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Y2K Serendipity: Benefits and Spinoffs

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Y2K Serendipity: Benefits and Spinoffs

By

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for the degree of Doctor of Philosophy

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We hereby certify that this dissertation, submitted by Roy Gwen Taunton, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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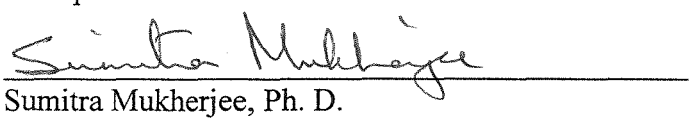

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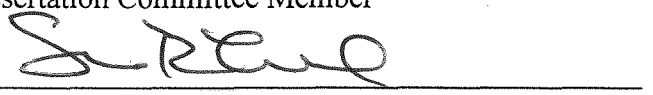

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An Abstract of a Dissertation Submitted to Nova Southeastern University
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The primary purpose of the researcher this study was to determine what, if any, unexpected benefits, spin-offs, and other "serendipitous" events occurred as a result of the year 2000 remediation process undertaken by businesses, industry, and other organizations. This was measured through the use of an online survey instrument comprised of a series of questions designed to measure and discover those benefits. The survey was sent to approximately 50 different businesses/organizations during the pilot stage of this study and 250 during the main stage of this study. These businesses/organizations were randomly selected from the sampling frame using random sampling techniques. The random samples that were used included the areas of financial services, health care, non-computer manufacturing, telecommunications, transportation, and utilities. The survey responses were analyzed in an effort to determine what benefits were common to these businesses as well as to discover possible unique benefits some business may have experienced. Of particular interest were any benefits that companies indicate were totally unexpected or serendipitous. Final analysis of the data was accomplished through the use of canonical correlation. This statistical procedure was chosen because of its usefulness in determining correlations between a set of independent variables and a set of dependent variables. The findings of the pilot study were, for the most part, inconclusive due to the small number of responses. The analysis of the data from the main study resulted in one significant canonical function. The canonical correlation between the computer generated variates created by this function was reported at approximately .86. This indicates a high degree of correlation between criterion variate 1 that represented the independent variables, and is the predictor variate 1 that represented the dependent variables. The variables PCSYS, NTSYS, MFSYS had the highest correlation with the Predictor1 variate. The variables ITISS, AWAREMIA, and AWAREBF had the highest correlation with the Criterion1 variate. Therefore, the

independent variables PCSYS, NTSYS, and MFSYS were most predictive of the dependent variables ITISS, AWAREMIA, and AWAREBF. To determine if there were unexpected benefits in those companies surveyed, a multiple regression was performed using the measured variable "SEREDIP" as the dependent variable and the measured variables Y2KEFFORT, ORGSP, and ORGHM as the independent variables. The null hypothesis was not rejected indicating that among the companies surveyed, the occurrences of serendipitous events were not statistically significant. However, the literature indicated that serendipitous events have occurred, although these occurrences were not universal.

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I would like to thank, first of all, my committee chair John Scigliano who has been diligent in guiding me through this entire process and who helped me take a fledgling idea and turn it into this dissertation. In addition, I would like to thank my other committee members, Dr. Sumitra Mukherjee and Dr. Steven R. Terrell who also provided valuable feedback thus helping to further refine this document. I would also like to thank my wife, Jan, who has been an encouragement through all the years of my formal education. I would also like to thank all those in my church who have prayed for me during this process, and it is my prayer that God will get the glory for all my efforts.

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Chapter 1

Introduction

January 1, 2000 was a much anticipated event in modern-day history. Several years prior to this date, it became apparent that a trivial shortcut in computer programming had resulted in a massive effort that cost an estimated $250 billion or more in repairs and contingency planning (Feder, 2001). It seemed that in an effort to conserve space, many computer programmers had used a two-digit date format instead of a four-digit date format in their code. This meant that at midnight on January 1, 2000, many of the world's computers would interpret the date as 1900 instead of 2000, thus causing major disruptions in numerous computer systems (Stanglin & Ahmad, 1998). When these programs were originally developed, no one had foreseen that they would be used for as long as they were. The implications of the glitch were mind-boggling since many of these programs frequently used date computations in their respective algorithms. Predictions ranged from the banking system going into gridlock to public utilities shutting down completely (Ansary, 2001).

What followed after the initial realization that there was a serious problem in the making could be described as near panic (Hawaleshka, 2000). There were extremists who were predicting catastrophic results such as plane crashes, massive power outages, food shortages, and the list goes on (Crawford, 2001). Numerous web sites began to appear describing in horrific detail the events that were about to befall mankind. In fact, even

though many months have now passed by, the World Wide Web still contains an elephant's graveyard of Y2K sites (Ansary, 2001).

Throughout business and industry, however, the approach was more methodical. The problem had been identified, and it had become a matter of setting aside the funds and the manpower to combat the possibility of Y2K rollover glitches (Y2K opens door to new era of e-commerce, 2000). Encumbered by the added expense of Y2K remediation, many companies showed poor earnings for the year; many closures were also blamed on the year 2000 problem (Caldwell, 1999). A number of individuals began to claim that year 2000 fixes were monetarily excessive (Capoccia, 2000). In addition, legal questions began to arise as to who was financially liable for costs (Nicholson, 1998).

As the Y2K remediation process continued, a new revelation came to light. Many organizations claimed that they had seen positive, transformational effects above and beyond what had been originally expected (Melymuka, 2000). From this point, the year 2000 problem would no longer be viewed as a totally negative occurrence but rather as an enriching experience from which the IT (Information Technology) sector could learn from and benefit (Lehman, 2000).

Statement of the problem

The problem that was investigated in this study was the relationship between the time, money, and effort put into the Year 2000 remediation effort (Kappelman, 2000) and the benefits that have occurred as a result of the process. For the purpose of this study, benefits were defined as spinoffs, positive outcomes, improvements in procedures, and

other "serendipitous" type events or occurrences that happened unexpectedly or as a byproduct of Y2K remediation.

Before the Y2K event, most questions centered on whether or not industry was ready for the new year to roll in. In the aftermath, the focus began to shift to the factors that went into preparing for Y2K ("Fear-Based Spending Led to Much-Needed Upgrades," 2000). While IT executives breathed a collective sigh of relief that the damage wasn't more serious, many were also preparing a defense for the critics who claimed that the Y2K computer problem was over priced and over hyped. Because of the emphasis on Y2K, spending on many unrelated projects was frozen (Hoffman & King, 2000). Many felt that substantial problems with Internet security and stability were not addressed because everybody was focusing time and energy on a largely fictional problem (James, 2000). Some even suggested that it was all a hoax (Wilson, 2000).

In addition to answering for the monies that had to be spent, the IT community was having to account for funds that some say were wasted. As early as eighteen months prior to Year 2000, one IT manager advised his colleagues that they were overspending due to "Y2K hysteria" (Scannell & Epstein, 2000). In a recent report, President Clinton's Y2K Czar, John Koskinen, suggested that as much as $10 billion may have been wasted in the debugging effort. In that same report, research conducted by International Data Corporation put the waste at $41 billion (Kappelman, 2000).

Practitioners in the business IT community are not the only ones fearful of Y2K repercussions due to perceived waste. Now that the Y2K disaster has been successfully averted, inquiries began as to the amount of money spent to avert a problem that did not

materialize that could result in many competent government IT managers losing their jobs (Y2K fallout: Government witch hunt begins, 2000).

So, without question, the biggest impact of the Y2K problem has been, and will probably remain the overall cost. The Gartner Group still stands by its projection that places Y2K project spending worldwide at between $300 billion and $600 billion. If cost for non-information technology factors such as risk management and contingency planning are included, the worldwide bill escalates to close to $1 trillion dollars. Finally, if the cost of litigation and business failures are added to the mix, the total cost comes to between $1 trillion and $2 trillion dollars (Caldwell, 1999). Reportedly, some companies spent as much as 40% of their IT budgets on Y2K projects in 1999 (Wilson, 2000). The aforementioned figures only reflect Y2K spending in a very general way. A closer examination of the literature shows where the monies were spent and why the Y2K effort has been such a painful process.

Another area of Y2K expenditures deals with the replacement of legacy systems. For years, the dilemma over whether to upgrade or replace aging computer systems had existed for many companies and government agencies. With Y2K, the question was no longer if they should be replaced or upgraded but when. This question became extremely complicated for smaller municipalities with limited budgets. Was existing hardware Y2K compliant? If so, could the software be fixed within a reasonable time and at a reasonable cost? Would it support software changes? Were replacement parts available? In most cases, replacing a system was less costly than upgrading it. This option was particularly attractive to many smaller organizations where it was impossible to upgrade antiquated

software. Frequently, employees who developed the software had moved to other jobs making the replacement of the system a necessity (Sharp, 1999).

Behind the spending for upgrades of legacy systems is still another unspoken truth; a lot of the money went for equipment upgrades that had little or nothing to do with Y2K compliance. In fact, companies may have spent a lot on the Y2K remediation process, but in exchange, many got a lot of IT modernization in return. Many used Y2K as an excuse to upgrade their routers, their mainframes, their PC's from 486's to Pentiums, and some even used it as an opportunity to switch to distributed networks (Marsan, 2000).

Many companies were still in the review process well after the dawn of the year 2000. Post Y2K, we know only what has been reported. There is chance that a number of incidents have gone totally unreported due to the potential backlash in the stock market and other anxiety that such reports would cause (Beach, 2000). Many companies blamed Y2K for disappointing earnings results (Caldwell, 1999). Other events, such as the malfunction of a U.S. Defense Department satellite, may have been downplayed to alleviate fears that could have resulted from such news (Jones, 2000).

Another question that arose was "What responsibility, if any, do insurers have to cover the costs that businesses have incurred to 'fix' the Y2K computer bug?" Several companies -- about a half-dozen at this point -- said insurers ought to pay for at least some of the costs. In general, they turned to what is known as the "sue-and-labor clause" in making their case. Among the group are GTE Corp., Xerox Corp., Unisys Corp., and Blue Bell (Kroll, 2000).

The Year 2000 problems have reinforced this assertion. In an increasingly technologically sophisticated society, the reliance on computers carries significant risk. The incredible complexity of computers in both software and hardware means that the number of variables that can contribute to a serious failure is astronomical. Add business requirements, desire to save time and money, sleep deprivation, just plain laziness, and the probability of system failure increases that much more (Piven, 2000).

Given the newness of this situation, a preliminary review of the literature published up to this point has not revealed an intensive disclosure of the benefits derived from the many year 2000 remediation endeavors nor has it presented an all-inclusive report on the benefits and spinoffs uncovered by business and industry as a result of their individual Y2K efforts. This was, therefore, the impetus of this study: to go through a discovery process whereby these benefits and spinoffs were formally documented.

Goal

The goal of the researcher of this dissertation was to investigate the extent to which benefits and spinoffs may have resulted during the Y2K (Year 2000) remediation effort by business and industry. In this study, the researcher also sought to identify serendipitous benefits of Y2K-related projects and those factors that led to such benefits. A list of factors (independent variables) used to measure and identify these benefits was included in the methodology section of this study. Data concerning these benefits were collected through use of a survey instrument developed by the researcher. The instrument was distributed to an appropriate sample of large companies throughout the United States. A large company was defined as one with more than 500 employees for the

purposes of this study (Pride, Hughes, & Kapoor, 1996). The specific areas of business and industry that were targeted for this survey included financial services, health care, non-computer manufacturing, telecommunications, transportation, and utilities. After the surveys were completed and returned, the results were analyzed and conclusions drawn using the research hypothesis and research questions.

Hypothesis

The research hypothesis for this study was as follows: Organizations that have gone through year 2000 remediation have experienced unexpected benefits and spinoffs as a result.

Research Questions

In addition to the aforementioned hypothesis, the researcher in this study sought to answer the following research questions:

1. What types of benefits and spinoffs were most common? *(survey items 20-25)*
2. Were certain benefits and spinoffs serendipitous? *(survey items 26 & 27)*
3. What types of systems were mostly involved? *(survey items 5-19)*
4. What were the cost of remediation? *(survey items 1-4)*

There is evidence that these benefits have occurred. IT professionals report a host of benefits because of inventories, business analysis, and system testing completed under the umbrella of Y2K (Marsan & Cox, 2000). The problem may even represent a competitive opportunity, along with a number of internal and external benefits. These benefits include being able to reuse the materials developed to neutralize the problem, forced rationalization of system components, competitive advantage in a number of

business markets, improved business operations, increased systems flexibility, and enhanced delivery of new technology (Robertson & Powell, 1999).

New tools and disciplines were also created and implemented by IT organizations to make sure that their Y2K projects came in on time. In addition, it appears that the involvement of top executives has increased the awareness of how pervasive and critical IT is to business (Caldwell, 1999).

Relevance and significance

The Y2K cloud could hold a silver lining if senior management and IS (information systems) management both recognize the opportunities and act accordingly. Given that Y2K has presented IT departments with a wealth of benefits, both documented and undocumented, how can business and industry use this information? One obvious answer is future system and remediation efforts. This section will focus on how business, industry, and other organizations are benefitting from their Y2K remediation efforts.

How Y2K has helped corporate America

One specific example is General Motors. GM's Y2K spending was about $760 million that was spread out over several years. The benefits aside from doing business as usual were substantial. Inventories of every piece of computer hardware, software, networking gear, and embedded chips were necessary at GM, as well as at other companies performing Y2K fixes as part of Y2K preparedness. These inventories were "an absolute gold mine for opportunities such as cost reduction," said GM's corporate director Don Costantino (Caldwell, 1999).

For the sake of being prepared for Y2K, many companies mandated self-imposed system lockdowns, refusing to spend any money on any new or existing projects until the year 2000 had passed (Hoffman & King, 2000). Now that companies have finished spending billions of dollars on Y2K fixes, they will be able to afford other high-tech spending (Hawaleshka, 2000). Some companies set aside as much as 30% of their 1999 IT budgets to combat the possibility of Y2K rollover glitches (Y2K opens door to new era of e-commerce, 2000). Experts now agree that as Y2K fears subside, enterprises will move ahead with e-commerce projects at an unprecedented pace (Conry-Murray & Greenfield, 2000).

Another issue of paramount importance to the IT profession is that of hackers and computer viruses. Fearing attacks on their systems, many companies went into a high state of alert during the Year 2000 roll-over period and monitored their systems closely. This being the case, it would not have been good for a hacker to try to infiltrate a system since they would have been detected instantly (Radcliff, 2000). One example is that of Trend Micro that discovered fourteen new viruses during Y2K. These viruses were discovered immediately and cleaned before they could do any damage proving that close monitoring of computer systems can prevent harm resulting from such attacks (Hacker, virus writers hold back absent Y2K chaos, 2000).

The European Monetary Union (EMU) and other Y2K- type issues

In many ways, the EMU conversion presented a system challenge that is as serious as Y2K despite the scant attention that it has been given. Under this plan, the nations in the European community began conversion from their present respective

systems of currency to the new Euro dollar starting on January 1, 1999. This concern was echoed in a September 22, 1997/report, "The Future of IT" issued by the Gartner Group. In this report, it is stated that the EMU is very much an issue in the United States since so many organizations share code and financial information between U.S. and European operating companies (Beyond the Year 2000 computer issue, European Monetary Union looms as another major headache, says IMI Systems, 1997).

The Director of Technology at the Royal Bank of Scotland, a U.K. clearing bank, claimed that the cost of EMU readiness was three to four times that of Y2K readiness. Technologically, EMU and Y2K preparations involved similar efforts, but EMU will absorb twice as much user and business time. As in Y2K readiness, EMU readiness presented the need to inventory all software, conduct modify and regression tests, and manage the readiness of vendors, suppliers, and customers (Robertson & Powell, 1999).

Companies aggressively preparing for the euro see a golden opportunity to gain an edge on competitors in Europe simply by being ready to handle the new currency as it takes hold. Case, Chase Manhattan, Ford, State Street Bank, and Tectonics are among the multinationals spending millions of dollars and devoting huge staffs to the changeover, making euro readiness an IT and business priority (Violin, 1999).

There is another issue that has Y2K-type implications. A proposed amendment to Section 508 of the Rehabilitation Act would require all government web sites, as well as portals that belong to the 11,000 companies that do business with the government, to be user-friendly for physically disabled users (Kahn, 2001). The act seeks to remedy such situations as streaming audio that is not subtitled for the hearing impaired and keyboard

commands that do not account for those with limited mobility. In recent years, advocates for the disabled have been forced to use the courts to force web site operators to take disabled users into consideration. Revamping government and other Web sites nationwide is expected to cost about $690 million, mostly in fees paid to tech consultants and software developers.

The Y2K Senate Report

In its final report "Y2K Aftermath - Crisis Averted," the U.S. Senate Committee on Y2K stated that enduring lessons have been learned and benefits derived as a result of Y2K. Below is a brief quote from the report:

> There now exists a more through understanding of IT-related challenges, effective quantification of IT problems and their probable impact. There is also a higher awareness of the integral role IT plays in business functions, and the effort involved yo actively manage ephemeral information and high-tech organizational assets.
>
> As a result of Y2K, IT foundations and management mechanisms have been modernized. Critical infrastructure protection and other IT issues now rake higher among the mission priorities of corporate and government the executives. In addition, new public/private partnerships and more effective avenues of communication – both domestically and internationally – have been created their will be beneficial in addressing future IT challenges.
>
> The attention of executive-level personnel at vital stages of Y2K prioritizing, planning, and remediation has resulted in higher levels of accountability and reliability in IT management. For the first time – and at a critical juncture in the development of an IT–driven economy – private firms and public organizations have been forced to look critically at the role of IT assets and to manage them as mission-critical resources. Information systems, via strategic management, have graduated to the board room. (United States Senate Special Committee on the year 2000 technology problem, 2000, p. 17)

The report also stated that useful partnerships were also established internationally. Many international organizations were instrumental in highlighting worldwide Y2K awareness and stimulating action. Furthermore, Y2K prompted the government and the private sector to closely examine the IT infrastructure upon which they had come to rely. Another important revelation was that, to varying degrees, the entire business enterprise of virtually every private organization and government entity has been at risk to sudden access by outsiders. As contractors and subcontractors were brought in to do inventory assessments and to do testing and remediation of software and hardware, the organizations began to think carefully about the risk to information security.

Barriers and issues

The year 2000 problem has had wide ranging effects, with some companies claiming that related costs drove them out of business while others blamed Y2K costs for disappointing earnings results. Analysts have said that Y2K costs and effects have been difficult to pinpoint. In addition, it has been hard to determine which businesses were actually shut down or otherwise affected because of Y2K cost. However, companies admit that year 2000 costs were not the only culprit in poor year-end results, but it is certain that blame was and will be assigned freely (Caldwell, 1999).

In this section, an overview is presented of the effects that Y2K has had on business and industry. Some of the areas discussed in this section include the ways in which Y2K has affected company earnings, as well as how Y2K has been a factor in the closing of many businesses. Also, in this section, the legal ramifications of Y2K are

considered. But even though companies have been affected in a diverse number of ways, there have been many positive outcomes of Y2K as well. These positive outcomes will be talked about next. Finally, the limitations and delimitations of the study was discussed.

The nature of the problem

Many of the world's computers could not recognize a date that began with "20" instead of the familiar "19" because, to save space, programmers used only the last two digits to refer to a given year. It was feared that when the millennium finally arrived, thousands of computers around the world would interpret the year "2000" as the year "1900" and make a literal mess of daily life. Theoretically, fixing the Y2K problem was simple, but very time consuming. Someone had to examine every line of code in every computer, locate the instructions regarding the dates, and rewrite them to accept "2000" as the year designation. But despite the warnings, surveys indicated that too few managers in business and government recognized how little time was left to complete the task. In fact, one of the myths that surrounded the Y2K problem was that someone would develop a fix that would automatically cure all of the imminent problems that were bound to result (Stanglin & Ahmad, 1998).

Y2K effects

There have been numerous effects that were reportedly attributed to the Y2K phenomenon. These incidents range from laughable, minor or insignificant, to potentially dangerous. For example, 150 slot machines failed at race tracks in Delaware. Cash registers throughout the country of Greece printed receipts showing the year as "1900." Parking attendants at the University of Guelph in Ontario Canada were forced to

enter the date manually when a computer issued tickets dated in 1900 (Hawaleshka, 2000). Point-of-sale credit card companies posted transactions multiple times to credit card accounts, because they did not download an eleven-hour patch (Beach, 2000). Thousands of Medicare claims were rejected because they were dated 1900 or 2099 (Lehman, 2000). Numerous clock failures occurred, including one in a Federal building in whole Omaha Nebraska. These Y2K-related glitches resulted in a security system door remaining open. Other incidents included difficulty with clock synchronization and energy management system computers of several electric utilities. What would have happened if the clocks and the federal buildings and utility companies around the globe that suddenly stopped, allowing an open access to normally secure federal buildings? What if everyone had lost electricity for an indeterminable amount of time? (Beach, 2000).

One fear that never quite materialized was that of the hacker threat. The lack of Y2K related glitches denied hackers and virus writers an opportunity to launch attacks on the computers systems of the world. Nevertheless, enterprises were still in a high state of alert during the year 2000 transition. Hackers were expected to use the cover of Y2K as a means to create havoc on corporate networks, but since systems were "locked down," there was little chance of this happening. Although there were many cases where viruses were detected, they were immediately caught and cleaned up before any damage could occur (Hackers, virus writers hold back absent Y2K chaos, 2000).

Some of the effects of Y2K could be considered nothing less than frightening. The Department of Defense openly acknowledged that one of its satellite-based

intelligence systems sustained a hit from the notorious Y2K bug. DOD Deputy Secretary of Defense John Hamre stated that although the department could not process information for several hours, they never lost control of the situation. Hamre also said that operations were restored quickly because of backup procedures that were in place and that the effects were insignificant. The reason given for the problem was that the DOD performed modular testing due to an inability to do a comprehensive test of the system (Jones, 2000).

Other disturbing situations occurred as well. Nine nuclear plant incidents occurred in Japan, and seven occurred in the United States, all of which were apparently minor electric power supply problems. According to the press reports, the incidences did not involve a compromise of safety-related systems or require plants to be shut down. Wind-sheer alert systems malfunctioned in a number of airports across the nation including Atlanta, Denver, Orlando, and Tampa. Computer systems had to be, re-booted, which took two hours. What if aviation experts had not been able to rectify this system failure? Without operable wind shear alerts systems, airlines cannot guarantee safe operation of their planes, which increases the dangerousness of commercial flying. However, it is important to note that all of these organizations had gone to great lengths to remediate their systems; if they hadn't, the results would not have been so benign (Beach, 2000).

Strangely enough, even the lack of Y2K problems created difficulties. When Y2K problems did not materialize to slow the booming U.S. economy, investors started to worry about inflation, sending markets around the world tumbling. But by the week's

end, many of the markets were recovering, some going on to post record gains (Hawaleshka, 2000).

For many companies, the cost of Y2K remediation took a severe financial toll. For example, when Supervalu Inc., a $17 billion company that operates 4,600 supermarkets, closed its Cheap Foods store in Chippawa Falls Wisconsin in 1999, it attributed the move to competition from larger stores as well as to Y2K-related costs. Supervalu estimated its Y2K related expenses at approximately $26 million. Prodigy Communications Corp., meanwhile, discontinued Prodigy Classic in October 1999, due to the fact that the Y2K cost would have been in the millions of dollars. Late in 1998, Dialog Corp. made a similar decision about its Compuserve-based Knowledge Index database service (Caldwell, 1999).

Others companies have blamed Y2K for disappointing earnings results. In recent filings, Citigroup and Sabre Group Holdings Inc., acknowledged that their earnings had been reduced by year 2000 costs. Citigroup, formed by the merger of Citibank and Travelers, has put its Y2K remediation costs at around $650 million while Sabre has estimated its costs at about $85 million (Caldwell, 1999).

Legal issues

Y2K legal issues were potentially as complex and frustrating as the technological and administrative issues. Many companies believed that the costs associated with Y2K should have been covered in their insurance policies, but insurers told policy holders that these costs were covered. For example, GTE Corporation launched a claim suing a number of its insurers for $400 million. This claim now seems to be just the start of the

Y2K insurance litigation as Xerox Corporation also started a lawsuit against one of its insurers seeking $187 million. Both claims are for incurred costs and expenses and for any additional expenses that may incur in the future to avoid or minimize imminent loss to insured property as a result of the year 2000 electronic date recognition problem. In other words, the claims sought to have the insurance companies pay for the costs the policy holders incurred to remediate their operations to prevent losses due to Y2K (Ledroit & Millar, 1999).

Another legal aspect of the year 2000 problem concerned whether Y2K related costs should have been expensed or capitalized. Many companies were required to make extraordinary expenditures in new technology to solve Y2K problems. Anticipation of being able to use these expenditures as valid business expenses factored in as to what degree they were able to take Y2K preventive measures (Nicholson, 1998).

Worried that a flood of Y2K cases could result in unending litigation, Congress, in 1999, passed legislation to limit lawsuits related to the computer problem. When that measure was being considered, some legal experts estimated a possible price tag of $1 trillion in legal costs and damages stemming from Y2K-related suits (Thibodeau, 2000). The Y2K Act, as it was called, encouraged businesses to be proactive in addressing and remedying their Y2K challenges, rather than defensive and fearful of a predicted flood of lawsuits (Y2K shield law seldom used, 2000).

U.S. government investigators now report that companies invoked it in court just eighteen times. A congressional critic saw this as a "fitting Postscript" to Y2K alarms that never materialized (Y2K shield law seldom used, 2000). Senator Patrick Leahy, who

voted against the legislation and commissioned the General Accounting Office report, said the study "confirms that in the court, the Y2K bill was mostly used by big companies to do away or side track relief to consumers." He added, "this is a lesson for the next time special interests who ask Congress for special legal protections." A colleague who worked to pass the measure countered that it helped businesses concentrate on solving the Y2K problem. The report by the investigative arm of Congress showed that defendants used theY2K Act only twelve times in Federal Court and six times in State Court. The suits involved class actions by customers, disputes between businesses, and disputes against insurers. Compilers said they had no way to tell how many times the law was invoked to keep cases out of court. In many cases, defendants invoking the Y2K act eventually settled the cases or had them dismissed. Ten cases were pending when the report was released in September 2000. (Y2K shield law seldom used, 2000).

Positive outcomes

Although there have been a number of cost, time, and legal issues, Y2K remediation was not a waste. Overall, the U.S. spent more than $100 billion fixing the Y2K problem since 1995, according to John Koskinen, the federal government's Y2K czar. He estimated that the rest of the world spent an additional $100 billion to repair and replace computer systems and networks in preparation for the millennium date change (Marsan & Cox, 2000).

The fact is, corporate executives have noted a host of benefits that will be enjoyed for years to come. As IT executives close up their command centers, they're putting together the lessons they've learned from the Y2K drill. One of the biggest

advantages that they have noted is that Y2K forced them to thoroughly inventory and document IT systems and networks (Marsan & Cox, 2000). This in turn allowed for the elimination of redundant applications and obsolete systems, thus reducing support costs. Corporate networks were looked at very carefully, examined, and cleaned up making the move onto the Internet and creating e-commerce type activities easier. For example, Prudential Insurance created strategic inventories of its software, hardware, and business partners. Irene Dec, Prudential's Y2K problem manager, said these inventories would allow the financial services giant, headquartered in Newark New Jersey, to move faster in adopting computing standards, which will in turn simplify software development, management, and maintenance (Marsan & Cox, 2000). Dec added that Prudential's IS management could now get a complete view of the current computing environment and software development which helps them accurately plan how to move forward with changes.

In addition to hardware inventories, Y2K caused many companies to take stock of their software assets. Brad Whitworth, Y2K communications manager at Hewlet-Packard had this to say: "Companies historically have done a decent job of looking at hardware and thinking about things like how many PCs, how many servers, and upgrades. Y2K forced a lot of people for the first time to create an inventory of their software assets." Whitworth added regular inventories of software helped HP "get better use from the software itself. Regular software tuning and upgrades makes a lot of sense. If it had been for Y2K, we probably wouldn't have done any revisions," so said Whitworth (McKendrick, 2000, p. 12).

During the Y2K rollover, computer hacking activity was actually lower than normal. In fact, it would have been the worst opportunity to try and hack into a system because the attacker would be noticed instantaneously. Moreover, hackers may have been deterred by the scrutiny of system administrators, who monitored their networks around the clock for suspicious activities. With all the focus on the Y2K problem, "anyone would have been a fool to have tried something," said Mike Higgins, president of Para-Protect, a Security Consultancy (Hackers, virus writers hold back absent Y2K chaos, 2000, p. 3). The lesson to be learned here it is, if networks could be monitored this closely all the time, computer hackers would be much less of a threat (Radcliff, 2000).

In coordinating Y2K remediation efforts, IT staffs also gained valuable experience with project management tools that will be put to use in the future. The Y2K coordination efforts have led to better working relationships for IT departments, within their organizations and with suppliers and partners (Marsan & Cox, 2000).

Y2K also precipitated a wealth of reusable materials. Many of the materials developed in a typical Y2K bug-neutralization program such as inventories, test plans, and test cases, are, if maintained properly, reusable in future projects in an ongoing management of corporate technology facilities–hence they have the potential to deliver continuing benefits. The key to this value is that the materials are comprehensive, validated, and maintained. Materials available under less dramatic circumstances than the panic over the Y2K risk usually satisfy none of these criteria. The benefits of reusable materials include improved control, a defined base, and better processes for future developments (Robertson & Powell, 1999).

Yet another positive outcome of Y2K was that companies have analyzed and prioritized their business systems and created disaster-recovery plans. "Y2K opened up a lot of eyes as to how large our network is and that it provides a lot of functionality," said Mike Green, a senior messaging analyst with Thomson Financial in Boston. "We had to consider what we would do if everything fell on its face . It forced us to consider our policies, procedures, and documentation." Procedures for testing applications, testing systems, and their interoperability were also tightened allowing IT departments to deliver higher-quality software, on time and at lower cost (Marsan & Cox, 2000, ¶12).

In addition to limiting the potential risk to IT and related systems, one of the most important benefits was the increase in awareness and understanding of IT as a strategic boardroom issue. As a direct result of Y2K planning, many senior managers now have a better understanding of the processes that are core to the organization and are of broader importance to business continuity management. But in order to take full advantage of this particular benefit, structures and processes put into place to involve senior management in the effective invocation of business continuity plans should be maintained to ensure the effective running of the business in the even of a major disruption (Dennis, 2000).

In its final report, a U.S. Senate committee that was established in 1998 to monitor the year 2000 problem concluded that in addition to averting major problems, Y2K preparations provided "enduring" benefits (Lehman, 2000). Although hundreds of Y2K problems were reported worldwide since the date changed to 2000, they have been relatively minor, according to the report, which was issued February 29 and includes an

extensive list of incidents in the U.S. and 74 other countries. The 13-page report lists numerous Y2K incidents in transportation, utilities, government, and business systems.

Federal estimates set the cost of the year 2000 preparations in the U.S. at $100 billion, with 8.4% of that amount spent by the government. But observers' estimates put the figure much higher – from $150 billion to $225 billion in the U.S. government and business expenditures, as estimated by Stamford Connecticut-based Gartner Group Inc., to International Data Corporation's (IDC) $320 billion worldwide estimate.

According to Dale Vecchio, a Y2K analyst at the Gartner Group, much of the money spent preparing for the bug can be attributed to "modernization costs," expenditures that are now returning high dividends. In fact, "You're probably getting back $6 or $7 for every dollar you spent," said Capers Jones, a chief scientist at Artmis Management Systems in Boulder Colorado, who analyzes software issues (Lehman, 2000, p. 8).

The United States Senate Special Committee on the Year 2000 Technology Problem concluded that in addition to averting major problems, Y2K preparations provided "enduring" benefits. "Most significantly, the IT infrastructure and mechanisms for more effectively managing it have been modernized," the report stated (Lehman, 2000, p. 8). "Also, Y2K has caused a heightened level of knowledge among executive-level managers as to the importance and vulnerabilities of information technology" (Lehman, 2000, p. 8). To most, Y2K money was money well spent. "Technological improvements aside, the money was still well spent if we got nothing more than the silver

linings of the Y2K that accrued to almost everyone involved-such as skills, knowledge, and attitudes," said Leon Kappelman, associate director of the Center for Quality and Productivity at the University of North Texas. Kappelman added: "We know we got plenty more than that any way " (McKendrick, 2000, p. 13).

Limitations and Delimitations

As stated previously in this document, the data about benefits gained from Y2K was gathered through the use of a survey instrument developed by the researcher that was administered to an appropriate sample of large companies throughout the United States. In the following section, the limitations and delimitations of this type of study are discussed.

Limitations

Salant and Dillman (1994) stated that sample surveys yield accurate results when researchers succeed in avoiding four kinds of errors. These are coverage errors, sampling errors, measurement errors, and non response errors. Coverage errors occur when the list or frame from which a sample was drawn does not include all elements of the population the researchers wish to study. Sampling errors occur when researchers surveyed only a subset or sample of all people in the population instead of conducting a census. In reference to this study, only a sample of large companies throughout the United States were surveyed. Since this will constituted the sample frame, the results of this study may not accurately reflect the results seen in mid-sized or small businesses.

Measurement error can occur when a respondent's answer to a given question is inaccurate, imprecise, or cannot be compared any useful way to other respondents answers. To guard against this type of error, Salant and Dillman suggested that clear, unambiguous questions be written that people can and want to answer. Since pretesting and validation of the survey instrument was be part of this study, it is hoped that measurement error was kept to a minimum.

Non-response errors occur when the number of people in the survey sample do not respond to the questionnaire and/or are different from those who do respond in a way that is important to the study. The survey in this study was by performed by allowing the respondents to complete a survey form on World Wide Web or a hard copy that was mailed to them. Since this study was administered to members of the information technology community, it was assumed that these individuals would have access to the Internet, and therefore the survey instrument. Although the respondents were given a choice of methods, the response rate was still low meaning that any results based on correlation could be spurious.

Delimitations

The scope of this study was limited to 250 large companies within the United States so that the project remained "doable." While in the process of determining what independent variables would be included in this study, serious consideration was given to include several variables that made inquiry into how much of an organization's total budget and time were spent on Y2K remediation efforts. While these variables are definitely measurable and could have a significant impact on the study, the decision was made not to include them due to a concern that many companies might not want to divulge such information, therefore affecting the response rate of this study. The content

of the survey instrument was structured so that emphasis was placed on the benefits and spinoffs of Y2K (the serendipity effect) and not on specific problems, difficulties, time, or budgetary issues that any of these businesses may have experienced.

Definition of terms

Following is a list of terms used within this study:

Y2K - Year 2000 Technology Problem (United States Senate Special Committee on the year 2000 technology problem, 2000). In an effort to conserve space, many computer programmers had used a two-digit date format instead of a four-digit date format in their code. This meant that at midnight on January 1, the date would be interpreted as 1900 instead of 2000. Computer programs frequently use date computations in their respective algorithms (Stanglin & Ahmad, 1998).

Y2K remediation - The process by which a company, business, or organization made corrections, adjustments, and/or modifications to its computer systems and code in order to correct for problems caused by the year 2000 computer problem (Marsan, 2000).

IT - IT (information technology) is a term that encompasses all forms of technology used to create, store, exchange, and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations, and other forms, including those not yet conceived). It's a convenient term for including both telephony and computer technology in the same word. It is the technology that is driving what has often been called "the information revolution" (Search390.com).

Serendipity - Positive events or occurrences that have come unexpectedly or as a byproduct of a search for something else (Marino, 1998).

Large company - A company having more than 500 employees (Pride, Hughes, & Kapoor, 1996).

Likert scale - A scale that asks an individual to respond to a series of statements by indicating whether she or he strongly agrees, agrees, is undecided , disagrees, or strongly disagrees (Gay, 1996).

General Linear Model - The general linear model is powerful heuristic device that can help researchers see three important commonalities that exist across various analytic methods. First, all these methods use weights to optimize explained variance and minimize model error variance. Second, all methods focus on the latent or synthetic variables created by applying the weights, such as beta weights, to scores on measured or observed variables. Third, all methods are correlational (Grimm & Yarnold, 2000).

ANOVA (analysis of variance) - ANOVA is a set of analytic procedures based on a comparison of two estimates of variance and is used when two or more means are compared to see if there are reliable differences among them (Tabachnick, 1989).

MANOVA (multivariate analysis of variance) - MANOVA is a generalization of analysis of variance in which there are two or more dependent variables. MANOVA tests whether mean differences among groups on a combination of dependent variables is likely to have occurred by chance (Tabachnick, 1989).

Canonical Correlation Analysis - A statistical methods employed to study relationships between two variable sets when each variable set consists of at least two variables (Thompson, 1984).

Within-group Variance - Also know as error variance, the variance that would naturally occur within a group totally by random chance (Gay, 1996).

Between-group Variance - The amount of variance between groups caused by manipulation of variables (treatment) (Gay, 1996).

Summary

In this section, the origin of the Y2K problem was discussed along with the implications of its probable effects had sufficient precautions not been taken. Also discussed were various reactions from both the public and private sectors that occurred once the problem had been identified and publicized. While the response from many in the public arena was that of panic and at times even apocalyptic, business and industry faced the problem head-on with much more resolve realizing that it had become a matter of allocating the funds and the manpower to get it fixed.

As the Y2K remediation process continued and began to conclude, many organizations claimed that they had seen benefits that surpassed expectation. There were many that began to tout their Y2K experiences as beneficial, even serendipitous and claimed that the effort was well worth the cost.

Since a preliminary review of the literature to date has shown that there have been positive effects of the Y2K remediation effort, the researcher attempted to measure and

correlate these factors with the various remediation actions taken. The procedures involved the use of a survey instrument that was completed by a number of large businesses within the United States.

Chapter 2

Review of the Literature

Introduction

This chapter begins with a historical overview of the origin of the term "serendipity" since the goal of this research was to discover unexpected (serendipitous) benefits and/or spinoffs of the Y2K remediation process. This chapter will also discuss the role serendipity has played in science, medicine, archeology, and industry. Next, it will elaborate on the background and history of the Y2K (Year 2000) computer problem, as well as discuss the possible effects and implications had the appropriate precautions not been taken. Finally, this chapter concludes with a discussion of the positive side of Y2K and the potential contributions from the results of this study. A summary of the statistical procedures used is also given.

Historical overview of the theory and research literature

Horace Walpole coined the word serendipity in 1754 after reading the Persian fairy tale "The Three Princes of Serendip," in which the princes had the unusual knack of making fortunate discoveries accidentally (Marino, 1998). Looking back through history, numerous accounts of serendipitous events can be found. But does serendipity occur by accident or is it a byproduct of hard work? Robinson and Stern (1997) stated that serendipity is present in every creative act whether it is apparent or not.

Innovations throughout the 20th century have demonstrated the power of serendipity: the airplane was not invented by the transportation industry, the camera was not invented by the photographic equipment industry, and synthetic fiber was not invented by the textile industry. All were developed by serendipitists from idea junk stored in their mental databases. All were outside-the-box thinkers (Marino, 1998).

Several aspects of serendipity are discussed in the following review of literature. In the section on historical serendipity, several past events involving serendipitous discoveries are discussed. The next section, scientific serendipity, relates how numerous discoveries in the field of science came about in unexpected ways. The section on medical serendipity deals with important unanticipated medical findings that have had a significant impact on health care. Many discoveries in the field of archeology have been of a serendipitous nature and the section on archeological serendipity discusses one particular example. Many well-known, commonly used products and brand names are discussed in the section on industrial, commercial, and business serendipity.

The next section, the theory and research literature specific to Y2K remediation, contains a discussion of factors that cause creativity to occur within a corporation; one of the main elements being serendipity. In the section on what is known and unknown about Y2K remediation, documented proof of unexpected benefits is presented. The last section of this review of literature suggests possible benefits and contributions this research will make to the field of computer science.

Historical Serendipity

One of the earliest recorded instances of serendipity involved the Greek mathematician Archimedes who lived in the third century B. C. (Archimedes, 1998). He is known for contributions such as the invention of the lever, the "Archimedes screw" that was used to raise and lower the waters of the Nile for irrigation, and the law of hydrostatics which is sometimes called the "principle of Archimedes." It was he who ran naked from the public baths through the streets of Syracuse shouting "Eureka, eureka!", "I found it."

What had he found? To answer this question, an understanding of exactly what Archimedes had on his mind when he stepped into the public baths that day is necessary. Hiero, the king of Syracuse and a friend to Archimedes had commissioned a local goldsmith to make a crown for him from pure gold. Upon receiving the crown, Hiero had doubts about whether the goldsmith had put all the gold into the crown. Could the goldsmith have substituted other metals into the crown and kept part of the gold for himself?

King Hiero called his friend Archimedes and presented the famous mathematician with the problem of finding out if the crown was in fact, pure gold. Archimedes had previously worked out formulas for the volumes of other irregular solids such as spheres and cylinders. He realized that if could determine the volume of Hiero's crown, he would be able to tell if the crown was pure gold since gold was more dense than other metals.

When Archimedes stepped into his bath, he noticed that the amount of water that ran over the top of the tub was exactly equal to the bulk of the part of his body submersed

below the surface of the water. He deduced from this occurrence that, using this technique, he could measure the volume of any irregularly shaped object.

It was now a simple matter to measure the volume of the king's crown. When the crown was measured, it was discovered that the volume of the crown was considerably greater than it should have been for one made of gold. The dishonest goldsmith received swift justice in the form of execution. So this serendipitous discovery of a way to measure the volume of a solid is what caused Archimedes to dash out of the public bath unaware that he had left his cloths.

There is also a legend from South America concerning an Indian who, burning with fever, was lost in a high jungle of the Andes (Roberts, 1989). Several species of the cinchona tree (known by the Indians as the quina-quina tree) grow on the warm most slopes of the Andes mountains. As he stumbled through the trees, he found a stagnant pool of water and threw himself to the ground at the edge of the pool to drink the cool water. One taste of the bitter water told him that it was tainted with the bark of the neighboring quina-quina trees which were thought to be poisonous. Caring more for the temporary relief of his burning thirst and fever than for the possible deadly aftereffects, he drank deeply.

To his surprise, he did not die; in fact, his fever abated and he was able to find his way back to his native village with renewed strength. He told the story of his miraculous cure to his friends and relatives and after that, they used extracts from the bark of the quina-quina tree to cure the dreaded fever. The fever was caused by malaria and the

discovery that the Indian made, purely by serendipity, was quinine. Quinine was the first chemical compound used to treat malaria.

Scientific Serendipity

Other examples of serendipity are abundant, but of particular interest of those examples that occurred during the last several centuries. For example, Sir Isaac Newton was a British physicist and mathematician who is regarded as one of the greatest scientists ever to have lived (Isaac Newton, 2000). In physics, he discovered the three laws of motion that bear his name and was the first to explain gravitation, clearly defining the nature of mass, weight, force, inertia and acceleration. He had already considered the motion of colliding bodies and circular motion, and had arrived at ideas of how force and inertia affect motion and of centrifugal force. As serendipity would have it, Newton was inspired to consider the problem of gravity by seeing an apple fall from a tree -- a story that, according to Newton himself, is true. He wondered if the force that pulled the apple to the ground could also extend into space and pull the Moon into an orbit around the Earth. Thus, was born his theory of gravity. Newton also found that his theory explained the laws of planetary motion that had been derived earlier that century by Johannes Kepler on the basis of observations of the planets. Serendipity had made itself known in the form of an apple.

And then there's the story of Joseph Henry, the most famous American physical scientist of his day (Millikan, 1997). Henry never got the chance to go to college and never learned to spell correctly. Henry was born in Albany, New York, on December 17, 1797, the son of an alcoholic cartman who died when Joseph was 13. Even before his

father's death, Henry had to live with relatives while his mother struggled to make ends meet and raise his siblings. Henry wasn't able to pursue formal schooling beyond the elementary level until his early twenties, when he enrolled as an overage student in the Albany Academy, the equivalent of high school. The academy emphasized mathematics and physical science, and its principal, T. Romeyn Beck, had a strong interest in science. Beck made Henry his chemical assistant after Henry completed his studies. As scientific serendipity would have it, even as Henry was pursuing his meteorological research, he was also making the scientific discoveries in electromagnetic induction that undergirded the telegraph, the invention that would soon revolutionize communications and make weather forecasting possible. Henry conceived of the telegraph as a teaching device, and with a practical, ground-breaking experiment, demonstrated how to transmit an electric current with sufficient force to produce a mechanical effect at a distance. In so doing, Henry proved it was possible to make a practical telegraph.

The first successful photographic process was invented by L. J. M. Daguerre in 1838 (Downey, 1996). Until this time, people had to rely on artists for the likeness of famous persons. There are two distinct scientific processes that combine to make photography possible (Leggat, 1999). It is somewhat surprising that photography was not invented earlier than the 1830s, because these processes had been known for quite some time. It was not until the two distinct scientific processes had been put together that photography came into being.

The first of these processes was optical. The Camera Obscura (dark room) had been in existence for at least four hundred years. There is a drawing, dated 1519, of a

Camera Obscura by Leonardo da Vinci; about this same period its use as an aid to drawing was being advocated. The second process was chemical. For hundreds of years before photography was invented, people had been aware, for example, that some colors are bleached in the sun, but they had made little distinction between heat, air and light.

Daguerre formed a partnership with Frenchman by the name of J. N. Niepce who had also been working on the photographic process. In 1833, Niépce died, but Daguerre continued the experiment. Up until this point, all progress on the photographic process had been a result of hard work. However, the next major advance in this process occurred as a matter of serendipity.

Daguerre had prepared plates of highly polished silver-plated copper and exposed them to iodine vapor, which produced a thin layer of silver iodide on the surface (Downey, 1996). Using his camera obscura, he exposed the plates causing a faint image to appear. He tried many ways different techniques to intensify the image, but met with no success. One day he placed the exposed plate, which he intended to clean and use again, in a cupboard containing various chemicals. After several days, he removed the plate and found a strong image on it surface. After much trial and error, he ultimately found out that the image had been developed as a result of mercury vapor from a broken thermometer in the cupboard. The result was the "Daguerreotype." Thereafter, photographers developed the latent image by placing an exposed plate over mercury heated to about 75 degrees Celsius.

Medical Serendipity

One of the most famous teaching tools about serendipity is the case of the floppy eared rabbits (Downey, 1996). One researcher studying the enzyme papain found that every rabbit given a papain injection later suffered floppy ears. Another researcher ignored the floppy ears while the first eagerly followed up on his chance findings. The case of the floppy eared rabbits led to new knowledge about treatments for cartilaginous tissues

Edward Jenner is credited with presenting to the world a vaccine which has saved many millions of people from a horrible death from smallpox and many more millions from the disfigurement the decease can cause (Jenner, 1998). At the age of 19, he was told by a milkmaid that she would never have smallpox because she had had cowpox before. He later investigated and found that milkmaids almost never contracted smallpox, even when they nursed those whom the deadly disease infected. The idea of inoculating patients with cowpox to prevent them from having smallpox occurred to him. The fact that cowpox gave immunity to smallpox came to him without effort on his part; he had the good judgement to recognize its value and make use of it.

At age 21, he went to London to study under a famous doctor, John Hunter. Although Jenner had many interests, he began to focus on medicine and was later granted an M.D. by St. Andrews. Meanwhile, the idea of vaccination was maturing in his head.

In May 1796 he inoculated an eight-year-old boy with matter taken from the vesicles (blisters) on the hands of a milkmaid infected with cowpox. The following July, the young boy was inoculated with smallpox, but he did not develop the disease. One

wonders why the parents of the young boy allowed Jenner to perform such an experiment on their child. A possible explanation is that, during this time, many people were inoculating themselves with smallpox preferring to take the smaller chance of dying with the inoculated disease than with the more deadly, often fatal natural one. After many more successful inoculations, news of Jenner's discovery spread all over the world.

Sometimes, serendipity can be explained in no other way than sheer luck. Alexander Fleming, one of London's foremost bacteriologist, is a good example (Parshall, Folkers, Brownlee, Peruyera, Cook, & Licking, 1998). Fleming, a poor farmer's son risen to a learned profession, spent nearly his entire career as a bacteriologist at St. Mary's Hospital in London. Serendipity made two notable visits to his lab. The first came in 1922, after Fleming, suffering from a cold, sneezed on a culture plate. He observed that when bacteria later formed on the plate, none developed in the spots of mucus. Pressing his investigation, Fleming discovered lysozyme – a substance found in body fluids and tissues that dissolves bacteria. He thought it might be the key to a potent natural antiseptic but soon lost interest; tests showed that it acted against harmless organisms only.

Serendipity came calling again in 1928 when a mysterious mold sprouted on a discarded culture plate that had gone unwashed for two weeks while Fleming was on holiday (Parshall, Folkers, Brownlee, Peruyera, Cook, & Licking, 1998). Once again he observed anti-bacterial action – bacteria covered all of the plate except where the mold was. Yet this time the bacteria affected were staphylococci, a source of serious and sometimes deadly human infection. The mold juice proved able to retard the growth of

many other kinds of virulent bacteria as well. Fleming called this new substance penicillin after identifying the mold and a type of Penicillium. However, Fleming recognized his discovery as an antiseptic and nothing more. Years later, a pair of Oxford scientists by the name of Howard Florey and Ernest Chain began investigating Fleming's serendipitous discoveries. After years of painstaking work and experimentation with laboratory animals, Florey and Chain finally uncovered the miraculous benefits of the penicillin vaccine.

The entire history of antibiotics is one marked by serendipity and chance. Although penicillin had proven to be a miraculous drug, a strain of "hospital staphylococcus" had become resistant to all the antibiotics currently available by the early 1950s (Hamilton-Miller, 1999). The actual solution to this problem had occurred some years prior to this date.

In July 1945, Giuseppe Brotzu, Professor of Hygiene at the University of Cagliari, Italy, isolated a fungus, identified as Cephalosporium acremonium, from a local sewage outfall. As serendipity would have it, Brotzu's original intent was to study the possible function of the antibiotic in the self-purification of sewage (Roberts, 1989). Cultures of this fungus inhibited several important pathogens, including Salmonella typhi and Brucella melitensis.

Brotzu, while realizing the potential of this discovery, appreciated that he had neither the facilities nor the expertise to exploit it fully (Hamilton-Miller, 1999). Having published his results in 1948, he arranged, through a British acquaintance, for the fungus to be sent to The Sir William Dunn School of Pathology at Oxford, UK. There, Sir

Howard Florey (Professor of Pathology) asked Edward Abraham to investigate the antibiotic properties of this culture. Most of the subsequent work was done jointly with Guy Newton. Now Florey asked Abraham to concentrate on cephalosporin C, which he saw as a possible agent against the hospital staphylococcus that had become resistant to all the antibiotics currently available. Using material from a mutant of Brotzu's fungus that made larger amounts of cephalosporin C, Newton and Abraham were able, despite considerable controversy, to deduce its exact chemical structure.

In order to produce semisynthetic cephalosporins, acid hydrolysis yielded trace amounts of 7ACA which, on reaction with phenacetyl chloride, gave the highly micro biologically active cephalosporin analogue of penicillin G. From this point, the pharmaceutical industry took over; an efficient process for 7 ACA production was followed by an inventive series of reactions that enabled penicillin to be converted directly to the corresponding deacetoxy cephalosporin. This chemistry ushered in the era of the semisynthetic cephalosporins that continues to this day.

Serendipitous discoveries with pharmaceuticals sometimes can provoke side effects that are not at all unwanted. When a new blood-pressure pill known as minoxidil went into popular use in the late 1970s, the makers of the drug began receiving reports from patients concerning new hair growth (Downey, 1996). Researchers for Upjohn Company tested their product again and found it would indeed grow new hair.

In 1988, minoxidil was reformulated into a cream to be rubbed onto the skin of men's shiny pates. In 1991, the formula was tested and approved for women with hair-loss woes. The minoxidil cream also stimulates better growth of transplanted hair

plugs. Users of the cream, however, do not experience lowered blood pressure. Scientists aren't sure why minoxidil spurs hair growth. One theory holds that the drug reverses the "miniaturization" of hair, in which individual hairs become smaller and weaker before falling out.

Interferons were described by Isaacs and Lindenman as a group of proteins and glycoproteins, produced by cells to combat virus infections (Roberts, 1989). The possibility of a new cancer drug, therefore, caught the eye of the press, the public, and the medical world. The progress in applying these agents in the clinic was very slow due to the difficulty in obtaining enough of the material. This changed a few years later when the first human interferon genes were cloned.

A chance observation during a clinical cancer experiment in 1984 led to a surprising discovery. Injections of interferon seemed to relieve the pain and swelling of rheumatoid arthritis. In preliminary studies, it was shown that the hormone worked in about two-thirds of the people who were not helped by conventional treatment. It was reasonable to assume that if these results were general, a whole new market would open up for genetic engineering's mass-produced human hormone.

This serendipitous discovery of the effect of the cancer drug against arthritis was made during a study at Bioferon, a German subsidiary of the biotechnology firm Biogen. Dr. Seth Rudnick said that a few patients who had both cancer and rheumatoid arthritis showed improvements in the pain of arthritis. Further tests in Germany found that 28 out of 38 patients were relieved of their arthritis pain with the pain totally subsiding for some.

The discovery of lithium as a psychoactive drug was one of the most improbable of all (Roberts, 1989). In the late 1940s, John Cade, a young Australian psychiatrist, speculated that the mania associated with manic-depressive illness might be caused by the abnormal metabolism of uric acid. In order to test his theory, he injected uric acid, in the form of a lithium salt along with lithium carbonate, into test animals. A dramatic therapeutic response was observed. Although his finding were published in an Australian journal, few psychiatrist took note of his work until the mid-1950s.

A Danish doctor, Mogens Schou, happened to run across Cade's paper and decided to test his compounds. Schou also found Cade's compounds effective in the treatment of mania. However, it soon became apparent that the uric acid had nothing to do with its effectiveness; it was the lithium salt that had been responsible for the therapeutic effect. Other lithium salts were consequently discovered to work as well.

Pharmaceutical companies were reluctant to commit to large-scale production since lithium salts were common and could not be patented. Another factor was a concern that the lithium ions might compete with the chemically related sodium ions in the body and have toxic effects.

Finally, around 1970 (more than 20 years after this discovery), lithium salt was introduced into the American psychiatric practice. The simple lithium ion is the most effective agent ever identified for the treatment of mania, but the mode of its action is still a mystery.

One commonly used artificial sweetener was also discovered by accident. After working on an ulcer cure in 1965, Jim Schlatter, a researcher at pharmaceutical-maker

G.D. Searle, turned up a tasty discovery (Downey, 1996). While researching two amino acids, normally a bitter- tasting concoction, Schlatter dabbled with some of the powder and unconsciously licked one of his fingers before turning a page from a study he was reading. The powder tasted sweet. Schlatter immediately knew he was on to something, because the powder, now known as aspartame, is utilized by the human body as a protein and therefore much lower in calories than sugar.

For the next sixteen years, aspartame was studied and finally gained approval from the United States Food and Drug Administration in 1981. Today, 5,000 tons of the sweetener, known commercially as Equal, is used every day in 5,000 products worldwide by 200 million people in about ninety nations.

Archeological Serendipity

One could safely say that many of the discoveries in the field of archeology could be considered serendipitous. For example, in 1947 two Bedouin shepherd boys were grazing their goats in Jordan along the barren cliffs bordering the northwest coast of the Dead Sea. An opening in one of the cliffs caught the attention of the shepherd boys and they decided to investigate further (Dead Sea Scrolls, 1992). The two boys managed to crawl inside the cave where they found several large earthen jars. In some of the jars, they found aged scrolls of parchment wrapped in linen. The boys took the scrolls back to their camp and later, some were sold to a Syrian merchant who sent them to Athansius Yeshue Samuel the Syrian Metropolitan of St. Mark's Monastery at Jerusalem. After an initial examination by series of experts, the scrolls were pronounced to be worthless.

But the archbishop was not convinced and sent them to the American School of Oriental Research in Jerusalem (Dead Sea Scrolls, 1992). It was there that the archaic forms of the Hebrew letters on the scrolls convinced Drs. John C. Trever and William Browlee of the sensational nature of the documents. Photographs of sections of one scroll (the book of Isaiah) were sent to Dr. William F. Albright, and authority on Hebrew paleography at John Hopkins University where he dated them at about 100 B.C. and called the scrolls "an absolutely incredible find." These scrolls antedated all but a few fragmentary Biblical manuscripts by 1,000 years.

Hostility between Arabs and Jews delayed further investigation by archaeologists until 1949 (Dead Sea Scrolls, 1992). The impoverished Bedouin of the area saw the possibility of a new source of income and began to busily scour the thousands of cracks and fissures in the wilderness near the Dead Sea. Since then, fragments of nearly 400 separate scrolls have been found, including portions of every book of the Old Testament except Ester. Further investigation by both Bedouin and archaeologists disclosed the remains of an ancient monastic settlement of an ascetic Jewish sect known as Essenes who produced and hid the scrolls.

Industrial, Commercial, and Business Serendipity

In the early sixteenth century, Columbus and other explorers found South American Indians playing games with a ball formed from a vegetable emulsion called latex exuded by certain trees (Bandrapalli, 1998). Although the Spanish explorers brought some of this "India gum" back to Europe, no practical use was found for it until Joseph Priestly, the discoverer of oxygen, found it could be used to "rub" out pencil

marks. Thus, it became known as "rubber." The main problem with this newly discovered substance was that it became soft and sticky at higher temperatures and stiff and brittle at lower temperatures.

At this point, Charles Goodyear entered the picture (Bandrapalli, 1998). After many attempts at making a more useful rubber product involving many different chemical substances, he accidentally allowed a mixture of rubber and sulphur to touch a hot stove. To his surprise, the rubber did not melt but only charred slightly. Goodyear immediately perceived the significance of his discovery, a process that became known as "vulcanization." Goodyear had serendipitiouly produced a rubber product with the characteristics needed to make it useful in hot and cold temperatures.

Glass has been around for a long time. We know that the Romans even used it for windows. In 1903, a French chemist named Edouard Benedictus, dropped a glass flask on a hard floor (Roberts, 1989). The flask shattered, but to his surprise, the fragments of glass did not fly apart. In fact, the flask retained its original shape. Benedictus examined the flask and found that it had a film on the inside to which the glass had adhered. This film had come from the evaporation of a solution of collodion (or cellulose nitrate, prepared from cotton and nitric acid) which the flask had contained. Benedictus made a note on the flask and put it away, but thought no more about it then.

Some time later, Benedictus read about a young girl who had been injured in an automobile accident by flying glass from a broken windshield. A few weeks later, he again read an account of an injury involving flying glass. It suddenly occurred to him that the incident with the broken flask could provide a solution to this dilemma.

Benedictus rushed back to his laboratory and began contemplating how a coating of some sort could be used to make glass safe. It is said that by the evening of the same day, he had produced the first sheet of "safety glass." The name "triplex" was coined for the new glass since it consisted of two sheets of glass with a layer of cellulose nitrate between them, bonded together with heat. Although Benedictus invented safety glass for use in windshields, this was not the first practical use. It was used first in World War I in the lenses of gas masks. It was not until the 1920s that safety glass became standard in automobiles.

Sometimes, serendipity takes other forms such as chance meetings between individuals. It was just such a chance meeting on a train platform in 1944 that led to John von Neumann's involvement in the electronic computer (Parshall, Folkers, Brownlee, Peruyera, Cook, & Licking, 1998). Herman Goldstine, a mathematician and the U.S. Army's liaison on the ENIAC (electronic numerical integrator and computer) project, recognized von Neumann and introduced himself. Von Neumann agreed to go to the Moore Engineering School at the University of Pennsylvania to see ENIAC.

Von Neumann had been a classic prodigy child. He had scarcely outgrown baby food before he was gulping down science and world history. When he was not yet out of high school, mathematicians were already treating him like a colleague. In his 20s, the milestones flew by--the award of his doctorate, appointments to the Universities of Berlin and Hamburg, publication of papers noticed around the world, including one in which he mathematicized quantum mechanics. A summons from Princeton brought his migration across the Atlantic in 1930. And in 1933 the 30-year-old von Neumann became the

youngest professor at the Institute for Advanced Study, a new think-tank stocked with big catches, Albert Einstein among them.

Ten feet high and 100 feet long, stuffed with 17,000 vacuum tubes, ENIAC was bigger than a dinosaur. But it had no more memory capacity than a gnat. Unleashing it on a new task meant laborious manual reprogramming, with a host of operators throwing switches and replugging cables. ENIAC' s designers, J. Presper Eckert and his partner, John Mauchly, welcomed the intrigued von Neumann as a consultant. They were completing ENIAC and designing its successor, eventually dubbed EDVAC (electronic discrete variable arithmetic computer).

The outlines of the stored-program computer took shape in the next several months as Eckert, Mauchly, and Goldstine met with von Neumann. At the core were five functional units, which von Neumann called central control, central arithmetic, input, output, and memory. The memory unit would hold both a program's instructions and the numerical data on which it operated. Eckert and Mauchly later claimed paternity of all these concepts when they sought unsuccessfully to patent EDVAC. They were, indeed, EDVAC's electronic wizards. But von Neumann was clearly its master logician; the elegant imprint of his mind was unmistakable. He described the stored-program computer in a 101-page "draft report." Mimeographed by the Moore School in June 1945 and finding its way to a small network of interested people in America and Britain, von Neumann's summary became the seminal work of a new industry.

Teflon is the trade name for polytetrafluoroethylene, the billion-dollar product of the Du Pont company used for various items such as nonstick frypans, space suits, and

heart valves (Roberts, 1989). Its discovery resulted from an accident observed by Roy J. Plunkett, a young Du Pont Chemist who had just received his Ph.D. from Ohio State University.

On April 6, 1938, Dr. Plunkett opened a tank of gaseous in hopes of preparing a nontoxic refrigerant from it. When no gas came out of the tank, Plunkett first checked the valve and after determining that the valve was not faulty, sawed the tank open. There he found a waxy white powder. The molecules of the gaseous tetrafluoroethylene had combined with one another to such an extent that they now formed a solid material.

The waxy white powder possessed remarkable properties. It not affected by strong acids, bases, or heat, no solvent could dissolve it, and was very slippery. In spite of its unusual properties, probably nothing would have come of it had it not been for World War II. Scientists involved in creating the first atomic bomb needed a material for gaskets that would resist the viciously Corrosive gas, uranium hexafluride, one of the materials used to produce the U-235 for the bomb.

General Leslie R. Groves, responsible for the U.S. Army's part in the atomic bomb project, happened to learn from Du Pont acquaintances about the inert new plastic. Told that it was expensive, General Groves replied that cost was not an object in this project. So the substance, now known as Teflon, was compounded into gaskets and valves and proved indeed to be resistant to the corrosive uranium compound. Du Pont produced Teflon for the government for years, but the public knew nothing of the new polymer until after the war. It was not until 1960 that Teflon coated muffin tins and frying pans appeared on the market.

The story of nylon is yet another example of industrial serendipity (Parshall, Folkers, Brownlee, Peruyera, Cook, & Licking, 1998). The DuPont Company decided in 1927 to create a lab for pure science. Wallace Hume Carothers, then an up-and-coming 31-year-old chemistry instructor at Harvard, was brought to DuPont to direct their new basic chemical research program which was housed in this facility. Carothers went to work with eight junior chemists to do what was then a daunting task – synthesizing polymers of heavy weight.

One day in 1927 while working with one of these substances, an associate of Carothers by the name of Julian Hill noticed that if he gathered a small ball of one of the polymers on the end of a glass stirring rod and drew it out of the mass and extended it, it would become very silky in appearance. Once hardened and stretched to several times their original length, the filaments of this substance became strong and elastic. Unfortunately, this new substance melted if laundered or ironed. Frustrated with the flaws of his "silk" superpolymer, Carothers set aside his project to investigate so-called cyclic compounds.

In 1934, Carothers' was coaxed back to the task of perfecting this new substance. He formulated a new strategy for synthesizing giant molecules and in a few months got the results he wanted. The new superpolymer reached the market in 1937 and later became known as nylon.

Background and history of Y2K

No one knew for sure what would happen at the stroke of midnight, Dec. 31, 1999, when computer clocks rolled over everywhere around the world. Some feared the

worst. Others were predicting everything from disrupted travel schedules to more-serious problems, like large-scale power outages or even a global recession. The processing of tax refunds, veterans' benefits, and employee checks could be hampered, government auditors were saying (Stanglin & Ahmad, 1998).

Experts began saying that we would all be experiencing inconveniences from what was becoming widely recognized as the "year 2000 problem." In some places, the problems had all ready started surfacing. One survey found that 44 percent of U.S. companies had already experienced a year 2000 failure--like the grocery in Warren, Mich., whose entire computer system crashed when a cashier tried to swipe a credit card bearing a 2000 expiration date. Even the Pentagon's Global Command Control system--a key communication link during the gulf war--failed a year 2000 readiness test last summer (Stanglin & Ahmad, 1998).

More than half of the technology executives polled by CIO magazine said that they would avoid flying commercially on Jan. 1, 2000. Another survey found that 38 percent of information technology industry professionals planed to pull money from banks and investments just before 2000. And near Pierre, S.D., an urban planner named Russ Voorhees was leasing plots for a year 2000 survival colony, guaranteeing electricity and satellite communications to those who fear digital doom after the arrival of the new millennium (Stanglin & Ahmad, 1998).

How Y2K began

The problem itself was rooted in the fact that many of the world's computers could not recognize a date that began with "20" instead of the familiar "19". It was

feared that when the millennium finally arrived, thousands of computers around the world would interpret the year "2000" as the year "1900" making a literal mess of daily life. This is due to the fact that many computers used the system date in a multitude of calculations (Stanglin & Ahmad, 1998).

Actually, this problem had been around for some time. Occasionally, stories could be heard about people whose ages got mangled in government computers because they were born in 18-something. And there are tales of a major fuss in financial markets in 1970 when the calculations on 30-year instruments went amuck because 00 minus 70 is a negative number (Greiner, 1995).

In addition, certain values, such as 99 and 00, were favorites of computer programmers since they were commonly used as end-of-file indicators or to represent error conditions. The two digit dates were being used in invoice numbers, policy numbers, or as sort keys. Any of these simple time savers was potentially a time bomb waiting to go off at the end of the century (Greiner, 1995).

Computers could not blindly differentiate a two-digit date or code from a four-digit one. They simply would preform arithmetic based on old algorithms and create errors on bank accounts, order systems, and inventory records. In many instances, backup software relies on dates to decide what files to copy, and when to re-use backup media - and sometimes to determine which

files have been inactive for a designated period and should be deleted (Greiner, 1995).

So why resort to a two-digit date? Conventional wisdom goes something like this: back in the 1950s, when computers were the size of office cubicles and the most

advanced data-storage system came on strips of punched cardboard, several scientists, including a Navy officer named Grace Murray Hopper, begat a standard programming language called COBOL (common business-oriented language). To save precious space on the 80-column punch cards, COBOL programmers used just six digits to render the day's date: two for the day, two for the month, two for the year. It was the middle of the century, and nobody cared much about what would happen at the next click of the cosmic odometer. But today the world runs on computers, and older machines run on jury-rigged versions of COBOL that would most certainly crash or go senile when they hit a double-zero date (Taylor, 1999).

But this small group of computer scientists were not the only ones at fault. "It was the fault of everybody, just everybody," says Robert Bemer, the onetime IBM whiz kid who wrote much of COBOL. "If Grace Hopper and I were at fault, it was for making the language so easy that anybody could get in on the act" (Taylor, 1999). And many were beginning to use the COBOL language including a group of Mormons in the late '50s who wanted to enlist the newfangled machines in their massive genealogy project--clearly the kind of work that calls for thinking outside the 20th century box. Bemer obliged by inventing the picture clause, which allowed for a four-digit year. From this point on, more than 40 years ahead of schedule, the technology was available for every computer in the world to become Y2K compliant (Taylor, 1999).

Programmers ignored Bemer's fix and so did his bosses at IBM, who unwittingly shipped the Y2K bug in their System/360 computers, an industry standard every bit as powerful in the '60s as Windows is today. By the end of the decade, Big Blue had

effectively set the two-digit date in stone. Every machine, every manual, every maintenance guy would tell you the year was 69, not 1969 (Taylor, 1999).

Theoretically, fixing the Y2K problem was simple, but the frightening part of the transition to the 2000's was the enormous volume of software changes required (Greiner, 1995). Someone had to examine every line of code in every computer, locate the instructions regarding the dates, and rewrite them to accept "2000" as the year designation (Stanglin & Ahmad, 1998). Furthermore, there were date calculations buried in software that had been in use for decades that no-one knew a thing about. Even if the source code could have been found, chances were that the documentation was long gone, as well as the original programmer (Greiner, 1995).

But despite the warnings, surveys indicated that too few managers in business and government recognized how little time was left to complete the task. In fact, one of the myths that surrounded the Y2K problem was that someone would develop a fix that would automatically cure all of the imminent problems that were bound to result (Stanglin & Ahmad, 1998).

While many companies were looking for this magic, one-step solution to the problem, Tony Toews, president of Granite Consulting based in Vermilion, Alta, said they were wasting their time. "There will not be a magic solution which some genius can solve. There are far too many varying systems, computer languages, programming styles, interrelated systems and many other factors" (Burger, 1997). In addition he stated, "There is no such thing as a 'Silver Bullet' which will solve all your problems."

In order to devise a method by which a company could predict the impact Y2K would have on any given company, a chart was conceived based on a formula developed by a team lead by CIO magazine publisher Gary Beach and IDC research director Tom Oleson. This chart listing the pre-Y2K predictions and probabilities can be viewed by visiting www.cio.com/info/releases/y2kchart.html. The Beach/Oleson Pain Index, as it was known, showed how the Year 2000 software glitch was further compounded by connectivity to external organizations, such as suppliers, customers, banks and other business partners (Beach & Oleson, 1998). This index predicted the majority of Y2K-related problems would appear as minor disruptions and inconveniences as opposed to catastrophic events.

Known effects of Y2K

After all of the hype, after all the survivalists had bought the last generators and loaded up on ammunition and after years of predictions of doom from the so-called experts, 2000 arrived without computers causing the end of civilization. No widespread public- safety calamities occurred, the energy grid did not shut down and nuclear missiles did not launch. Telephone, broadcast, Internet and wireless services continued to work just fine (Wiley, 2000).

While the date conversion was not entirely incident-free, problems truly were remarkably limited. A few credit-card transactions failed because of non-compliant software. Brief glitches occurred in 911 systems serving parts of Wyoming and North Carolina. The Internet experienced some slowdowns, but this easily could be attributed to

traffic. Although the nation's large telephone carriers reported surges in calling volumes near midnight on New Year's Eve, they were handled without difficulty (Wiley, 2000).

Post Y2K, we know only what has been publicly reported, and there is a chance some businesses are not reporting Y2K-related incidents, which, in most cases, are probably minor, or we would presumably be aware of them. Why would incidents go unreported? Most businesses don't have an incentive to come forward with their problems. The potential for spurring stock problems and creating unnecessary anxiety and negative publicity is a strong incentive for keeping quiet. However, there are some incidents we do know about (Beach, 2000):

- Nine nuclear power plant incidents occurred in Japan, and seven occurred in the United States, all of which were apparently minor electric power supply problems. According to press reports, the incidents did not involve a compromise of safety-related systems or require plants to be shut down.
- Point of sale credit card companies posted transactions multiple times to credit card accounts, because they did not download an eleventh-hour patch.
- The U.S. Defense Department experienced computer failures related to processing imagery from intelligence satellites, which resulted in an interruption in the flow of spy satellite information. However, the Pentagon insists the trouble did not jeopardize U.S. national security.
- Wind-shear alert systems failed at a number of airports across the nation including Atlanta, Denver, Orlando, Fla. and Tampa, Fla. Computer systems had to be rebooted, which took two hours. What if aviation experts had been unable to

rectify this system failure? Without operable wind- shear alerts, airlines cannot guarantee safe operation of their planes, which increases the dangerousness of commercial flying.

- Numerous clock failures occurred, including one in a federal building in Omaha, Neb. This Y2K-related glitch resulted in a security system door remaining open. Other incidents included difficulty with clock synchronization in the energy management system computers of several electrical utilities. What would have happened if the clocks in federal buildings and utility companies around the globe had suddenly stopped, allowing open access to normally secure federal buildings? What if everyone had lost electricity for an indeterminable amount of time?
- Amtrak's control center lost the ability to retain train symbols and thereby automatically track trains. What if technicians had not devised a contingency plan that enabled them to enter the train numbers manually? There could have been numerous train collisions throughout the United States.

The "serendipity" effect and corporate America

In a discussion of corporate creativity and what makes it happen, Robinson and Stern (1998) stated that there are six essential elements of corporate creativity. These elements are alignment, self-initiated activity, unofficial activity, diverse stimuli, within-company communication, and serendipity.

The first element, alignment, is about ensuring that the interests and actions of all employees are directed toward a company's key goals, so that the employee will recognize and respond positively to a potentially useful idea. Self-initiated activity and

unofficial activity are both types of activities that the employee take upon themselves without direction or prompting. A diverse stimuli can provide fresh insight into something a person has already set out to do, or it may cause a person to do something differently. Within-company communication is critical in carrying out planned activities and establishing the necessary lines of communication to support them. The last major element of the six is serendipity. A serendipitous discovery is one made by fortune accident in the presence sagacity. Creativity often involves recombining or making connections between things that may seem unconnected. The more abstruse the connection, the greater the intellectual distance that must be traverse to make it, and the greater the role for the unexpected. Serendipity helps to bridge this distance.

Robinson and Stern state that all although no one can predict the specific creative act that will follow, the likelihood of their happening will significantly increase when the six elements are in place. They also say that managing creativity is about raising probabilities, and in this respect is similar to operating a casino. Even though casinos do not know how well individual gamblers will do, they do know that if enough customers come and play for long enough against the odds, the casino will make profit. In the short term, it is a matter of profitability, but in the long term, profits are a matter of certainty. In much the same way, although companies cannot know where specific creative acts will come from or what they will be, they can take action to increase the frequency with which these events occur.

What is known and unknown about the Y2K remediation

Although information system managers are receiving praise for the smooth way in which the year 2000 rollover went, many are also receiving criticism that they had over exaggerated the threat of the year 2000 bug (Scannell & Epstein, 2000). Some executives, at levels both below and above those who made the spending decisions, have questioned why so much was needed given the toothless bite of the year 2000 bug. But John Matelski, assistant director of technology management for the city of Orlando Florida, is on record as saying that critics did not see critical systems fail during initial rollover test (Wilson, 2000). "I think preparation for Y2K was necessary, and we spent the appropriate amount of time and money to ensure a seamless transition," said Robert Rodin, CEO of Marshall Industries , a $1.6 billion electronics distributor (Wilson, 2000, p8). This attitude is reflected throughout the IT industry.

One of the most relevant documents to come out of the Y2K remediation effort was a final report from a U.S. Senate Committee that was established to monitor the year 2000 problem (Framingham, 2000). This committee declared that the Y2K bug is officially dead and that estimated $100 billion spent on preparations was well worth it. Although hundreds of Y2K problems were reported, they were all relatively minor.

The United States Senate Special Committee on the year 2000 technology problem also concluded that in addition to averting major problems, Y2K preparations provided "enduring" benefits. Most significantly, the IT infrastructure and mechanisms for effectively managing it have been modernized and Y2K has caused a heighten level of

knowledge among executive level managers as to the importance and vulnerabilities of information technology.

Capers Jones, a chief scientist at Artemis Management Systems Bolder Colorado estimates that for each dollar spent on Y2K remediation efforts, an organization can expect to get back six or seven (Lehman, 2000). Crawford (2001) stated that agencies that planned Y2K remediation properly gained other benefits from the work. IT firms came to know the state of their computer systems (hardware and software) better than before: where all the pieces are, what useless programs were still running, and where they should focus replacement efforts. Melymuka (2000) stated that Y2K managers say that the Y2K effort had positive, transformational effects on every level it touched, from information technology departments to businesses, multinational corporations and even entire industries with the big winner being project management.

A real-life example of benefits derived from Y2K remediation can be found in an article by Gladwin (2001). In this article, he vividly illustrated that lessons learned from Y2K remediation can be put to practical use. Case in point, the rolling blackouts of California. These were an emergency measure aimed at stretching limited power resources by cutting electricity to specified areas in roughly 2-hour clocks throughout California.

In response to the continuing threat of blackouts, Mel Reeves, CIO at ARB Inc., an international maker of oil pipelines in Lake Forest, Calif., one of ARB's sites in Pittsburg, Calif., has recently installed an additional uninterruptible power supply (UPS) - a backup battery system that supplies power for about one hour - and two backup

generators. The new system, which cost $40,000, also notifies Reeves of a power loss so that IT staff can get to the site to properly shut down computer systems before the alternate power runs out. Also, Raytheon Co. in Lexington, Mass., has asked its West Coast sites for contingency plans for an "orderly" shutdown of computer systems in response to a 15-minute advanced warning of a power outage, said Paul Christidis, a senior staff engineer at the $17 billion aerospace and defense giant. Gladwin stated that the reason these executives have a feel for resolving the issue with the rolling blackouts is because of contingency plans developed during Y2K projects.

The upside of Y2K

The recent Year 2000 computer problem was one of the most remarkable examples of global human cooperation ever conceived. It brought together many organizations such as the International Y2K Cooperation Center and its offshoot, YES Corps, the President's Council on Y2K led by John Koskinen, the World Bank, the United Nation's Informatics Committee and many others (Beach, 2000).

Yet another impressive aspect to the Y2K phenomenon was that thousands of business and community leaders came together and made Y2K remediation a priority and approved the appropriate expenditures. IT workers around the globe spent an unfathomable amount of time, energy and brain power on planning and implementation over the past few years to make it all happen (Beach, 2000).

An example excellent example of world-wide cooperation that occurred due to Y2K was seen in a 1999 meeting of a United Nations meeting of year 2000 coordinators from more than 120 countries (Kappelman, 1999). The attendees listened to reports on

the Y2K date-field problem's potential effects on electricity and energy, telecommunications and satellites, nuclear plants and weapons systems, maritime and air transportation, financial systems and central banks, and contingency planning. Afterwards, they formed regional committees, set goals, agreed to share information, and planned regional meetings for the next quarter and another general meeting for mid-1999. "Never before in the history of the U.N. has so much been done in one day, " said Ahmad Kamal, the U.N. ambassador from Pakistan who chaired the one-day session. Although many of the delegates were newly appointed and newly aware of the threat posed by the Y2K bug, all went home part of a global, albeit informal, year 2000 task force. They also helped set a precedent for global cooperation on future IT issues (Kappelman, 1999).

Gary Beach (2000, ¶ 2), publisher of CIO magazine states that "Through this experience, the world has entered what I call 'the Age of Digital Enlightenment', where technology is going to help nations govern and enable executives to conduct better business. There is now widespread awareness of how pervasive technology is in everyone's lives, not just those of the digital elite."

At company after company, the Y2K bug-hunt yielded unexpected benefits. DaimlerChrysler, which spent $260 million to smoke out some 250,000 Y2K bugs, ended up deep-sixing 15,000 old computer programs. That not only cleaned out the digital cobwebs, it also made it possible for two-thirds of its plants to connect with each other on the same network for the first time. Now, ``if we want to modernize again, we can all move at once in the same direction," says Roger Buck, the head of DaimlerChrysler's Y2K operations(Stepanek, 2000).

Kappelman (1999) listed numerous unexpected benefits that could result from any Y2K project. Here are some areas in which companies can see payoffs:

- Assets: Y2K projects help companies get a good handle on their information assets, positioning them for better management of hardware, software, data, and interfaces.
- People: A successful Y2K project requires mastery of many people skills. These are ever valuable for recruiting, organizing, and motivating strong teams.
- Practices and experience: Success with an enormous and complicated reengineering project helps establish good, repeatable processes for change management and version control. This will help companies deal with other projects.
- Attitude: The IT group can gain confidence and credibility by meeting an urgent business need on deadline.
- Knowledge: Solving the Y2K problem requires increased communication and cooperation, giving everyone a better sense of how IT aligns with and supports the rest of the enterprise.

Taken together, the benefits of completing a Y2K project set your organization up for some positive advantages Kappelman says. He also made the case that Y2K was an opportunity to improve relationships with customers and suppliers, capture market share, buy up assets at fire-sale prices, and initiate new competitive IT projects.

Now that we are on the other side of Y2K and massive remediation, we are seeing some unexpected benefits as a result of remediation. Businesses and the federal

government are now painfully familiar with the technology resources and systems they run and their importance in maintaining daily business operations. Antiquated computer systems have been thrown out, modernized, patched or replaced. The public and private sector have worked together on a major world problem, successfully tackled the problem and subsequently opened channels of communication that could be the means to new economy partnerships. The future of business is one where the boundaries between companies are becoming increasingly blurred competitors are collaborating, many members of supply chains have linked into a common technology-enabled system or process and companies are going "virtual" by outsourcing and contracting many parts of their businesses. Y2K should make people more confident in our nation's ability to thrive in such a world (Beach, 2000).

Even the federal government, which still relies on some systems installed decades ago, got with the modernization program. The Y2K bug was just the bogey monster needed to get more technology dollars put into agency budgets (Stepanek, 2000). Now is the time for the United States to leverage its experience and utilize these newly revitalized systems to better enable the business of governing. For example, this experience base and infrastructure could enable electronic voting, registering to vote and eventually voting online; it could enable the modernization of the Internal Revenue Service and U.S. Customs, and it could create wired communities where police, fire departments and schools are all linked to their townspeople (Beach, 2000).

There were other payoffs: Technology departments, famous for going over budget and missing deadlines, had new discipline imposed by Y2K. Now, says Marriott's

Kamenz, ``we've got tougher standards in place for the installation, purchase, and care of technology" (Stepanek, 2000).

Potential contributions from the Results of this study

In his book, Serendipity: Accidental Discoveries in Science, Roberts (1989) frequently used the term "sagacity" to describe those individuals involved in serendipitous discoveries. Webster's dictionary defines sagacity as the quality of being sagacious, that means having a keen sense of perception, judgment, discernment, and the ability to be shrewd. Robinson and Stern (1998) said that sagacity is keenness of insight. In simple terms, those individuals who were part of serendipitous discoveries had the ability to recognize the potential benefits of the discoveries that they had made.

A review of the current literature on the subject of Y2K has shown that there has been a host of benefits and spinoffs from the Y2K remediation process. For example, Feder (2001) stated that benefits of Y2K included the fact that the effort endowed the managers everywhere with updated information systems, software development tools and disaster plans, not to mention their most complete inventory of computer systems and how they were being used. It also helped big enterprises identify managers capable of handling complex projects reaching into every part of their operations. Business leaders, regulators, lawyers, insurers and the public all became more technically literate. Intangible benefits include changes in attitudes and procedures for information technology.

Gary Beach, publisher of CIO Magazine, is also on record as saying that "now that we are on the other side of Y2K, we are seeing some benefits as result of remediation"

(Beach, 2000, ¶ 10). Business and government are now painfully familiar with the technology resources and systems they run and their importance in maintaining daily business operations. Antiquated computer systems have been thrown out, modernized, patched or replaced. The public and private sector have worked together on a major world problem, successfully tackle the problem, and subsequently opened channels of communication that could be the means to new economy partnerships.

It is therefore the intent of the researcher of this study to provide the "sagacity" to uncover those benefits and spinoffs of the Y2K remediation process that have yet to be discovered. This kind of information could prove invaluable to those in managerial positions in business, industry, and government given that this type of situation could recur at some time in the future. It is also hoped that the reader of this study will take away with them the sense that a crisis such as Y2K can be used as a learning experience, and that the experience gained can be used as learning tools to prevent future crises as well as to correct for those that may occur. Perhaps the biggest tragedy of all of the Y2K saga would be that business and industry would come away from it without applying what they have learned. Feder (2001, ¶ 20) quoted Howard Rubin, an information technology consultant based in Pound Ridge N.Y. as saying "Ninety percent of the lessons learned that already been forgotten."

Statistical procedure used in this study

There are a number of statistical procedures from which a researcher can choose to analyze the relationship between sample means of groups to determine if a correlation or relationship exist. One of the most basic procedures is ANOVA (analysis of variance).

ANOVA is used to determine whether there is a significant difference between two or more means at a selected probability level (Gay, 1996). For example, in a study involving posttest from two or more groups, the means are bound to be different. The ANOVA procedure allows the researcher to differentiate whether or not the differences are significant at a specified probability level.

The concept underlying ANOVA is that the total variation, or variance, of scores can be attributed to two sources – variance between groups (variance caused by the treatment) and variance within groups (error variance) (Gay, 1996). A ratio is formed with the group differences as the numerator and the error term as the denominator. This ratio is know as the *F* ratio. At the end of a study on a measure of the dependent variable (treatment), we determine whether the between groups treatment differs from the within groups (error) variance by more than would be expected by chance. In other words, if the treatment variance is enough larger than the error variance, a significant *F* ratio results, thus, the null hypothesis is rejected and it is concluded that the treatment had a significant effect on the dependent variable.

To determine the level at which the *F* ratio becomes significant, a critical value of *F* can be computed or simply read from a table of critical *F* values. Once the researcher knows the critical value of *F*, it is compared with th computed value of *F* from the study. If the computed value of *F* is greater than the critical value of *F*, the researcher knows that the differences between means is indeed significant and did not occur by random chance.

Whereas ANOVA tests whether mean differences among groups on a single dependent variable are likely to have occurred by chance, MANOVA (multivariate analysis of variance) tests whether mean differences between groups based on a combination of dependent variables are likely to have occurred by chance (Tabachnick & Fidell, 1989). In MANOVA, a new dependent variable that maximizes group differences is created from the set of dependent variables (this is much the same as another commonly used procedure, multiple regression). The new dependent variable is a linear combination of the measured dependent variables, combined so as to separate the groups as much as possible. ANOVA is then performed on the newly created variable. As with ANOVA, hypotheses about means are tested by comparing variances – hence multivariate analysis of variance.

Although the aforementioned statistical procedures have been used with great frequency in a myriad of different studies, they lack the robustness required to analyze complex relationships that exist between groups of dependent and independent variables that often are more representative of real-life situations. In cases such as these, the preferred statistical technique is canonical correlation analysis (CCA). Canonical correlation analysis is an analytic method that can be used to investigate relationships among two or more variable sets (Grimm & Yarnold, 2000).

Canonical correlation analysis is the most general of the multivariate techniques. In fact, the other procedures – ANOVA, MANOVA, multiple regression – are all special cases of canonical correlation analysis, but it is also the least used (Tabachnick & Fidell,

1989). CCA was originally conceptualized by Hotelling in 1935 (Grimm & Yarnold, 2000).

The easiest way to understand CCA is to think in terms of multiple regression. In regression, there are several variable on one side of the equation and a single variable on the other (Tabachnick & Fidell, 1989). The several variables are combined into a predicted value to produce, across all subjects, the highest correlation between the predicted variable and the single variable. The combination of variables can be thought of as a dimension among the many variables that predicts the single variable.

In canonical correlation analysis, the same thing happens except that there are several variables on both sides. Sets of variables on each side are combined to produce, for each side, a predicted value that has the highest correlation with the predicted value on the other side (Tabachnick & Fidell, 1989). Each combination of variable sets is referred to as a canonical variate. The bivariate product-moment correlation coefficient, or structure coefficient as it is called, is nothing more or less than the multivariate canonical correlation between the weighted variables (variates) in the two variable sets.

If a statistically significant correlation is established between the two canonical variates, the next step is to examine the individual contribution of each variable that comprises the canonical variates. This is accomplished by using another computed value know as a structure coefficient. A structure coefficient is the bivariate product-moment correlation between scores on an observed or measured variable (dependent or independent), and scores on a synthetic or latent variable for that measured variable's variable set (Grimm & Yarnold, 2000). Variables with structure coefficients near zero

clearly have no effect on defining the synthetic variable associated with the canonical function.

The canonical correlation procedure has lain dormant for several decades due primarily to the complexity of the computations, but has reemerged due to computerization and its inclusion in many major statistical software packages (Grimm & Yarnold, 2000). Since canonical correlation analysis is such a robust technique, it was the technique chosen for this study.

Summary

This chapter contains a review of literature that reveals that serendipity has played a major part in the discovery of many new products that we use on a daily basis. It has also shown how serendipity has played a major part in many significant discoveries in the areas of science, medicine, and archeology.

Perhaps most importantly, it indicates that a number of unexpected results developed as a direct result of Y2K remediation. A quote from Gary Beach, publisher of CIO Magazine, sums it up this way:

> The recent year 2000 computer problem is the most remarkable example of global human cooperation I have ever witnessed. It brought many organizations together, like the International Y2K Cooperation Center and it's offshoot, YES Corporation; the President's Council on Y2K led by John Koskinen; the World Bank; the United Nations Informatics Committee, and many others. Perhaps even more impressive or the thousands of business and community leaders who made remediation a priority and approved the appropriate expenditures and the IT workers around the globe who spent an unfathomable amount of time, energy, and brain power on planning and implementation over the past few years. Through this experience, the world has entered what I call 'the Age of Digital Enlightenment' where technology is going to help nations govern and enable executives to conduct better business. There is now

> widespread awareness of how pervasive technology is in everyone's lives, not just those of the digital elite. (Beach, 2000, ¶ 2)

Most companies are aware that their creative potential greatly exceeds their creative performance (Robertson & Stern,1998). The problem is that they don't know what to do about it. A creative company is one in which employees do something new and potentially useful without being directly shown or taught. This desire to maximize the performance of a company's human assets is understandable, given that the perceived worth of such companies is on the rise. The trick to getting more value from a company's human assets is to create or allow the formation of an environment conducive to such thinking and activity. Furthermore, serendipity is more likely to occur when sagacious, keenly perceptive people are involved with each other. In order to increase the likelihood of serendipity, corporations must expand the possible occurrence of fortuitous accidents and increase their base of sagacious people. Once serendipity has occurred, the results should be shared with the appropriate parties so that the organization gets the benefits of the unexpected results.

Chapter 3

Methodology

Research method

As previously stated, the goal of the researcher in this study was to investigate the extent to which benefits and spinoffs may have resulted during the Y2K remediation effort by business and industry. Data concerning these benefits were collected through the use of a survey instrument developed by the author. The instrument was distributed to an appropriate sample of large companies throughout the United States. The specific areas of business and industry that were targeted for this survey included financial services, health care, non-computer manufacturing, telecommunications, transportation, and utilities. Once the surveys were completed and returned, the results were analyzed and conclusions drawn.

In this study, the researcher investigated the relationships between a set of dependent variables (the benefits and spinoffs) and a set independent variables (various remediation efforts). Given this situation, a correlational research model was used to determine which variables (independent and dependent) are related, making this research design well suited for this study. The variables that were included were selected on the basis of either a deductive or inductive rationale.

Assumptions

A number of assumptions were necessary in order to perform this research. First of all, the researcher felt that there was interest by the IT community in Y2K benefits since so much attention had been given to this topic by the media. The researcher also felt that the IT community would be willing to contribute useful and practical information about their own experiences with the Y2K remediation process due to the fact that the majority of those involved were comfortable with the amount of time and money that they had spent on their individual efforts. It was also assumed that although most systems were affected, Y2K remediation efforts resulted in a minimum number of problems once the Year 2000 had arrived. In addition, the researcher felt that awareness of IT-related issues increased and that some benefits that occurred were unexpected. Lastly, it was assumed that the measure used was valid, unbiased, and would either support or disprove the hypothesis of this research. The following items represent assumptions about the procedures used in conducting the survey:

1. Respondents would provide useful information about the benefits of the Y2K remediation process.
2. Most organizations would respond that they spent the appropriate amount of money and man-hours on Y2K remediation efforts.
3. Nearly all systems within their organizations were affected, at some level, by Y2K related issues.
4. That the severity of the Y2K rollover within their organization was minimal and that the recovery time was relatively short, but this was due to remediation efforts.

5. That there is a heightened awareness of IT-related issues.
6. A number of unexpected benefits from Y2K have occurred.
7. It was assumed that there is an interest by the IT community in Y2K benefits.
8. It was assumed that biases are accounted for.
9. It was assumed that a measure is valid and would either support or disprove the hypothesis.

Specific procedures employed

Rea and Parker (1997) have identified an eleven-stage process by which to perform survey research. Their model was used in this survey. The stages were identifying the focus of the study and method of research, determining the research schedule and budget, establishing an information base, determining the sampling frame, determining the sample size and sample selection procedures, designing the survey instrument, pretesting the survey instrument, selecting and training interviewers, implementing the survey, coding the completed questionnaires and computerizing the data, and analyzing the data and preparing the report. One other step listed dealt with the selecting and training of interviewers for a survey. Since this survey was conducted by a single researcher and did require additional personnel, this step was omitted.

1. Identified the focus of the study and method of research

Action - As previously stated in the goal section of this document, the purpose of the researcher in this study was to investigate the unexpected (serendipitous) benefits and spinoffs related to the Y2K (Year 2000) remediation effort by business and industry . The means by which this was accomplished was through the use of a survey instrument

made available via the World Wide Web to a representative sample of organizations in business and industry.

Fit - In order for a survey to be successful, the focus of the study had to be throughly defined and the most appropriate means of conducting the research decided upon. Without this focus, both the questions asked in the survey, as well as the results, may become vague and insignificant.

Background Literature - A survey is an attempt to collect data from members of a population in order to determine the current status of that population with respect to one or more variables (Gay, 1996). Making sure the survey will provide useful information means raising two specific questions: What problem are you trying to solve? What new information do you need to solve it? (Slant & Dillman, 1994). The problem is the fundamental issue raised in the survey while the new information will, presumably, help to solve the problem. The problem under investigation and the topic of the questionnaire must be of sufficient significance to motivate subjects to respond (Gay, 1996).

2. Established a research schedule and budget

Action - Once the preliminary stages of this study were completed, a schedule for distribution for the questionnaire was developed and a target date for analysis of the data set. The resources for this project , including the budget, were specified in the resources section of this document.

Fit - The determination of a research schedule, and the development of a budget, help to facilitate the researcher in the allocation of time and funds for the completion of a research project. Proper planning of the research budget allows the researcher to focus of

the content of the study, rather than being distracted by unexpected expenses once the project has gotten underway.

Background Literature - Budgetary and time considerations permeate and constrain each step of the survey process, so it is important that the researcher be diligent in the time and cost estimates at the outset (Rea & Parker, 1997). The timetable must be flexible enough to accommodate unforeseen delays and yet capable of satisfying the needs of the research sponsor. Budgets must be inclusive of all costs that may be incurred throughout any of the stages listed in this document and should be based upon factors such as survey type, size, duration, and labor costs (Salant & Dillman, 1994).

3. Established an information base

Action - This stage was accomplished through a process of discovery. The first step of this process was a comprehensive review of literature on the subject of year 2000 remediation (please see the reference list at the end of this document). Sources to be considered in this review will include magazine articles, journal articles, newspaper articles, reports, books, and Internet web sites. After these documents were acquired, they were reviewed for possible topics from which to formulate survey questions. Particular attention was given to those documents that contain possible benefits reaped due to those efforts. The questions were written in such a manner as to allow the respondents to rate specific topical areas using a Likert-type scale which is a scale that asks an individual to respond to a series of statements by indicating whether she or he strongly agrees, agrees, is undecided , disagrees, or strongly disagrees (Gay, 1996). In addition to questions that required the respondents to rate or categorize items, some questions were included that

would allow the respondents to give short answers or elaborate briefly on unique benefits they have observed and/or Y2K severity within their organization (see Appendix B).

Fit - It is essential to the success of a survey of this type to formulate questions based upon known information. For this reason, a review of literature was conducted as specified above in order to gain insight into possible spinoffs and benefits that were documented as a result of Y2K remediation. This facilitated the creation of an information base to build the survey questions.

Background Literature - At the heart of survey research is the questionnaire development process. No questionnaire can be regarded as ideal for soliciting all the information deemed necessary for a study and most questionnaires have inherent advantages as well as inherent flaws (Rea & Parker, 1997). Salant and Dillman (1994) stated that at their very best, surveys can produce close estimates of what people think or do. Therefore, an important part of ensuring that a survey will provide useful information means rasing two specific questions: What problem are you trying to solve? and What new information do you need to solve it? (Salant & Dillman, 1994).

An abundance of literature has already been written touting the benefits that Y2K remediation has brought about to business and industry. One such piece of literature (Fowler, 1993) has suggested that one technique that could be used in the survey instrument development process is the drafting of a set of tentative survey questions. A review of literature uncovered the information necessary to construct this set of questions for the questionnaire. Any necessary adjustments to the questionnaire was made during pilot testing and validation of the questionnaire.

4. Identified the organizations for the sample

Action - The sample for the main study consisted of 250 companies and organizations within the United States selected randomly from the 500 largest U.S. companies, ranked by revenues, according to Fortune magazine's classic list (this list can be viewed online at http://www.fortune.com/fortune/fortune500/). Listed below, is the procedure that was used for the selection of these companies or organizations:

- Utilizing the Hoover's online database of company information, each company in the sample was researched and a contact list complied. The contact information was acquired by using the company name as a "keyword" and performing a search of the Hoovers online database.
- Once the contact list was completed, a form letter was written describing the nature and purpose of the survey and providing the survey respondents with the URL of the Y2K survey web site (see Appendix D). A hard copy of the survey was also included (see Appendix B) to give respondents another option. The complete survey package consisted of the form letter along with the survey and a self-address, stamped envelope.
- This entire process was performed once for the pilot test and once for the main study.

Fit - Surveys can either be census surveys or sample surveys. Although census surveys provide the most accuarate information, they are often impractical, especially if the population is large. The sample must be determined so that an appropriate sample of the population will participate in the survey.

Background Literature - Any sample selection procedure will give some individuals a chance to be included while excluding others which is the concept behind the sample frame (Fowler, 1993). The researcher(s) should be reasonably certain that the selected population possesses the knowledge and information needed to fulfill the requirements of the research project. After the general population, or "universe," is defined in a conceptual sense, the list of identifiable and contactable members of this general population must be obtained. It is from this list that a sample of respondents was drawn (Rea & Parker, 1997). A sample survey of this type will, therefore, provides information about the population that makes up the frame and no more (Salant & Dillman, 1994). Since the population from which the current sample was drawn was 500, a sample size of 50 to 100 was used. Fowler (1997) suggested an actual figure of 81 for a population of 500 given a 95% level of confidence with a confidence interval of ±10%.

5. Determined the sample size and sample selection procedures

Action - Once the sample was established as stated in step four, a sample appropriate for the purposes stated in this study was selected from the sample frame. Approximately 250 different businesses/organizations was randomly selected from the sample using random sampling. Random sampling was used in the sample selection process since this technique yields the highest probability of having a representative sample of the population.

Fit - The sample was drawn from Fortune Magazine's top 500 performing companies. In order to appear on this list, all companies on the list must publish financial data and must report part or all of their figures to a government agency. Private companies and

cooperatives that publish a 10-K report were included. Subsidiaries of foreign companies incorporated in the U.S. are excluded.

Background Literature - Once the researcher has made a decision about a sample frame, the next question becomes how to select the sample. Fowler (1993) identified three methods by which samples can be drawn. These methods are simple random samples, systematic samples, and stratified samples. Simple random sampling approximates drawing a sample out of a hat. Members of a population are selected one at a time, independent of one another and without replacement. Once a unit of the sample is drawn, it has no further chance to be selected. Systematic samples are drawn using a recurring pattern. Most statistics books warn against systematic samples since the recurring pattern can differentially affect the sample. When the sample is selected using a structuring process that will more likely reflect the total population, it is referred to as stratified sampling (Fowler, 1993). The sampling method chosen for this research was the simple random sample.

6. Prepared the survey instrument for distribution

Action - After the information base was assembled, the questionnaire was constructed for use in the survey. Questionnaire construction was accomplished by using the following steps:

- An information base was established by performing a review of current literature dealing with benefits and/or spinoffs that have occurred as a result of Y2K remediation as specified previously in stage three, establishing an information base.

- The questions were constructed using the information acquired from the review of literature.
- A pilot study was completed and validation of the revised survey instrument was performed as presented in stage seven of this section.
- Approval of the final questionnaire was received from the Nova IRB (Institutional Review Board) representative per NSU policy (see Appendix A for IRB artifacts).

Fit - The questionnaire was carefully planned, attractive, and made as succinct as possible so as to encourage response while acquiring the necessary information for the survey. The questionnaire is included in Appendix B. The questionnaire was developed after a review of the literature available that dealt with the benefits that have occurred as a result of Y2K remediation. Questions 1-15 were designed such that they each measured a specific independent variable on a Likert-type scale (*1- Strongly Disagree, 2- Disagree, 3 - No Opinion, 4 - Agree, or 5 - Strongly Agree*). Likewise, questions 16-21 each measured a specific dependent variable on a Likert-type scale. These dependent variables represent various benefits and spinoffs that the literature has indicated have occurred as a result of Y2K remediation. During questionnaire pretest and evaluation, items can be added and/or removed as necessary. In addition to the survey questions, the respondents had the opportunity to supply the answers to a limited number of open-ended questions (see Appendix B).

Background Literature - As a rule, the questionnaire was brief and as easy to respond to as possible (Gay, 1996). Generally speaking, the longer the questionnaire, the greater the

costs associated with its implementation and the lower the response rates (Rea & Parker, 1997). The questions contained in the questionnaire were phrased in such a manner as to avoid emotional and biased wording and not seeded with "leading" information and "half-truths" (Salant & Dillman, 1994). A potential disadvantage is the possibility that a respondent's true response may not be listed among the alternative responses. Therefore, an "other" category was included and a space for the respondent to write in an answer if they so desire (Gay, 1996). A well written questionnaire will maximize the relationship between the answers recorded and what the researcher is trying to measure (Fowler, 1993).

7. Validated and pilot tested the survey instrument

Action - Before actual implementation of the survey, the questionnaire was validated and pilot tested. Validation was performed by a panel of three individuals; a college business department head, an MIS director, and a programmer/analyst. The panel met as a group and consensually made recommendation for changes to the questionnaire. Aside from a few editorial changes, the panel suggested that questions dealing with systems types be broken into separate questions about hardware and software upgrades for each system type. These changes were made to the questionnaire, therefore completing the initial phase of validation.

A prototype of the web page survey instrument was then constructed using the validated questionnaire. Pilot testing involving a small number of the possible

respondents was then performed. The procedure for administering this pilot test was the same as specified in part nine (Administer the survey) of this chapter.

Fit - Pilot testing and validating the survey instrument was necessary to ensure that the instrument adequately measures what it is intended to measure.

Background Literature - After a draft of the survey instrument has been prepared and the researcher believes that the questions will obtain the information necessary to achieve the goals of the study, it is important to pilot test the instrument under survey conditions (Rea & Parker, 1997). The questionnaire should be administered to a small number of persons drawn from the population considered in the study with the results used to clarify items or perhaps to eliminate some (Ary, Jacobs, & Razavieh, 1990). From the researcher's point of view, there is a need to convince potential respondents that their participation is useful both to the survey's sponsor and to the respondents themselves (Rea & Parker, 1997). In addition to providing insights about the subject of the survey, people who have helped in the "brainstorming" of the survey are more likely to accept the results as being reliable and ultimately to use them (Salant & Dillman, 1994).

8. Administered the survey

Action - The survey administration phase involved the development of a web site on which to host the web-based survey form and an appropriate domain name for the site. A standard html-type form containing the survey questions was placed on the site and was processed using a Perl script that automatically e-mailed the survey results to the researcher. The statistical software that was used was NCSS (Number Cruncher Statistical System) that is a statistical and data analysis system for Windows. In this way,

multiple dependent variables. This extension gives the general linear model important advantages over the multiple and the so-called multivariate regression models, both of which are inherently univariate (single dependent variable) methods.

Fit - Coding of the data into a computer application facilitated statistical analysis and standardized the reporting of the data. In addition, once the data had been coded, it could usually be easily imported into a computer program designed to do statistical analysis. This is of great importance to the researcher since it facilitated the process of analyzing the data as well as reduced the chance that computational errors will occur.

Background Literature - The final questionnaire was formatted in such a way that responses could be entered directly into the computer for data processing (Rea & Parker, 1997). Coding the questionnaires means expressing in terms of numbers all responses that will eventually be analyzed. Editing and cleaning was also a part of this process as an effort to get rid of erroneous responses that make no sense at all, sometimes called outliers (Salant & Dillman, 1994).

It was the original plan of the researcher to categorize and code the open ended responses and then build a "frequency of response" table for each open-ended question questions used in the survey (Reporting of Open-end Question Findings, 2001). However, due to a smaller-than-expected number of responses, that step was not performed. Instead, it was the decision of the researcher to use the opened responses as a means to reinforce the findings presented in Chapter 4 of this document.

10. Analyzed the data and reported the results.

Action - The survey responses were analyzed during this last phase in an effort to determine what benefits were common to these businesses as well as to uncover possible unique benefits some business may have experienced. Analysis of the data was accomplished through the use of canonical correlation which was chosen because of its usefulness in determining correlations between a set of independent variables and a set of dependent variables. Of particular interest were benefits that companies indicated were totally unexpected. The research hypothesis of this study was as follows: Companies and organizations who have gone through year 2000 remediation have experienced unexpected benefits and spinoffs as a result.

Fit - Once all results were received and coded in the computer, the final data were analyzed and a final report generated. During final data analysis, an attempt was made to locate any serendipitous events that had occurred as a result of Y2K remediation. If a company identified any such events, the analysis of the data would show if there was a correlation between those events and their remediation efforts.

Background Literature - The formal statistics and data summaries formed the basis of the report that culminated in the survey. The recorded data input were summarized, placed in tabular form, and prepared for statistical analyses that will shed light on the research issues at hand. In addition, statistical significance tests, measures of central tendency, determinations of variability, and correlations among variables can be used where appropriate (Rea & Parker, 1997). In this study, the researcher investigated the degree of

relationship between a set of variables (the benefits and spinoffs) and a set independent variables (various remediation efforts). Given this situation, a correlational research model was used. Gay (1996) stated that correlational studies may be designed either to determine which variables of a list of likely candidates are related, or to test hypotheses regarding expected relationships, making this research design well suited for this study. Variables to be included should be selected on the basis of either a deductive or inductive rational.

As stated earlier, final analysis of the data was accomplished through the use of canonical correlation analysis. In this study, the researcher attempted to determine which combination of predictor measures best correlated with the composite factors represented by the various outcome measures (Borg & Gall, 1993). Yet another reason for using canonical correlation analysis is that, as a general rule, when several hypotheses regarding the same data set are tested using multiple univariate tests, the experiment alpha level is actually inflated to an unknown degree, leaving the researcher uncertain as to which statistically significant results are errors and which are not; in other words, Type I errors are increased when using multiple univariate techniques to analyze data sets. By simultaneously testing relationships among all of the variables, the possibility of a Type I error occurring in the experiment is limited to the nominal alpha level (Campbell & Taylor, 1996).

Bar charts, histograms, and other graphics were also be used where appropriate to communicate the results of the survey. These graphical tools offered an excellent way to

condense large amounts of data and emphasize important findings (Salant & Dillman, 1994).

Reliability and validity

Designing a question for a survey is designing a measure and the answer from that question is only valuable to the extent that it can be shown to have a predictable relationship to facts or subjective states that are of interest (Fowler, 1993). In its most basic form, a survey is designed to provide information about public opinions, to measure perceptions, or to determine preferences and interests. In addition, a survey should be both valid and reliable, else the information obtained from the survey process has no meaning. Gay (1992) defines reliability as dependability or trustworthiness. Basically, it is the degree to which something measures consistently what it is supposed to measure. Likewise, validity is the degree to which an instrument measures what it is designed to measure and, consequently, permits appropriate interpretation of results.

Fowler (1993) identified several elements to ensuring reliability and validity of a survey instrument. One way is to supply each respondent with the same set of questions. Another factor that Fowler says could cause a concern with reliability and validity is survey question wording that is ambiguous, biased, or misleading. One last concern is that of ensuring consistent meaning to all respondents.

In order to ensure reliability and validity, the researcher used the aforementioned factors as a guide in constructing the survey instrument. First, all survey participates were supplied with the same set of questions. In fact, the online survey and the hard copy

survey were exact duplicates and all questions were presented in the same order in both documents with the only difference being the format in which they were presented. Since the respondents to this survey were members of the information technology sector, there should be little or no ambiguity about the terms used within this survey.

As a way of validating the survey before actual implementation, the questionnaire was validated by a panel of three individuals; a college business department head, an MIS director, and a programmer/analyst. The panel met as a group and made consensual recommendations for changes to the questionnaire which were given to the researcher. These changes were made to the questionnaire therefore completing the initial phase of validation. The pilot test also served as a means of validating and ensuring reliability.

Variables in this study

This study consisted of a set of 17 measured independent variables and a set of seven measured dependent variables. The independent variables were designed such that they measured factors such as overall Y2K effort by the company, spending, and time in man hours. They also measured the types of systems and types of system software affected by Y2K issues. The dependent variables were designed such that they measured factors such as understanding of IT-related issues, awareness of the role of IT within an organization, the importance of the IT infrastructure, and of course, unexpected benefits. Shown in Table 1 are the survey questions that appear on the survey and the variables measured by them.

Table 1. Survey Questions/Variables

Survey Questions	Variables
1. Our organization went through a Y2K effort whereby the computer systems within our organization were upgraded so that they would not be affected by the year 2000 date change.	Y2KEFFORT
2. Our organizational expenditures on Y2K preparation were justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K.	ORGSP
3. The amount of time (man-hours) that our organization spent on Y2K preparation was justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K.	ORGMH
5. Hardware upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort.	DTNBHWCA
6. Software upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort.	DTNBSWCA
7. Hardware upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort.	DTNBHWMC
8. Software upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort.	DTNBSWMC
9. Hardware upgrades on server(s) within our organization were a part of our Y2K effort.	SERVHW
10. Software upgrades on server(s) within our organization were a part of our Y2K effort.	SERVSW
11. Hardware upgrades on network(s) within our organization were a part of our Y2K effort.	NTWKHW
12. Software upgrades on network(s) within our organization were a part of our Y2K effort.	NTWKSW
13. Hardware upgrades on mainframe(s) within our organization were a part of our Y2K effort.	MAINFHW
14. Software upgrades on mainframe(s) within our organization were a part of our Y2K effort.	MAINFSW

Table 1. Survey Questions/Variables (continued)

Survey Questions	Variables
15. Upgrades on Internet service within our organization were a part of our Y2K effort.	INTER
16. Upgrades on Network security within our organization were a part of our Y2K effort.	SECUR
17. Upgrades on Embedded chips housed inside equipment within our organization were a part of our Y2K effort.	EMCHP
18. Upgrades on Plant/Floor equipment within our organization were a part of our Y2K effort.	PTFLE
20. As a result of Y2K, there now exists a more thorough understanding of IT-related challenges, including effective quantification of IT problems and their probable impact.	UND
21. As a result of Y2K, there is now an increased awareness of the integral role IT plays in business functions.	AWAREBF
22. As a result of Y2K, there is now an increased awareness of the integral role IT plays in effectively managing information assets.	AWAREMIA
23. As a result of Y2K, IT foundations and management mechanisms have been modernized.	FDMAN
24. As a result of Y2K, critical infrastructure protection and other IT issues now rank higher among the mission priorities of corporate executives as a result of Y2K.	ITISS
25. A significant amount of funds that our organization spent on Y2K efforts were spent replacing/upgrading legacy systems that would have eventually had to have been replaced/upgraded anyway.	LEGRP
26. As a direct result of Y2K efforts, our organization has been the beneficiary of benefits that were unanticipated.	SERENDIP

Following is a comprehensive list of the variables listed in Table 1 by name along with a detailed description of how they are used.

Independent Variables

- Y2KEFFORT (Year 2000 Effort) - This variable measured whether or not an organization went through a Y2K remediation process.
- ORGSP (Organizational spending) - This variable measured the respondents impression of the appropriateness of spending within their organization.
- ORGMH (Organization man-hours) - This variable measured the respondents impression of the appropriateness of time spent of Y2K within their organization.
- DTNBHWCA (desktop PC and notebook hardware of "casual users" affected by Y2K issues) - This variable measured the degree to which the personal computer hardware of causal users was affected by Y2K remediation efforts.
- DTNBSWCA (desktop PC and notebook software of "casual users" affected by Y2K issues) - This variable measured the degree to which the personal computer software of causal users was affected by Y2K remediation efforts.
- DTNBHWMC (mission-critical desktop PC and notebook hardware affected by Y2K issues) - This variable measured the degree to which mission-critical personal computer hardware was affected by Y2K remediation efforts.
- DTNBSWMC (mission-critical desktop PC and notebook software affected by Y2K issues) - This variable measured the degree to which mission-critical personal computer software was affected by Y2K remediation efforts.
- SERVHW (Server hardware affected by Y2K issues) - This variable measured the degree to which server hardware was affected by Y2K remediation efforts.

- SERVSW (Server software affected by Y2K issues) - This variable measured the degree to which server software was affected by Y2K remediation efforts.
- NTWKHW (Network hardware affected by Y2K issues) - This variable measured the degree to which the respondents' network hardware was Y2K remediation efforts.
- NTWKSW (Network software affected by Y2K issues) - This variable measured the degree to which the respondents' network software was Y2K remediation efforts.
- MAINFHW (Mainframe hardware affected by Y2K issues) - This variable measured the degree to which mainframe computer hardware was affected by Y2K remediation efforts.
- MAINFSW (Mainframe software affected by Y2K issues) - This variable measured the degree to which mainframe computer software was affected by Y2K remediation efforts.
- INTER (Internet affected by Y2K issues) - This variable measured the degree to which Internet service was affected by their respective Y2K remediation efforts.
- SECUR (Security affected by Y2K issues) - This variable measured the degree to which security issues within their organizations were affected by Y2K remediation efforts.
- EMCHP (Embedded chips affected by Y2K issues) - This variable measured the degree to which systems which contained electronic components with possible Y2K glitches were affected by their respective Y2K remediation efforts.

- PTFLE (Plant/Floor equipment affected by Y2K issues) - This variable measured the degree to which other systems such as plant/floor were affected by their respective Y2K remediation efforts.

Dependent Variables

- UND (Understanding of IT-related challenges, including effective quantification of IT problems and their probable impact) - This variable measured the degree to which Y2K remediation efforts have increased the understanding of information technology related problem and how they can impact an organization if and when they occurs.
- AWAREBF (Awareness of the integral role IT plays in business functions) - This variable measured the degree to which Y2K remediation efforts have increased the awareness of the importance that information technology has on day-to-day business function.
- AWAREMIA (Awareness of the integral role IT plays in effectively manage information assets) - This variable measured the degree to which Y2K remediation efforts have increased the awareness of the importance that information technology has on managing information assets.
- FDMAN (Modernization of IT foundations and management mechanisms) - This variable measured the degree to which Y2K remediation efforts have caused IT foundations and management mechanisms within their organization to be updated.

- ITISS (Critical infrastructure protection and other IT priorities of corporate executives) - This variable measured the degree to which Y2K remediation efforts have caused executives to have a heightened realization of the importance of protecting their information system infrastructure.
- LEGRP (Legacy systems upgrading/replacement) - This variable measured the degree to which an organizations legacy systems were replaced or upgraded.
- SERENDIP (Unexpected or unanticipated benefits) - This variable measured the degree to which an organization experienced benefits beyond those that were anticipated.

Resource requirements

The resources necessary for this study, other than a list of major companies to contact, was a host web site for the survey form, a domain name, and an e-mail address to be used as a collection point for the submitted surveys. A personal computer with web page development software installed was used to develop the actual web pages. The statistical software that was used was NCSS (Number Cruncher Statistical System) which is a statistical and data analysis system for Windows (available at http://www.ncss.com/). This software was chosen because of its ability to perform various types of statistical analysis.

Summary

The goal of the researcher in this study was to investigate the extent to which benefits and spinoffs may have resulted during the Y2K remediation effort by business and industry. In order to establish whether or not these benefits occurred, the researcher

used data collected through the use of a survey that was distributed to 250 randomly selected Fortune 500 companies in the United States. A variety of businesses and organizations were targeted. The survey itself measured a number of aspects of the Y2K remediation process using a set of 17 independent variables and a set of seven dependent variables. The independent variables were designed such that they measured factors such as effort, spending, time, systems types, and software affected by Y2K issues. The dependent variables were designed such that they measured factors such as understanding of IT-related issues, awareness of the role of IT within an organization, the importance of the IT infrastructure, and of course, unexpected benefits.

The researcher used an eleven-stage process by which to perform this research. The stages consisted of identifying the focus of the study and method of research, determining the research schedule and budget, establishing an information base, determining the sampling frame, determining the sample size and sample selection procedures, designing the survey instrument, pretesting the survey instrument, implementing the survey, coding the completed questionnaires and computerizing the data, and analyzing the data and preparing the report. One other stage not listed dealt with the selecting and training of interviewers for a survey. Since this survey was conducted by a single researcher and did require additional personnel, this step was omitted.

Once the surveys were completed and returned, the results were analyzed and conclusions drawn. In this study, the researcher investigated the degree of relationship between a set of dependent variables (the benefits and spinoffs) and a set independent variables (various remediation efforts). Given this situation, a canonical correlation analysis was the statistical procedure used.

Chapter 4

Presentation and Discussion of Results

Introduction

In this chapter, the researcher presents the findings and conclusions of this study along with the relevant data, tables, and diagrams. As mentioned in Chapter 3 (Methodology), this study was conducted in two parts: a pilot study and the main study. The pilot study will be presented first along with the findings. Finally, a discussion of the main study will be presented along with the findings.

The bulk of the literature reviewed thus far in the process of conducting this study has shown that, overall, the Y2K remediation process has been a profitable one with many "enduring" benefits (Lehman, 2000). Although an immense amount of money was spent in the process, most organizations found that the money was well spent (Kappelman, 2000).

Y2K managers said the Y2K effort had positive, transformational effects on every level it touched, from information technology departments to businesses, multinational corporations and even entire industries with the big winner being project management (Melymuka, 2000). During the readiness process, new relationships and partnerships were forged to combat the shared risk of Y2K vulnerability. The interconnectedness and interdependencies of modern organizations, across all industry sectors, required that

programs addressing Y2K not simply focus internally, but also on supply chain relationships and business partnerships (United States Senate Special Committee on the year 2000 technology problem, 2000).

In addition to limiting the potential risk to IT and related systems, one of the most important – though less publicized – benefits accruing from this estimated $450 billion investment has been the increase in awareness and understanding of IT as a strategic boardroom issue. Many senior managers now have a better understanding of the processes that are core to the organization or business (Dennis, 2000). Y2K has heightened awareness about the importance of high-tech infrastructure protection (United States Senate Special Committee on the year 2000 technology problem, 2000).

Another benefit of the Y2K experience was that many organizations tightened up their procedures for testing applications, systems and interoperability. This should allow IT departments to deliver higher quality software, on time, and at lower cost (Marson & Cox, 2000).

Many have argued that as much as $10 billion was wasted on various Y2K remediation efforts in the U.S. alone (Kappelman, 2000). While these criticisms may abound, most IT executives firmly believe that would-be disasters were averted because they had spent enough money (Scannell & Epstein, 2000). If it is true that the total spending in the U.S. was $100 billion, then one dollar in ten was wasted. The fact is that about 25% of IT projects totally failed to deliver anything. So if Y2K waste was approximately 10%, then Y2K was one of the best managed IT projects in history (Kappelman, 2000).

Critics have stated that Y2K was essentially a non-event, but the response to those critics has been that the reason Y2K did not have serious repercussions was that IT staffs did the job they were supposed to do . In addition, those who were launching the verbal assaults on the IT community never saw systems fail during preliminary Y2K testing (Wilson, 2000).

Overview of results

The results of the pilot study were, for the most part, inconclusive due to the small number of responses. Analysis of the data from the main survey has shown that the variables ITISS (Critical infrastructure protection and other IT priorities of corporate executives) and UND (Understanding of IT-related challenges, including effective quantification of IT problems and their probable impact) had the highest rating of the variables measured. This implied that among all the variables measured, these were the two areas that benefitted the most from Y2K remediation.

This study did not demonstrate conclusively that serendipitous events were a universal phenomena, however, the fact that a review of literature continues to produce cases where these events have occurred cannot be overlooked. The results of the survey showed that network systems were the most involved with Y2K issues followed by personal computer systems, and lastly mainframe systems. These were measured with the variables NYSYS, that is a composite of the variables that measured network hardware and software, PCSYS, that is a composite of the measured variables that correspond to personal computer hardware and software,, and MFSYS, that is a composite of the variables that measured mainframe hardware and software.

Although no questions were asked about costs, a review of the literature has yielded a number of estimates. Feder (2001) estimated that the costs of Y2K remediation at $250 billion or more in repairs and contingency planning. The Gartner Group projected Y2K project spending worldwide at between $300 billion and $600 billion. If costs for non-information technology factors such as risk management and contingency planning are included, the worldwide bill escalates to close to $1 trillion dollars. If the costs of litigation and business failures are added to the mix, the total costs comes to between $1 trillion and $2 trillion dollars (Caldwell, 1999). Revamping government and other Web sites nationwide had an estimated costs of approximately $690 million, mostly in fees paid to tech consultants and software developers.

The pilot study

Initial work on the pilot study began with the drafting of a set of tentative survey questions after performing a review of the literature as proposed by Fowler (1993). The review of literature uncovered the information necessary to construct the set of questions for the survey. Any necessary adjustments to the survey were made during pilot testing and validation of the questionnaire which was done with the assistance of a review panel.

In order to randomly select a sample for the pilot study, a random number generator program was written in C++. The program included code that allocated memory for an array and code to generate a pre-determined number of unique random numbers from one to 50. As each random number was generated, the array was scanned to see if that particular number was already in the array. If so, the number was discarded. If the generated number was unique (did not already exist in the array), it was placed into the

next available slot in the array. This process continued until the appropriate number of random numbers had been generated. Finally, the array was sorted in ascending order and written to a text file.

Using the sequence of numbers in the random number list as a guide, the corresponding company names were pulled from the Fortune 500 list of company names. For example, if the random number was three, then the third company name from the Fortune 500 list was used as part of the sample for the pilot study.

When all the names for the pilot study were assembled, work began on a contact list. One-by-one, the companies' web sites were visited, and e-mail messages sent or phone calls made as a prelude to sending out the survey instrument. It was during this phase of the pilot study that two important factors were discovered. First, many companies were reluctant to fill out surveys for various reasons. In fact, many companies even had policies against employees participating in surveys. Secondly, the companies were hesitant about divulging the names of senior managerial personnel within their respective companies.

Given this setback, another method was identified to reach the individuals needed to complete the surveys. The solution was the acquisition of a subscription to Hoovers Online at http://www.hoovers.com. Through this web site, Hoover's delivers continuously updated intelligence about public and private companies worldwide. Hoover's is headquartered in Austin, TX and has offices in New York City and San Francisco.

Utilizing the Hoover's database, each company in the sample was examined and a contact list complied. The contact information was acquired by using the company name as a "keyword" and performing a search of the Hoover's online database. Once the company's name was located in the database, the contact information could be found by following a series of links. The information collected included the companies' home office addresses and the individual(s) responsible for the companies' respective information technology departments. These individuals typically had the title of SVP (Senior Vice President) of Information Management, CTO (Chief Technical Officer), SVP Information Services and CIO (Chief Information Officer), VP (Vice President) of Information Technology, etc.

Once the contact list was completed, a form letter was written describing the nature and purpose of the survey and providing the survey respondents with the URL of the Y2K survey web site (see Appendix D). In an effort to increase response rates, and at the same time give respondents another option, a hard copy was also included (see Appendix B). The complete survey package consisted of the form letter along with the survey and a self-address, stamped envelope. This package was then mailed using conventional U.S. mail.

The first mailing attempt with a sample size of 20 resulted in an insufficient response rate, so a second sample of 50 was generated to form a new mailing list. Of the 50 companies in the new list, one company's home office had an overseas address, so it was deleted from the list. Out of the remaining 49, five hard copy responses were received.

In an effort to increase the number of responses during the pilot phase of this study, a follow-up letter was also sent to the original recipients of the surveys (see Appendix E). No additional electronic submissions were received as a result of this letter, so the final response rate was 10%. There were no comments sent in with any of these surveys, so no additional variables were created.

Creation of the latent variables

Since a number of variables were used in this study, it was the opinion of the researcher to combine selected homogeneous independent variables together into a smaller number of latent or composite independent (predictor) variables. The dependent (criterion) variables were unaltered. Grimm and Yarnold (2000, p. 6) defined a *latent variable* as one that cannot be measured directly and is operationalized by one or more other measured variables sometimes referred to as *indicators* or *manifest variables*. In social and behavioral research, scales on personality inventories, measures of socioeconomic status, health indices, and many other variables are actually composites of several items (Tabanick & Fidell, 1989).

The NCSS software provides a number of convenient ways to transform and create composite variables. For the purposes of this study, simple averages were derived from the indicator variables. Following is a list of the composite variable set used for this study and their respective grouping:

- TOTEFF (Total Y2K effort) - consists of Y2KEFFORT (Year 2000 effort), ORGSP (organizational spending), and ORGMH (organizational man-hours).

- PCSYS (personal computer systems) - consists of DTNBHWCA (desktop PC and notebook hardware of casual users), DTNBSWCA (desktop PC and notebook software of casual users), DTNBHWMC (desktop PC and notebook hardware of mission critical users), and DTNBSWMC (desktop PC and notebook software of mission critical users).
- NYSYS (network systems) - consists of SERVHW (server hardware), SERVSW (server software), NTWKHW (network hardware), and NTWKSW (network software).
- MFSYS (mainframe systems) - consists of MAINHW (mainframe hardware affected by Y2K), MAINSW (mainframe software affected by Y2K), and LEGRP (legacy systems upgrade/replacement).
- ECPFSYS (embedded chip and plant/floor equipment) - consists of EMCHP (embedded chips systems affected by Y2K), and PTFLE (plant floor equipment affected by Y2K).

Analysis of results from the pilot study

Since there were only five responses during this phase, a simple correlation matrix was generated using the NCSS software. The correlation matrix consisted of the six independent variables and the six dependent variables (see Appendix F). The matrix lists the correlation factors (*Pearson r*'s) along with the significance of the correlation show directly underneath the correlation factor for each independent/dependent variable pair.

Findings of the pilot study

Such a small number of responses greatly restricted the ability of the researcher to obtain any statistically significant results from the pilot study. At first glance, there appear to be a number of relatively large correlation coefficients in the matrix, but all but a couple are statistically insignificant ($p>.05$) due to the small number of degrees of freedom ($df = 3$).

The matrix shows a minor but statistically significant correlation between SECUR (Security issues affected by Y2K) and TOTEFF (Total Y2K effort). Also shown is another minor but statistically significant correlation between FDMAN (Modernization of IT foundations and management mechanisms) and MFSYS (Mainframe systems). Even though these small correlations exist, they are meaningless and, for the most part, inconclusive due to the small number of responses.

The main study

The main study was conducted in much the same way as the pilot study. However, due to the small number of responses received in the pilot study, a much larger random sample of 250 was generated for use in the main study. Once the list was generated and the company names pulled from the Fortune 500 list of company names, they were compared to the names that were used in the pilot study. Any names that appeared in the main study group sample of 250 that also appeared in the pilot study group were deleted from the main study group sample. Then, each company's IT officer was examined at Hoover's Online and company addresses collected for the main study.

As with the pilot study, any company names that had an overseas address listed was also removed from the list. This left a total of 239 companies for the main study.

Packets with the cover letter (see Appendix D) and a stamped, self-addressed envelop containing a hard copy of the survey (see Appendix B) were sent to the companies on the list. Two weeks later, a follow-up letter (see Appendix E) was also sent to solicit more survey responses. Out of the 231 companies contacted, 19 hard copies of the surveys were completed and sent back and 8 submissions were received via e-mail from the Y2K survey web site for a total of 27 responses. The response rate was 11.7%, approximately the same as the pilot study. Although a number of comments were included with the main study instruments, it was the opinion of the researcher that these comments did not require the creation of additional variables for use within this study. These comments are included in Appendix G.

Presentation of results from the main study

A canonical correlation analysis was performed on the data from the main study to determine the relationships, if any, that exist between the independent (predictor) variables and the dependent (criterion) variables. Because canonical correlations are reported in descending order of importance, usually only the first few pairs of variates are significant (Tabacnick& Fidell, 1989). For this reason, the NCSS software was set to generate three canonical functions (although as many canonical functions can be generated as there are numbers of variables in the smallest variables set used for the correlation).

Table 2. Correlation Matrix for Main Study

	UND	AWAREBF	AWAREMIA	FDMAN	ITISS
UND	1.000000	0.786796	0.575876	0.223952	0.430946
AWAREBF	0.786796	1.000000	0.763293	0.256174	0.369495
AWAREMIA	0.575876	0.763293	1.000000	0.315476	0.308623
FDMAN	0.223952	0.256174	0.315476	1.000000	0.360060
ITISS	0.430946	0.369495	0.308623	0.360060	1.000000
SERENDIP	0.458368	0.253143	0.309649	0.746203	0.623618
SECUR	0.363347	0.298446	0.528854	0.338007	0.338402
TOTEFF	0.459002	0.320027	0.368433	-0.014233	-0.006086
PCSYS	0.195961	0.166362	0.294557	-0.019297	0.326119
NTSYS	0.171327	0.170556	0.273221	0.152051	0.385811
MFSYS	0.266870	0.336416	0.412413	0.342833	0.393043
ECPFSYS	0.406326	0.254980	0.318307	0.270782	0.085071

Correlation Matrix (continued)

	SERENDIP	SECUR	TOTEFF	PCSYS	NTSYS
UND	0.458368	0.363347	0.459002	0.195961	0.171327
AWAREBF	0.253143	0.298446	0.320027	0.166362	0.170556
AWAREMIA	0.309649	0.528854	0.368433	0.294557	0.273221
FDMAN	0.746203	0.338007	-0.014233	-0.019297	0.152051
ITISS	0.623618	0.338402	-0.006086	0.326119	0.385811
SERENDIP	1.000000	0.542191	-0.014566	0.061274	0.263245
SECUR	0.542191	1.000000	0.093468	0.310226	0.634425
TOTEFF	-0.014566	0.093468	1.000000	0.632468	0.191113
PCSYS	0.061274	0.310226	0.632468	1.000000	0.505371
NTSYS	0.263245	0.634425	0.191113	0.505371	1.000000
MFSYS	0.495010	0.532933	0.349390	0.601086	0.474494
ECPFSYS	0.350627	0.630597	0.575824	0.605872	0.601635

Correlation Matrix (continued)

	MFSYS	ECPFSYS
UND	0.266870	0.406326
AWAREBF	0.336416	0.254980
AWAREMIA	0.412413	0.318307
FDMAN	0.342833	0.270782
ITISS	0.393043	0.085071
SERENDIP	0.495010	0.350627
SECUR	0.532933	0.630597
TOTEFF	0.349390	0.575824
PCSYS	0.601086	0.605872
NTSYS	0.474494	0.601635
MFSYS	1.000000	0.656449
ECPFSYS	0.656449	1.000000

Table 2 is a presentation of the correlation matrix that resulted as part of the canonical analysis. Table 3 presents the results from the canonical correlations section of the NCSS output. Of the three canonical functions shown, only the first one is statistically significant at the $p<.05$ level. Wilk's lambda, that is the multivariate generalization of r^2, is reported at .034267. The Wilks' lambda statistic is interpreted just the opposite of r^2: a value near zero indicates high correlation while a value near one indicates low correlation. The canonical correlation between the

Table 3. Canonical Correlations Section

Variate Number	Canonical Correlation	R-Squared	F-Value	Num DF	Den DF	Prob Level	Wilk's Lambda
1	0.858347	0.736760	2.06	36	64	0.005655	0.034267
2	0.812970	0.660921	1.67	25	57	0.054977	0.130173
3	0.754940	0.569934	1.14	16	50	0.348102	0.383902

function 1 computer generated variates is reported at approximately .86. This indicates a high degree of correlation between criterion variate 1 that represented the independent variables, and the predictor variate 1 that represented the dependent variables. In Table 3, the reported F-value tests whether the first canonical correlation and those following are zero. The critical value of F was computed at 1.60. Since the this critical value is less than the report value of F from the Table 3 (2.06), the null hypothesis was rejected. Figure 1 shows the raw scores for predictor 1 plotted against the criterion 1 scores. Tables 4 and 5 illustrate the relationships (correlation) between the independent variables and the predictor1 variate, and the dependent variables and the criterion1 variate.

The variable TOTEFF had the highest *Pearson r* correlation (+.3949) with the Predictor1 variate with 15.6% of this variable being useful within this canonical function.

The ECPFSYS variable and the NYSYS variable also correlate with the Predictor1 variate by factors of +.3358 and +.3105 respectively. Approximately 11% of the ECPFSYS variable is useful within this canonical function and approximately 10% of the NYSYS is useful. The variables PCSYS and MFSYS correlate equally with the Predictor 1 variate at approximately -.26% with both being approximately 7% useful within this canonical function. The SECUR variable had a negligible contribution to the correlation. Talbachnick and Fidell (1989, p. 640) suggested that as a rule of thumb, only variables with loadings greater than approximately 30% (that are considered to be poor) should be interpreted, but the actual cutoff size for interpretation of the correlation is a matter of the researcher's preference.

Figure 1. Scatter Plot

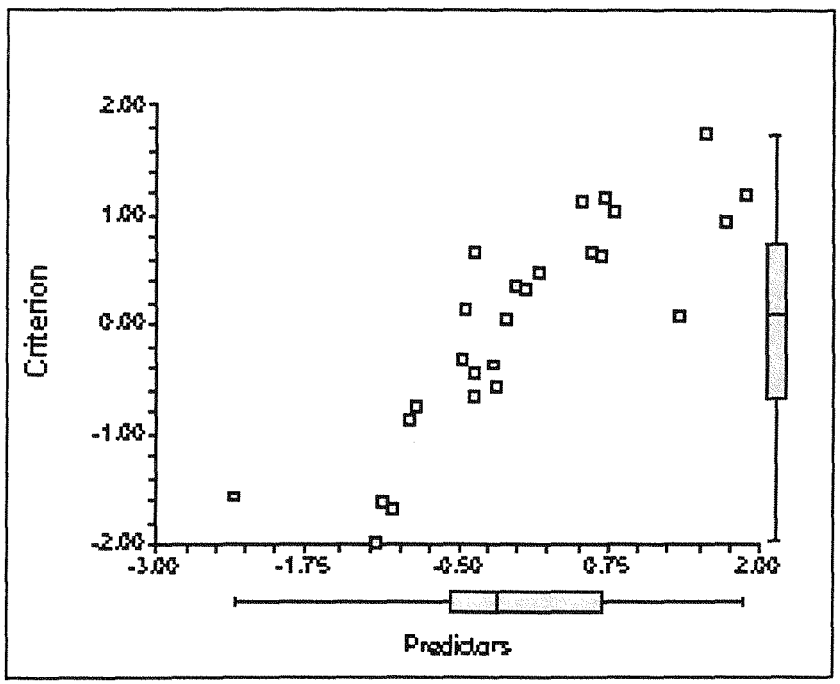

Table 4. Variate/Variable Correlation Section for Predictor 1

	Function Coefficient	Structure Coefficient (*Pearson r*)	Structure Coefficient Squared
SECUR	-0.0716	-0.0758	0.57%
TOTEFF	+0.4251	+0.3949	15.60%
PCSYS	-0.6631	-0.2573	6.62%
NYSYS	-0.4625	-0.3105	9.64%
MFSYS	-0.5000	-0.2564	6.57%
ECPFSYS	+1.1443	+0.3358	11.28%

Table 5. Variate/Variable Correlation Section for Criterion 1

	Function Coefficient	Structure Coefficient (*Pearson r*)	Structure Coefficient Squared
UND	+1.2080	+0.3396	11.53%
AWAREBF	-0.4796	+0.0572	0.33%
AWAREMIA	-0.1741	-0.0523	0.27%
FDMAN	+0.4429	+0.0590	0.35%
ITISS	-0.9403	-0.6066	36.79%
SERENDIP	-0.1850	-0.0625	0.39%

The variable ITISS correlates with the Criterion1 variate by a factor of +.6066 (37% overlapping variance) which is considered to be very good (Talbanick & Fidell, 1989). The UND variable has a correlation factor of +.33 which is considered poor. Approximately 12% of this variable is useful within this function. All other variable had a negligible effect on the Criterion 1 variate. Therefore, the independent variables TOTEFF, ECPFSYS, NYSYS, PCSYS, and MFSYS are most predictive of the dependent variables ITISS, and UND.

Discussion of results in respect to the research questions

1. What types of benefits and spinoffs were most common?

In terms of benefits and spinoffs, analysis of the data from the survey has shown that ITISS (Critical infrastructure protection and other IT priorities of corporate

executives) had the highest rating (refer back to Table 5). This variable measured the degree to which Y2K remediation efforts were related to executives having a heightened realization of the importance of protecting their information system infrastructure. This variable was followed by UND (Understanding of IT-related challenges, including effective quantification of IT problems and their probable impact) that measured the degree to which Y2K remediation efforts have increased the understanding of information technology related problem and how they can impact an organization if and when they occurs. Following are some of the comments on benefits that were common that were given on the Y2K survey:

> *"Inventory of applications, retirement of some legacy (systems), improvement in libraries for (?), harvest of some technologies and equipment."*
>
> *"Better inventory of IT assets and understanding of embedded chip issues."*
>
> *"This was the opportunity to replace obsolete equipment, update equipment inventories and dispose of redundant/obsolete software. It got its moments of glory, soon forgotten, thus the lower ranking on these last questions."*
>
> *"Improved inventory of assets enabling better asset management."*
>
> *"We chose to start an ERP solution."*
>
> *"Elimination of underutilized IT assets (?/software) eliminating the need to maintain or replace ultimately savings dollars."*
>
> *"Issues were so minor and insignificant that management thinks we overstated the risks."*

2. Were certain benefits and spinoffs serendipitous?

In an extended effort to determine if there were indeed unexpected benefits in those companies surveyed, a multiple regression was performed with the NCSS software using the measured variable "SEREDIP" as the dependent variable and using the measured variables Y2KEFFORT, ORGSP, and ORGHM as the independent variables. Table 6 shows the results for the regression analysis.

Since a combination of variables usually results in a more accurate prediction than any one variable alone, prediction studies often result in a prediction equation referred to as a multiple regression equation. A multiple regression equation uses variables that are known to predict (correlate with) the criterion to make a more accurate prediction (Gay, 1996).

Multiple regression is an extension of bivariate regression (e.g. ANOVA) in which several independent variables instead of just one are combined to predict a value of a dependent variable. The result of the regression is an equation that represents the best prediction of a dependent variable from several independent variables (Tabachnick & Fidell, 1989).

The goal of regression is to arrive at the set of *B* values, called regression coefficients, for the independent variables that bring the *Y* values predicted from the equation as close as possible to the *Y* values obtained by measurement. The regression coefficients that are computed accomplish two goals: they minimize (the sum of the squares) deviations between predicted and obtained *Y* values and they optimize the

correlation between the predicted and the obtained *Y* values for the data set (Tabachnick & Fidell, 1989).

Even using an alpha level of .10, the null hypothesis was not rejected indicating that among the companies surveyed, the occurrences of serendipitous events were not statistically significant given that the reported probability level is 0.5836. The R-Squared measure (0.106255) indicates the percent variation in the dependent variable explained by the independent variables in the regression model.

Table 6. Multiple Regression Analysis

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	2.18732	3.727756	0.5868	0.56	Accept Ho	0.15
Y2KEFFORT	0.6152738	0.7103152	0.8662	0.40	Accept Ho	0.22
ORGSP	0.8097983	0.834981	0.9698	0.34	Accept Ho	0.25
ORGMH	-1.190202	0.834981	-1.4254	0.17	Accept Ho	0.40
R-Squared	0.113422					

As previously mentioned, results in this study could not demonstrate conclusively that serendipitous events were a universal phenomena, however, the fact that a review of the literature continues to produce cases where these events have occurred cannot be overlooked. Following are some of the comments about unexpected benefits that were given in the Y2K survey:

> *"I believe your survey is right on target, not only did it raise the level of understanding of IT systems and architectures, it did force some companies to modernize which had they not done that would not have been prepared for B2B, CRM and other current mission critical initiatives."*

> *"Business resumption planning efforts for Y2K have been re-used and regularly updated. These have helped improve startups following plant shutdowns, holiday periods."*

"It is hard to distinguish between Y2K preparations and the evolution to a knowledge management economy. Y2K just happened to occur during the embryonic stages of this evolution. Admittedly, Y2K may have brought greater attention to this evolution and accelerated the development of infrastructure necessary to operating in the emerging environment."

"Total company effort promoted communication and cooperation across company. Stronger ties with customers needing Y2K support and their appreciation for cooperation and support."

3. What types of systems were most involved?

The results of the survey showed that the variable NYSYS, which is a composite of the variable that measured network hardware and software , had the highest function coefficient (refer back to Table 4). It was followed by PCSYS, that is a composite of the measured variables that correspond to personal computer hardware and software, and then MFSYS, that is a composite of the variables that measured mainframe hardware and software. Following are some of the comments on systems and software types involved in Y2K that were solicited in the survey:

"Our older applications were mainly IBM mainframe. Y2K was not a big deal primarily because we had developed our own "Y2K ready" date handling utility as far back as the early 70s."

"Major effort to ... All embedded chip problems throughout the gas and electric systems in ... And LI. Everything had to be tested."

"We addressed the Y2K effort as a comprehensive plan, including all infrastructure items likely to be impacted by the 'millennium bug.'"

"We had more issues (very minor) with printers than any other devices (usually drives were reinstalled)."

4. What were the costs of remediation?

Feder (2001) estimated that the costs of Y2K remediation at $250 billion or more in repairs and contingency planning. The Gartner Group projected Y2K project spending worldwide at between $300 billion and $600 billion. If costs for non-information technology factors such as risk management and contingency planning are included, the worldwide bill escalates to close to $1 trillion dollars. If the costs of litigation and business failures is added into the mix, the total costs comes to between $1 trillion and $2 trillion dollars (Caldwell, 1999). Reportedly, some companies spent as much as 40% of their IT budgets on Y2K projects in 1999 (Wilson, 2000). Revamping government and other Web sites nationwide had as estimated costs of approximately $690 million, mostly in fees paid to tech consultants and software developers. Following are some of the comments on Y2K expenditures that were solicited in the survey:

> *"Project was mid 1997 to early 2000, with between $50 and $100 million spent."*
>
> *"Spent $23 million dollars over 4 years 1996-2000. Countless man-hours - over 100 FTE's on average over the course of 4 years."*
>
> *"Preparation started in 1996. Related money & most resources were included in the subsequent business plans. We had a strong support from out top executives."*
>
> *"Due to the nature of our 24/7 Hotel/Casino operations we spent several years planning and migrating systems to y2K compliant platforms - a huge effort."*
>
> *"Neither time or costs were excessive. We did... get contacted by a number of attorneys representing patent or the actual property rights holders to Y2K solutions which we ignored."*
>
> *"We really did not spend a lot of $$ on Y2K - Maybe $500,000 total - which is not a lot for a 4 billion annual sales company."*

Summary

In this chapter the researcher has presented the results from the survey used in this research project. As stated earlier, the results of the pilot study were inconclusive due to the small number of responses. Analysis of the data from the main survey has shown that the areas that benefitted the most from Y2K remediation were critical infrastructure protection and other IT priorities of corporate executives, and corporate awareness of the integral role IT plays in effectively managing information assets.

The results of the survey showed that network systems were the most involved with Y2K issues followed by personal computer systems, and lastly mainframe systems. This study could not demonstrate conclusively that serendipitous events occurred during the Y2K remediation process, but a review of literature continues to produce cases where such events were documented.

Although no questions were asked about costs, review of the literature has yielded and number of estimates. Some have estimated the costs of Y2K remediation at $250 billion or more in repairs and contingency planning while other have es5timated spending worldwide at between $300 billion and $600 billion. Adding in other factors such as management and contingency planning, the worldwide bill escalates to close to $1 trillion dollars.

Chapter 5

Conclusions and Implications

Conclusions

The problem that was investigated in this study, and the goal that was achieved, were attempts to investigate the relationships between the time, money, and effort put into the Year 2000 remediation effort (Kappelman, 2000) and the benefits that have occurred as a result of the process. Additionally, an attempt was made to determine the extent to which benefits and spinoffs may have resulted during the Y2K (Year 2000) remediation efforts undertaken in business and industry. For the purpose of this study, benefits were defined as spinoffs, positive outcomes, improvements in procedures, and other "serendipitous" type events or occurrences that happened unexpectedly or as a byproduct of Y2K remediation.

The survey instrument used in this study (see Appendix A) consisted of 27 questions designed to measure various aspects of the remediation effort (time, effort, dollars spent, etc.) as well as aspects relating to benefits that have occurred (understanding and awareness of the functions of IT, etc.). An analysis and discussion of the survey data in Chapter 4 have shown a statistically significant correlation between the dependent variables and the independent variables, thus indicating that benefits have occurred as a result of Y2K remediation. However, it should be emphasized that any results based on correlation may be spurious due to the small response rate.

The research hypothesis

The research hypothesis for this study was as follows: Organizations that have gone through year 2000 remediation have experienced unexpected benefits and spinoffs as a result.

Although this research has shown that benefits occurred as a result of Y2K remediation, analysis of the survey data from the companies responding to the survey have not proven conclusively that any of these benefits were serendipitous. This possibly could be attributed to the fact that a large proportion of the companies that were contacted about participating the in this research, elected not to participate for various reasons. The low response rate could also have affected these results as well.

This presents somewhat of a paradox in that much of the literature to date has indicated that unexpected benefits have occurred. Beach (2000) said that the recent Year 2000 computer problem was one of the most remarkable examples of global human cooperation ever conceived in that it brought together many organizations in an effort to find viable solutions. On a local level, thousands of business and community leaders came together and made Y2K remediation a priority and approved the appropriate expenditures.

Technology departments, famous for going over budget and missing deadlines, had new discipline imposed by Y2K. (Stepanek, 2000). Stepanek also stated that at company after company, the Y2K bug-hunt yielded unexpected benefits. Many companies ended up eliminating old computer programs that made it possible to modernize existing systems.

Dennis (2000) stated that in addition to limiting the potential risk to IT and related systems, other benefits accruing from the money spent on Y2K has been the increase in awareness and understanding of IT as a strategic boardroom issue. Many senior managers now have a better understanding of the processes which are core to the organization an of broader importance to the business community.

Kappleman (1999) made the case that Y2K was an opportunity to improve relationships with customers and suppliers, capture market share, buy up assets at fire-sale prices, and initiate new competitive IT projects.

In some cases, most of the monies that were set aside in IT budgets in 1999 – estimates are as high as 30% of the total company budget – were actually spent on e-commerce upgrades. Thus, Y2K became a catalyst for leveraging company position within the market place (Y2K opens door to new era of e-commerce, 2000).

Furthermore, on that fateful morning of September 11, 2001, many in the financial industry realized that all the effort and planning that had gone into Y2K remediation had been worthwhile (Nine ideas that shaped financial services in 2001, 2002). After the attacks on the World Trade Center and Pentagon, regulators said that they and their banks had dusted off their old Y2K plans, used them to figure out whom to contact in various affected areas, and organized regional supervisors to monitor local situations. "What we did in Y2K is what we did last week," said John Lane, associate director for supervision at the Federal Deposit Insurance Corporation. He also stated that "The contingency planning we went through ...was invaluable" (Nine ideas that shaped financial services in 2001, 2002).

Additionally, technology and defense academics say that the United States has learned too much from the false alarm of Y2K to risk losing essential data and telecommunication services to a terrorist attack. Despite the attack on the World Trade Center and the Pentagon causing serious damage to mobile and fixed-line telephone networks, commentators said businesses and financial markets would continue to function (Hayes, 2001).

Y2K has also brought fourth a multitude of improvements in business practice and philosophy that are applicable in many areas. Following is a quote from a Government Accounting Office report on the year 2000 problem:

> Individual agencies also gleaned lessons from their Y2K efforts that can be carried forward. Specific management practices that contributed to Y2K success included top- level management attention, risk analysis, project management, development of complete information systems inventories and strengthened configuration management, independent reviews by internal auditors and independent contractors, improved testing methods and procedures, and business continuity and contingency planning (Year 2000 computing challenge-lessons learned can be applied to other management challenges. (2000, p. 4-5)

Research Questions

In addition to the aforementioned hypothesis, the researcher in this study sought to answer the following research questions:

What types of benefits and spinoffs were most common?

Conclusion 1: It is concluded that in terms of benefits and spinoffs, analysis of the data from the survey has shown that Critical infrastructure protection and other IT priorities of corporate executives had the highest rating with a structure coefficient of 61% (see Table

5). These characteristics were measured using the variable ITISS that was designed to measure the degree to which Y2K remediation efforts were related to executives, to heightened realization of the importance of protecting their information system infrastructure.

The characteristic that had the next highest rating dealt with the level of understanding of IT-related challenges. This was measured by the variable UND that measured the degree to which Y2K remediation efforts have increased the understanding of information technology related problem and how they can impact an organization if and when they occurs. This variable had a structure coefficient of 34% (see Table 5).

Were certain benefits and spinoffs serendipitous?

Conclusion 2: It is concluded that serendipity was not a universal phenomena, however, the fact that a review of literature continues to produce cases where these events have occurred cannot be overlooked. One of the contributing factors in this study to the lack of statistically significant results of "Y2K serendipity" may lie in the fact that the response rate was not as high as expected.

What types of systems were most affected?

Conclusion 3: It is concluded that, according to analysis of the results from the survey, network systems were most affected by Y2K. This was measured using the variable NYSYS, that is a composite of the measured variables that correspond to network hardware and software. This variable had a structure coefficient of 31%.

The systems that were the next most involved in Y2K were personal computer systems. This was measured using the variable PCSYS, that is a composite of the

variables that measured personal computer hardware and software. This variable's structure coefficient is reported as 25.73%. Mainframe hardware and software came in next with a structure coefficient of 25.64% which is extremely close to the structure coefficient of PCSYS. This was measured using the variable MFSYS that is a composite of the variables that measured mainframe hardware and software. It is noteworthy to state that had the response rate been higher, the relative position of any of these affected systems could have changed.

What were the costs of remediation?

Conclusion 4: No questions in this study were directly related to an organization's spending. It was the decision of the researcher that most organizations would not be forthcoming with information of this nature. However, a review of the literature yielded approximate figures for total Y2K remediation spending. Feder (2001) estimated that the cost of Y2K remediation at $250 billion or more in repairs and contingency planning. The Gartner Group projected Y2K project spending worldwide at between $300 billion and $600 billion. If cost for non-information technology factors such as risk management and contingency planning are included, the worldwide bill escalates to close to $1 trillion dollars. If the cost of litigation and business failures is added into the mix, the total cost comes to between $1 trillion and $2 trillion dollars (Caldwell, 1999). Reportedly, some companies spent as much as 40% of their IT budgets on Y2K projects in 1999 (Wilson, 2000). Revamping government and other Web sites nationwide had as estimated cost of approximately $690 million, mostly in fees paid to tech consultants and software developers.

Implications

The Y2K cloud holds a silver lining for senior management personnel, information systems management personnel, and chief information officers that can both recognize the opportunities that Y2K has yielded and act wisely. Given that Y2K has presented IT departments with a wealth of benefits, both documented and undocumented, business and industry can obviously use this information in future system and remediation efforts.

Implication #1 - By realizing the potential that exists in major information restructuring projects, businesses and organizations that anticipate such a restructuring of their information systems can be the beneficiaries of the same commonly found benefits and spinoffs as those businesses and organizations that have gone through Y2K remediation.

Application - A new law known as the Health Insurance Portability and Accountability Act, or HIPAA, has created an atmosphere in the health-care industry reminiscent of the Y2K crisis, when consultants urged costly testing and upgrades to avoid computer meltdowns (Shinkle, 2001). Facing penalties under federal law, the health-care industry is moving slowly to spend billions of dollars to upgrade computer systems, even though the federal government says HIPAA will save the health-care industry nearly $30 billion over 10 years, mainly by streamlining billing processes. By learning from other businesses and organizations that have gone through Y2K remediation, the health-care industry could potentially reap huge benefits from their efforts.

But the Y2K preparation proved invaluable to a handful of organizations in New York and at the Pentagon (Miller, 2001). The destruction of the Twin Towers

underscored the reality that in meeting the needs of customers, the financial services industry is not immune. The size of a firm or operation is no protection, and insurance will not cover every loss (Miller, 2001).

Implication #2 - Although serendipitous events may have not been the norm among businesses and organizations involved in situations such as Y2K, they do occur with limited frequency.

Miller (2001, p.8) noted a number of unanticipated benefits that have resulted from Y2K preparations that can be used to build upon:

- Director and senior management involvement is critical, with ongoing oversight and feedback.
- Interdepartmental and functional area teams provide a broader perspective in addressing all aspects of doing business, including systems, telecommunications, lending, operations, and audit.
- Comprehensive inventories of technology support, databases, and records are necessary to ensure proper backup and to guide business resumption.
- Oversight of vendor and third-party service providers is important; managing them and their support is an integral part of the overall disaster recovery plan.
- Regular testing can assess the effectiveness of a disaster recovery program and business resumption plan.
- Strong internal controls and security procedures are required.

- Public relations must be able to provide accurate information to customers and the public.
- Timely information sharing with peers and vendors will help to develop strong, workable disaster recovery programs.
- Legal counsel, audit, and compliance provide oversight to address critical points that affect future operations.

The Year 2000 problem has raised public and governmental awareness of information issues to such an extent, that some have called for the formation of a new office in government: that of Federal Chief Information Officer (U.S. Representative Stephen Horn (R-Ca) Chairman, 2000) . In September of 2000, the subcommittee on government management, information, and technology held hearings on the establishment of a federal chief information officer. They examined two bills that would establish a federal chief information officer and the installation of centralized management of the government's vast information resources. H.R. 4670 was introduced by the subcommittee's ranking minority member, Representative Jim Turner of Texas, and H.R. 5024 was introduced by subcommittee member, Representative Tom Davis from Virginia.

A federal Chief Information Officer could bring about ways to use IT to better serve the public, facilitate improving access to government services, and help restore confidence in the national government. With respect to specific responsibilities, a federal CIO could be responsible for a number of key functions (Year 2000 computing challenge-lessons learned can be applied to other management challenges, 2000, p. 37):

- Re-engineering and/or consolidating interagency or government-wide process and technology infrastructure.
- Managing shared assets.
- Evaluating high-risk, complex information systems modernization efforts.

Implication #3 - Although major refurbishment of an organization's computer system infrastructure may affect one type of system more than others, ultimately, their interconnectivity causes an interdependency between individual components such that one component's malfunction can result in disruption of service of the entire system.

One finding of this research has been that personal computer systems, network systems, and mainframe systems all ranked very close to one another so far as their contribution to the total Y2K remediation process. This may be a direct result of the increase of distributed computing as a means of implementing computer-driven business functions.

In the distributed environment, potentially all the resources required to process a job are in multiple locations. Programs are executed, and data are processed on separate systems. Data and printed output are routed to separate locations. Moreover, each job is typically part of a larger unit of work called a schedule, consisting of multiple jobs running on multiple systems. In many cases, one job depends on the completion of another job in another location or on the arrival or creation of a new file (Sheridan, 1997). Furthermore, when applications are distributed, the interaction between the applications and the systems they run on is increasingly complex.

Implication #4 - Although the costs of system remediation can be substantial, the costs is justified given that the cost of inaction can be devastating to a business or organization.

While criticisms may abound, most IT executives firmly believe that would-be disasters were averted because they had spent enough money. "There is no question that in the system code we looked at, there would have been failures if we had not taken action. I have no regrets about the money we spent," said Frank Petersmark, vice president of information technology at Amerisure, an insurance company in Southfield, Michigan (Scannell & Epstein, 2000,). Furthermore, dates were buried in every aspect of business, and the readiness of public utilities or other support services had to be scrutinized (Feder, 2001).

Recommendations

Results of this research have revealed much about the relationships that the Year 2000 computer bug has had with business, industry, as well as other organizations. However, there were impediments that prevented this research from providing the kind of robust results about Y2K that could have been potentially gleaned. Nevertheless, this research has opened the door to further exploration into the Y2K phenomena and its implications for the field of information systems. The following recommendations are given as they related to the research questions presented in this document.

1. What types of benefits and spinoffs were most common?

Recommendation #1 - It is recommended that further research into commonly found benefits and spinoffs be performed.

The review of literature presented in this study has presented a fairly standard set of benefits such as improved inventories, elimination of redundant applications and obsolete systems, reduced support costs due to elimination of obsolete systems, better positioning in relation to e-commerce type activities, a wealth of reusable materials test plans and test cases that can be reusable in future projects, etc. However, further research could yield even more specific benefits that were not as common, but may have been just an important such as Y2K's impact on people, business practices and experience, knowledge, attitudes, and relationships.

2. Were certain benefits and spinoffs serendipitous?

Recommendation #2 - It is recommended that a future study be performed with an increased sample size, thus yielding a higher response rate.

Future research could include the entire Fortune 500 list of companies, the Fortune 1000, and/or even international companies. Another option that could be a consideration for future research in this area would be to solicit responses from middle- and lower-level management given that upper-level management, for the most part, was unresponsive to the survey for various reasons.

It is uncertain why the majority of those solicited to respond to this survey elected not to participate. Since the number of actual responses were limited, the predictive power of the canonical correlation was reduced, since canonical correlation analysis is a large sample rate statistical procedure (Grimm & Yarnold, 2000).

Another factor that could expedite the survey process would be to do the survey totally online. This would reduce the overall expense to the researcher thus allowing the researcher to focus on expanding the sample frame to other areas and improve response. A more succinct, one-page version of the survey instrument might also be in order.

3. What types of systems were most involved?

Recommendation #3 - It is recommended that an additional research be performed into the system types involved in Y2K.

Further research into this topic could provide insight into which systems were most involved in Y2K issues and with an emphasis on "why" certain systems were more involved than others. As mentioned above, the size of the sample base would need to be expanded though various means so as to produce the needed amount of useable data for analysis.

4. What were the costs of remediation?

Recommendation #4 - It is recommended that more research be done in the area of Y2K remediation costs.

Once again, the sample base would need to be expanded though various means so as to produce a significant amount of useable data for analysis. Complete anonymity would have to be guaranteed to the participants in order to obtain the figures needed for such a project. With this data, correlations between monies spent and benefits derived could be one of the objectives. However, Beach (2000) has stated that mst companies don't have the incentive to come forward with their problems. The potential for spurring

stock problems and creating unnecessary publicity is a strong incentive for keeping quiet which may be one explanations for the low response rate for this survey.

Summary

The primary purpose of the research in this study was to determine what, if any, unexpected benefits, spin-offs, and other "serendipitous" events occurred as a result of the year 2000 remediation process undertaken by businesses, industry, and other organizations. This was measured through the use of an online survey instrument comprised of a series of questions designed to measure and uncover those benefits.

The survey was sent to approximately 50 different businesses and/or organizations during the pilot stage of this study and 250 during the main stage of this study. The companies and contacts within these companies were randomly selected from the Fortune 500 list of U.S. companies and researched at the Hoovers Online web site. The random samples that were used included the areas of financial services, health care, non-computer manufacturing, telecommunications, transportation, and utilities.

The survey responses were analyzed in an effort to determine what benefits were common to these businesses as well as to uncover possible unique benefits some business may have experienced. Of particular interest were any benefits that companies indicate were totally unexpected. Final analysis of the data was accomplished through the use of canonical correlation analysis and multiple regression. These statistical procedures were chosen because of their usefulness in determining correlations between a set of independent variables and a set of dependent variables.

The findings of the pilot study were, for the most part, inconclusive due to the small number of responses. The analysis of the data from the main study found one significant canonical function. The Pearson product moment (*r*) correlation value between the computer generated variates created by this function was reported at approximately .86. This indicated a high degree of correlation between criterion variate 1 that represented the independent variables, and the predictor variate 1 that represented the dependent variables. The variables NTSYS, PCSYS, MFSYS had the highest correlation with the Predictor1 variate. The variables ITISS, and UND had the highest correlation with the Criterion1 variate. Therefore, the independent variables NTSYS, PCSYS, and MFSYS were most predictive of the dependent variables ITISS, and UND.

To determine if there were unexpected benefits in those companies surveyed, a multiple regression was performed using the measured variable "SEREDIP" as the dependent variable and the measured variables Y2KEFFORT, ORGSP, and ORGHM as the independent variables. The null hypothesis was not rejected indicating that among the companies surveyed, the occurrences of serendipitous events were not statistically significant. However, the literature indicated that serendipitous events have occurred, though these occurrences were not universal.

Appendix A - Institutional Review Board artifacts

Institutional Review Board for Research with Human Subjects (IRB) Submission Form

To be completed by IRB/Center/College Representative:
Date Received _____Center/College_____
Representative_____
*Protocol Number_____
*(To be assigned by the Office of Grants & Contracts)
Protocol Qualifies for: Full Review____ Expedited Review____ Exemption____

Instructions: In order to comply with federal regulations as well as to conform with guidelines of the University's Institutional Review Board (IRB), the principal investigator is required to complete all of the following items contained in the Submission Form and the IRB Protocol. Upon completion of all information, the principal investigator must submit the original Submission Form and one copy of the IRB Protocol, including all consent forms and research instruments (questionnaires, interviews, etc.) to the appropriate IRB College/ Center Representative for review and action. Once reviewed and signed off by the Center Representative, the principal investigator is responsible for submitting the original Submission Form along with 22 copies of the Submission Form, IRB Protocol, and consent forms to the Office of Grants and Contracts. In addition, one copy of all research instruments (questionnaires, interviews, etc.) must be submitted to the Office of Grants and Contracts. The completed package must be received by the Office of Grants and Contracts by the last business day of the month prior to the next scheduled IRB meeting. The Office of Grants and Contracts' web site should be consulted for IRB meeting dates. Incomplete forms may delay review by the IRB. For further information, refer to the Policy and Procedure Manual for Research with Human Subjects.

I. General Information

A. Project Title Y2K Serendipity: Benefits and Spinoffs
B. New_X_Continuation/Renewal_____ Revision_____

Proposed Start Date Nov. 1, 2001
Proposed Duration of Research 2 Weeks
Performance Site(s) The actual research survey will be conducted via the World Wide Web.

C. Principal Investigator__R. G. Taunton
Faculty _____ Staff _____ Student__X___

D. Center/College/Department Graduate School of Computer and Information Science

Home Mailing Address 724 Lee Road 415
City Auburn State Alabama Zip 36830
Home Phone Number (334)745-4782
Office Phone Number (334)745-6437 ext. 5392
Co-Investigator(s) _____

Principal Investigator's Signature R. G. Taunton Date August 24, 2001

II. Funding Information

If this protocol is part of an application to an outside agency, please provide:

A. Source of Funding _____
B. Project Title (if different from above)_____
C. Principal Investigator (if different from above)_____
D. Type of Application:
E. Grant_____ Subcontract_____ Contract_____ Fellowship_____
F. Date of Submission _____

III. Cooperative Research

Cooperative research projects are those that involve more than one institution and can be designed to be both multi-site and multi-protocol in nature. Each participating institution is responsible for safeguarding the rights and welfare of human subjects and for complying with all regulations. If this proposal has been submitted to another Institutional Review Board please provide:

Name of Institution _____
Date of Review _____ Contact Person _____
IRB Recommendation _____

IV. Subject/patient Information

A. Types of Subjects/Patients (check all that apply)
Fetus in Utero/non-viable fetues/abortuses ____
Newborns/Infants____
Children (aged 2-12)____
Adolescents (aged 13-18)____
Adults (over 18)__X__
Pregnant Women____

Special populations (e.g., prisoners, mentally disabled) ____
Specify _____

B. Other (Check all that apply)
Use of investigational drugs or devices
Information to be collected may require special sensitivity
(e.g. substance abuse, sexual behavior)

C. Number of Subjects/Patients 50 to 100

D. Approximate time commitment for each subject/patient approximately 15 minutes.

E. Compensation to subjects/patients : Yes_____ No_X_

F. Form (e.g. cash, taxi fare, meals) _____ Amount_____

V. Continuation or Renewals

A. Attach a copy of the original IRB protocol

B. Indicate all proposed changes in the IRB protocol affecting subjects

C. Progress Report

- Indicate the number of subjects entered in the study, including their group status, whether they are active or completed, the number of subjects still pending, and the time frame of subject participation.
- Indicate adverse or unexpected reactions or side effects that have occurred or are expected. If none, state none.
- Summarize the results of the investigation to date (in terms of subjects entered, in process, completed, and pending).

D. Attach consent form(s) to be used and indicate if any changes have been made.

Institutional Review Board for Research with Human Subjects (IRB)
Research Protocol

Description of Study

Purpose and Potential Benefits: The goal of the author of this dissertation is to provide decisive evidence that many benefits and spinoffs have occurred as a direct result of the Y2K (Year 2000) remediation effort by business and industry. The proof of these benefits will be gathered through the use of a survey instrument developed by the author which will be distributed to an appropriate sample of large companies throughout the United States. Once the surveys have been completed and returned, the results of the survey will be analyzed and the conclusions extrapolated.

There is evidence that these benefits have occurred. IT (information technology) professionals report a host of benefits because of inventories, business analysis, and system testing completed under the umbrella of Y2K). The problem may even represent a competitive opportunity, along with a number of internal and external benefits. These benefits include being able to reuse the materials developed to neutralize the problem, forced rationalization of system components, competitive advantage in a number of business markets, improved business operations, increased systems flexibility, and enhanced delivery of new technology.

Location of Study: This study will not have a location per se. The means by which this will be accomplished is through the use of a survey instrument distributed via the world wide web to a representative sample of organizations in business and industry.

Dates of Study: Start Date: Nov. 1, 2001; End Date: Dec. 14, 2001

Subjects: Data concerning these benefits will be collected through the use of a survey instrument developed by the author. The instrument will be distributed to an appropriate sample of large companies throughout the United States. The specific areas of business and industry to be targeted for this survey will include financial services, health care, non-computer manufacturing, telecommunications, transportation, and utilities. Once the surveys have been completed and returned, the results will be analyzed and conclusions drawn. The sample will consist of 50 to 100 large companies and organizations within the United States selected randomly from the 500 largest U.S. companies, ranked by revenues, according to Fortune magazine's classic list (this list can be viewed online at http://www.fortune.com/fortune/fortune500/). Listed below, is the procedure that will be used for the selection of these companies or organizations:

- Initial contact with the company or organization will be made via email or standard mail and a request for participation in the survey will be solicited.

- After a list of participating companies or organizations have been established, a smaller sample of these we will be randomly selected to participate in pretesting the survey instrument.
- After the survey instrument has been pretested, the actual survey will be administered to organizations that have acknowledge their desire to participate in the survey.

Methods and Procedures: A ten-stage process will be used to perform this research. The stages are identifying the focus of the study and method of research, determining the research schedule and budget, establishing an information base, determining the sampling frame, determining the sample size and sample selection procedures, designing the survey instrument, pretesting the survey instrument, implementing the survey, coding the completed questionnaires and computerizing the data, and analyzing the data and preparing the report.

1. Identify the focus of the study and method of research

Action - As previously stated in the goal section of this document, the purpose of the researcher in this study is to investigate the unexpected (serendipitous) benefits and spinoffs related to the Y2K (Year 2000) remediation effort by business and industry . The means by which this will be accomplished is through the use of a survey instrument made available via the World Wide Web to a representative sample of organizations in business and industry.

Fit - In order for a survey to be successful, the focus of the study must be throughly defined and the most appropriate means of conducting the research decided upon. Without this focus, both the questions asked in the survey, as well as the results, may become vague and insignificant.

Background Literature - A survey is an attempt to collect data from members of a population in order to determine the current status of that population with respect to one or more variables. Making sure the survey will provide useful information means raising two specific questions: What problem are you trying to solve? What new information do you need to solve it?. The problem is the fundamental issue raised in the survey while the new information will, presumably, help to solve the problem. The problem under investigation and the topic of the questionnaire must be of sufficient significance to motivate subjects to respond.

2. Determine the research schedule and budget

Action - Once the preliminary stages of this study have been completed, a schedule for distribution for the questionnaire will be developed and a target date for analysis of the

data set. The budget (resources) for this project are specified in the resources section of this document.

Fit - The determination of a research schedule and the development of a budget help to facilitate the researcher in the allocation of time and funds for the completion of a research project. Proper planning of the research budget allows the researcher to focus of the content of the study, rather than being distracted by unexpected expenses once the project has gotten underway.

3. Establish an information base

Action - This stage will be accomplished through a process of discovery. The first step of this process will be a comprehensive review of literature on the subject of year 2000 remediation (please see the reference list at the end of this document). Sources to be considered in this review will include magazine articles, journal articles, newspaper articles, reports, books, and Internet web sites. After these documents have been acquired, they will be reviewed for possible topics from which to formulate survey questions. Particular attention will be given to those documents that contain possible benefits reaped due to those efforts. The questions will be written in such a manner as to allow the respondents to rate specific topical areas using a Likert-type scale. In addition to questions that require the respondents to rate or categorize items, some questions will be included that will allow the respondents to give short answers or elaborate briefly on unique benefits they have observed and/or Y2K severity within their organization.

Fit - It is essential to the success of a survey of this type to formulate questions based upon known information. For this reason, a review of literature will be conducted as specified above in order to gain insight into possible spinoffs and benefits that have been documented as a result of Y2K remediation. This will facilitate the creation of an information base from which to build the survey questions.

4. Identify the organizations for the sample

Action - The sample will consist of 50 to 100 large companies and organizations within the United States selected randomly from the 500 largest U.S. companies, ranked by revenues, according to Fortune magazine's classic list (this list can be viewed online at http://www.fortune.com/fortune/fortune500/). Listed below, is the procedure that will be used for the selection of these companies or organizations:

- Initial contact with the company or organization will be made via email or standard mail and a request for participation in the survey will be solicited.
- After a list of participating companies or organizations have been established, a smaller sample of these we will be randomly selected to participate in pretesting the survey instrument.

- After the survey instrument has been pretested, the actual survey will be administered to organizations that have acknowledge their desire to participate in the survey.

Fit - Surveys can either be census surveys or sample surveys. Although census surveys provide the most accurate information, they are often impractical, especially if the population is large. The sample must be determined so that an appropriate sample of the population will participate in the survey.

5. Determine the sample size and sample selection procedures

Action - Once the sample has been established as stated in step four, a sample appropriate for the purposes stated in this study will be selected from the sample frame. Approximately 50 to100 different businesses/organizations will be randomly selected from the sample using random sampling. Random sampling will be used in the sample selection process since this technique yields the highest probability of having a representative sample of the population.

Fit - The sample will be drawn from the Fortune magazine's top 500 performing companies. In order to appear on this list, all companies on the list must publish financial data and must report part or all of their figures to a government agency. Private companies and cooperatives that produce a 10-K are, therefore, included; subsidiaries of foreign companies incorporated in the U.S. are excluded.

6. Prepare the survey instrument for distribution

Action - Upon completion of the information base, the questionnaire will be constructed for use in the survey. The questionnaire was constructed by using the following steps:

- An information base was established by performing a review of current literature dealing with benefits and/or spinoffs that have occurred as a result of Y2K remediation (see stage 3) .
- The questions were be constructed using the information acquired from the review of literature.
- A pretest and validation of the survey instrument was performed according to step seven of this section.
- Approval of the final questionnaire was received from the Nova IRB (Institutional Review Board) representative per NSU policy.

Fit - The questionnaire was carefully planned, attractive, and made as succinct as possible so as to encourage response while acquiring the necessary information for the survey. The questionnaire items are included in Appendix A. This particular questionnaire was developed after a preliminary review of the literature presently available dealing with the benefits that have occurred as a result of Y2K remediation. Questions 1-15 are designed

such that they each measure a specific independent variable on a Likert-type scale (1- Strongly Disagree, 2- Disagree, 3 - No Opinion, 4 - Agree, or 5 - Strongly Agree). Likewise, questions 16-21 each measure a specific dependent variable on a Likert-type scale. These dependent variables represent various benefits and spinoffs that the literature has indicated have occurred as a result of Y2K remediation. During questionnaire pretest and evaluation, items can be added and/or removed as necessary. In addition to the survey questions, the respondents will have the opportunity to supply the answers to a limited number of open-ended questions.

7. Validate and pilot test the survey instrument

Action - Before actual implementation of the survey, the questionnaire was validated and pilots tested. Validation was performed by a committee of three individuals; a college business department head, an MIS director, and a programmer/analyst. The committee met as a group and consensually made recommendation for changes to the questionnaire. Aside from a few editorial changes, the committee suggested that I break the questions dealing with systems types into separate questions about hardware and software upgrades for each system type. These changes were made to the questionnaire, therefore completing the initial phase of validation.

A prototype of the web page survey instrument was then constructed using the validated questionnaire. Pilot testing involving a small number of the possible respondents was then performed. The procedure for administering this pilot test was the same as specified in part nine (Administer the survey) of this chapter.

Fit - Pilot testing and validating the survey instrument was necessary to ensure that the instrument adequately measures what it is intended to measure.

8. Administer the survey

Action - The survey administration phase will involve the development of a web site on which to host the web-based survey form and an appropriate domain name for the site. A standard html-type form containing the survey questions will be placed on the site and will be processed using a Perl script that will automatically e-mail the survey results to the researcher. The statistical software that will be used will be NCSS (Number Cruncher Statistical System) which is a statistical and data analysis system for Windows. In this way, the survey data can be analyzed when all respondents have had an opportunity to take the survey. The URL of the site will be provided to the respondents and they will be asked to respond to the survey within two to three weeks. The ease of use of the web-based survey form hopefully will ensure a high response rate for the survey. In addition, the survey respondents will be notified in advance that they have been selected for the survey and that their participation would be appreciated.

Fit - The questionnaire was validated and modified so that the actual survey could be implemented. Once collected, the data can then be analyzed and conclusions drawn.

9. Code the completed questionnaires and computerize the data

Action - As stated in step eight, a standard html-type form containing the survey questions will be placed on the World Wide Web and will be processed using a Perl script that will automatically e-mail the survey results to the researcher. The results will then be keyed into a statistical analysis software package and will be analyzed using multiple analysis of variance (MANOVA) . The results can then be presented in text and/or bar chart form. This method was chosen since it compares within-group variances and between-group variances and determines if those variances are significant. If so, the null hypothesis will be rejected. Since the model being used for this study is a correlational model and most correlational models are based on linear relationships (Gay, 1996), it is anticipated that a linear relationship will be found between the independent variables used and the dependent variable.

MONOVA utilizes a statistical concept know as the general linear model which is an improvement over the multiple regression model (StatSoft, 2001). With regard to the generality of the multiple regression model, one limitation is that it can be used to analyze only a single dependent variable. The general linear model goes a step beyond the multivariate regression model by allowing for linear transformations or linear combinations of multiple dependent variables. This extension gives the general linear model important advantages over the multiple and the so-called multivariate regression models, both of which are inherently univariate (single dependent variable) methods.

Fit - Coding of the data into a computer application facilitates statistical analysis and standardizes reporting of the data. In addition, once the data has been coded, it can usually be easily imported into a computer program designed to do statistical analysis. This is of great importance to the researcher since it facilitates the process of analyzing the data as well as reduces the chance that computational errors will occur.

10. Analyze the data and report results.

Action - The survey responses will be analyzed during this last phase in an effort to determine what benefits were common to these businesses as well as to uncover possible unique benefits some business may have experienced. Of particular interest will be benefits that companies indicate were totally unexpected. Therefore, the research hypothesis of this study is as follows: Companies and organizations who have gone through year 2000 remediation have experienced unexpected benefits and spinoffs as a result.

Multivariate analysis of variance will be used to determine what relationships exists between the dependent variables and the independent variables. Final analysis of the data will be accomplished through the use of factor analysis. This statistical procedure was chosen because of its usefulness in determining correlations between a set of independent variables and a set of dependent variables. Shown below are the variables that will be measured by the questionnaire. The variable number corresponds to the question on the questionnaire that measures it (see Appendix A for the questionnaire).

Fit - Once all results have been received and coded in the computer, the final data can be analyzed and a final report generated. During final data analysis, an attempt will be made to locate any serendipitous events that have occurred as a result of Y2K remediation. If a company identifies any such events, the analysis of the data should show if there is a correlation between those events and their remediation efforts.

Participant Payments or Costs: There are no costs to the participants.

Subject Confidentiality: In the cover letter for this survey, the participants are advised that their participation is voluntary and that they may terminate the process at any time if necessary. Their individual responses will be kept confidential and no type of identifying notation will be used in the final report that will disclose the identity of the company or organization for which they work. The results of this survey will only be reported only in the aggregate. To guarantee this confidentiality, the subjects responses will be gathered using a web-based survey form. Since the form does not require that the respondent enter any type of personal information (name, address, email, etc.), and given that the form submissions will be processed by a CGI script on the Y2K survey web site, responses will be totally anonymous.

Potential Risks to Subjects: The only foreseen risk to any company or organization involved in this study is the potential disclosure of problems/difficulties they might have experience to competitors. To minimize this risk, the survey results will be kept private (see Subject Confidentiality above).
Risk/Benefit Ratio (if required for funded project): NA
Informed Consent: (See Instructions for Preparation and Sample Informed Consent Form
See Sample Research Protocol

Appendix B - Cover letter and questionnaire

To All Y2K Research Participants,

First of all, I would like to express my sincere appreciation for your willingness to participate in this survey. I am sure that even though the year 2000 has now come and gone, the amount of time, hard work, and financial expenditures that your company may have put fourth in anticipation of the new millennium is still fresh on the minds of many of you.

In an effort to make the most of the experiences that many of you have encountered during your Y2K preparations, I am conducting a survey with the intent of discovering any unexpected (serendipitous) benefits that your company may have experienced as a result of your remediation processes. The results will only be reported in the aggregate.

The only requirement for your participation in this process in that you complete the following survey that should only take a few minutes of your time. Your participation is voluntary and you may terminate the process at any time if necessary. Your individual responses will be kept confidential and no type of identifying notation will be used in the final report that will disclose the identity of your company.

As a service to those participating in this survey, the final report will be made available to anyone who requests the results. Please be advised that, since this is an independent research effort, it may be several months before the final analysis of the data is completed.

This research questionnaire has been approved by the NSU Institutional Review Board (IRB). The IRB oversees all research conducted at Nova Southeastern University that involves any participation by human subjects.

Once again, Thanks!

R. G. Taunton

Year 2000 Survey

Instructions: Please respond to the following statements by selecting one of the following options: 1- Strongly Disagree, 2- Disagree, 3 - No Opinion, 4 - Agree, or 5 - Strongly Agree. If a particular question is not applicable to your organization, please leave the "NA" showing in the response box.

(The following survey items (1 - 4) were designed to provide answers to research question #4 - What were the cost of remediation?)

Y2K Preparation

1. Our organization went through a Y2K effort whereby the computer systems within our organization were upgraded so that they would not be affected by the year 2000 date change.

Expenditures for Y2K (expenditures can include financial expenditures for equipment upgrades, facilities upgrades, software upgrades, etc.)

2. Our organizational expenditures on Y2K preparation were justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K.

3. The amount of time (man-hours) that our organization spent on Y2K preparation was justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K.

4. Include any additional information/comments on Y2K expenditures or time spent on Y2K remediation within your organization that you wish to contribute (there will be a text box here for input).

(The following survey items (5 - 19) were designed to provide answers to research question #3 - What types of systems were most affected?)

System Types Involved in Y2K

5. Hardware upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort.

6. Software upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort.

7. Hardware upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort.

8. Software upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort.

9. Hardware upgrades on server(s) within our organization were a part of our Y2K effort.

10. Software upgrades on server(s) within our organization were a part of our Y2K effort.

11. Hardware upgrades on network(s) within our organization were a part of our Y2K effort.

12. Software upgrades on network(s) within our organization were a part of our Y2K effort.

13. Hardware upgrades on mainframe(s) within our organization were a part of our Y2K effort.

14. Software upgrades on mainframe(s) within our organization were a part of our Y2K effort.

15. Upgrades on Internet service within our organization were a part of our Y2K effort.

16. Upgrades on Network security within our organization were a part of our Y2K effort.

17. Upgrades on Embedded chips housed inside equipment within our organization were a part of our Y2K effort.

18. Upgrades on Plant/Floor equipment within our organization were a part of our Y2K effort.

19. Include any additional information/comments on system types within your organization affected by Y2K (there will be a text box here for input).

(The following survey items (20 - 25) were designed to provide answers to research question #1 -What types of benefits and spinoffs were most common?)

Understanding and awareness of Information Technology (IT) -related issues

20. As a result of Y2K, there now exists a more thorough understanding of IT-related challenges, including effective quantification of IT problems and their probable impact.

21. As a result of Y2K, there is now an increased awareness of the integral role IT plays in business functions.

22. As a result of Y2K, there is now an increased awareness of the integral role IT plays in effectively managing information assets.

23. As a result of Y2K, IT foundations and management mechanisms have been modernized.

24. As a result of Y2K, critical infrastructure protection and other IT issues now rank higher among the mission priorities of corporate executives as a result of Y2K.

25. A significant amount of funds that our organization spent on Y2K efforts were spent replacing/upgrading legacy systems that would have eventually had to have been replaced/upgraded anyway.

(The following survey items (26 & 27) were designed to provide answers to research question #2 - Were certain benefits and spinoffs serendipitous?)

26. As a direct result of Y2K efforts, our organization has been the beneficiary of benefits that were unanticipated.

27. Briefly elaborate on any unanticipated or unexpected benefits of your Y2K efforts (there will be a text box here for input).

Appendix C - Questionnaire Web Page

Year 2000 Survey

Instructions: Please respond to the following statements by selecting one of the following options: 1- Strongly Disagree, 2- Disagree, 3 - No Opinion, 4 - Agree, or 5 - Strongly Agree. If a particular question is not applicable to your organization, please leave the "NA" showing in the response box.

Y2K Preparation

1. Our organization went through a Y2K effort whereby the computer systems within our organization were upgraded so that they would not be affected by the year 2000 date change. NA

Expenditures for Y2K (expenditures can include financial expenditures for equipment upgrades, facilities upgrades, software upgrades, etc.)

2. Our organizational expenditures on Y2K preparation were justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K. NA

3. The amount of time (man-hours) that our organization spent on Y2K preparation was justified and within reason given the nature and magnitude of the problem within our organization and the possible repercussions of not adequately preparing for Y2K. NA

4. Include any additional information/comments on Y2K expenditures or time spent on Y2K remediation within your organization that you wish to contribute.

System Types Involved in Y2K

5. Hardware upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort. NA

6. Software upgrades on "casual user" desktop PC's and notebooks within our organization were a part of our Y2K effort. NA

7. Hardware upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort. NA

8. Software upgrades on mission-critical desktop PC's and notebooks within our organization were a part of our Y2K effort. NA

9. Hardware upgrades on server(s) within our organization were a part of our Y2K effort. NA

10. Software upgrades on server(s) within our organization were a part of our Y2K effort. NA

11. Hardware upgrades on network(s) within our organization were a part of our Y2K effort. NA

12. Software upgrades on network(s) within our organization were a part of our Y2K effort. NA

13. Hardware upgrades on mainframe(s) within our organization were a part of our Y2K effort. NA

14. Software upgrades on mainframe(s) within our organization were a part of our Y2K effort. NA

15. Upgrades on Internet service within our organization were a part of our Y2K effort. NA

16. Upgrades on Network security within our organization were a part of our Y2K effort. NA

17. Upgrades on Embedded chips housed inside equipment within our organization were a part of our Y2K effort. NA

18. Upgrades on Plant/Floor equipment within our organization were a part of our Y2K effort. NA

19. Include any additional information/comments on system types within your organization affected by Y2K.

Understanding and awareness of Information Technology (IT) -related issues

20. As a result of Y2K, there now exists a more thorough understanding of IT-related challenges, including effective quantification of IT problems and their probable impact. NA

21. As a result of Y2K, there is now an increased awareness of the integral role IT plays in business functions. NA

22. As a result of Y2K, there is now an increased awareness of the integral role IT plays in effectively managing information assets. NA

23. As a result of Y2K, IT foundations and management mechanisms have been modernized. NA

24. As a result of Y2K, critical infrastructure protection and other IT issues now rank higher among the mission priorities of corporate executives as a result of Y2K. NA

25. A significant amount of funds that our organization spent on Y2K efforts were spent replacing/upgrading legacy systems that would have eventually had to have been replaced/upgraded anyway. NA

26. As a direct result of Y2K efforts, our organization has been the beneficiary of benefits that were unanticipated. NA

27. Briefly elaborate on any unanticipated or unexpected benefits of your Y2K efforts (there will be a text box here for input).

Send this Survey Cancel

Appendix D - Form Letter Mailout

R. G. Taunton • 724 Lee Road 415 • Auburn AL, 36830
Home 334-745-4782 • Work 334-745-6437 Ext 5392 • E-mail gtaunton@suscc.cc.al.us

May 7, 2002

Company's Name
Attn: Officer's Name
Company's Address

Dear Officer's Name,

My name is R. G. Taunton and I am a doctoral student at Nova Southeastern University conducting research in which I am attempting to discover any unexpected benefits that your company, and other companies as well, may have experienced during your Y2K remediation process. I would like to gratefully ask that you complete and mail back to me within 14 days the enclosed survey, or you may go online at http://www.y2ksurvey.com and complete and submit the survey via the Internet. If you are the Human Resources representative within your company or if you feel that you are not the appropriate person within your company to complete this survey, I would like to ask that you please forward this letter to the appropriate IT/MIS personnel. The Submission of the survey is totally anonymous. Your individual responses will be kept confidential and no type of identifying notation will be used in the final report that will disclose the identity of your company.

As a service to those participating in this survey, the final report will be made available to any participate who requests the results. Please be advised that, since this is an independent research effort, it may be several months before the final analysis of the data is completed.

This research questionnaire has been approved by the NSU Institutional Review Board (IRB). The IRB oversees all research conducted at Nova Southeastern University that involves any participation by human subjects.

I really need your help, so thank you in advance your participation!

Sincerely,

R. G. Taunton

Appendix E - Followup Letter

R. G. Taunton • 724 Lee Road 415 • Auburn AL, 36830
Home 334-745-4782 • Work 334-745-6437 Ext 5392 • E-mail gtaunton@suscc.cc.al.us

June 17, 2002

Company's Name
Attn: Officer's Name
Company's Address

Dear Officer's Name,

This letter is a follow-up to the letter you received a couple of weeks ago pertaining to the Y2K survey research project I am conducting. I would like to say a word of thanks to those of you who have already taken the Y2K Survey and submitted your results. Your input has been an integral part of what I am trying to accomplish with this project.

However, for this stage of the project to be a success, I still need input from many more of you. I am aware that, as a rule, many companies do not participate in surveys. However, in light of the academic nature of this survey and what I am trying to accomplish, I would like to once again gratefully request that you complete and submit the Y2K Survey document. The survey will only take a few minutes of your time. If you feel that another individual within your organization would be better suited to this task (colleague, subordinate, etc.), please pass this letter on to them as ask them to complete the survey. Also, if you no longer have the hard copy of the survey instrument and the stamped envelope, you can go online and complete the survey at the following web site:

http://www.y2ksurvey.com

By going online, it will expedite the submission process. Thanks for your consideration in this matter!

This research questionnaire has been approved by the NSU Institutional Review Board (IRB). The IRB oversees all research conducted at Nova Southeastern University that involves any participation by human subjects.

Sincerely,

R. G. Taunton

Appendix F - Pilot Study Correlation Matrix

Appendix G - Comments from Surveys

Comments on Y2K expenditures:

Project was mid 1997 to early 2000, with between $50 and $100 million spent.

Spent $23 million dollars over 4 years 1996-2000. Countless man-hours - over 100 FTE's on average over the course of 4 years.

Preparation started in 1996. Related money & most resources were included in the subsequent business plans. We had a strong support from out top executives.

Due to the nature of our 24/7 Hotel/Casino operations we spent several years planning and migrating systems to y2K compliant platforms - a huge effort.

Neither time or costs were excessive. We did ... get contacted by a number of attorneys representing patent or the actual property rights holders to Y2K solutions which we ignored.

Comments on system types affected by Y2K:

Our older applications were mainly IBM mainframe. Y2K was not a big deal primarily because we had developed our own "Y2K ready" date handling utility as far back as the early 70s.

Major effort to ... All embedded chip problems throughout the gas and electric systems in ... And LI. Everything had to be tested.

We addressed the Y2K effort as a comprehensive plan, including all infrastructure items likely to be impacted by the "millennium bug."

We had more issues (very minor) with printers than any other devices (usually drives were reinstalled).

Comments on unanticipated or unexpected benefits:

Business resumption planning efforts for Y2K have been re-used and regularly updated. These have helped improve startups following plant shutdowns, holiday periods.

Total company effort promoted communication and cooperation across company. Stronger ties with customers needing Y2K support and their appreciation for cooperation and support.

Inventory of applications, retirement of some legacy (systems), improvement in libraries for (?), harvest of some technologies and equipment.

We really did not spend a lot of $$ on Y2K - Maybe $500,000 total - which is not a lot for a 4 billion annual sales company.

Better inventory of IT assets and understanding of embedded chip issues.

This was the opportunity to replace obsolete equipment, update equipment inventories and dispose of redundant/obsolete software. It got its moments of glory, soon forgotten, thus the lower ranking on these last questions.

Improved inventory of assets enabling better asset management.

It is hard to distinguish between Y2K preparations and the evolution to a knowledge management economy. Y2K just happened to occur during the embryonic stages of this evolution. Admittedly, Y2K may have brought greater attention to this evolution and accelerated the development of infrastructure necessary to operating in the emerging environment.

We chose to start an ERP solution.

I believe your survey is right on target, not only did it raise the level of understanding of IT systems and architectures, it did force some companies to modernize which had they not done that would not have been prepared for B2B, CRM and other current mission critical initiatives.

Elimination of underutilized IT assets (?/software) eliminating the need to maintain or replace ultimately savings dollars.

Issues were so minor and insignificant that management thinks we overstated the risks.

Conry-Murray, A. & Greenfield, D. (2000, February). The competitive edge in business technology. *Network Magazine*, (15) 2, 24.

Crawford W. (2001).Y2K: Lessons from a non-event. *Wilton*, 2 (25), 73-74.

Dead Sea Scrolls. (1992). Collier's Encyclopedia . (Vol. 7, pp 751-753). New York: Maxwell Macmillan International Publishing Group.

Dennis, S. (2000). Don't waste your Y2K experiences, says Insight. *E-Commerce Times*, http://www.ecommercetimes.com/news/articles2000/000204-nb1.shtml. Accessed August 25, 2000.

Downey, C. (1996, March). When research turns serendipitous, *Kiwanis*, 36-39.

Evink, J. R. (1998, February). Corporate creativity: how innovation and improvement actually happen. *The Academy of Management Executive*, 12, 92-93.

Fear-based spending led to much-needed upgrades (2000, January). *EFT Report*, 23(1) ,6.

Feder, B. J. (2001). The legacy of a debacle that wasn't. *The New York Times on the Web*, http://www.nytimes.com/2001/01/01/technology/01COMP.html. Accessed March 29, 2001.

Electronic Statistics Textbook. Tulsa, OK: StatSoft. WEB: http://www.statsoft.com/textbook/stathome.html. Accessed August 25, 2001.

Fowler, F. J. (1993). Survey Research Methods. Newbury Park, CA: Sage Publications, Inc.

Gay, L. G. (1996). Educational Research: Competencies for Analysis and Application. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Gladwin, L. C. (2001). Calif. IT girds for grid woes. *Computerworld*, 9(35), 1, 14.

Greiner, L. (1995, May 5). Year 2000 a time bomb ready to explode. *Computing Canada*, 11.

Grimm, L. G., & Yarnold, P. R. (Eds.). (2000). Reading and understanding more multivariate statistics. Washington, DC: American Psychological Association.

Hackers, virus writers hold back absent Y2K chaos, (2000, January). *Internetweek*, 795, 8-9.

Hale, M. (1999, November). No joke: IT shops show their Y2K mettle. *Government Computer News*. http://www.gcn.com/state/vol5_no11/opinion/507-1.html. Accessed August 25, 2001.

Hamilton-Miller, J. M. T. (1999, November). Sir Edward Abraham and the discovery of the cephalosporins. Newsletter of the International Society of Chemotherapy, 3, 5.

Hawaleshka, D. (2000, January). Business: And now what?: Companies are readjusting their focus – and their spending – after Y2K was largely a non-event. *Maclean's*, 52-53.

Hayes, Simon (2001, September). US learnt a lesson from Y2K. *The Australian*, p. 34.

Hoffman, T., & King, J. (2000). Y2K buying freeze. *Network World Fusion*, http://www.nwfusion.com/news/2000/0118y2kthaw.html?nf. Accessed August 25, 2000.

Isaac Newton. (2000). The Hutchinson Dictionary of Scientific Biography. (3rd ed.). (2, pp. 716-719), Oxford UK: Helicon.

James G. (2000, February). Y2K waste left IT unprepared for a real problem. *Computerworld*. 34(9), 35.

Jenner, E. (1998). The new encyclopedia Britannica (15th ed., Vol. 6, pp 530). Chicago: Encyclopedia Britannica.

Jones, J. (2000). Defense Department acknowledges that it downplayed hit. *InfoWorld.com*, http://www.infoworld.com/cgi-bin/deleteframe.pl?story=/articles/ec/xm.../000104ecdefense.xm. Accessed May 24, 2000.

Kahn, J. (2001, June 6). A mini-Y2K for the Web. *Fortune*, 143(12), 46.

Kappelman, L. (1999, January 4). Behind the news: Y2K's unexpected benefits. *InformationWeek*, 94.

Kappelman, L. (2000, January). Y2K was not a waste. *CIO.com*, http://www.cio.com/forums/y2k/edit/010700_defense.html. Accessed August 25, 2000.

Kroll, K. M. (2000, February). Are Y2K costs covered? *Industry Week*. 249(3), 69.

Ledroit, P., & Millar, J. (1999, July 16). Insurance companies facing Y2K claims. The London Free Press, pp. D3.

Leggat, R. (1999). A history of photography from its beginnings till the 1920s. http://www.rleggat.com/photohistory/index.html. Acessed March 28, 2001.

Lehman, D. (2000, March). Senate: Y2K fixes worth the billions spent, *Computerworld*, 34(10), 8.

Marino, S. F. (1998, April). Serendipity is where you find it (history and usage of the word). *Industry Week*, 247, 22.

Marsan, C. D. (2000). Y2K figures hide hardware upgrades. *Network World Fusion News*, http://www.nwfusion.com/news/2000/0110y2kside1.html, Accessed August 25, 2000.

Marsan, C. D. & Cox, J. (2000). Y2K efforts have log-term benefits. *Network World Fusion News*, http://www.nwfusion.com/news/2000/0110y2k.html. Accessed August 25, 2000.

McKendrick, J. (2000). Y2K threat forged a new IT. *Ent*, 5(4), 12-13.

Melymuka, K. (2000). Y2K's fallout of good fortune. *Computerworld*, 6 (34), 52-53.

Miller, J. (2001, October 10). Attacks,Y2K Teach Lessons For Disaster Recovery Plans. *American Banker*, p. 8.

Millikan, F. (1997, October). A self-made scientist. *Weatherwise*, 50, 16-17.

Nicholson, N. (1998, November). Legal problems of Y2K are complex, too. *South Carolina Business Journal*, 17(10), 8.

Nine ideas that shaped financial services in 2001 (2002, January). *American Banker*, p. 10.

Parshall, G., Folkers, R., Brownlee, S., Peruyera, N., Cook, W. J., & Licking, E. F. (1998, August). The masters of discovery. *U.S. News & World Report*, 125, 28-74.

Pedhazur, E. J. (1982). Multiple regression in behavioral research (2nd ed.). New York: CBS College Publishing.

Piven J. (2000, January). Y2K and lessons learned. *Computer Technology Review*, 20(1), 6.

Pride, W. M., Hughes, R. J. & Kapoor, J. R. (1996). Business. Geneva, IL: Houghton Mifflin Company.

Radcliff, D. (2000, January). Y2K's real lessons. *Computer World,* 34(2), 62.

Rea, M. R., & Parker, A. P. (1997). Designing and Conducting Survey Research . San Francisco, CA: Jossey-Bass Publishers.

Reporting of Open-end Question Findings (2001). [Online]. GuideStar Communications. http://www.guidestarco.com/Open-end-survey-questions.htm. Accessed August 25, 2001.

Roberts, R. M. (1989). Serendipity: Accidental Discoveries in Science. New York NY: John Wiley & Sons, Inc.

Robertson, A. & Stern, S. (1998). Corporate Creativity : How Innovation and Improvement Actually Happen. San Francisco, Ca: Berrett-Koehler Publishers.

Robertson, S. & Powell, P., (1999, September). Exploiting the benefits of Y2K preparation, *Communications of the ACM*, 42(9), 43-48.

Salant, P., & Dillman, D. A. (1994). How to Conduct Your Own Survey. New York, NY: John Wiley & Sons, Inc.

Scanell, E., & Epstein, E. (2000, January). Did IT spend too much. *NetworkFusion News*. http://www.nwfusion.com/news/2000/0110y2kdough.htm?nf. Accessed May 24, 2000.

Search390.com Definitions.(n.d.). Retrieved August 13, 2002, from http://www.apastyle.org/elecsource.html#77.

Sharp, J. (1999, March). Confronting aging IT systems. *American City & County*, 114, 10.

Sheridan, P. (1997, November). Workload management gets pulled in all directions. *Enterprise Systems Journal*, 38-42.

Shinkle, Peter (2001, December 30). Consultants hope new law produces an Rx for profit computer firms move to capitalize on Y2K-like crisis in health care. St. Louis Post-Dispatch, p F1.

Stanglin, D. & Ahmad, S. (1998, June). Year 2000 time bomb. *U. S. News and World Report*, 124, 45-48.

Stepanek, M. (2000, January). News: Analysis & Commentary: the y2k bug repellent wasn't a waste. *Business Week*, 35.

Tabachnick, B. G., & Fidell, L. S. (1989). Using Multivariate Statistics (2nd ed.). New York: Harper & Row.

Taylor, C. (1999, January 18). Y2K: The history and the hype computer scientists may disarm the Y2K bomb in time, but that doesn't mean they didn't screw up. *Time*, 72.

Thibodeau, P. (2000). Government report finds few Y2K-related lawsuits. *Computerworld.com.* http://www.computerworld.com/cwi/story/0%2C1199%2CNAV47_STO51232%2C00.html?pm. Accessed August 25, 2000.

Thompson, B. (1984). Canoncial Correlation Analysis; uses and interpretation. Thousand Oaks CA: Sage Publications, Inc.

U.S. Representative Stephen Horn (R-Ca) Chairman (2000, September 12). *U.S. Representative Stephen Horn (RCa) holds hearing on the need for a federal CIO.* Washington, DC: Washington Transcript Service.

United States Senate Special Committee on the year 2000 technology problem (2000). Y2K aftermath-crisis averted: final committee report. http://www.senate.gov/~y2k/. Accessed October 9, 2000.

Violino, B. (1999, January). Trends: Globalization: Euro is a slow go - system conversions still lag in currency transition. *Information Week*, 52, 54, 56.

Wiley, D. (2000, January). Y2K was important hype: Let me tell you why. *ISP Business News*, 6(4), 6.

Wilson, T. (2000, January). IT: Success justifies Y2K costs. *Internet Week*, 795, 1, 8-9.

Y2K opens door to new era of e-commerce. (2000, January 10). *Electronic Commerce News*, 5(2), 1-2.

Y2K shield law seldom used. (Sept. 21, 2000). *The Associated Press.* http://news.cnet.com/news/0-1009-200-2856571.html. Accessed September 28, 2000.

Year 2000 computing challenge-lessons learned can be applied to other management challenges (Sept. 2000). *Government Accounting Office Report* .