obtained by making projections with those numbers. As a result, birth rates for Monterey (93940), Old Fort Ord Community (93941), Naval Postgraduate School (93942&3) and Defense Language Institute (93944), Marina (93933), and Seaside (93955) were analyzed. A high correlation between birth rates and kindergarten start rates or district total second month enrollment would enable a more accurate prediction of future enrollment figures and assist in a more structured budget and staffing projections. Chapter IV will highlight the results of the birth rate analysis.

E. CENSUS 2000

The release of the Census 2000 figures provided some clarity to the question of the population and demographics of the future for the MPUSD. On the Peninsula, Census 2000 results for the MPUSD show that every city, except Sand City, lost population since 1990. Sand City grew by 30.5 percent, but it took just 61 new residents to cause that increase. The decline was sharpest in Seaside and Marina, which suffered huge losses following the closure of Fort Ord in the early 1990s. But, significantly, the census showed that both Seaside and Marina have begun rebounding after their populations bottomed out in the late 1990s (Moore, 2001).

Though Seaside's population was down by 18.5 percent from 1990 and Marina's was down 5 percent, both cities actually grew significantly in the closing years of the decade. With the base closing, both cities also lost significant African-American populations, contributing to an overall 33 percent drop in the peninsula's African-American population (Moore, 2001).

In both cities, however, the Hispanic population increased dramatically. In Seaside, the Hispanic population grew by 75 percent to nearly 11,000 which is more than a third of the total population. In Marina, the number of Hispanics more than doubled, to 5,822 (Moore, 2001).

The City of Monterey's population fluctuated during the 1990s, growing some in the latter part of the decade only to dip again in 2000. Though state estimates put Monterey's population above 30,000 each year of the 1990s, it fell to 29,674 in 2000, according to the first wave of California census numbers (Moore, 2001). The initially released Census figures will presumably undergo several revisions over the next year before being declared official (Moore, 2001) but are assumed valid for analysis purposes in this thesis. The declining population could provide some insight into the rapidly declining enrollment within the MPUSD during the 2000-2001 school year discussed earlier.

F. GOODWILL

Although there was significant publicity associated with the district's solvency issue, the Proposition 38 Draper Voucher Initiative presented on the November 2000 California elections ballot made the MPUSD a target for further scrutiny. The Draper Voucher Initiative proposed providing annual $4,000 vouchers funded by public tax dollars to students currently enrolled in parochial or private schools. In addition, vouchers would have been provided to every public school student who left a public school to attend a private school. The money would have been paid directly to the latter school. The initiative did not receive enough votes to pass into law. The exact quantitative impact of the two issues of financial solvency and Proposition 38 on the district's goodwill is difficult to establish. For MPUSD, no current metric reports indicators of goodwill. Due to the sudden drop in enrollment for the 2000-2001 school year, independent variables to model the decline would be helpful. A proper measure of performance (MOP) for goodwill could form a bridge to assessing fluctuations in future enrollment associated with an economic recession, remodernization, or other developments.

G. WATER

The allocation of fresh and gray water on the Monterey Peninsula has been a growing concern for citizens and city planners alike. For the past three years, most construction requests that require that require an allocation of additional sources of water have been put on hold or denied. According to city planners and city managers of affected MPUSD areas, the lack of the ability to construct adversely affects their ability to attract new residents and collect additional revenue (Kim, 2001).

Over 93 percent of the district's water is derived from a network of water sources collectively known as the Monterey Peninsula Water Resources System (MPWRS), which includes the Carmel River and its tributaries, the Carmel Valley Alluvial Aquifer, and the Seaside Coastal Ground Water basin. The District's Water Allocation Program limits MPWRS production to twenty distinct, 287 acre-feet units per year. During the 1998-1999 reporting year, production totaled 16,537 acre-feet. Production from wells and water distribution systems outside of the MPWRS was approximately 1,225 acre-feet of water (MPWMD, 2000).

In 1999, the greatest factor limiting the water supply was not drought, but the State Water Resources Control Board Order 95-10 that required California-American Water Company (Cal-Am) to cut back its water production from the Carmel River by 20 percent in the near term and up to 75 percent in the long term. The cutbacks were ordered because Cal-Am does not hold a valid right to the water and because the excess pumping was harming the Carmel River environment. At the end of 1999, approximately 42 acre-feet of water remained for new construction and remodel projects within the Cal-Am service area. Most of that water had been set aside by the jurisdictions for projects that are awaiting final planning department approval. Presently, no new water source is available to serve Cal-Am customers within the District (MPWMD, 2000).

All new construction or remodeling projects that include the installation of water fixtures must obtain a water permit from the water authority before construction. The

District maintains a record of the amount of water assigned to new uses and remodels, so that the total remains under the amount of water allocated to the jurisdictions for construction projects. No additional water will be allocated to the jurisdictions for water permits until Cal-Am's water production shortfall identified in State Order 95-10 is satisfied. (MPWMD, 2000) In consideration of the current water and construction moratorium, the population growth of the Peninsula will be constrained by its inability to provide water for some time. As a result, the construction or remodernization of public schools or any major housing structures will be delayed.

Fresh water availability is directly related to the ability of the Peninsula to conduct major construction projects. The value of water as a variable in an enrollment management model comes from the fact that the Peninsula's population growth may be stymied by the lack of water to construct housing. This may explain the sudden decrease in enrollment at the MPUSD.

H. ENROLLMENT MANAGEMENT

Enrollment management is an organizational concept and systematic set of activities whose purpose is to exert influence over student enrollments (Hossler, Bean, and Associates, 1990). Many school districts public and private currently use the term. It is a method of using new tools and creative talents to better manage the district operations. At its best, enrollment management creates a highly interactive team of committed staff and faculty that uses established principles of planning, implementation, evaluation, and revision to ensure the institution's constant and consistent success in meeting its educational commitments to students while remaining accountable to the taxpaying local constituents. Enrollment management is a mature concept, one that now deserves high visibility within MPUSD (Dixon, 1995).

The need to manage student enrollment from the point of initial contact (kindergarten or early kindergarten) through high school graduation has become increasingly important to fiscal budgeting and forecasting projections. The need has taken on more importance as education professionals begin to examine the serious financial problems confronting many publicly funded institutions today (Freidrich, 2000). Enrollment managers must have access to information about federal and state sources of funding, and must understand demographic factors to be able to appropriately assist their superintendents to face the challenges before them.

Numerous surveys and studies over the course of 15 years show the impact of enrollment management systems on public institutions. Declining enrollments are second only to declining appropriations as the reason for public school districts' financial problems. Additionally, enrollment management is one important technique by which to assist public institutions to attain their budgetary and manning goals, and remain financially solvent (Penn, 1999).

Enrollment managers' concentration on data, quality service, cooperation, communication, and collaboration is important to institutional success. Those in the field must have broader formal and informal education. The chief enrollment manager must stay abreast of state and federal legislation, be able to discuss funding allocations, and know how to measure the general public's support for public education. This professional needs background in computers, communications, marketing, research and analysis, personnel management, and fiscal concepts (Noel-Levitz, 1996). The support generated for a comprehensive enrollment management program may be the result of the managers' ability to influence, communicate, persuade, lobby, and bargain with others. If a program is to be successful, the Superintendent and district staff must not only endorse the program verbally, but also make sure it is properly funded. Therefore, the relationship of the chief enrollment manager to the superintendent can be a critical element in a successful enrollment program (Penn, 1999).

Effective enrollment management is the backbone to optimum operational performance of the district. A broad understanding of the depth of this management acumen could benefit the district management team in future decision making ventures. The thesis will use the Forecasting and Enrollment Management (FEM) model and the FORECAST.XLA Excel add-in to provide forecasting and enrollment management services for MPUSD. Both models will be discussed in detail in Chapter III.

I. SUMMARY

There are several extrinsic factors that can have an impact negatively or positively on the district student enrollment. We just took a look at several. Any correlation between these variables could result in a more accurate prediction of enrollment and provide a decreased level of variance. In addition, any achieved accuracy could be used for the continuous improvement of the forecasting enrollment management process. The professional enrollment manager can, by using information technology and a combination of theory and practice, provide staff and principals with information about programs, the quality of student learning, demographics trends for graduates/non-graduates, attrition, and measures of goodwill. By bringing management sciences to the forefront of the process, decision-making can be made optimal as soon as possible. We have discussed some of the external factors that may have an impact on the accuracy of a computational forecast. An understanding and basic level of knowledge is necessary for decision-makers to properly evaluate whether anticipated results match the calculated results from the model. This serves as validation for the enrollment management process.

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III. METHODOLOGY

Data for this study was taken entirely from the attendance archives of the MPUSD. This chapter describes the data and the methods used to analyze the data and to forecast student enrollment and staffing requirements.

A. ENROLLMENT DATABASE

1. Description of the MPUSD Database

The MPUSD Enrollment database consists of two binders of enrollment figures ranging from 1980 to the present. The last seven years appear to be printouts using LOTUS 1-2-3 software. The data includes the number of students present at each of the twenty-three schools by month; some reports are special reports used for budgeting. This quantitative information, once digitized, can be used for analysis purposes.

Because of the reviews within the *Monterey Herald* regarding the financial solvency of the MPUSD, a verification, validation and accreditation (VV&A) procedure was developed for the data. First, we sifted through several boxes of written notes and archives of finished reports to create a working database in matrix form (see Appendix A), interviewed all of the key employees who provided input reports to the previous process and became very familiar with the formal guidelines for attendance accounting. Second, the VV&A consisted of a random sample of 100 of the records on the master matrix which were compared to the archive records within the MPUSD vault. The verification process entailed comparing the sample to the remaining records within the set to verify whether the records was correct. The validation process entailed comparing the sample value with the records provided by the teacher’s hand written homeroom reports.

The accreditation process was conducted annually by an independent auditor who verified the accounting values used by the Business Office for budgeting purposes. There were no negative reports in the reviewed audits from the independent auditor. In the VV&A process, a 100% of the sampled records were valid. The continuing assumption was made that the data was valid and used as recorded throughout the thesis to create other databases and spreadsheets.

School systems within California operate on a 180-day cycle. Their reporting cycles are nearly divided equally into ten, 18 workday sessions called school months. MPUSD followed this type of schedule. Some schools were opened since the closure of Fort Ord and had smaller sample sizes than the established schools. Specifically, Larkin and Del Monte Elementary Schools both opened in 1998. The Forecasting Enrollment Management (FEM) Model (see Appendix B) and its associated output reports (see Appendices D & E) developed in this thesis was designed to handle small sample sizes. Larkin and Del Monte did not have the thirty-six data points required by the FORECAST.XLA forecasting model (see Appendix C). Besides requiring thirty-six data points, FORECAST.XLA provides a forecast of exactly twelve periods. The model assumption is that the data is organized as a twelve-period seasonality index. Since the MPUSD data set is based on a ten-period seasonality index, the data set was adjusted to include periods eleven and twelve. This addition enhanced the accuracy of the forecast and allowed the full use of the model's computational structure.

2. MPUSD Feeder Matrix

The MPUSD assigns students to elementary, middle and high schools through a feeder system shown in Figure 3.1. The feeder system promotes a more effective management process and supports budget forecasting compared to a random enrollment system. For operational reasons and since the closure of Fort Ord, the MPUSD had made several revisions to the feeder system. In particular, the closing and opening of several schools near Fort Ord and the consolidation of enrollments from those adjustments into nearby schools. Each change has an effect on the overall distribution of data when compared to history, and could introduce significant variance into the forecasting model.

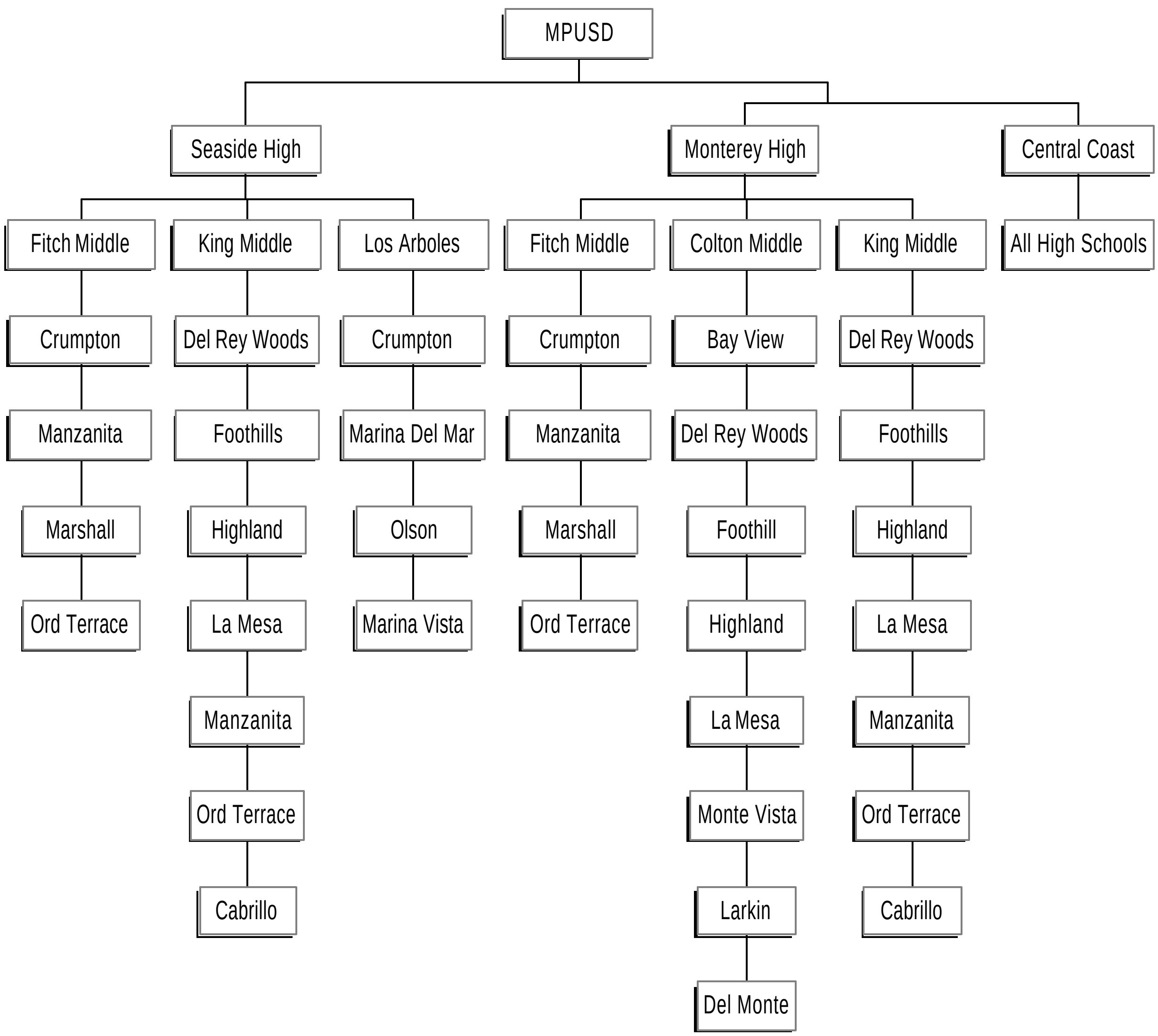


Figure 3.1. MPUSD Enrollment Feeder Matrix.

In addition, future adjustments to the existing feeder matrix will impact the accuracy of any developed forecasting model by introducing additional variance. As a result, forecasting future demand using a time series method will be adversely affected.

3. Data Extraction/Database Formulation

The initial data for analysis was provided by the MPUSD Business Office. A working electronic database was created from the available sources of information. The database was constructed using Microsoft Excel - the existing software package of the district. Selecting an existing software package for model creation reduced cost and optimized training opportunities. The database is a network of twenty-four separate matrixes; one matrix for each of the 23 schools and one master matrix (see Appendix A). The elementary school matrixes are 80 X 7 in size. The master matrix is 80 X 24 in size. The matrixes columns represent the grade or school and the rows represent the school month and year. The data is arranged as a times series to better facilitate the forecasting model. In addition, two output reports are provided (see Appendices D and E) that detail the enrollment projections for each school by grade and its associated staffing level for the forecasted month of choice by a decision maker.

B. ANALYSIS OF DEMOGRAPHIC TRENDS

Demographic trends, when integrated into a mathematical projection method, can help account for variations inherent in a community experiencing one or more changing conditions. Four trends that might be considered are:

- Residential housing trends
- Birth trends
- Historical enrollment trends
- Kindergarten enrollment trends

C. SPECIAL OR UNIQUE SITUATIONS

Special conditions may need to be considered that are unique to individual communities. Some examples are:

- Migrant students (including seasonal workers)
- Foster homes
- Refugees
- Social/economic movement
- Industry closures/layoffs/openings
- Private school attendance
- The aging of a district and its rejuvenation
- Military establishments (including base closures, i.e. BRAC)
- Multi-families (two or more families living in a single dwelling)

D. ANALYSIS PROCEDURE

1. Enrollment Projection Methods

Time series analysis predicts the future from the past. A time series is a set of time-ordered observations on a variable during successive and usually equal time periods. In time series analysis, historical data is analyzed and decomposed to identify the relevant components that influence the variable being forecasted. Time series data may contain up to four interacting components – levels trends, seasonal variations, cyclical variations, and random variations (Tersine, 1994). If the historical components persist in the future, a reliable forecast will be obtained (CASBO, 1998). The below briefly describes several basic projection methods that could have been used for analysis purposes.

2. Grade-Level Progression Cohort Analysis

A grade-level progression for grades kindergarten through eighth grade would project each grade a selected number of years forward (not more than 1-3 years are suggested), and would assume incoming kindergarten at the same level as the current year. This method should be used only if the enrollment environment is stable. Areas with increasing or declining trends should not consider using this method alone for analysis (CASBO, 1999). The MPUSD's enrollment environment is not stable therefore not suitable for cohort analysis.

3. Regression Analysis

Regression analysis establishes a temporal relationship for the forecast variable. The variable to be predicted (number of students enrolled) is referred to as the dependent variable, while the variable(s) used in predicting (past enrollment figures) is called the independent variable(s). If two phenomena are observed to move in the same direction or opposite directions consistently, they are correlated. This does not mean that one causes the movement of the other, but only that they are statistically related. A cause-and-effect relationship is often suspected (CASBO, 1999). The simplest type of relationship is a linear regression. The regression line encompasses the trend effect, but not the seasonal effect.

4. Exponential Weighted Moving Average (EWMA)

The exponentially weighted moving average, also referred to as exponential smoothing, is a special type of moving average that does not require keeping long historical records. Like most forecasting techniques, the EWMA uses historical data as its prediction basis. The simple moving average gives equal weight to each piece of demand history considered and gives zero weight to those observations farther than "*n*" units into the forecast. The weights given to past data are not equal, but decrease geometrically with increasing age of the data. Exponential smoothing "smoothes out" variations in a times series by not giving a proper weighting to the last observation (Tersine, 1994). The prediction in period "*j*" is then a simple weighted combination of the preceding observation and the prior error:

$$pred_j = \alpha\, obs_{j-1} + (1 - \alpha)\, pred_{j-1}, \tag{3.1}$$

$pred_j$ is the prediction in period j, where obs_{j-1} and $pred_{j-1}$ are the respective observation and prediction in the preceding period j-1, and $0<\alpha<1$ is the smoothing constant. More recent data are weighted more heavily than less recent ones depending on the assigned value of alpha (α). Alpha (α) is a smoothing constant that satisfies $0 < \alpha < 1$. The major advantage of the EWMA is that the effect of all previous data is included in the previous forecast figure, so only one number needs to be retained to represent the demand history.

5. Time Series Analysis

Time series analysis predicts future values of an uncertain quantity based on past values of the same quantity. Regardless of the technique used, forecasts are generally not exact. It is important, therefore, not to ignore the estimates of errors also produced by most types of forecasts. For the distribution displayed by the data for the MPUSD total student enrollment, the Winter's method for seasonality was appropriate because the series contained tend, level and seasonality. The Winter's method is used to forecast time series when seasonality and possibly trend are present. In fact, in cases when the value of α (same value used in EWMA) that minimizes the Mean Average Deviation (MAD) exceeds 0.5, then trend, seasonality, or cyclical variation is probably present. As a result, Winter's Method of exponential smoothing with trend and seasonality is the better forecasting method than simple EWMA. To give the reader an idea of how Winter's method works, a fictitious data set was created. In this example shown in Figure 3.2, Alpha Technical Services (ATS) provides computer trouble call services on a monthly basis. The times series graph exhibits an upward trend and seasonality.

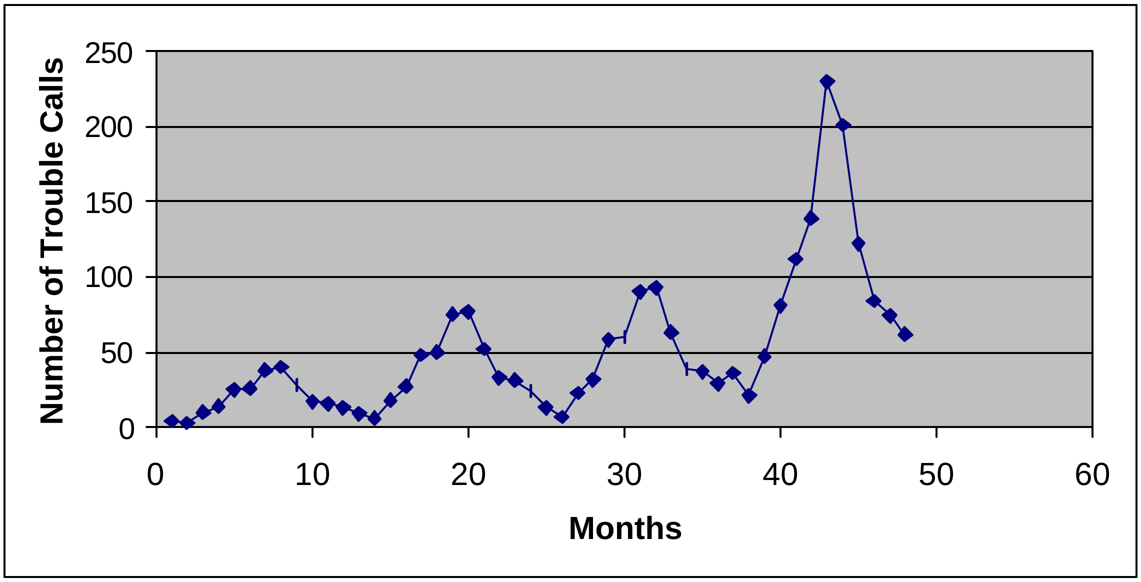


Figure 3.2. Time Series Graph of Trouble Calls.

Therefore, Winter's method was a logical candidate for forecasting these trouble call service requirements. Table 3.1 shows the monthly numbers of trouble calls serviced by ATS from 1997 to 2000.

	1997	**1998**	**1999**	**2000**
	4	9	13	36
	3	6	7	21
	10	18	23	47
	14	27	32	81
	25	48	58	112
	26	50	60	139
	38	75	90	230
	40	77	93	201
	28	52	63	122
	17	33	39	84
	16	31	37	74
	13	24	29	62
Average	19.5	37.5	45.33333	100.75
Sum	234	450	544	1209

Table 3.1. Number of Trouble Calls for Alpha Technical Services (ATS).

Time series methods for analyzing data in this thesis will use the following models: the FEM model and the FORECAST.XLA add-in. Since the objective of the thesis was to provide a low-cost, computational model using existing or inexpensive COTS software, the two different models represent different alternatives for the MPUSD. The FEM model was developed specifically to forecast enrollment for the two elementary schools (Cabrillo and Del Monte) that were opened in 1998. In those cases, the requisite 36 minimum data points requirement for FORECAST.XLA was not achieved. FEM accomplished that requirement. The FORECAST.XLA Excel add-in was designed for times series forecasting but is limited to forecasting twelve periods not the future. Figure 3.3 compares the advantages and disadvantages of the two models.

	Advantages	**Disadvantages**
Forecasting Enrollment Management (FEM) Model	▪ no cost ▪ forecast data with < 36 inputs ▪ calculates/optimizes MAD and MSE ▪ provides graphical display ▪ provides unlimited forecast	▪ requires prior knowledge of formulas ▪ not robust ▪ not totally user friendly
FORECAST.XLA	▪ low cost: $75 range PC only ▪ include with Excel site license ▪ forecast large data set ▪ calculates/optimizes MSE ▪ generates seasonality factors ▪ provides graphical display ▪ provides 12 forecasts ▪ user-friendly	▪ large data sets only (>36) ▪ process one data set at a time ▪ provide exactly 12 forecasts

Figure 3.3. Advantages and Disadvantages of the Forecast Models.

a. Using Forecasting Enrollment Management (FEM) Model

Instructions on using the FEM model shown on the spreadsheet in figure 3.4 are contained in Appendix B, using the ATS troublecall service data from Table 3.1 as the input.

		Alpha Technical Services Monthly Troublecall Data Using FEM Model								
School Year	**Periods**	**Trouble Calls**	**Smoothed Level (Li)**	**Smoothed Trend (Ti)**	**Smoothed Seasonal Factors (Si)**	**Forecast**	**Error**	**AbsError**		
1998-01	1	9			0.294694935				**Alpha**	0.432629
1998-02	2	6			0.174282830				**Beta**	0.000546
1998-03	3	18			0.484618061				**Gamma**	0
1998-04	4	27			0.743284192				**MAD**	5.558866
1998-05	5	48			1.223691432				**MSE**	71.11448
1998-06	6	50			1.345505117					
1998-07	7	75			2.089390843					
1998-08	8	77			2.033280381					
1998-09	9	52			1.329096888					
1998-10	10	33			0.858013672					
1998-11	11	31			0.792444817					
1998-12	12	24	37.99290856	0	0.631696833					
1999-01	13	13	40.64081743	0.001445874	0.294694935	**11.19632**	1.803682	1.803682		
1999-02	14	7	40.43561193	0.001333033	0.17428283	**7.083249**	-0.083249	0.083249		
1999-03	15	23	43.47534647	0.002992132	0.484618061	**19.59647**	3.403526	3.403526		
1999-04	16	32	43.29396721	0.002891458	0.743284192	**32.31676**	-0.316762	0.316762		
1999-05	17	58	45.07094536	0.003860186	1.223691432	**52.98199**	5.018005	5.018005		
1999-06	18	60	44.86632721	0.003746348	1.345505117	**60.64838**	-0.648382	0.648382		
1999-07	19	90	44.09336689	0.003322232	2.089390843	**93.75112**	-3.751121	3.751121		
1999-08	20	93	44.80715553	0.003710178	2.033280381	**89.66093**	3.339067	3.339067		
1999-09	21	63	45.93126324	0.004321964	1.329096888	**59.55798**	3.442018	3.442018		
1999-10	22	39	45.72716009	0.004208155	0.858013672	**39.41336**	-0.41336	0.41336		
1999-11	23	37	46.14651044	0.00443484	0.792444817	**36.23959**	0.760414	0.760414		
1999-12	24	29	46.04588243	0.004377471	0.631696833	**29.15341**	-0.153406	0.153406		
2000-01	25	36	78.97764156	0.022357255	0.294694935	**13.57078**	22.42922	22.42922		
2000-02	26	21	96.95142105	0.032159514	0.17428283	**13.76834**	7.231657	7.231657		
2000-03	27	47	96.98358528	0.032159516	0.484618061	**46.99999**	5.27E-06	5.27E-06		
2000-04	28	81	102.1900181	0.034984895	0.743284192	**72.11027**	8.889731	8.889731		
2000-05	29	112	97.5964514	0.032457504	1.223691432	**125.0919**	-13.09186	13.09186		
2000-06	30	139	100.0853848	0.033798847	1.345505117	**131.3602**	7.639804	7.639804		
2000-07	31	**230**	104.4284922	0.036151917	2.089390843	**209.1881**	20.81189	20.81189		
2000-08	32	**201**	102.0377636	0.034826735	2.033280381	**212.4059**	-11.40591	11.40591		
2000-09	33	**122**	97.62475822	0.032398025	1.329096888	**135.6644**	-13.66436	13.66436		
2000-10	34	**84**	97.76245021	0.03245552	0.858013672	**83.79118**	0.208825	0.208825		
2000-11	35	**74**	95.88570983	0.031413016	0.792444817	**77.49707**	-3.497066	3.497066		
2000-12	36	**62**	96.88241526	0.031940107	0.631696833	**60.59054**	1.409457	1.409457		
Forecast 1	37					**29.50462**				
Forecast 2	38					**17.45495**				
Forecast 3	39					**48.55232**				
Forecast 4	40					**74.49237**				
Forecast 5	41					**122.6804**				
Forecast 6	42					**134.9383**				
Forecast 7	43					**209.6118**				
Forecast 8	44					**204.0514**				
Forecast 9	45					**133.4275**				

Figure 3.4. Forecasting Enrollment Management (FEM) Model.

The time series must be in one numeric column. The time series may not include any missing values. If there are missing values, provide estimates of the missing values must be provided.

- With seasonal data, estimate the missing values as the fitted values using a logical estimation procedure
- With non-seasonal data, estimate the missing values by the fitted values using a moving average procedure (Ragsdale, 1998)

To describe Winter's method, we require two quantities. First, we need c, the number of periods in the length of the seasonal pattern (c=4 for quarterly data, c=12 for monthly data and c=52 for weekly data). Second, for each period t, we need s_t, an estimate of the seasonal factor for period t, obtained after observing y_t. To illustrate the seasonal factor, suppose that month 7 is July and s_7=2. Then July's number of trouble calls tends to be twice as large as the number of trouble calls during an average month (all other things being equal). Similarly, if period 12 is December and s_{12}=0.4, then December's number of trouble calls tend to be 40% as large as the number of calls during an average month.

An important concept with seasonal data is deseasonalizing, that is, removing the seasonality. Again, assume that the seasonal factor for July is s_7=2 and the seasonal factor for December is s_{12}=0.4. Also, assume the observations in months 7 and 12 are y_7=200 and y_{12}=45. Then we find the deseasonalized values by dividing the observations by their seasonal factors. The deseasonalized value for July is y_7/s_7=200/2=100, whereas the deseasonalized value for December is y_{12}/s_{12}=45/0.4=112.5. This makes intuitive sense. July observations tend to be twice as large as "typical" observations, so to put them on the same scale as typical observations, we divide them by 2. Similarly, we divide December observations by a number less than 1 to make them as large as typical observations.

At each period, L_t, T_t (defined in equations 3.2 and 3.3) and s_t are updated (in that order) by using Equations 3.2-3.4.

$$L_t = \frac{\alpha\, y_t}{s_{t-c}} + (1-\alpha)(L_{t-1} + T_{t-1}) \tag{3.2}$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)\, T_{t-1} \tag{3.3}$$

$$s_t = \gamma \frac{y_t}{L_t} + (1-\gamma)s_{t-c}, \tag{3.4}$$

where α (alpha), β (beta) and gamma (γ) are three smoothing constants each of which is between 0 and 1.

Equation 3.2 updates the estimate of the series level by taking a weighted average of the following two quantities (Ragsdale, 1998):

- y_t, the current observation
- $L_{t-1} + T_{t-1}$, an estimate of the period *t* level based on previous data. Similarly, T_t is a weighted average of the following two quantities:
  - $L_t - L_{t-1}$, the change in the level from period *t*-1 to period *t*
  - T_{t-1}, the previous estimate of the trend
- y_t/s_{t-c}, the current observation after deseasonalizing by the most recent seasonal factor for that month (the one from a year ago)

Equation 3.3 is used to update trend in the method. Equation 3.4 updates the estimate of month *t*'s seasonal factor by taking a weighted average of the following two quantities (Ragsdale, 1998):

- s_{t-c}, the most recent estimate of the month's *t*'s seasonal factor

- y_t / L_t, an estimate of month's t's seasonal factor, obtained from the current month's observation. L_t is essentially a deseasonalized value. Therefore, dividing y_t by L_t yields an estimate of a seasonal factor.

The forecast F_t of y_t made in period t–1 is

$$F_t = (L_{t-1} + T_{t-1})\, s_{t-c} \qquad (3.5)$$

That is, to forecast the value of y_t, we multiply the estimate of the month t level, $L_{t-1} + T_{t-1}$, by the most recent estimate of the month t's seasonal factor from May 1996 since no new seasonal factor for May 1997 is available in April 1997, when the forecast is being made (Winston, 1997).

b. Using Insight XLA EXCEL Add-in Package

As with the FEM model, the time series must be in one numeric column. The time series may not include any missing values. If there are missing values, estimates of the missing values must be provided.

- With seasonal data, estimate the missing values as the fitted values using a logical estimation procedure
- With non-seasonal data, estimate the missing values as the fitted values using a moving average procedure (Ragsdale, 1998)

The proper operations of the Menu and Dialog box are contained in Figure 3.5.

- Run Forecast: Opens the forecasting dialog box.
- Save Results: Saves a current forecast's results as a workbook named by the user.
- Live Simulation: Creates a live simulation of the forecast's first period to be used with SIM.xla.
- Close: Closes FORECAST.xla and removes the Forecast menu.

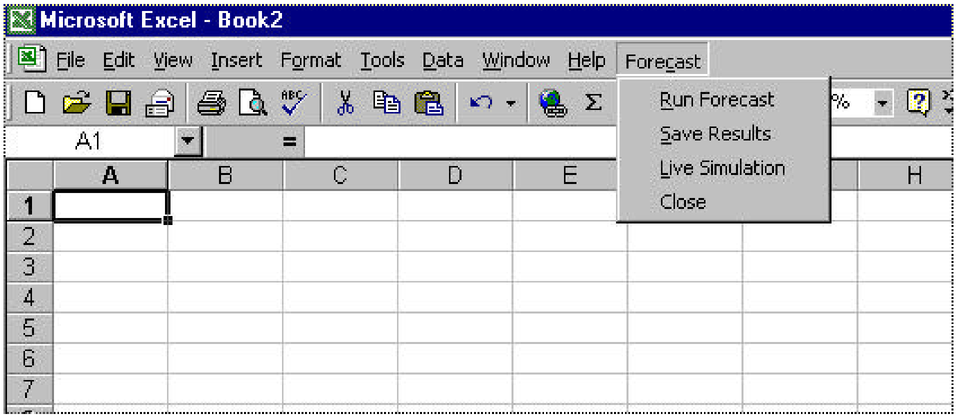


Figure 3.5. FORECAST.xla Menu and Dialog Box.

The graphical user interface (GUI) to show the options to run a forecast are contained in Figure 3.6.

- Data: Range containing time series.
- Untrended: Specify One Parameter Smoothing for series without a trend.
- Trended: Specify Two Parameter Smoothing for series with trend.
- Seasonal: Specify data displaying a 12-month seasonality.

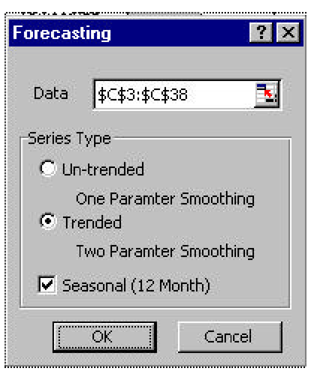
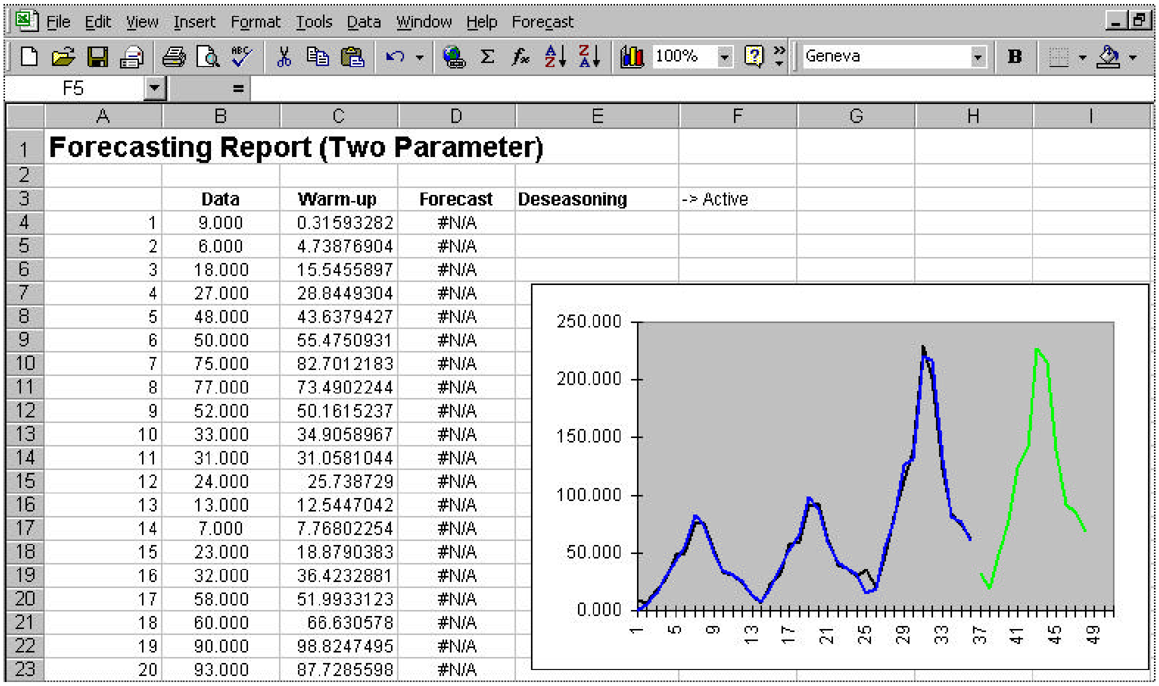


Figure 3.6. RUN FORECAST Dialog Box.

One-parameter exponential smoothing does not accurately track time series with a trend. For time series with either a constant or slowly varying trend, two-parameter exponential smoothing is appropriate (Savage, 1998).

The resulting worksheets of a two-parameter smoothing model are contained in Figure 3.7. Columns B, C, and D contain the original data, the fitted "warm-up" series, and the future forecast respectively. The term "warm-up" will be explained later in this section. Notice that the forecast column does not have meaning until the first period into the future. For the current example, this is month 37, which is found in row D40 of Figure 3.8.

The FORECAST.XLA model considers errors generated by times series modeling. The control period in forecasting is the past. By using early periods of the past data to predict later periods of the past data, an estimate of the method's accuracy is obtained. A period called the forecast period is set aside at the end of the historical data as a surrogate for the future. The remaining period is known as the warm-up period as shown in Figure 3.7. The parameters alpha and beta are set to values that provide reasonable forecasts for most trended time series. The mean square error (MSE) displayed in Figure 3.7 is the square root of the average of the squared differences between the actual data and the fitted series. For any particular series, the mean square error can generally be reduced further by adjusting α and β (Salvage, 1998).



	A	B	C	D	E	F
1	**Forecasting Report (Two Parameter)**					
2						
3		**Data**	**Warm-up**	**Forecast**	**Deseasoning**	-> Active
4	1	9.000	0.31593282	#N/A		
5	2	6.000	4.73876904	#N/A		
6	3	18.000	15.5455897	#N/A		
7	4	27.000	28.8449304	#N/A		
8	5	48.000	43.6379427	#N/A		
9	6	50.000	55.4750931	#N/A		
10	7	75.000	82.7012183	#N/A		
11	8	77.000	73.4902244	#N/A		
12	9	52.000	50.1615237	#N/A		
13	10	33.000	34.9058967	#N/A		
14	11	31.000	31.0581044	#N/A		
15	12	24.000	25.738729	#N/A		
16	13	13.000	12.5447042	#N/A		
17	14	7.000	7.76802254	#N/A		
18	15	23.000	18.8790383	#N/A		
19	16	32.000	36.4232881	#N/A		
20	17	58.000	51.9933123	#N/A		
21	18	60.000	66.630578	#N/A		
22	19	90.000	98.8247495	#N/A		
23	20	93.000	87.7285598	#N/A		

Use Deseasoned Data
TRUE

	Warm-up	Forecast	Total Data
Data Points	48	0	48
Data Range	B4:B51		
Error Ranges	G4:G51	G52:G51	
MSE	130.240	#N/A	
Slope	2.012		
Y-Intercept	1.470		

Alpha	Beta
0.7728154	0

Figure 3.7. Forecast Graph Using Two-Parameter Smoothing.

The month number, original series, "fitted" data, and the forecast appear in columns A through D of Figure 3.8 of the results sheet where applicable. (#NA denotes not applicable)

	A	B	C	D
33	30	139.000	131.628421	#N/A
34	31	230.000	220.994419	#N/A
35	32	201.000	216.846065	#N/A
36	33	122.000	131.128855	#N/A
37	34	84.000	82.0061238	#N/A
38	35	74.000	76.9775142	#N/A
39	36	62.000	60.898136	#N/A
40	37	#N/A	#N/A	31.5066486
41	38	#N/A	#N/A	18.6546167
42	39	#N/A	#N/A	48.7618836
43	40	#N/A	#N/A	78.3383204

Figure 3.8. Numbers Dialog Box.

The Deseason sheet displayed in Figure 3.9 contains the seasonality factors as well as a copy of the original and deseasonalized data. The seasonality factors can be interpreted as a percentage of an average month. The calculation of these factors were previously discussed.

	A	B	D	E	F	G
1	**Deseason**					
2						
3		Original Data	Deseasoned Data	Seasonality Factors		
4	1	9	28.48706897		0.31593282	
5	2	6	32.39705882		0.185202	
6	3	18	37.55113636		0.47934635	
7	4	27	35.40535714		0.76259646	
8	5	48	40.42201835		1.18747163	
9	6	50	36.86412316		1.35633227	
10	7	75	34.85759494		2.15161144	
11	8	77	38.10220126		2.02088062	
12	9	52	40.27988748		1.29096686	
13	10	33	38.8349359		0.84975034	
14	11	31	40.07805164		0.77349069	
15	12	24	38.31304348		0.62641852	
16	13	13	41.14798851			
17	14	7	37.79656863			

Figure 3.9. Deseason Dialog Box.

The deseasonalized data in Figure 3.9 is found by dividing each month of the historical data by the corresponding seasonality factor. The Excel Chart Wizard can graph the original and deseasonalized data side-by-side, allowing the extent to which seasonality has been removed to be observed.

The smoothing sheet contains the formulas that calculate the non-seasonal part of the forecast. These are discussed in more detail later. Figure 3.10 displays the Warm-up and Forecast data points as viewed in the program.

I	J	K	L
	Use Deasoned Data		
		TRUE	
	Warm-up	**Forecast**	**Total Data**
Data Points	36	0	36
Data Range	B4:B39		
Error Ranges	G4:G39	G40:G39	
MSE	171.198	#N/A	
Slope	1.000		
Y-Intercept	1.000		
	Alpha	**Beta**	
	0.85811368	0	

Figure 3.10. Optimized Smoothing Data.

The warm-up data is used to calculate the forecast. It defaults to the entire data set; the requested forecast is assumed to be for twelve months into the future. The forecast data is set aside at the end of the historical data as a surrogate for the future.

As an example, type “12” into **Forecast** on column K of the smoothing sheet. **Warm-up** in column J will now equal 24. This means that the forecast is now based only on the first 24 months of the data. The forecast graph is shown in the Figure

3.11. It clearly displays the trend, level and seasonal patterns that make Winter's method applicable.

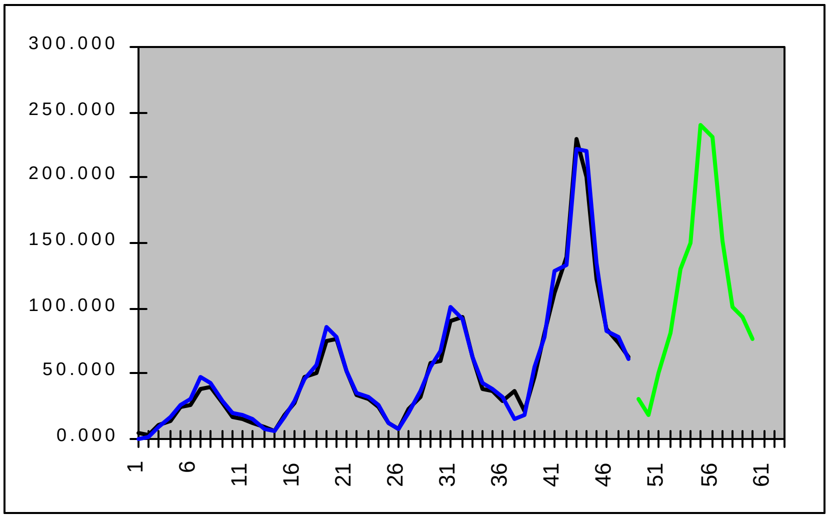


Figure 3.11. Optimized Forecast Graph.

In two-parameter exponential smoothing, which is the basis of FORECAST.XLA, a second parameter is added to smooth random fluctuations in the trend of a series. The two parameters are referred to as α (alpha) and β (beta). The approach used in FORECAST.XLA is modeled by the Winter's method for Time Series distributions.

The two-parameter smoothing routine in FORECAST.xla makes its initial estimate of the trend by performing linear regression on the data, and then the smoothing adapts the trend to fluctuations in the data. As with one-parameter smoothing, the data is divided into warm-up and forecast periods.

Linear regression is performed on the warm-up period with the resulting Y-intercept and slope used as the initial level and trend; α and β can be adjusted to minimize the MSE over the designated period using the Excel solver. The model is much more sensitive to changes in β than it is to changes in α because β has a significant effect on slope. Default values for α and β are 0.1 and 0.01 respectively. (Savage, 1998)

The forecast for period *t* in a one-parameter exponential smoothing is

$$F_t = F_{t-1} + \alpha E_{t-1}, \tag{3.6}$$

where

$$E_{t-1} = Y_{t-1} - F_{t-1}. \tag{3.7}$$

Equation 3.7 is the error of the forecast at time *t*–1.

Two-parameter exponential smoothing models F_t as the sum of two parts, a level S_t, and a trend T_t. This is based on the following equations:

$$F_t = S_{t-1} + T_{t-1}, \tag{3.8}$$

where

$$S_t = F_t + \alpha \mathrm{E}_t, \tag{3.9}$$

$$T_t = T_{t-1} + \beta \mathrm{E}_t, \tag{3.10}$$

$$E_{t-1} = Y_{t-1} - F_{t-1}, \tag{3.11}$$

and where α and β are smoothing parameters between 0 and 1.

To get the model started, linear regression is performed on the sample, whereupon S_0 and T_0 are set to the Y-intercept and slope of the regression line respectively. With *n* data points, the forecast for period *n* + 1 is

$$F_{n+1} = S_n + \mathrm{T}n \tag{3.12}$$

Because Y_t is assumed to have either a constant or slowly changing trend, we would expect the series to increase by the trend amount for each time period. Hence, for all future periods the formula for the forecast is

$$F_t = F_{t-1} + T_n, \quad t > n+1. \qquad (3.13)$$

Note: Both a level and a derivative are being forecast, so the forecast should not be relied upon many periods into the future. If α and β are both set to 0, then for each t, $S_t = F_t$ and $T_t = T_0$. In this case, this model reduces to a linear regression of Y against t.

When a time series displays repeating seasonal fluctuations, the data should be deseasonalized or seasonally adjusted before other forecasting techniques are applied. A forecast based on the deseasonalized data can then be made using exponential smoothing. Finally, this forecast is reseasonalized to get the desired result.

Deseasonalization is generally not performed unless there are at least three full seasons of data (i.e., 36 data points). FORECAST.xla assumes that one full season is 12 months. MPUSD has a season of 10 that was modified by the addition of two points linearly interpolating between the 10^{th} month and the following 1^{st} month. Deseasonalizing and reseasonalizing are accomplished as follows:

- Calculate seasonality factors s_j where j = 1, 2, …, 12 for each month, indicating that month's percentage of the average monthly total for the series, a follows:

$$s_j = (12/N) \sum_{i=1}^{N} Y_{ij} \,/A_i \,, j = 1,2,\ldots 12 \qquad (3.14)$$

where N is the number of complete years worth of data, Y_{ij} is the value of the time series Y_t in month j of year i, and A_i is the annual total of the series in year i. Note: A perfectly average month will have a seasonality factor of 1.0.

- Calculate the deseasonalized data by dividing the data in each month by its corresponding seasonality factor. Use the following:

$$D_{ij} = \frac{Y_{ij}}{s_j}, \quad i = 1, 2, \ldots, N, \; j = 1, 2, \ldots, 12. \tag{3.15}$$

Notice that if some month j of the time series data consistently had very small or zero values, then the s_j would be very small or zero and lead to instabilities in this equation.

- A 12-month forecast, f_j is made of the D_{ij}'s, using one- or two-parameter exponential smoothing.
- Find the final forecast F_j by multiplying each month of the future forecast by its corresponding seasonality factor, as specified in the following equation:

$$F_j = S_j f_j, \; j = 1, 2, \ldots, 12. \tag{3.16}$$

E. CONVERTING ENROLLMENT TO ADA

The resulting output from either model will be used to convert enrollment projection to Average Daily Attendance (ADA) figures for budgeting purposes. The accuracy of a district's enrollment projection relates directly to its ability to accurately project its major source of revenue, the total calculated ADA Revenue Limit. Each student enrolled develops a unit of ADA that is the accumulated number of days the student was in actual attendance or excused for defined reasons.

Each district should compare a selected statistical month or series of months for the Period-1 and Period-2 ADA derived from those numbers of students attending. Generally, kindergarten through eighth grade can expect a higher percentage relationship between enrollment and ADA (usually in excess of 97-98%) than can high school districts (mid-90's). Each school district is unique, however, and should be analyzed on a grade-by-grade, school-by-school basis.

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IV. RESULTS

A. DESCRIPTIVE STATISTICS

1. Summary Enrollment Statistics

This thesis may help the MPUSD with recurring budget issues relating to enrollment forecasting since the closure of Fort Ord and the loss of the corporate knowledge base for enrollment management. The anticipated student enrollment is the most significant revenue source for the district and establishes the monetary limits for expenditure budgets and the costs of personnel. As a result, an accurate approximation of enrollment is critical to the success of the district's efforts to provide a high quality and challenging education to its students and to maintain funding for enhanced education programs (e.g., GATE, MAGNET). A well-developed model provides an overall fiscal management tool that may assist in proper budgeting and forecasting from year to year. Appendix E and F contain the decision support output from the model.

MPUSD operates on a 180 school-day schedule. That schedule is divided into ten equal periods for planning and budgeting purposes. To improve the accuracy of the forecasting models, the data sets were recorded in twelve-period increments rather than ten-period increments. This adjustment was necessary to maximize the efficiency of the FORECAST.XLA forecast model which was coded for a twelve-period seasonality index.

The model used data from 1994, the year that Fort Ord was closed, to the year 2000 to forecast district-wide student enrollment for the 2000-2001 school year. The series was consistent with the characteristics of a Time Series model. The student enrollment errors recorded in Table 4.1 were as follows:

Period	Actual	Forecasted	% Error	# Students	ABS # Students
2001-01	12106	12106.4152	-0.000034	-0.42	0.42
2001-02	12090	12089.9989	0.000000	0.00	0.00
2001-03	12001	12000.2554	0.000062	0.74	0.74
2001-04	11919	11914.810	0.000352	4.19	4.19
2001-05	11859	11861.1342	-0.000180	-2.13	2.13
2001-06	11825	11826.0255	-0.000087	-1.03	1.03
2001-07	11758	11768.7097	-0.000911	-10.71	10.71
		Ave % Error	-0.000114		
				Ave Student Error	2.75

Table 4.1. Forecast Model Output Enrollment Errors.

The model's output resulted in a seven-month cumulative average forecast error of 2.75 students. Approximated at 3 students out of a population of 12,000, the error was negligible. In addition, the distribution of the data was conducive for a Multiplicative Times Series distribution that made the Winter's Method an ideal model. A graphical display of the data reveals level, trend and seasonality components. Winters' Method smoothes data by exponential smoothing and provides short- to medium-range forecasting. This procedure can be used when both trend and seasonality are present, with the two components being either additive or multiplicative. Winters' Method calculates dynamic estimates for three components: level (α), trend (β) and seasonality (γ). This level of accuracy could be helpful in the budgeting and staffing process.

2. Statistical Analysis

An analysis of Figure 4.1 shows that the overall differences in projected enrollment within the MPUSD since school year 1992-1993. The (–) minus and (+) plus conventions assigned to the percent variance is consistent with the system as reported at the District Headquarters.

MPUSD Enrollment Projections Vs. Actual 1992 - 2001										
Second School Month										
	1992 - 1993	1993 - 1994	1994 - 1995	1995 - 1996	1996 - 1997	1997 - 1998	1998 - 1999	1999 - 2000	2000 - 2001	
Projection	14545	10496	11105	11018	11299	11531	11988	12363	12081	
Actual	14303	11689	11048	11046	11366	11693	12083	12103	11919	
Difference	-242	1193	-57	28	67	162	95	-260	-162	824
% Variance	-1.69%	10.21%	-0.52%	0.25%	0.59%	1.39%	0.79%	-2.15%	-1.36%	7.51%
Revenue Limit per ADA	$ 3,319.88	$ 3,348.35	$ 3,458.35	$ 3,554.35	$ 3,748.18	$ 3,904.17	$ 4,227.58	$ 4,287.58	unavailable	
Estimated Cost/Lost	$ (803,410.96)	$ 3,994,581.55	$ (197,125.95)	$ 99,521.80	$ 251,128.06	$ 632,475.54	$ 401,620.10	$ (1,114,770.80)		
										Grand Total
										$ 3,264,019.34

Legend	minus (-)	over forecasted	underbudgeted
	plus (+)	underforecasted	overbudgeted

Figure 4.1. MPUSD Enrollment Percentages.

In the case when a (–) difference is assigned, the projected forecast is greater than the actual enrollment. This corresponds to an over-budgeted scenario. In the case when a (+) difference is assigned, the projected forecast is less than the actual enrollment. This corresponds to an under-budgeted scenario. In either case the outcome is somewhat unfavorable to the overall fiscal operation of the school district. During the closure of Fort Ord (second month school year 1993-1994), the district enrollment was under-estimated by 1193 students; that corresponded to a 10.21% error. This was the largest error of that decade and amounted to an estimated under-budgeting of $3.9 million for that academic year. Prior to the beginning of the school year, several meetings were conducted between the Fort Ord Reuse Authority, the MPUSD and Fort Ord military transfer personnel. Unfortunately, the transfer of military families did not occur at the pre-designated time and sequence as scheduled and therefore placed the fiscal burden on the school district to provide temporary (one- to five-month) services to the remaining families. MPUSD was not prepared for this surge in student population and as a result additional staffing was necessary to accommodate the delay in transfers. MPUSD was not financially compensated by the federal government for the temporary surge in staffing to accommodate the remaining students.

As a result of the base closure, the revenue previously generated by the Federal Impact Aid was reduced significantly from a high of $8.3 million during the 1991-1992 school year to a greatly reduced $774,137 during school year 1999-2000 as shown in Figure 4.2.

School Year	8110 (Maint & Ops) PL874	ADA	8331 GATE	Revenue Limit/ADA
1990-1991	$ 7,792,410.00	13,276.00	$ 93,723.00	$3,048.88
1991-1992	$ 8,316,896.00	13,282.00	$101,633.00	$3,194.88
1992-1993	$ 8,112,999.00	13,282.00	$100,006.00	$3,319.88
1993-1994	$ 8,029,604.00	13,254.00	$ 96,304.00	$3,348.35
1994-1995	$ 6,467,859.00	13,250.00	$ 76,587.00	$3,458.35
1996-1996	$ 5,874,558.00	12,835.00	$ 75,842.00	$3,554.35
1996-1997	$ 1,705,302.00	12,841.00	$ 86,200.00	$3,748.18
1997-1998	$ 131,340.00	12,306.00	$103,952.00	$3,904.17
1998-1999	$ 683,064.00	13,577.00	$111,834.00	$4,227.58
1999-2000	$ 774,137.00	12,230.00	$109,517.00	$4,287.58
Average	**$ 4,788,816.90**	**13013.3**	**$ 95,559.80**	**$3,609.22**

Figure 4.2. MPUSD Audited Budget Section Values, Section J-201R.

This decrease in funding represented the vast decrease in federally connected students attending public school within the MPUSD. In addition, it highlighted the need for the necessary budget cuts of programs such as GATE, MAGNET and music throughout the district. Since the federal funds were not intended solely for use by the schools that serviced federally connected students, the reduced funding impacted all district schools. Since La Mesa Elementary, located within the La Mesa Military

Housing Community, lost both the GATE and the district's only MAGNET programs, the impact of budget cuts appeared to affect its educational program base more than schools without those enhanced programs.

One would assume that the number of births, as shown in Figure 4.3, in a community would be a good indicator of the number of children starting kindergarten 5 years later.

Year	School-Year	Total Births	Kindergarten Enrollment	District-wide Enrollment
1988	1988-1989		1673	13644
1989	1989-1990	**2301**	1669	14034
1990	1990-1991	**2409**	1534	14427
1991	1991-1992	**2493**	1654	14719
1992	1992-1993	**2477**	1569	14518
1993	1993-1994	**2025**	1209	11914
1994	1994-1995	**1515**	1104	11299
1995	1995-1996	**1453**	1118	11244
1996	1996-1997	**1226**	1157	11572
1997	1997-1998	**1382**	1204	11901
1998	1998-1999	**1400**	1219	12276
1999	1999-2000	**1334**	1147	12290
2000	2000-2001	**1380**	1140	12090
Total		21395	15724	152284
Average		1783	1310	12690

Figure 4.3. MPUSD Birth (MCHD, 2001).

In the case of the MPUSD, birth rates did not highly correlate with the kindergarten enrollment historical data nor did it correlate with the District-wide enrollment. Data for actual births were obtained for the Monterey County Health Department (MCHD) in Salinas, California by zip code to provide an accurate measure for the MPUSD area of responsibility. Appendix F is a table of that actuarial information. The health department maintained data only from 1988 and beyond in calendar year order. A student will typically enroll in kindergarten at age 5. Therefore, the 1989 births were manually adjusted five years forward and compared to the 1994 kindergarten enrollment. The remaining years were adjusted accordingly. The Pearson Correlation and p-value between births adjusted five years and kindergarten enrollment was –0.223 and .596, respectively. Because of the restrictions related to birth dates in enrolling a child in school after December, an additional correlation model was conducted with births adjusted for six years. The resultant Pearson correlation and p-value were 0.063 and 0.893, respectively. The conclusion is that births were not a good predictor for Kindergarten enrollment within the MPUSD. The results suggest that there may exist another more-correlated variable not considered in this analysis.

The 2000 Census report for the Monterey Peninsula, as displayed in Figure 4.4, highlighted that the population which comprises the MPUSD has declined in numbers by 10.85% since the 1990 census.

	1990	2000	% Change
Monterey County Total:	355,660	401,762	12.962
Monterey Peninsula cities total	119,372	107,985	-9.539
Del Rey Oaks	1,661	1,650	-0.662
Marina	26,436	25,101	-5.050
Monterey	31,954	29,674	-7.135
Sand City	200	261	30.500
Seaside	38,893	31,696	-18.505
MPUSD Affected Total	99,144	88,382	-10.855

Figure 4.4. Monterey Peninsula Population by the Numbers: Census 2000 (Herrera, 2001).

Although the majority of the decline (nearly 5400) was due to the BRAC of Fort Ord, some 5000 other residents vacated the area as well. Speculation would be that the reason for the additional decline could be job-related moves in connection with the BRAC of Fort Ord and possibly the high cost of living observed over the last seven years due to increased tourism and fewer settlers on the peninsula. Tourism has increased drastically since the BRAC of Fort Ord and although the economy has been bolstered by gains from the increased exposure of visitors, it has done little for population growth. The Monterey Peninsula population growth has also been constrained by the unavailability of water for construction of new living facilities.

The most important factor in estimating the value or quality of the service that a business can provide a customer can be measured externally and internally by goodwill indicators. Externally, one may provide a market survey to the customer and based on the analysis of the feedback make analytical assumptions about the level of quality provided. Internally, one may look at define indicators with their developed processes to search for trends to give an internal indication of the findings reported from an external survey and what is actually occurring. MPUSD had a decrease in enrollment from 12,290 students in school year 2000-01 to 12,090 in school year 2001-02. This decrease in enrollment came as a surprise to MPUSD's enrollment officials because no quantitative indicators had been available. An internal indicator was put in place by the author in December 2000 in an attempt to record the transfer process and the results are recorded in Figure 4.5.

School Year-Month	(B) Number Records Transferred	California (out-of-district)	Out of State	(A) Local (within-the-district)	Military (PL874)	Loss of Goodwill (A/B)%
2000-09	N/A	N/A	N/A	N/A	N/A	N/A
2000-10	N/A	N/A	N/A	N/A	N/A	N/A
2000-11	N/A	N/A	N/A	N/A	N/A	N/A
2000-12	99	19	49	10	13	10.101
2001-01	137	35	72	29	57	21.168
2001-02	86	21	24	39	19	45.349
2001-03	65	22	23	18	13	27.692
2001-04	61	15	28	18	19	29.508

Figure 4.5. Goodwill Variable (MPUSD, 2001).

Due to the lack of a detailed tracking procedure for establishing or relinquishing student cumulative records upon transfer, a Statistical Quality Control (SQC) process was established to record the cumulative number of records transferred out of the district's elementary and middle schools. The high schools maintain, store and transfer the records for their students. The recorded data was used to assess a quantitative value to the term "goodwill variable," a relative measure of the amount of students that transfer private or home schools within the district. The SQC process was a simple tally sheet that recorded the number of records transferred on a monthly basis as outlined in Figure 4.5 and the results was reported to management for decision-making analysis purposes. Upon inspection of the four or more different methods of transfer practices, it was evident that there was neither consistency nor an overall guiding procedure on how to transfer or track cumulative records. The techniques in place were controlled by the technicians and were sufficient for a single user operation. The SQC process put in place will allow the management team to detect large variations in the movement of student records out of their control and the knowledge of their final destinations. For example, in the month of

February 2001, 45% of the 86 record transfer requests were for students that moved to another non-MPUSD school within the district. In most cases, the student was transferred to a private or home school program. What this means to the District management team is that parents are opting to pay for private schooling rather than choosing their public institution. In addition, nearly 20% of those transfers involve military students, and as a result the associated ADA and supplemental PL874 funds were lost for federally connected transferees. The use of a tracking mechanism would have established the parameters that the management team could approve as an acceptable tolerance level for transfers within the district to private or home schools. When necessary the district could react accordingly. For example, a reaction was to send out surveys to the parents of the transferred students to identify areas within the district in need of management attention as a result of a loss.

In addition, the need to implement an advanced technological student management system was identified. Current systems, SCHOOLWISE and CAST are adequate, coded in COBOL and have unreliable databases. A new decision support management system, such as SchoolMax (DMG MAXIMUS, 2001), would be a benefit to the district. SchoolMax is discussed in chapter IV.

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V. RECOMMENDATIONS AND FOLLOW UP

A. RECOMMENDATIONS

The MPUSD has been provided with two invaluable tools, the FEM model and FORECAST.XLA model, to assist it in its need to achieve accuracy within their Forecasting Enrollment Management process. FEM contains a working database, a computational spreadsheet model, a FEM MPUSD Enrollment Output report, and a FEM MPUSD Staffing Output report. These are services not available to MPUSD prior to this thesis but similar in scope and presentation to the works of the late DepSup. The thesis identifies the level of accuracy available from forecasting future enrollment with historical enrollment data. The thesis was conducted at no cost to the District and included recommendations that led to improved personnel communication, enhanced developmental training, and cutting-edge decision support and management systems. The FORECAST.XLA model provided an optimized usage of an existing software package to achieve the forecasting goals of the District. FORECAST.XLA is scalable within Microsoft Excel as an add-in feature and should become even more powerful in future revisions. As a result of this thesis MPUSD is able to accomplish the following tasks as requested:

- Project student enrollment for any grade at any school for at least one year (twelve periods) in the future
- Provide the necessary staffing assignments by school and grade
- Use existing hardware and software systems
- Provide a scalable and portable database management system with the following attributes:
    - Low-cost or no-cost

- Easy to train existing personnel for use
- Developed, tested and operational before the 15th April deadline for submission of budget requests to the California Department of Education

Public school districts, in general, need to concentrate on the use of enrollment management tools, including predictive modeling, outcomes-based research on retention, programs, and activities, and evaluation of students' satisfaction to meet the needs of students, parents and society in general. Enrollment management changes the way school districts approach the business of public education. With appropriate planning and evaluation, district-wide participation, well-prepared professionals, and adequate fiscal resources, enrollment management can help public school districts meet future challenges posed to public school institutions. Excluding the significant loss of students during the closure of Fort Ord, the MPUSD has been very fortunate over the last two decades not to be burdened with unpredictable enrollments. In the past, MPUSD has received formal recognition from county and state authorities for its accurate levels of enrollment predictions. When compared to other Districts across the country, MPUSD programs and management were considered top tier (Friedrich, 2001). MPUSD has shown no evidence of an enrollment forecasting problem, but has shown substantial evidence of an enrollment management problem. The difference is that the forecasting enrollment is a merely a subset of the enrollment management process performed over the last two decades. The loss of the past DepSup took away the entire corporate knowledge on the subjects of attendance accounting, enrollment forecasting, personnel allocation, class size reduction management and budgeting. The duties held by that one person were more than enough for four full-time executive employees. The enrollment forecasting process was inaccurately title as a forecasting enrollment management procedure.

The process of hiring a new capable and competent Chief Business Officer fulfilled only one vacancy created by the loss of the DepSup; there were many more tasks left unassigned. During the course of this research, the author was not convinced that the new organizational management structure (since the departure of the DepSup) had successfully completed the necessary task reassignments. The transition has been slow and with great caution at a cost of not communicating clearly and concisely with the lower-tier employees and the community. In order for the district to move forward, management personnel must accept ownership of the situation left behind and the desire to take responsibility for its repair. MPUSD is an organization with a multi-million dollar budget and over 12,000 customers. It is unmistakably a large business and the district management team must make the crucial transition to an organization in which business acumen and management skills are required and expected in all decisions. Especially with the advent of new technology (SchoolMax), business as usual will not result in success of the ultimate goal. The current superintendent's technology infusion transition plan is propelling the leadership team into the information age. The proactive approach to the rapid implementation of cutting-edge decision support and management technology tools such as SchoolMax continuously to reiterates a commitment to quality for the community and district employees.

The MPUSD is faced with an issue that all public institutions such as the Post Office or the Public Library System must address at some point. The issue is how to measure customer satisfaction so the district can minimize customer dissatisfaction. The district's level of customer satisfaction is directly related to the quality of services provided to the community. A recommended method for the District to combat this issue is to establish a Quality Assessment Group within its organizational structure. This group would assist greatly in forging a district-wide service transformation from a reactive to a proactive posture. The purpose of this group would be to perform quality assessment for all targeted functional processes within the District's operations, make recommendations to the leadership team, and develop procedures to maintain the new-found level of quality and performance. Figure 5.1 shows the proposed initial structure of the assessment group and its major units.

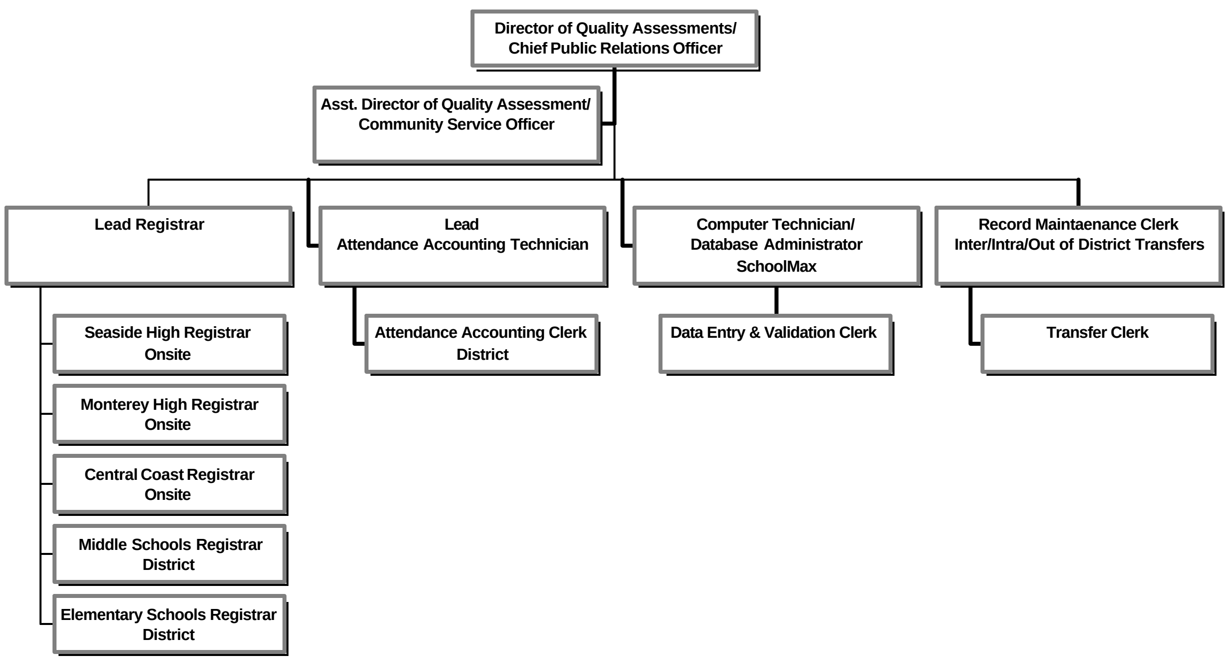

Figure 5.1. Quality Assessment Group Structure.

The group function is not to be compared to an Internal Affairs Division within a Police Department. Rather, its function is to focus on continuous improvement of internal operational functions. The group would evolve from an expansion of the existing Assessment Division but with greater depth and responsibilities. It is further recommended that the current Assessment Division Head be advanced to the Director level to accurately represent the level of responsibilities of the tasks assigned. The Director would report administratively to the Chief Business Officer and to the Superintendent for internal audit results. The Quality Assessment Group could be formed at no additional cost to the District by realigning existing personnel to jobs that fit their skill levels and expertise. Although the most crucial initial task for the group would be to develop Standard Operating Procedures (SOP) for most critical district operations, some of the basic responsibilities of the group would be as follows:

- Inter/Intra-District Transfers
- Zoning assignments
- Attendance reporting
- SchoolMax (see section C) implementation and continuous improvement training
- Cumulative record maintenance and transfers
- Total Enrollment processing visibility
- Ex-officio assignment to any established working groups
- Writing of Standard Operating Procedures (Internal)
- Internal Auditing and On-site Training
- Public Relations
- Centralized Registration
- Federal Impact Aid Reporting/Recording (PL 874)
- Class size reduction grants and penalties

This list is not all-inclusive. There are several other functions to the benefit of the district that could be added to the operational functions of the group. The bottom line is that the Director of Quality Assessment would be responsible for any process by which a student may enter or exit the District and any technology that supports the addition or subtraction of a student. Invariably, a centralized Internet-driven registration processing and reporting system (i.e., SchoolMax IQ version) will be the eventual goal of organizational structure change. It is reasonable to suppose that vast improvement will be realized within the district's total operations base and budgeting system by implementing automated processes immediately.

Some current procedures are redundant, costly and inaccurate. The end result is a dissatisfied student and/or parent – i.e., the customer. The extended organizational structure could assist in improving the customers' level of satisfaction at a reduced cost to the District. For example, the Gap Model (Ziethaml and Smith, 1990) explains causes of customer dissatisfaction. The model illustrates the path from customer expectation to customer experience. The following is a brief discussion of the five gaps in the model with reasons for each as described (Bergman, 1994):

- Gap 1: Between customers' expectation and management's perceptions of these expectations. Some reasons for this gap are:
- Lack of marketing research
  - Inadequate upward communication
  - Too many levels of management
- Gap 2: Between management's perceptions of customers' expectations and service quality specifications. Some reasons for this gap are:
  - Inadequate management commitment to service quality
  - Perception of infeasibility
  - Inadequate task standardization
  - Absence of goal setting
- Gap 3: Between service quality specifications and service delivery. Some reasons for this gap may be:
  - Role ambiguity
  - Role conflict
  - Poor employee job fit
  - Poor technology job fit
  - Inappropriate supervisory control systems

- Lack of perceived control
- Lack of teamwork

- Gap 4: Between service delivery and external communications to customers about service delivery. Some reasons for this gap are:
  - Inadequate horizontal communication among operations, human resources, instructions and business office
  - Propensity to over-promise
- Gap 5: Between customers' expectation and perceived service.
  - Good service is one which matches or exceeds customer expectations

A desired goal would be to create a total quality management environment capable of reaching the standards set by the Malcolm Baldridge National Quality Awards, the Deming Prize, or a continuous improvement equivalent. The Quality Assessment Group would be responsible for evaluating the level of customer/client satisfaction and making unbiased recommendation for process improvements. Since the audits are multi-purpose, to identify, correct and train on the problem, the District's overall readiness should improve immediately as a result of each audit.

1. Process Improvement

When looking for the causes of variation in a process, it is important to tackle the problem systematically and accurately. For MPUSD, variation can be caused by factors such as water shortages, building construction freezes, loss of goodwill with the community, loss of federal impact aid, or loss of enrollment management forecasting abilities and many more yet unclassified. There are often several problems or causes present. The problem that is the most serious will normally be first to be attacked. Figure 5.2 illustrates the improvement cycle: Plan - Do - Study - Act also know as the PDSA cycle (Bergman, 1994) that is a recommended approach for the District's Quality Assessment Division. The stages in the cycle are described below. Another list with roughly the same contents can be found in Figure 5.2 which outlines the methodology of the improvement process.

- Plan. When problems are detected, the principal causes of the problem must be established. Large problems have to be broken down into small, manageable ones. The decision concerning changes must be based on facts and not emotions. That means that one would have to look at the problem systematically for different plausible causes using scientific tools, working groups or any method that promotes free thinking without criticism. Afterwards, the compilation of data in such a way that one could detect causes of error and variation would be helpful. It is vital not to "over-react" in such a way that the solution of a problem becomes a costly experience based on trial-and-error (Bergman, 1994).

- Do. When an important cause of a problem is found, an improvement team is given the task of carrying through the appropriate steps to recovery. It is of great importance to make everyone involved fully aware of the problem and of the improvement steps decided upon (Bergman, 1994).

- Study. When appropriate steps have been taken, the results should be investigated to see if the implementation of the improvement program was actually successful. To monitor the level of progress, scientific tools should be employed. When the team is convinced that the steps taken have had a positive effect and that the quality level has been raised, the new level must be retained (Bergman, 1994). In some cases a control chart will be an idea tool for tracking progress.

- Act. The steps involve learning and gaining experience from the improvement process in order to avoid the same problem the next time. If the steps taken were successful, the new and better quality level should be made permanent. If not, the cycle is started again. It is also very important to analyze the entire cycle of problem solving once again in order to learn and to improve the improvement process itself (Bergman, 1994).

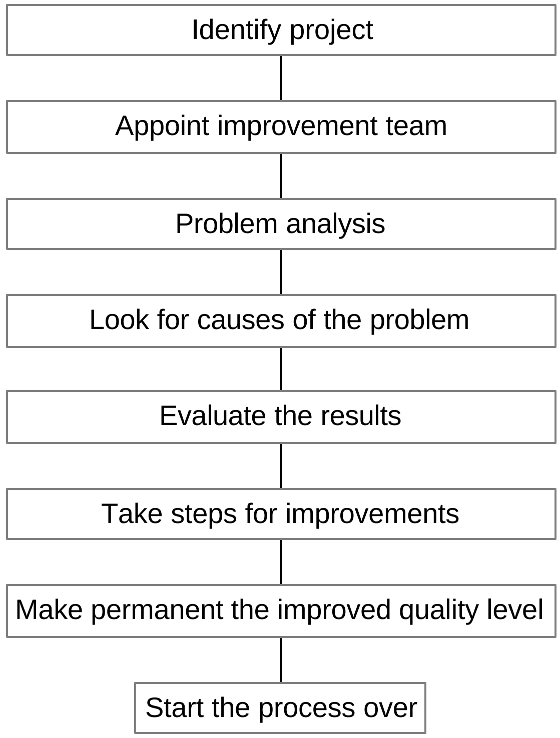

Figure 5.2. Improvement Cycle Methodology.

In addition, it is imperative that the District form a working relationship with the constituents of the servicing community. First, the District must understand and correctly interpret the needs of the community. Second, the community must understand and correctly interpret the needs of the District. The requirements of each run hand-to-hand and their public policies should reflect that relationship. The District could gain substantial benefits by properly educating the community on the need and the process involved with seeking modernization the existing public schools. In addition, the District must effectively communicate to the community its increased need for volunteers at all levels within the District system and how success in that one area can improve the quality of educational services provided to the students. Conversely, the community leadership must step forward and assist in outreach initiatives sponsored by the District that benefit the students and their quality of education. That includes encouraging citizens to volunteer at all levels in the system and educating the general populace on the value of their contribution.

B. SUPPLEMENTAL RECOMMENDATIONS

The following recommendations were generated while conducting research for the Forecasting Enrollment Management (FEM) Model from October 2000 to January 2001. Implementation of these recommendations is required in order for the model to accurately forecast enrollment and for management decisions to be properly supported. The recommendations (not listed in priority order) are as follows:

- Modify the enrollment identification codes within CASTS and SCHOOLWISE to capture PL874 candidate data
- Modify the existing drop codes within CASTS and SCHOOLWISE to capture data related to transfers
  - within CA but outside the District (e.g., Salinas, Pacific Grove, Carmel)
  - to home school
  - as a result of military/federal transfers (PL874)
  - to Mexico
  - out of the United States but not Mexico
  - within the district (i.e., private school)
- Organize a working group among registrars, attendance clerks and secretaries to develop a Standard Operating Procedure (SOP) for on-site attendance accounting
- Record and report monthly the final destinations and count of cumulative academic records transferred out of the district by the registrars
- Create an internal audit unit centered on the CASBO audit checklist for attendance accounting inspections and report monthly until officially inspected by the state
- Establish a Perfect Attendance Award Recognition Program with a certificate to the student and a form letter to the parents signed by a District Headquarters employee

- Pursue any endeavor that would lead to an enhanced community perception and increased goodwill for the District (e.g., community appearances)
- Empower and gain the trust of the employees at all levels within the District to be Ambassadors to the District within the community
- Develop a unified standard for dis-enrolling absent students (e.g., 15 days, 30 days, etc.)
- Develop a unified standard for student transfers to Central Coast High School
- Institute a training development plan for TIES/SchoolMax implementation that includes formal off-site training coupled with a self-paced on-site training module
- Include input from representative(s) of the Business Office-Enrollment on the facilities remodernization project to include the optimization of state mandated class sizes and the minimization of class size penalties for violations during maintenance periods
- Include input from representative(s) of the Business Office-Enrollment on the facilities remodernization project to include the necessary adjustments and the resultant impact from feeder assignment changes
- Establish a single or multiple (one per zip code) registration site(s) for student enrollment
- Solicit volunteer or professional consulting support on issues related to the Bond Election initiative (see section C) and resultant data analysis
- Establish a Child and Parent Together Program, and Early Enrichment and Kindergarten (EEK) programs at Fort Ord and La Mesa Military Communities. The goal is to encourage parent participation at the early stages and to expose parents to other services offered by MPUSD that are otherwise unnoticed. Federally connected students generate more revenue for the District per child than other community students.
- Once the school year has begun, the actual attendance and resulting estimated ADA should be reviewed periodically. The first review should take place after the information for the first statistical month is received. Income projections should be adjusted accordingly, and staffing adjustments should be made, if possible. To maximize staffing resources, class size should be monitored on a monthly basis. Class sizes exceeding state required levels (generally 20 for kindergarten, 28 for grades one to three, and etc.) would result in a reduction in revenue limit ADA. (CASBO, 1998)

C. FOLLOW-UP

At the time of publication, the MPUSD had implemented several of the suggested recommendation into their operational business plan. In particular the following were implemented or considered:

- MPUSD solicited professional consultants from a private consultant firm for their Bond Initiative to remodernize the public schools. The Bond Initiative seeks to provide necessary funding through a municipality bond to facilitate the cost of facilities in need of repairs.
- The Parent Teacher Student Association (PTSA) throughout the district has become more active in volunteer participation within the schools. Parents and teachers have begun a crusade of grant writing initiatives that has produced several thousands of dollars for school enhancement programs.
- MPUSD modified its existing drop codes within their decision support system to provide more relevant management information by creating a database more reflective of actual district operations
- The District adjusted its SchoolMax implementation schedule to train end users first. In addition, the contractor developed an internal self-paced training module to facilitate additional training and qualification standards. Now the District can develop an internal training program unique to MPUSD.
- MPUSD registrars, attendance clerks and secretaries had their first ever all-hands training. It was pledged at the meeting that a working group would be formed to create a Standard Operating Procedure (SOP) for District attendance accounting. The event was supported and attended by upper management and was well received.
- The Business Office implemented an internal audit process for attendance accounting practices that was based on the inspection checklist from the California Association of School Business Officer (CASBO) regulations. The on-site audit identified, corrected and upgraded of all defective units to state standards. MPUSD has been advised that they would be audited within the next 18 months.
- The Records Office began a Statistical Process Control (SQC) tracking method for transferred cumulative records. This action gave the District management visibility into the number of students leaving their schools (i.e., to private school) but not the District. This was considered a useful variable to assist in measuring the District's loss of goodwill.

- The Facilities Department competed a contract for Request for Qualification (RFQ) to determine who, when and what will be remodernized if the Bond Initiative is passed.
- The Automated Data Processing Division researched and adopted SchoolMax, a student information system that gives the user on-line access to a single district-wide database with up-to-the-minute student, family and school information for the current year, as well as historical data from prior years. The user can access the database from any location throughout the district. SchoolMax is scalable and can maintain up to 1,000,000 records. With the addition of IQ, an Internet-server based add-on module available in June 2001, centralized registration could be realized within the District (DMG Maximus, 2001).
- Introduced two additional thesis research topics from the Naval Postgraduate School, (1) a contrast and comparison of detailed budgeting vice categorical budgeting and (2) the development and installation of a T1 backbone and fiber optic cabling for a computer center at Fitch Middle school that can be used for video conferencing and training by staff and students.
- Made a diligent effort to increase public exposure to the community on all issues relevant to the District's Operations. This included the formation of community action committees to advise management on matters related to District remodernization.
- Restructured the existing District leadership team to clarify areas of responsibilities.

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APPENDIX A. MPUSD MASTER DATABASE

Year	Value	Bayview	Cabrillo	Crumpton	Del Monte	Del Rey Woods	Foothill	Highland	Le Mesa	Larkin	Manzanita	Marina Del Mar	Marina Vista	Marshall	Monte Vista	Olson	Ord Terrace	Colton	Fitch	King	Los Arboles	Monterey High	Seaside High	Central Coast High	Totals
1995-01	1	349	0	551	0	616	590	529	613	0	404	430	0	655	440	406	664	725	389	699	604	1354	1126	205	11349
1995-02	2	351	0	534	0	625	595	529	575	0	404	444	0	655	436	406	664	712	389	699	595	1324	1111	224	11272
1995-03	3	353	0	519	0	620	595	518	567	0	398	440	0	629	440	402	660	706	387	702	589	1292	1100	235	11152
1995-04	4	353	0	520	0	619	583	518	559	0	394	430	0	624	439	400	653	702	392	687	585	1256	1071	233	11018
1995-05	5	347	0	519	0	617	580	506	543	0	387	437	0	619	444	399	646	700	384	683	583	1239	1053	227	10913
1995-06	6	343	0	515	0	618	580	506	536	0	383	440	0	607	435	400	654	700	386	680	578	1233	1035	224	10853
1995-07	7	344	0	515	0	621	586	510	520	0	385	433	0	598	435	401	653	694	379	676	574	1209	1008	235	10776
1995-08	8	345	0	509	0	614	587	506	509	0	385	436	0	580	435	392	652	692	364	684	574	1195	982	229	10670
1995-09	9	345	0	508	0	614	584	503	493	0	380	443	0	548	437	388	651	683	362	681	573	1181	960	227	10561
1995-10	10	335	0	506	0	614	585	506	489	0	379	437	0	521	438	386	652	682	356	681	573	1180	955	220	10495
1995-11	11	336.65	0	519.2	0	617.3	577.74	509.96	500.88	0	379.33	447.89	0	549.05	436.02	396.9	654.31	694.87	377	682	590.49	1250.62	1012.75	211.75	10744
1995-12	12	338.3	0	532.4	0	620.6	570.48	513.92	512.76	0	379.66	458.78	0	577.1	434.04	407.8	656.62	707.74	398	683	607.98	1321.24	1070.5	203.5	11079
1996-01	13	340	0	546	0	624	563	518	525	0	380	470	0	606	432	419	659	721	419	684	626	1394	1130	195	11251
1996-02	14	341	0	537	0	620	568	532	507	0	386	471	0	629	433	425	670	708	427	690	622	1356	1124	198	11244
1996-03	15	346	0	536	0	624	568	521	507	0	379	475	0	618	438	420	663	708	448	682	619	1318	1094	212	11176
1996-04	16	342	0	534	0	624	568	517	504	0	376	479	0	612	441	414	669	702	418	682	619	1291	1125	212	11129
1996-05	17	341	0	544	0	627	562	507	498	0	382	470	0	585	446	416	662	709	413	689	656	1296	1061	203	11067
1996-06	18	337	0	547	0	632	559	511	503	0	386	469	0	594	442	411	674	702	416	691	657	1287	1060	213	11091
1996-07	19	345	0	549	0	634	562	508	493	0	384	474	0	599	443	411	672	694	416	688	610	1266	1038	235	11021
1996-08	20	348	0	554	0	633	560	500	471	0	393	478	0	585	444	408	673	680	414	686	605	1239	1013	235	10919
1996-09	21	343	0	549	0	632	557	499	460	0	393	472	0	571	446	409	668	678	407	674	600	1234	985	227	10804
1996-10	22	337	0	549	0	635	560	492	455	0	393	467	0	547	443	395	665	678	404	672	597	1229	979	225	10722
1996-11	23	334.69	0	551.31	0	636.32	573.86	495.96	485.69	0	398.94	472.61	0	570.76	439.04	399.3	615.83	696.15	420	676	614.82	1301.27	1060.51	214.44	11036
1996-12	24	332.38	0	553.62	0	637.64	587.72	499.92	516.38	0	404.88	478.22	0	594.52	435.08	403.6	566.66	714.3	436	681	632.64	1373.54	1142.02	203.88	11349
1997-01	25	330	235	556	0	639	602	504	548	0	411	484	0	619	431	408	516	733	453	685	651	1448	1226	193	11672
1997-02	26	330	235	564	0	640	602	504	540	0	398	485	0	613	435	411	517	728	454	671	643	1417	1178	207	11572
1997-03	27	337	244	574	0	642	606	509	526	0	395	464	0	600	432	411	505	713	450	673	635	1393	1143	224	11476
1997-04	28	337	236	572	0	646	599	502	528	0	396	464	0	595	433	409	499	716	447	667	633	1365	1137	225	11406
1997-05	29	335	236	574	0	646	601	498	514	0	393	448	0	590	427	415	500	720	448	661	632	1361	1147	202	11348
1997-06	30	339	239	590	0	655	595	496	518	0	397	458	0	584	427	420	499	716	448	664	632	1348	1130	214	11369
1997-07	31	340	243	594	0	654	591	499	513	0	396	458	0	579	429	417	494	713	445	657	630	1333	1117	223	11325
1997-08	32	341	238	600	0	657	586	496	494	0	406	452	0	570	438	415	496	715	448	654	631	1314	1132	222	11305
1997-09	33	341	234	604	0	651	583	498	487	0	400	442	0	557	438	418	498	713	439	653	632	1301	1117	216	11222
1997-10	34	340	229	601	0	643	584	497	471	0	398	445	0	541	435	415	498	713	432	652	632	1298	1115	205	11144
1997-11	35	342.64	238.9	544.57	0	653.89	568.82	505.58	500.04	0	395.03	411.67	0	575.32	433.68	405.1	505.59	719.27	453	640	631.67	1385.45	1169.45	202.36	11397
1997-12	36	345.28	248.8	488.14	0	664.78	553.64	514.16	529.08	0	392.06	378.34	0	609.64	432.36	395.2	513.18	725.54	474	628	631.34	1472.9	1223.9	199.72	11650
1998-01	37	348	259	430	0	676	538	523	559	0	389	344	349	645	431	385	521	732	495	616	631	1563	1280	197	11911
1998-02	38	349	257	431	0	670	544	532	559	0	392	346	350	639	427	391	540	727	493	620	630	1539	1257	208	11901
1998-03	39	339	257	429	0	661	551	527	525	0	392	356	349	637	424	387	533	721	490	609	654	1506	1215	220	11782
1998-04	40	343	259	437	0	647	552	524	528	0	393	346	349	630	422	384	522	714	489	595	655	1498	1175	234	11696
1998-05	41	349	259	439	0	661	548	518	512	0	391	346	365	635	411	386	523	710	516	582	653	1500	1165	234	11703
1998-06	42	349	259	435	0	664	552	524	514	0	392	349	365	638	415	385	521	710	478	589	653	1487	1163	240	11682
1998-07	43	349	259	429	0	665	556	518	518	0	393	365	364	622	416	383	528	715	477	583	640	1464	1138	240	11622
1998-08	44	349	253	434	0	663	554	523	491	0	388	366	361	621	417	388	521	715	483	581	639	1447	1113	254	11561
1998-09	45	346	256	431	0	652	556	527	484	0	382	366	361	600	413	386	517	714	483	578	631	1434	1103	239	11459
1998-10	46	336	256	428	0	647	556	525	483	0	381	362	362	585	409	385	516	714	474	578	631	1427	1095	236	11386
1998-11	47	321.15	273.49	446.81	0	597.5	527.95	503.88	480.36	0	393.87	354.08	372.89	613.71	387.88	384	527.55	717.3	499	586	644.53	1513.46	1153.74	216.86	11664
1998-12	48	306.3	290.98	465.62	0	548	499.9	482.76	477.72	0	406.74	346.16	383.78	642.42	366.76	383	539.1	720.6	524	594	658.06	1599.92	1212.48	197.72	11942
1999-01	49	291	309	485	249	497	471	461	475	200	420	338	395	672	345	382	551	724	550	602	672	1689	1273	178	12229
1999-02	50	292	322	483	249	497	473	466	481	198	426	337	402	670	347	377	558	725	552	603	675	1683	1267	193	12276
1999-03	51	295	320	483	247	500	468	462	450	197	429	340	399	662	349	373	568	720	556	587	676	1664	1242	205	12192
1999-04	52	295	314	482	244	495	464	460	452	190	426	335	403	660	349	372	559	712	562	584	676	1648	1217	207	12106
1999-05	53	293	301	487	246	496	464	459	434	189	428	338	403	629	355	376	564	716	551	572	670	1632	1202	196	12001
1999-06	54	294	311	479	247	500	469	446	434	187	421	337	401	632	362	379	564	716	552	555	670	1605	1182	206	11949
1999-07	55	298	310	479	246	500	472	452	428	185	423	339	399	630	356	382	569	714	558	554	679	1581	1157	223	11934
1999-08	56	293	312	478	249	496	468	449	426	185	423	333	406	627	352	381	577	713	554	546	682	1559	1134	228	11871
1999-09	57	293	317	469	244	496	467	453	425	190	416	330	407	604	351	384	579	711	555	545	683	1553	1124	244	11840
1999-10	58	291	317	468	244	496	467	453	425	190	415	330	405	566	348	379	577	710	550	546	682	1550	1119	236	11764
1999-11	59	282.42	322.28	471.63	257.2	498.97	459.41	449.37	439.85	194.6	411.04	323.07	401.04	600.98	345.69	395.2	572.71	717.59	552	572	683.32	1576.4	1204.8	216.53	11948
1999-12	60	273.84	327.56	475.26	270.4	501.94	451.82	445.74	454.7	199.2	407.08	316.14	397.08	635.96	343.38	411.3	568.42	725.18	554	598	684.64	1602.8	1290.6	197.06	12132
2000-01	61	265	333	479	284	505	444	442	470	204	403	309	393	672	341	428	564	733	556	625	686	1630	1379	177	12322
2000-02	62	266	334	472	284	506	442	449	456	206	402	309	395	667	340	422	558	739	558	626	681	1616	1375	187	12290
2000-03	63	271	330	469	285	499	441	446	438	212	400	310	394	644	342	417	544	741	543	631	681	1598	1349	186	12171
2000-04	64	274	329	466	287	497	441	448	446	211	397	313	393	630	345	413	539	741	542	619	679	1569	1326	188	12093
2000-05	65	275	315	469	289	498	437	449	419	210	396	319	392	627	346	410	541	750	538	615	676	1553	1322	189	12035
2000-06	66	273	323	472	287	499	436	451	423	205	392	312	395	621	348	411	539	751	542	608	667	1535	1307	196	11993
2000-07	67	273	325	473	287	500	436	448	411	202	398	316	395	616	347	411	536	745	536	607	665	1520	1292	194	11933
2000-08	68	277	325	468	277	498	440	444	399	207	391	315	398	603	347	411	538	737	527	603	663	1490	1310	189	11857
2000-09	69	276	330	462	278	500	438	445	398	206	383	315	397	587	348	406	538	728	520	602	660	1470	1249	208	11744
2000-10	70	275	328	461	278	496	437	446	396	207	383	313	397	570	347	406	535	727	514	600	658	1463	1247	202	11686
2000-11	71	271.7	326.68	461.66	285.59	496	437.66	441.05	409.2	214.3	389.93	310.36	398.65	581.88	339.41	402.7	537.97	725.02	532	596	662.62	1499.63	1313.33	191.11	11825
2000-12	72	268.4	325.36	462.32	293.18	496	438.32	436.1	422.4	221.5	396.86	307.72	400.3	593.76	331.82	399.4	540.94	723.04	551	591	667.24	1536.26	1379.66	180.22	11963
2001-01	73	265	324	463	301	496	439	431	436	229	404	305	402	606	324	396	544	721	570	587	672	1574	1448	169	12106
2001-02	74	261	336	467	303	498	437	428	427	229	396	301	408	612	327	404	541	716	573	589	661	1554	1451	171	12090
2001-03	75	252	332	472	302	497	441	437	413	230	390	297	408	595	327	408	542	716	560	581	657	1525	1439	180	12001
2001-04	76	255	324	471	300	501	437	433	405	226	386	297	407	579	325	413	543	716	559	570	650	1505	1420	197	11919
2001-05	77	259	331	468	298	497	437	432	392	226	392	300	398	573	328	409	547	709	557	569	656	1503	1395	183	11859
2001-06	78	262	320	476	297	493	440	430	394	229	385	300	402	572	329	415	542	708	550	573	658	1493	1370	187	11825
2001-07	79	262	330	459	291	495	437	425	392	227	392	304	409	554	328	415	537	707	544	579	654	1465	1357	195	11758

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APPENDIX B. FEM METHOD ON A SPREADSHEET

The spreadsheet implementation of Winter's method contains an extra column for the seasonal factors. Also, a space must be provided for 12 periods of seasonal factors, s_{-11} through s_0. The following steps outline the procedure for the data set for ATS for years 1997 to 2000. The data set contains 48 points. FEM was specifically designed for data set distribution with less than 36 periods and for its ability to generate optimal values for α, β, and γ using Microsoft Excel Solver.

- **Initialization.** Starting from the original FEM2DATSET.xls file, copy the trouble call data from years 1998 to 2000 values in the range B3:B38. To make room for the starting values L_o, T_o, and the initial seasonal factors, insert 11 blank rows below row C3:C14. These rows will refer to months "-11" through "0." Then enter the vales for L_o, T_o, and s_{-11} through s_0 in cells B14, C14, and the range D3:D62. (See Figure 3.1.)
- **Smoothing constants.** Enter values of the smoothing constants α, β, and γ, such as 0.50, 0.40, and 0.60, in cells I3:I5. The smoothing constants shown in Figure 3.1 are "optimal," as will be explained shortly.)
- **Levels (a).** To implement Equation 3.1, enter the formula

  =$I$2*A15/I3 + (1-$M$15)*(G14 + H14)

  in cell G15 and copy it to the range G16:G62.

- **Trends (b).** To implement Equation 3.2, enter the formula

  = $M$17*(G15 – G14)*(1 - $M$17)*H14

  in cell H15 and copy to range H16:H62.

- **Seasonal factors (g).** To implement Equation 3.3, enter the formula

  =$M$19*F15/G15 + (1 - $M$19)*I3

  in cell I15 and copy it to the range I16:I38.

- **Forecasts.** The one-month ahead forecast can now be calculated in column J. In cell J15, enter the formula.

$$=(G14 + H14)*I3$$

and copy it to the range J16:J39. Note the forecast in cell J39 is for month 25, made in month 24. Forecasts for months 26 and beyond can be made in month 24 by entering the formula

$$= (G38 + 2*H38)*I28$$

in cell J40. These forecasts are really composed of two parts. The part inside the parenthesis is the forecast of the deseasonalized value: the level plus a multiple of the trend. Then this deseasonalized is multiplied by the appropriate seasonal factor to "reseasonalize" the forecast.

- **Forecast errors.** Calculate the errors, the absolute errors, and the MAD in columns K, L and I.
- **Graph.** Use columns A, F, and J (along with the labels in row 2) to draw a line graph of the forecasts against the actual District Enrollment values as shown in Figure 3.11. Although the agreement is far from perfect, the seasonality is captured quite well. The agreement between predicted and actual enrollment is least good during months 15 and 17. During these months the forecasts are much too high. Perhaps some type anomaly occurred during those months and requires further investigation by the enrollment manager.
- **Optimize MAD.** To optimize the MAD, the Solver function of Excel can be used to find the "best" smoothing constants of α, β, and γ. Invoke the Solver function with the following settings:
    - ➢ The cell to minimize is L39 (MAD)
    - ➢ The changing cells are M15, M17, and M19
    - ➢ The constraints are that α, β, and γ must be between values 0 and 1.

Note: Although the values of α and β that minimizes the MAD should not exceed 0.5 (as in the Holt method), it is not uncommon for the best value of γ to exceed 0.5. This is because for monthly data, each monthly seasonal factor is updated during only 1/12 of all periods. Since the seasonal factors are updated so infrequently, there is a need to sometimes give more weight to each observation so that $\gamma > 0.5$ is not out of the question.

Key Cell Formulas

Cell	Formula	Copied to
F3	=((C3/AVERAGE($C$3:$C$14)))	F4:F14
D14	=C14/F14	--------
D15	=$K$3*C15/F3 + (1-$K$3)*(D14+E14)	D16:D38
E14	=0	--------
E15	=$K$4*(D15-D14)+(1-$K$4)*E14	E16:E38
F15	=$K$5*(C15/D15) + (1-$K$5)*F3	F16:F38
G15	=SUM(D14:E14)*F3	G16:G38
H15	=C15-G15	H16:H38
I15	=ABS(H15)	I16:I38
K6	=AVERAGE(I15:I38)	--------
K7	=SUMXMY2(G15:G38,C15:C38)/COUNT(G15:G38)	--------
G39	=($D$38+C3*$E$38)*F27	G40:G50

Note: for increased accuracy make the following substitution:

Cell	Formula	Copied to
F3	=((C3/AVERAGE($C$3:$C$14)) +(C15/AVERAGE($C$15:$C$26)) +(C27/AVERAGE($C$27:$C$38))) / (COUNT($C$3:$C$38)/12)	F4:F14

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APPENDIX C. FORECAST.XLA ON A SPREADSHEET

Once FORECAST.xla is loaded, the **Forecast** menu containing the following items will appear:

- Choose Forecast ▶ Run Forecast.
- Select data file or column from Excel spreadsheet.
- In Data, enter the column containing the time series.
- In Series Type, select Trended Two Parameter Smoothing and Seasonal (12 Month).
- Then click OK.

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APPENDIX D. FEM MPUSD ENROLLMENT OUTPUT

Monterey Peninsula Unified School District
2001-2002 Projected 6th Month Enrollment

School Site	K	1	2	3	4	5	6	7	8	9	10	11	12	Total Site-Calc	Total Site-Fore
Bay View	35	28	40	57	45	41								247	247
Cabrillo	48	66	70	60	60	43								348	347
Crumpton	78	78	77	71	71	77								451	460
Del Monte	37	70	64	38	48	47								304	312
Del Rey Woods	91	89	71	76	68	70								465	465
Foothill	73	53	63	64	99	70								422	410
Highland	72	63	85	67	60	68								415	415
La Mesa	66	69	63	57	53	65								372	372
Larkin	53	38	37	36	36	51								251	250
Manzanita	68	59	71	68	66	54								387	387
Marina Del Mar	39	43	39	48	53	46								269	269
Marina Vista	74	70	78	76	66	51								416	416
Marshall	129	116	97	87	73	73								575	576
Monte Vista	45	43	50	55	56	58								307	307
Olsen	66	73	82	80	57	56								415	414
Ord Terrace	98	98	88	93	102	67								546	522
Total Elementary	1074	1057	1074	1034	1015	936								6191	6171
Colton							220	244	248					712	713
Fitch							204	196	183					583	583
King							163	163	228					553	552
Los Arboles							236	210	227					672	672
Total Middle							823	812	886					2521	2520
Monterey										417	362	375	317	1471	1474
Seaside										446	398	300	282	1427	1425
Central Coast										4	57	88	29	179	182
Total High										867	818	763	628	3076	3080
												Grand Total - Calc		11788	
												Grand Total - Forecast			11771
												Grand Total - Actual			

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APPENDIX E. FEM MPUSD STAFFING OUTPUT

Monterey Peninsula Unified School District
2001-2002 Projected 6th Month Staffing

School Site	K	1	2	3	4	5	6	7	8	9	10	11	12	Total Site-Calc
Bay View	2	2	3	3	2	2								14
Cabrillo	3	4	4	4	3	2								20
Crumpton	4	4	4	4	3	3								22
Del Monte	2	4	4	2	2	2								16
Del Rey Woods	5	5	4	4	3	3								24
Foothill	4	3	4	4	4	3								22
Highland	4	4	5	4	3	3								23
La Mesa	4	4	4	3	2	3								20
Larkin	3	2	2	2	2	2								13
Manzanita	4	3	4	4	3	2								20
Marina Del Mar	2	3	2	3	2	2								14
Marina Vista	4	4	4	4	3	2								21
Marshall	7	6	5	5	3	3								29
Monte Vista	3	3	3	3	2	3								17
Olsen	4	4	5	5	2	2								22
Ord Terrace	5	5	5	5	4	3								27
Total Elementary	60	60	62	59	43	40								324
Colton							8	9	9					26
Fitch							8	7	7					22
King							6	6	8					20
Los Arboles							9	8	8					25
Total Middle							31	30	32					93
Monterey										14	13	13	11	51
Seaside										15	14	10	10	49
Central Coast										1	3	5	2	11
Total High										30	30	28	23	111
													Grand Total	528

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APPENDIX F. ACTUAL BIRTHS MPUSD BY ZIP CODE

			Actual Birth						Second Month	
Number	YEAR	SCHOOL YEAR	Monterey 93940	Fort Ord 93941	NPS/DLI 93942/3/4	Marina 93933	Seaside 93955	Total Birth	Kindergarten Enrollment	District-wide Enrollment
	1988	1988-1989							1673	13644
1	1989	1989-1990	558	841	15	387	500	2301	1669	14034
2	1990	1990-1991	536	944	14	376	539	2409	1534	14427
3	1991	1991-1992	559	939	14	380	601	2493	1654	14719
4	1992	1992-1993	534	938	14	404	587	2477	1569	14518
5	1993	1993-1994	541	608	10	318	548	2025	1209	11914
6	1994	1994-1995	439	191	6	305	574	1515	1104	11299
7	1995	1995-1996	386	3	11	293	760	1453	1118	11244
8	1996	1996-1997	259	0	3	259	705	1226	1157	11572
9	1997	1997-1998	383	0	3	291	705	1382	1204	11901
10	1998	1998-1999	357	0	2	286	755	1400	1219	12276
11	1999	1999-2000	320	0	3	291	720	1334	1147	12290
12	2000	2000-2001	343	0	4	306	727	1380	1140	12090
Forecast 13	2001	2001-2002								
Forecast 14	2002	2002-2003								
Totals			5215	4464	99	3896	7721	21395	15724	152284
Average			434.5833	372	8.25	324.6667	643.4167	1782.917	1310.333333	12690.33333

Source: Monterey County Health Department, March 28, 2001.

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