
INTRODUCTION

The Year 2000 (Y2K) technology problem started as an innocuous short-term solution to the oppressively high cost of computer memory in the 1950s and 1960s. Programmers expected that the problems created by the limited, two-digit method of date storage would solve themselves as companies, governments and other computer-owners updated their hardware and software. Fifty years after the introduction of the computer, the Y2K problem has the potential to develop into a worldwide crisis. Two common human failings contributed to the crisis—the tendency to follow a path of least resistance and the reluctance to champion difficult and complex issues. The Y2K problem does not have to be a story of failure, however. If addressed successfully, Y2K may encourage political and corporate leaders to better understand and protect the critical infrastructure.

As memory costs fell dramatically, software writers and hardware manufacturers did not immediately expand date variables. Newer versions of hardware and software needed to interface with older versions. While some programs were modified so

that a new system could accept four-digit years and still exchange information with two-digit based systems, the extra effort required slowed the changeover process. Additionally, the equipment that earlier computer experts predicted would fall into obsolescence long before 2000 survived through layers of programming updates and modifications. Instead of solving itself, the Y2K problem self-propagated around the globe.

Just as programmers found it easy to follow the tradition of using a two-digit date field, management and leadership have found it easy to defer addressing the Y2K problem. Y2K competes poorly against issues such as trade agreements, military operations, market share and product development. It lacks familiarity, and in a results-driven economy, Y2K remediation costs are difficult to justify to taxpayers or shareholders. Additionally, few wished to be associated with the potential repercussions of a failed Y2K remediation attempt.

At the heart of the problem lies a serious disconnect between those

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who use technology and those who create it. On a worldwide scale, leaders of corporations and countries are struggling to understand the Y2K problem. In the process, they are receiving a crash course in the fragile mechanics of information technology.

The Committee feels strongly that Y2K, as the first widespread challenge of the information age, must leave a legacy of increased awareness and appreciation of information technology's role in social and economic advancement.

UNDERSTANDING THE PROBLEM

The goal of this section is to provide background on the Y2K problem and answer common Y2K questions.

What is the Year 2000 computer technology problem?

The phrases the "Year 2000 Computer Technology Problem," the "Millennium Bug," the "Century Date Change," or simply, "Y2K"¹ all refer to the same problem—a defect that exists in millions of computer programs worldwide that causes erroneous handling of date (i.e., day, month and year) information if not corrected. The effect of the Y2K flaw on computer systems is not easily predictable. It may bring a computer to a crashing halt. It may cause the computer to generate obviously incorrect outputs. Or alternatively, it could allow the computer to produce invalid data that will not be detected until much later, forcing users to cor-

rect a range of accumulated errors while searching for the source of the problem.

Why is two digit notation defective?

To save memory in the early days of computing, programmers represented four-digit years with only two digits. For instance, 1968 or 1974 would be stored and processed as 68 and 74, respectively. The number 19, indicating years in the 1900s, was implied, much as personal checks once had the number 19 preprinted on the dateline.

This worked smoothly until users started to input dates occurring after December 31, 1999. Computers ran into problems when required to calculate a number based on the difference in two dates, such as the interest due on a mortgage loan. Computers continued to assume that the prefix 19 was implied, so dates such as 00 or 01 were treated as 1900 or 1901. Consequently, computers could not correctly calculate the difference between a year in the 20th century and a year in the 21st century.

For example, we know that the time between July 1, 1998, and July 1, 2005 is exactly 7 years. However, a computer with a Y2K problem could calculate an answer of either 93 years or -7 years, depending on the specific program. Calculations that used either of these results would be in error and may themselves cause subsequent problems.

Another Y2K problem occurs in the storage of information. Many kinds

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of data are organized and processed by date, such as driver's license records and credit card accounts. Computers have had problems processing credit cards that have expiration dates after December 1999. Due to two-digit dating, computers have thought that cards expiring in 2000 or later had expired almost a century ago.

What is the scope of Y2K problems?

The Y2K problem affects two general classes of equipment. The first class comprises business systems or mainframe systems. These computers perform a variety of data-intensive calculations—balancing accounts, making payments, tracking inventory, ordering goods, managing personnel, scheduling resources, etc. The second class of equipment has several common names, including embedded chips, embedded processors and embedded control systems. Many aspects of modern society rely on microchip-enhanced technology to control or augment operations. Examples are ubiquitous. Automatic teller machines, toll collection systems, security and fire detection systems, oil and gas pipelines, consumer electronics, transportation vehicles, manufacturing process controllers, military systems, medical devices and telecommunications equipment all depend on embedded chip-technology.

Y2K related failures in business systems will generally cause an enterprise to lose partial or complete control of critical processes. In the

private sector, loss of business systems means that a company may have difficulty managing its finances, making or receiving payments and tracking inventory, orders, production or deliveries. In the public sector, government organizations may be severely hindered in performing basic functions such as paying retirement and medical benefits, maintaining military readiness, responding to state and local emergencies, controlling air traffic, collecting taxes and customs and coordinating law enforcement efforts.

Y2K problems in embedded systems have the potential to affect public health and safety. Problems that need to be fixed have already been detected in medical treatment devices, water and electricity distribution and control systems, airport runway lighting and building security systems.² Other suspect areas are pipeline control systems and chemical and pharmaceutical manufacturing processes.

How was the Y2K mistake made?

Several factors explain the creation of the Y2K problem. In the early days of computers, computer memory was very expensive. In the IBM 7094 of the early 1960s, core memory cost around \$1 per byte. Today's semiconductor memory costs around \$1 per million bytes. Thus, there was a very strong economic incentive to minimize the amount of memory needed to store a program and its data in the computer's memory.

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Additionally, early computer programming was highly time-consuming. Programs and data were recorded and entered into computers via 80 column punch cards. Each of the 80 columns could contain exactly one byte of information, which corresponded to one of the four digits needed to represent a year. The cumbersome nature of punched cards encouraged using as few of them as possible.

Although programmers and managers knew they had built software with latent defects in it, no one thought that software written in the 60s and 70s would survive to the Year 2000. Compounding the problem, newer software had to interface and share data with the older software. Although the new software could have handled dates internally in four digit formats and swapped data in two digit formats with the older software, to do so added complexity and hence added cost to new software. The net result was that the two-digit standard for representing years continued much longer than anyone would have guessed.

When will Y2K problems start?

Y2K problems have already surfaced in many places. Cap Gemini, a technology consulting firm, reported that as of December 1997, 7% of a group of 128 large U.S. companies had experienced Y2K related problems.³ By March 1998, that number leaped to 37%. The Gartner Group, an information technology research company, has developed a model to predict the rate of occurrence of Y2K problems. This prediction is based

on data collected quarterly from over 15,000 firms and government organizations in 87 countries. Gartner estimates a rapid increase in problems in 1999 with a peak sometime after January 1, 2000. Problem occurrences will drop off after 2000, but will still occur for another 3 to 5 years at a lower level. Finally, the Information Technology Association of America has reported that about half the major corporations in America have already experienced some form of Y2K disruption as of March 25, 1998.⁴

How can we fix Y2K and how long will it take?

It is beyond the scope of this report to cover the technical nuances of these various solutions. However, various techniques are briefly described in Appendix III.

How much are Y2K fixes going to cost?

There is no generally agreed upon answer to this question. The Gartner Group's estimate of \$600 billion worldwide is a frequently cited number. Another number from a reputable source is that of Capers Jones, Software Productivity Research, Inc. of Burlington, MA. Jones' worldwide estimate is over \$1.6 trillion.⁵ Part of the difference is that Jones' estimate includes over \$300 billion for litigation and damages but Gartner's does not. A sense of the scale of the cost can be gained from looking at the Y2K costs of six multinational financial services institutions; Citicorp, General Motors, Bank America, Credit Suisse

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Group, Chase Manhattan and J.P. Morgan. These six institutions have collectively estimated their Y2K costs to be over \$2.4 billion. Additionally, the estimated cost of Y2K repairs is increasing, as shown in figure 2.

Figure 2. Y2K Repair Estimates⁶

<i>Company</i>	<i>Past Est. (millions)</i>	<i>New Est. (millions)</i>
Aetna	\$139	\$195
ATT	\$300	\$900
Bankers Trust	\$180-\$230	\$220-\$260
Cendant	\$25	\$53
Chase Manhatt.	\$300	\$363
General Motors	\$400-\$500	\$890
McDonald's	\$8	\$30
Merrill Lynch	\$375	\$560
Sears	\$63	\$143
Xerox	\$116	\$135

Can't we develop an easy Y2K fix?

Popular sentiment suggests that a technological quick fix will appear just in time to kill the millennium bug. So far, "quick fix" claims have proved to be claims for a particular product that may show promise in one particular application, for example, finding where the actual dates and date processing routines are hidden in a program.

Software programs and computer hardware vary too greatly to be fixed by one solution. Currently, there are over 500 programming languages in use. A universal or broadly applicable Y2K solution would have to be compatible with many or most of these languages. Additionally, finding all the dates and date processing in an estimated 36,000,000 pro-

grams⁷ is an enormous task difficult to automate.

The embedded processors pose another problem. Although the percentage of embedded chips with a Y2K problem is estimated to be relatively small, potentially millions of chips exist that may have to be replaced. Unfortunately, most of them are not readily accessible or easily modified.

Where can I learn more about the Y2K problem?

Many solid references can be found in the endnotes of this section and elsewhere in this report. An enormous amount of Y2K information resides on the Internet. However, legitimate information is buried among overstated rumors and half-truths. As with most other information derived from Internet sources, Y2K information must be verified for accuracy.

Additional information can be obtained through the Committee's website at www.senate.gov/~y2k and the President's Council on Year 2000 Conversion's website at www.y2k.gov.

CRITICAL INFRASTRUCTURES

Critical infrastructures can include both computerized services and physical services essential to minimum functioning of economy and government. More than abstract systems, critical infrastructures enable the average person to use an

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ATM, make a phone call and fly on an airline. In the past, many of these key infrastructures or sectors were separate. However, advances in information technology have caused many of these systems to be interconnected and linked through networks. The Committee has approached the critical infrastructures by examining the Y2K work occurring both vertically within specific sectors and horizontally across different interrelated sectors, such as banking and telecommunications.

Recognizing that the Y2K problem could have serious implications on the smooth functioning of our defense and economy, Senator Moynihan wrote President Clinton in July of 1996 and suggested a special Y2K commission. While Senator Moynihan's suggestion was not taken, Executive Order 13010 created the President's Commission on Critical Infrastructure Protection. The Commission was not tasked to study Y2K, but it recognized the potential for the Y2K problem to cause long-term problems in the infrastructures. Due to late starts, many organizations have contracted out work on sensitive systems. In some cases, organizations are sending code overseas to foreign firms. The correction of code overseas could lead to increased incidents of corporate espionage and intentional cyber disruptions. The broad scope of Y2K corrections could allow an adversary to build an exceptional understanding of sensitive systems thus enabling it to "design a subtle or

comprehensive attack" against critical systems.⁸

It is absolutely vital that the owners, operators and regulators of the nation's critical systems continue to be aware that Y2K may provide an opportunity for those with malicious intent. Sandia National Laboratories warned the Committee that:

*"Thinking that we will be so preoccupied with Y2K that we would not notice deliberate malicious intent, terrorists, hackers and other criminals might see Y2K as a prime opportunity to attack pieces of our infrastructure. Or they might use Y2K-induced infrastructure failures as cover for theft, arson, bombings, etc. We must be watchful of such groups in the months leading up to Y2K and we must be especially careful when monitoring the crisis as it occurs to discern deliberate intent."*⁹

**THE QUESTION IS NOT
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SEVERE THE
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-SENATOR DODD**

Current national security and emergency preparedness policies are not designed for the challenges of the information age. The U.S. needs a system or process whereby the government can coordinate responses with the privately owned and operated critical infrastructures. We must build the broad based contingency plans necessary to ensure that the national security and emergency preparedness posture of the U.S. is not compromised by Y2K. The U.S. must remain ready to mitigate the (economic, emergency or security) effects that could be caused by Y2K.

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Y2K is an opportunity to educate ourselves first hand about the nature of 21st century threats. Technology has provided the U.S. with many advantages, but it also creates many new vulnerabilities. Recognizing shifts in the technological topography of the nation requires vision. Reverting to a world without microchips or technology-dependent systems is not only undesirable, but also impossible. Instead, we, as a nation and as individuals, need to consider carefully our reliance on information technology and the consequences of interconnectivity, and work to protect that which we have so long taken for granted.

FORMATION OF THE SPECIAL COMMITTEE

Senator Robert Bennett first identified the Year 2000 as an issue for the legislative agenda in 1996 as the Senate organized for the 105th Congress. He shared his concerns with Senator Alfonse D'Amato, Chairman of the Senate Banking Committee, who urged Senator Bennett to take up the issue in his new role as Chairman of the Subcommittee on Financial Services and Technology.

The Subcommittee naturally focused its first efforts on the regulators' efforts to ensure Y2K compliance. In February 1997 and again in April 1997, Senators D'Amato and Bennett requested information on Y2K preparations from the following financial regulatory agencies:

- The Federal Reserve Board (FRB)
- The Federal Deposit Insurance Corporation (FDIC)
- The Office of Thrift Supervision (OTS)
- The National Credit Union Administration (NCUA)
- The Office of the Comptroller of the Currency (OCC)
- The Securities and Exchange Commission (SEC)

Shortly after the Committee inquiry, the Federal Financial Institutions Examination Council (FFIEC), an inter agency body made up of FRB, FDIC, OTS, NCUA and OCC, issued guidelines for the financial institutions and federal examiners to focus on issues they must address to avoid major service disruptions due to Y2K.¹⁰

Individual agency responses revealed varying degrees of readiness. The SEC's response detailed extensive plans for remediation and testing, while other agencies demonstrated little more than a general awareness and initial response to the problem. Many of the regulatory agencies deferred to statements published by FFIEC without providing any substantive information about their own progress. These results prompted Senator Bennett to conduct the first hearing on financial services and the Year 2000 on July 10, 1997.

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At the end of the first hearing, Senator Christopher Dodd quickly recognized the importance of the Y2K issue and voiced his support for additional hearings on Y2K. The Subcommittee held another eight hearings to investigate the scope and severity of the Y2K problem and to prompt action in the financial community.

On November 10, 1997, Senator Bennett introduced the Computer Remediation and Shareholder Protection Act of 1997 (CRASH Protection Act), which required the Securities and Exchange Commission to increase its disclosure regulations relative to Y2K readiness. With the threat of the CRASH Protection Act looming, the SEC redoubled its efforts to raise awareness of Y2K implications.

Also in November 1997, Senator Bennett wrote President Clinton to express concern over a lack of national leadership in the Y2K arena. The Senator suggested the appointment of a Y2K "czar" to oversee the Y2K compliance of the federal government and initiate a public-private Y2K action. Three months later, President Clinton issued Executive Order 13073, creating the President's Council on Year 2000 Conversion. Subsequently, John Koskinen was tapped to chair the new council.

During these events, the Subcommittee struggled to reach industries outside of banking. SEC disclosures provided a tool, albeit blunt, to raise Y2K awareness and planning within public companies. Despite staff

bulletins emphasizing the application of disclosure law to the Y2K issue, the level of information disclosed in March 1998 was disappointingly low. Indeed, some companies overlooked Y2K entirely under the premise that Y2K did not present a material threat to their businesses. Meanwhile, off-the-record discussions with Subcommittee staff suggested that many corporations preferred to incur SEC fines than a drop in their stock prices. The Subcommittee invited the SEC to a June 1998 hearing, which led to additional guidance in the form of an interpretive release on Y2K disclosure. However, the point was made that the Subcommittee on Financial Services and Technology simply did not provide the scope necessary to adequately address the breadth and depth of the Y2K problem.

Voicing this concern, Senators Bennett and Dodd met with the Senate leadership. Senate Majority Leader Trent Lott recognized the importance of Senate leadership in the Y2K arena and with the assistance of Minority Leader Tom Daschle, cleared the way for the creation of the Special Committee on the Year 2000 Technology Problem.

On April 2, 1998, the U.S. Senate unanimously voted to establish a new committee to address the Y2K technology problem. The Special Committee on the Year 2000 Technology Problem was authorized through February 29, 2000. The Majority Leader named Senator Bennett to serve as its Chairman. Committee membership included:

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- Vice-Chairman Senator Christopher Dodd (D-Connecticut)
- Senator Jon Kyl (R-Arizona)
- Senator Susan Collins (R-Maine)
- Senator Gordon Smith (R-Oregon)
- Senator Daniel Patrick Moynihan (D-New York)
- Senator Jeff Bingaman (D-New Mexico)
- Senator Ted Stevens (R-Alaska) *ex-officio*
- Senator Robert Byrd (D-West Virginia) *ex-officio*

Because the Committee does not have legislative authority, each of the members was carefully selected based on membership on other committees, such as Judiciary, Armed Services and Government Affairs.

According to the legislation that created it, the Senate Special Committee on the Year 2000 Technology Problem will exist until February 29, 2000, after which it will permanently disband.

¹ Y2K is an acronym that stands for the Year 2000. The letter K is scientific shorthand for 1000.

² "Year 2000 Recession?," Edward Yardeni, Version 9.1, November 2, 1998, chapter 3, <http://www.yardeni.com/y2kbook.html>.

³ "Year 2000 Survival Guide," Edmund X. DeJesus, BYTE Magazine, July 1998, p. 57.

⁴ ITAA Press Release, March 25, 1998, <http://www.ita.org/y2kpr.htm>.

⁵ "The Global Economic Impact of the Year 2000 Software Problem," Capers Jones, version 5.2, January 23, 1997, Software Productivity Research, Burlington, MA, pp. 57-58.

⁶ Business Week, December 14, 1998, p.39.

⁷ "The Global Economic Impact of the Year 2000 Software Problem," Capers Jones, version 5.2, January 23, 1997, Software Productivity Research, Burlington, MA, p. 20.

⁸ Critical Foundations: Protecting America's Critical Infrastructures (PCCIP report, October 1997).

⁹ Testimony of Sandia National Laboratories before the Special Committee on the Year 2000 Technology Problem, United States Senate, July 31, 1998.

¹⁰ Richard M. Nunno, "The Year 2000 Computer Problem: Activity in the 105th Congress," Congressional Research Service, October 1, 1998.