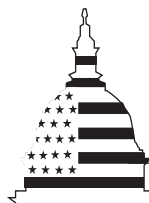


September 2000

SECURITIES PRICING

Trading Volumes and NASD System Limitations Led to Decimal-Trading Delay

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**United States General Accounting Office
Washington, D.C. 20548**

General Government Division

B-285368

September 20, 2000

The Honorable Thomas J. Bliley, Jr.
Chairman, Committee on Commerce
House of Representatives

The Honorable Michael G. Oxley
Chairman, Subcommittee on Finance and
Hazardous Materials
Committee on Commerce
House of Representatives

The Honorable Edward J. Markey
Ranking Minority Member, Subcommittee on
Telecommunications, Trade, and Consumer Protection
Committee on Commerce
House of Representatives

This report responds to your April 27, 2000, request that we examine the progress that the securities industry has made toward the implementation of decimal pricing for U.S. stocks. The U.S. equity markets are the only major equity markets in the world that still use fractional pricing and some observers have projected significant savings to investors following the implementation of decimal pricing.

In January 2000, the Securities and Exchange Commission (SEC) issued an order requiring all stocks and options exchanges and the National Association of Securities Dealers, Inc. (NASD), which administers the Nasdaq Stock Market, Inc., to develop a plan that would ensure that decimal trading would begin by July 3, 2000. However, in March 2000, NASD officials announced that they would not be able to meet this deadline. As a result of this announcement, SEC suspended the order requiring the markets to implement decimal trading by July 3, 2000. On August 28, 2000 after SEC issued a new order, a small number of stocks and options began trading in decimal prices, and a new phased schedule for the implementation of decimal trading was put into place. This schedule called for all securities to be quoted and traded in decimals by April 9, 2001.

As agreed with your office, this report addresses the following questions: (1) what were the specific reasons that the Nasdaq market was not ready for the July 3, 2000, implementation date and how NASD's decimal-trading preparations compared with those of the New York Stock Exchange (NYSE); (2) how SEC approached oversight of the securities industry's implementation of decimal trading and how this compared with its Year 2000 oversight effort; and (3) what challenges remain regarding implementing decimal trading for the industry.

Results in Brief

Although the Nasdaq market experienced a surge in trading volume in late 1999, its existing systems were able to process the resulting message traffic. However, NASD was unable to meet the original July 2000 implementation date for decimal trading in stocks because the new system it developed for quoting prices in decimals had insufficient capacity to process the increase in trading volume. The primary reason that this system's capacity was insufficient was that it lacked the capability to use multiple computers for processing. In addition, NASD's volume forecasting methodology does not adequately incorporate the volatility of the trading on its market; thus, it lacks effective criteria for determining whether its systems have sufficient excess capacity. In contrast, both NYSE's processing environment and approach for preparing for decimal trading differed from that of NASD. NYSE reported being ready to trade in decimal prices by the original July deadline. NYSE experienced lower increases in its trading volumes than did the Nasdaq market, and its officials indicate that they use a more flexible information technology architecture that allows their exchange to more easily expand processing capacity.

SEC's approach for overseeing the securities industry's implementation of decimal trading was similar to the approach it used to oversee the industry's Year 2000 readiness efforts. As it did for the industry's Year 2000 preparations, SEC assisted in the establishment of standards and set progress deadlines for securities market participants. Also similar to its Year 2000 oversight, SEC relied largely on industry participants to report their own progress and has conducted some on-site examinations of market participants' preparations for decimal trading. Although SEC conducted various reviews of NASD that raised capacity concerns, SEC officials relied on NASD's representations regarding its decimal-trading preparations and did not identify in advance the system limitations that caused NASD's delay.

Various challenges remain for the industry as it progresses toward implementing decimal trading for all securities yet to be converted to decimals. Although decimal trading for a selected number of securities began August 28, 2000, the securities industry must complete a phased implementation of all remaining securities, including Nasdaq-traded stocks, by April 9, 2001 in accordance with a revised order from SEC. As part of this, data on how decimal trading is affecting information system processing volumes, participant operations, and trading behavior are to be analyzed before allowing additional securities to begin trading in decimals. In addition, the options markets continue to make limited progress in taking steps to reduce the message traffic volumes expected to result from decimal trading and, as a result, intend to implement decimal trading with higher minimum price increments than will be used for stocks. Additional challenges for securities market participants may arise if all securities listed on NYSE and the other regional exchanges begin trading in decimal prices before such trading begins for Nasdaq-listed securities, but industry participants indicated that various steps could be taken to address these challenges.

This report includes recommendations to SEC regarding the need for improvements in NASD systems capacity planning and SEC's oversight of NASD's preparations for decimal trading. SEC and NASD provided technical comments, which were incorporated into the letter as appropriate. In its letter, SEC said that it would be taking action to implement our recommendation that it ensure that NASD makes various improvements to its capacity planning process and intends to consider our recommendation that it conduct more on-site examinations of NASD. In its letter, Nasdaq stated that its efforts to implement decimal trading were on schedule; however, Nasdaq objected to our report's characterization of the way in which their capacity planning process accounts for market volatility as a weakness because their techniques are standard for the industry. However, although we agree that their trading environment presents them with a more unique and challenging task than that faced by other markets, ensuring that their volume forecasts better incorporate their trading volume volatility is a key component for determining whether their information systems will have adequate processing capacity. Nasdaq also objected to our draft report's characterization of the criteria they use for assessing the adequacy of their system capacities as inconsistent; in response, we revised our report to instead indicate that their current criteria are not effective and refined the language in our recommendation regarding the criteria needed.

Background

Decimal pricing for securities trading is expected to result in various benefits for U.S. investors and U.S. securities markets. Trading in decimal increments should result in smaller spreads between the prices at which securities are bought and sold, which should produce savings for investors. The securities industry, led by the Securities Industry Association (SIA), has been preparing to implement decimal trading since 1998.

In March 2000, we testified on the progress the industry had made and the challenges that it continued to face.¹ At that time, we cited adequate systems capacity as being the primary challenge to the timely implementation of decimal trading. When decimal trading is implemented, traders will be able to quote prices using an increased number of price increments. Currently, securities prices are usually quoted in increments of 1/16 of a dollar in the United States, which provides 16 increments, but quoting prices in pennies results in up to 100 potential increments. Having additional price increments is expected to increase the number of price quotes and executed trades, which will increase the amount of message traffic that must be processed by securities market participants' information technology systems. In our testimony, we noted that the greatest increases in message traffic were likely to be experienced by the Nasdaq market and the options markets.

Scope and Methodology

To determine why the Nasdaq market was not able to implement decimal trading by the initial SEC-ordered implementation date of July 3, 2000, we interviewed and obtained extensive documentation from NASD officials regarding their approach to implementing decimal trading and their capacity planning efforts. In addition, we reviewed external consultant studies on Nasdaq market capacity planning and technology and SEC examinations of Nasdaq market information systems. To understand the approach that NYSE used to ready its systems for decimal trading, we interviewed officials and reviewed documentation relating to the exchange's information technology systems and capacity planning process.

To determine how SEC approached the oversight of the industry's implementation of decimal trading, we met with SEC officials and reviewed orders, information technology guidance, and surveys and examinations of industry participants. In addition to discussions with SEC officials and file reviews, we also referred to our past work on SEC Year

¹ Securities Pricing: Progress and Challenges in Converting to Decimals (GAO/T-GGD-00-96, Mar. 1, 2000).

2000 oversight² to compare the SEC oversight approach to decimals with its approach to oversight of industry Year 2000 readiness. We also interviewed SEC officials, representatives of securities firms, including online broker-dealers; electronic communication networks (ECN);³ and a representative of an investor advocate organization to obtain their views on any challenges that remain as part of implementing decimal trading. We also reviewed the comment letters that SEC received from securities market, broker-dealer, data vendor, and other officials on the impacts of beginning trading in all securities listed on NYSE and the other regional exchanges before such trading began for all Nasdaq market securities.

We conducted our work in Washington, DC; Chicago, IL; and New York, NY; between April and September, 2000, in accordance with generally accepted government auditing standards.

Insufficient System Capacity and Unprecedented Trading Volumes Delayed Nasdaq Decimal Trading

NASD was unable to meet the July 3, 2000, SEC-mandated implementation date for decimal trading because the system it developed to quote decimal prices lacked sufficient capacity to process the trading volumes being experienced by its market. In late 1999 and early 2000, the Nasdaq market experienced unprecedented increases in trading and message traffic volumes. In March 2000, NASD officials announced that the Integrated Quote Management System (IQMS), which it intended to use to quote prices in decimals, would not be capable of processing the message traffic arising from this increased trading activity. However, IQMS' capacity could not be readily expanded because the initial version that NASD developed was not capable of using multiple computers. In addition, IQMS was written in a programming language that was less efficient than that used for its existing quotation system. The capacity of IQMS also did not prove to be as adjustable through programming changes as NASD expected. Shortcomings in NASD's approach to capacity planning also contributed to its inability to meet the original decimal-trading implementation date because it does not adequately incorporate the increasing volatility in its trading volume and it lacks effective criteria for determining whether its systems have sufficient excess capacity. In contrast, NYSE, although experiencing less of an increase in trading volume, has information technology systems whose capacity can be more readily expanded and attempts to maintain a targeted level of excess capacity. Rather than designing a new system, NYSE chose to primarily

² SEC Year 2000 Report: Future Reports Could Provide More Detailed Information (GAO/GGD/AIMD-98-51, Mar. 6, 1998).

³ ECNs are generally privately operated, screen-based electronic systems that allow customers to enter orders that are displayed to other customers and executed as appropriate.

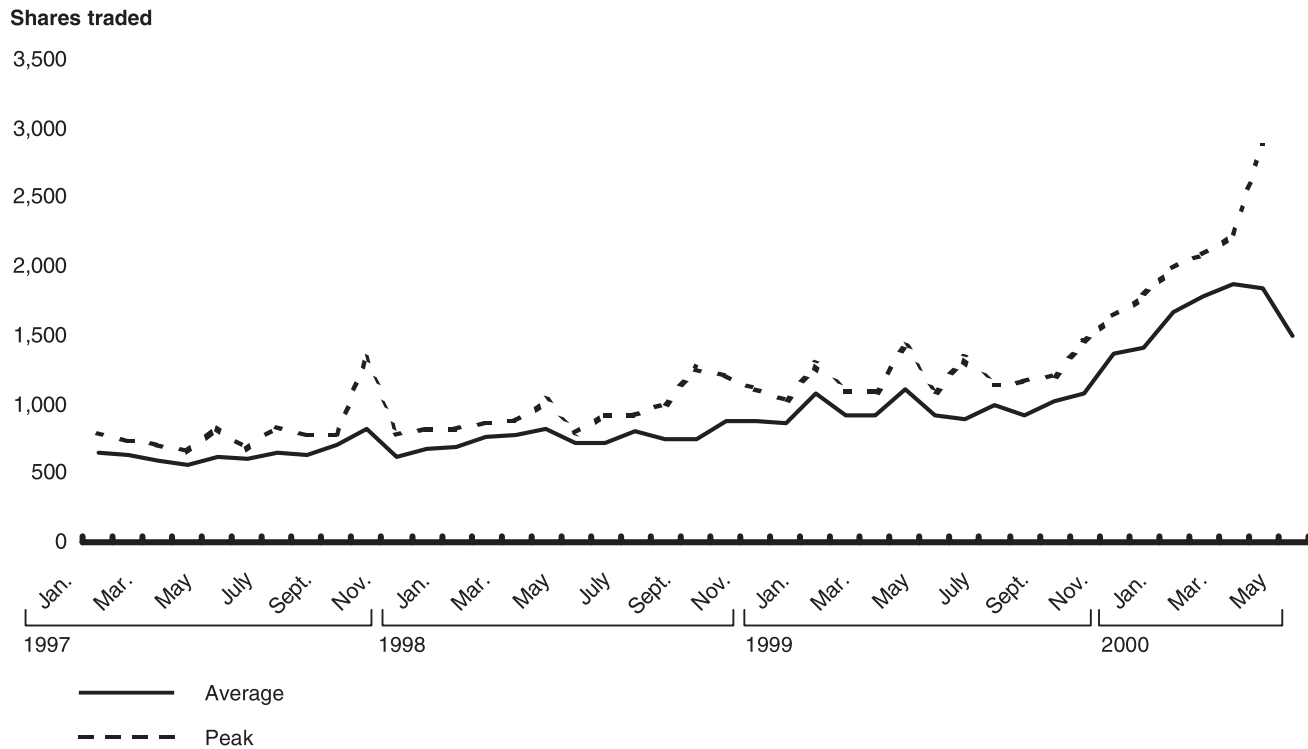
convert its existing systems to process decimal prices and reported having made all necessary changes before the original July deadline.

Nasdaq Trading Volumes Increased Rapidly in Late 1999 and Early 2000

In late 1999 and continuing into early 2000, the Nasdaq market experienced an unprecedented level of trading activity. In 1993, the average number of shares traded daily on the Nasdaq market was about 263 million.⁴ By 1996, the Nasdaq market's average daily shares traded had increased to about 500 million. Beginning in 1997, trading volumes on the Nasdaq market began to increase more rapidly, and it experienced a peak trading day of over 1 billion shares in October 1997, as shown in figure 1. By 1999, trading volumes on its market were averaging about 1 billion shares daily.

Subsequently, the Nasdaq market experienced an even more rapid increase in trading activity. As can be seen in figure 1, this rapid increase in trading began in the third quarter of 1999. The figure also shows that trading volume on the Nasdaq market increased from an average of about 1 billion shares a day during September 1999 to an average of 1.8 billion shares during April 2000, which represents an 80-percent increase in 7 months. NASD officials said that their market had never experienced growth at such a high rate as occurred during this period.

⁴ Trades executed on the Nasdaq market usually involve securities firms, which act as market makers for particular securities, buying from or selling shares to an investor. Thus, 100 shares being sold by one investor and bought by another results in Nasdaq eventually reporting 200 shares as having traded. This occurs because the market maker reports an executed trade when it buys the shares from the first investor and also reports a trade when it sells the shares to the second investor. In contrast, executed trades on the exchanges generally result from the direct matching of investors' orders to buy or sell. As a result, the Nasdaq market's trading volume statistics may appear higher than those of the exchange markets. Regardless, the information systems of the Nasdaq market are required to process the message traffic resulting from the transactions between investors and its market making firms.

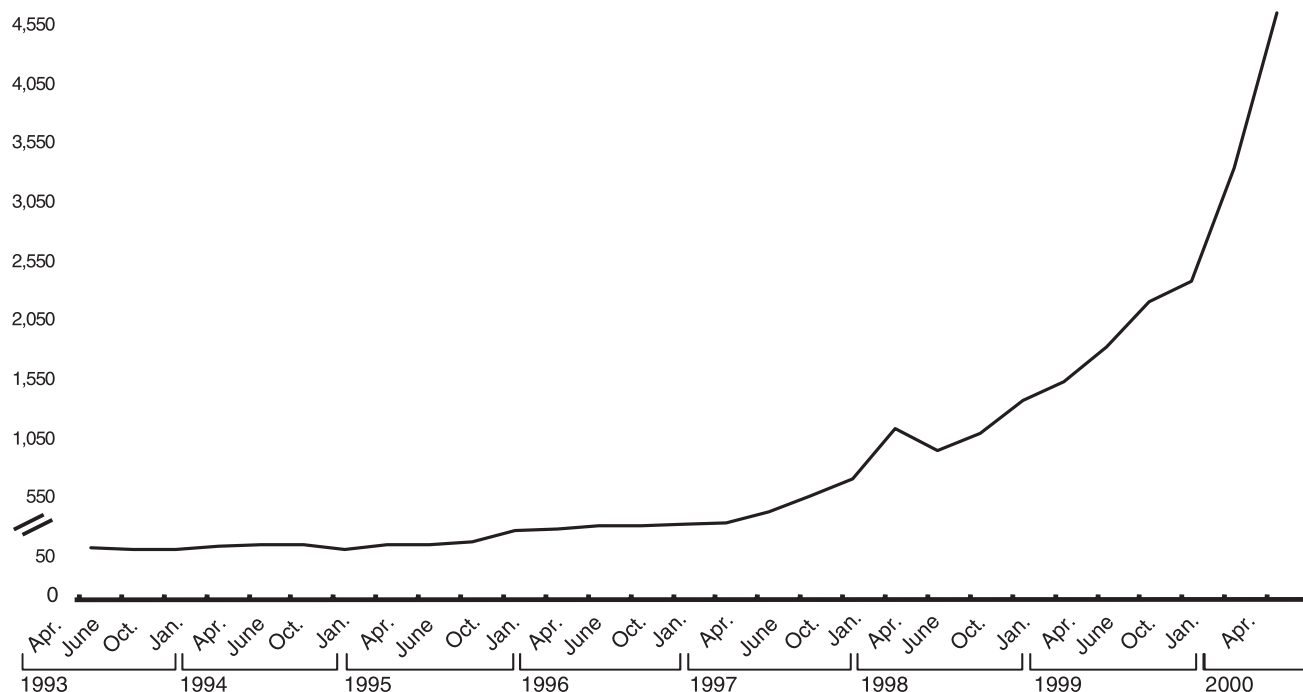
Figure 1: Average Daily and Peak Shares Traded on the Nasdaq Market, by Month (1997-2000)

Source: GAO analysis of data from NASD.

Overall, as its trading volume increased, the amount of message traffic being processed by Nasdaq's information technology systems increased even more rapidly. As part of conducting trading activities, various messages are sent through Nasdaq's systems among the broker-dealers acting as market makers in individual securities. These messages include the price quotes at which they are willing to buy or sell securities, customer orders, and reports of executed trades. As shown in figure 2 below, price quotation message traffic for the Nasdaq market has increased substantially, increasing by over 1,121 percent between January 1997 and April 2000. In late 1999, the rate at which quotation message traffic was growing increased even more rapidly on the Nasdaq market because quotation traffic increased by 105 percent from September 1999 to April 2000.

Figure 2: Average Daily Quotation Messages on the Nasdaq Market, by Quarter (1993-2000)

Daily quotation messages (messages in thousands)



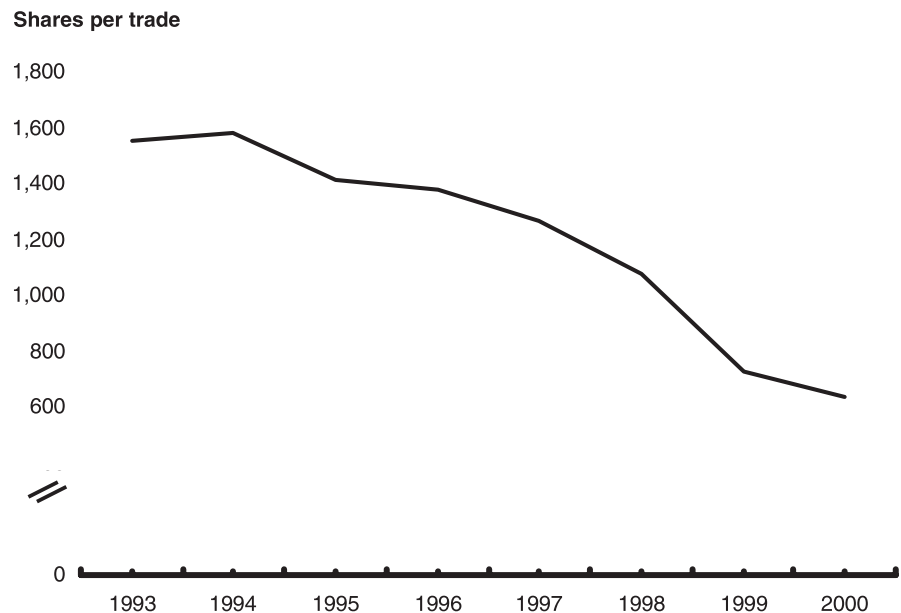
Source: GAO analysis of data from NASD.

The amount of message traffic that the Nasdaq market experiences for any given level of trading volume has increased partly because of changes in the way that trading on its market is conducted. Although trading volume and message traffic volume are generally correlated, a market could experience a peak in message traffic on a day that is not a peak trading volume day. Conversely, a peak trading volume day may not result in peak message traffic. According to NASD officials, a key reason its overall message traffic has increased at an even faster rate than its trading volume is because fewer shares are being bought or sold as part of each trade. NASD officials attributed the decline in average trade size to an increase in the number of individuals investing in stocks directly, the implementation of the SEC Order Handling Rules,⁵ and the increased popularity of day

⁵ SEC's Order Handling Rules required Nasdaq market makers to display customer limit orders and to disseminate the best prices for orders placed by market makers in the trading systems operated by ECNs.

trading.⁶ As shown in figure 3, the average trade size on the Nasdaq market has consistently fallen since 1994, with about half as many shares being traded per trade in 1999 as compared with the 1996 levels.

Figure 3: Average Shares Per Trade on the Nasdaq Market (1993-2000)



Source: NASD.

Although the trading volumes on the Nasdaq market have declined somewhat since the high volumes it experienced in early 2000, market participants expect trading volumes to continue to increase. After hitting a peak of 2.88 billion shares on April 4, 2000, trading volumes on the Nasdaq market averaged about 1.54 billion shares daily from April 5 until August 4, 2000. However, trading volumes are expected to increase and remain volatile. For example, an external consultant⁷ that reviewed NASD's information technology systems said market volume growth and volatility are likely to increase. NASD officials agreed that volumes on their market were likely to continue to increase.

⁶ Day trading is a strategy that generally involves making multiple purchases and sales of the same security during the day to profit from short-term price movements. See *Securities Operations: Day Trading Requires Continued Oversight* (GAO/GGD-00-61, Feb. 24, 2000).

⁷ As a result of a January 2000 SEC report on Nasdaq's information systems, SEC recommended that NASD hire an external contractor to review NASD's infrastructure capacity and its capacity planning process. In response, NASD contracted with SRI/Atomic Tangerine to conduct this review.

Nasdaq's Decimal Price Quotation System Lacked Sufficient Capacity

Limitations in the capacity of the system that NASD developed to process decimal prices resulted in its inability to meet the July 3, 2000, deadline for implementing decimal trading. To disseminate price quotations across its market, NASD has traditionally relied on a system that runs on a single-mainframe computer, and this system successfully processed the unprecedented trading volumes that Nasdaq experienced beginning in late 1999. However, IQMS, which was the system that NASD was developing to replace this older system, lacked sufficient capacity to process such volumes and was not capable of having its capacity easily upgraded. Although IQMS is currently being used to process quotations for some of the trading being conducted on the Nasdaq market, NASD does not plan to use it for decimal trading for the rest of its market and instead is readying its older system to process decimal prices.

Older NASD System Provided High Level of Reliability and Capacity Flexibility

In contrast to NYSE and the other regional exchanges, the Nasdaq market is a more widely distributed processing environment. To conduct trading on the Nasdaq market, market makers located around the country enter into the Nasdaq's computer systems the prices at which they are willing to buy or sell particular securities. These price quotations are consolidated by NASD and displayed to all its members by one system; trades that are based on these prices are executed through several other systems. NASD officials told us that their various systems currently process around 3,000 messages per second (MPS). The system NASD currently uses to process and disseminate price quotations across its market is known as its Legacy System. This system has been in place since 1971 and was designed to run on a single-mainframe computer. According to several external reviews of NASD's technology, Legacy has provided NASD with a very high level of reliability and performance.

Although written to operate on a single-mainframe computer, NASD has been able to upgrade Legacy to handle the increasing trading volumes and volatility occurring on the Nasdaq market over the years. The mainframe running Legacy has been replaced several times with more powerful computers, and the latest upgrade resulted in NASD using the most powerful machine currently made by this particular computer manufacturer. In addition, NASD systems specialists have continuously expanded Legacy's capacity by making adjustments to its programming software in a process called "tuning." The hardware upgrades and its use of the tuning process has allowed NASD to increase Legacy's capacity by almost 20,000 percent since 1972. During the increased surge in trading volumes in late 1999, NASD officials reported being able to further increase Legacy's capacity by 77 percent during a 5-month period.

IQMS Designed With Capacity Limitations

Although NASD's existing systems have proven successful, the system NASD designed to replace Legacy and allow it to process decimal quotations was not capable of processing the trading volumes being experienced by its market. IQMS is the system that NASD designed to replace Legacy. According to NASD, the development work on IQMS originally began in 1992, and it was expected to be implemented by 1994. Unlike Legacy, IQMS is capable of processing price quotations in decimal format, and NASD has used this system to process quotations for the stocks traded on its Over The Counter Bulletin Board market⁸ since 1998.

NASD officials told us IQMS' capacity was expected to be adequate to process the message traffic associated with a 2-billion share trading day, and, in 1992, Nasdaq's trading volumes averaged about 200 million shares daily. NASD officials indicated that, at that time, IQMS' capacity was projected to be greater than that of Legacy, but the continual tuning adjustments have allowed NASD to greatly increase the older system's capacity. However, NASD experienced technical problems and other delays in completing IQMS as originally scheduled. In some cases, NASD was required to complete other technology initiatives, such as implementing changes for the Order Handling Rules and readying its systems for the Year 2000 date change. According to NASD's Chief Information Officer, as IQMS was being developed, the system designers primarily focused on getting the system to function at the 2-billion shares per day level and did not revisit the system's capacity until June 1999. At that time, they determined that such a capacity should still be adequate because average trading volumes were not projected to exceed that level for several years.

The primary reason that IQMS' capacity was limited was that it lacked the capability of performing processing across multiple computers. Using multiple computers to perform processing is now commonplace among organizations that rely on large-scale information processing because it allows additional hardware to be added to systems as necessary to expand capacity. However, NASD officials said that the initial version of IQMS was designed to run only on the same single-mainframe computer as Legacy, which it was to replace. NASD officials told us that they envisioned eventually rewriting the software to allow it to process across multiple computers or "load share."

⁸ Stocks traded on the Bulletin Board are usually small companies with insufficient revenue or assets to be listed on the Nasdaq's primary market.

Because securities trading volumes have generally increased over time, developing a system with more flexibility in terms of capacity could have led NASD to incorporate into IQMS the capability to load share as part of its initial design. NASD officials told us that, at the time they first considered the design of IQMS, they analyzed and tested two other computer platforms that had load-sharing capability. However, according to NASD officials, these platforms did not meet certain performance requirements as well as the hardware that was used for Legacy and IQMS. After conducting further testing of IQMS to determine its processing capacity and considering the increasing Nasdaq market trading volumes, NASD decided in June 1999 to develop a second version of IQMS.

This second version would have the capability of distributing processing over additional computers and provide it with greater capacity than the initial version. NASD officials indicated that they had previously anticipated the need to create such a version of IQMS but had determined that the system should first be implemented and proven to be operational before being revised to allow load sharing. They also said that developing an IQMS version capable of load sharing would be extremely challenging because such distributed processing capability had not been accomplished using this particular type of computer in a large-scale transaction processing environment like that of the Nasdaq market. In addition, NASD officials estimated that creating this version would require about 18 months; thus, it would not be ready on the original implementation date in July 2000. Instead, NASD planned to use the first IQMS version to begin decimal trading then and bring the second version with load-sharing capability into operation later. However, as previously noted, the volumes in the market grew too rapidly and NASD officials determined that, although IQMS could handle the processing for a 2-billion share day, implementing it without sufficient reserve capacity would have been too risky in such a market environment.

NASD also selected a programming language that limited IQMS' capacity. Although IQMS was written using a more recent programming language than used for Legacy, NASD officials told us that they determined that IQMS requires more resources to process price quotations than would be required by Legacy. The external consultant that reviewed NASD's capacity and systems development processes noted that NASD's systems developers used a programming methodology and language for IQMS that were popular when the design of this system began in 1992. This methodology used a programming language not commonly chosen for systems today and also relied on prewritten programming modules to perform certain standard functions. However, the external consultant

indicated that such a methodology was an inappropriate choice for a system that had to handle the large processing volumes on a real-time basis as was necessary for IQMS.

IQMS' capacity also proved to be less capable of being adjusted through software adjustments. As previously noted, NASD was able to vastly increase the processing capacity of Legacy through software tuning. In its report on NASD's capacity planning process, the external consultant noted that NASD's capacity requirement forecasts assume that it will continually be as successful at increasing its systems capacities through tuning as it has been in the past. NASD officials told us that they similarly expected to be able to increase the processing capacity of IQMS through tuning once it was operational. After testing, NASD estimated that IQMS' capacity could likely be improved by as much as 30 percent. However, the initial attempts to tune the program produced improvements of only 3 percent, which reflected the differences in the programming languages used in IQMS compared with the language used by Legacy.

NASD Changed Its Approach to Implement Decimal Trading

As a result of the capacity limitations in IQMS, NASD has had to take several actions. First, NASD officials told us that, as of July 31, 2000, they have begun using the initial version of IQMS to process the price quotations for the exchange-listed securities that its members trade on its market.⁹ This has allowed the Nasdaq market to process decimal price quotations when such trading began for selected exchange-listed securities.

To price quotations for its own Nasdaq-listed securities, NASD officials intended to use the second version of IQMS that they had begun working on in June 1999 that would be capable of sharing processing load across multiple computers. However, NASD had also begun working on rewriting the Legacy System to give it the capability of processing decimal quotations. In May 2000, NASD decided to curtail further development of the second version of IQMS. NASD officials said that they chose this course of action because they could get better capacity performance with Legacy than with IQMS. Because they will not be continuing to prepare IQMS to process decimal quotations for trading for the rest of the Nasdaq market, these officials expected that the rewriting of Legacy would be complete during the first quarter of 2001 in time to meet the SEC's planned

⁹ Securities listed by one exchange are also usually traded on other exchanges or markets. For example, many stocks listed on NYSE are also listed and traded by the other regional exchanges, such as the Pacific Exchange or the Chicago Stock Exchange. In addition, some members of the Nasdaq market also make markets in exchange-listed securities. This trading of exchange-listed securities on Nasdaq is commonly referred to as the "Third Market."

implementation date. NASD also intends to implement a new system sometime in 2001 that will replace Legacy, operate on multiple computers, and have more advanced capabilities than its systems currently possess.

NASD Capacity Planning and Systems Development Does Not Adequately Incorporate Trading Volatility

Forecasting Methodology Does Not Adequately Incorporate Trading Volatility

Shortcomings in NASD's capacity planning process also contributed to its inability to be ready for the original decimal-trading deadline. NASD uses a forecasting methodology that has worked well in the past but does not sufficiently consider the recent volatility in its market's trading volume. Moreover, it lacks effective criteria for ensuring that its systems have sufficient excess systems-processing capacity, given its volatile market.

A shortcoming exists in the approach that NASD uses to forecast its future trading and transaction volumes. NASD officials told us that they annually develop forecasts of the trading volumes that are likely to be experienced by the Nasdaq market over the next 3 years. The forecasting model used to project trading volume is based on historical trading activity over the last 36 months. Using the output of this model, NASD forecasts estimates of the expected average and peak transaction volumes. It also calculates a likely range for these estimates, including a high-and-low expected value for each estimate. These estimates are also updated monthly to account for current market activity. According to these officials, this methodology has been very successful, as NASD actual peak volumes have exceeded its predicted values only twice in 20 years.

However, trading and message traffic volumes on the Nasdaq market have become more volatile in recent years. As previously shown in figure 1, trading volumes on Nasdaq began to be more volatile starting in late 1997. For example, NASD officials said that the surge in trading activity in 1999 that prevented them from implementing decimal trading was unprecedented, and, therefore, they had no basis to expect such trading activity to occur.

However, according to the external consultant's study of NASD capacity planning, NASD's forecasting methods, although standard for the industry, do not adequately take into account this more recent volatility in the trading activity on the Nasdaq market. In its report, this consultant described a new technique that could potentially be used to improve the forecast NASD produces of its expected trading volumes because it places greater emphasis on more recent trading activity than does NASD's current methodology. The consultant's report uses this technique to project NASD volumes for 3 months into the future. However, NASD officials told us that the technique in the consultant's report would require additional

NASD Lacks Effective Criteria for Ensuring That Its Systems Have Sufficient Excess Capacity

refinement to determine if it could be used to create forecasts of sufficient length to be useful for systems capacity planning purposes.

NASD's capacity planning process also lacks effective criteria for determining whether the information systems it currently uses and those under development have sufficient excess processing capacity. NASD officials explained that they use the forecasts of expected transaction volume to ensure that the actual processing capacities of their systems are adequate to meet the highest level of these expected volumes, and they have had considerable success using this method. However, NASD officials acknowledged that they need to develop a better means of assessing the adequacy of their systems' processing capacities given the increased volatility and rapid growth in their trading volume.

Developing criteria for assessing whether information systems have adequate excess processing capacity is an increasing challenge for all organizations active in the securities markets. The amount of excess capacity in information technology systems can vary widely depending on the type of processing that is required and the speed at which information can be sent into such systems. The demands placed on systems used in the financial markets can be particularly high as market conditions or external news events can create unpredictable surges in trading volumes. However, SEC officials told us that no standard criteria for making such determinations currently exist for the securities industry. Some organizations attempt to maintain excess capacity levels at set multiples above their forecasted peak volumes. NASD officials indicated that they do not use similar multiples of their forecasted peak, although they estimated that they maintain levels of excess capacity that, at times, are comparable to those of organizations that do use such targets. However, given the volatility of their trading and the structure of their market, which can result in more extreme surges in trading activity than usually occurs on other markets, NASD officials said that the means they use to assess the adequacy of excess capacity in their current and new systems will have to more effectively reflect these differences. Having such criteria and applying them during IQMS' development may have also indicated the capacity shortcomings of that system, such as when the Nasdaq market's trading volume peaked on October 28, 1997, with over 1.3 billion shares. At that point, IQMS' capacity was less than 2 times this peak.

Concerns had also existed that NASD's capacity planning efforts had not adequately taken into consideration the expected impact of decimal trading on message traffic volumes. In April 1999, a study was completed by SRI Consulting on behalf of SIA that estimated the impact that decimal

trading would have on industry information systems processing volumes.¹⁰ In its study, SRI projected that quotation volumes on the Nasdaq market would increase by as much as 231 percent by year-end 2001 over their 1998 levels following the implementation of decimal trading if minimum price variations (MPV) were a penny. In addition, in our March 2000 testimony, we noted that SRI had revised its estimates upward in February 2000, to project increases in quotation volume on the Nasdaq market as much as 700 percent by year-end 2001 from the 1998 levels due to increased market trading activity.

NASD officials had initially indicated that the projections in SRI's decimals capacity study were not accurate for its market systems. Instead, they indicated that their own research was more appropriate for estimating the impact of decimal trading on their market. Using these projections, NASD officials told us that they expected that their IQMS system would have had adequate capacity to process the additional traffic resulting from decimal trading. However, as previously noted, the growth in trading on Nasdaq's market exceeded expectations; thus, NASD had to postpone its implementation of decimal trading. However, NASD has recently contracted with SRI to produce forecasts of the impact of decimal trading on the processing volumes for the Nasdaq systems that better incorporate the specifics of their operations. NASD officials told us that these new projections are much lower than the original study predicted. However, we were not able to review the methodology and these results in detail before the publication of this report.

SEC Has Also Raised Concerns Regarding NASD Capacity Planning Process

SEC has also raised concerns over aspects of NASD's capacity planning process. According to an SEC official responsible for conducting information system reviews, NASD has had capacity-related problems since 1992. SEC has also noted these concerns in reviews done in recent years. For example, in a 1997 review of Nasdaq market systems, SEC staff expressed concerns about the ability of Nasdaq market systems to sustain acceptable levels of service during periods of sudden and extreme surges in transaction and quotation volume. At the time, SEC was anticipating greater message traffic volumes on the Nasdaq market as a result of the implementation of the Order Handling Rules, the advent of ECNs, and the effects of smaller MPVs. According to NASD officials, they had developed a plan and had begun to upgrade and expand their systems' capacities to address these concerns. In its report, SEC recommended that the Nasdaq market accelerate these efforts, and NASD officials told us that they took

¹⁰ Assessing the Impact on Message Traffic of Trading Equities and Options in Decimal Increments, SRI Consulting (Arlington, VA: Apr. 6, 1999).

various steps at that time to increase the capacities of their various systems.

After conducting another review of NASD systems in the summer of 1999, SEC issued a report in January 2000. In this report, SEC expressed concerns that Nasdaq's systems would not have sufficient capacity to sustain acceptable service for current and projected levels of message traffic, which were expected to further increase following the implementation of decimal pricing. As a result of this concern, SEC recommended that the Nasdaq market obtain an external review of its capacity planning process that would be reported to the NASD governing board by June 30, 2000. NASD received the final version of the report completed by this external consultant in June and has been reviewing and considering the study's recommendations. Although the consultant confirmed IQMS' capacity limitations and NASD's shortcomings in its capacity planning, it also reported that NASD exceeded industry standards in several areas, including systems reliability and in stress-testing capabilities.

NASD has also undertaken various other improvements to expand its system capacities. For example, NASD upgraded the capacity of its enterprisewide communication network. In addition, NASD replaced the mainframe computer it uses for quotation processing in October 1999 to the largest unit offered by that manufacturer. NASD also implemented new, multimessage switch architecture in the first quarter of 2000 that doubled its message-switching capacity.

NYSE Had a Different Approach to Readying Its Systems for Decimals and for Capacity Planning

The processing environment differs for NYSE and its approach for preparing for decimal trading also differed from that of NASD. According to NYSE officials, their systems have been ready for decimals since April 2000, and NYSE was prepared to implement decimal trading by the initial deadline of July 3, 2000. NYSE officials told us that their approach to converting their systems for decimals was similar to the approach they took for correcting Year 2000 flaws in their systems. They said that in most cases, they programmed their existing trading systems to process decimal prices, rather than creating new systems with decimal-trading capabilities, which allowed them to ready their operations fairly quickly.

NYSE's market structure, processing environment, and approach to capacity planning also differs from that of NASD. With a widely distributed network of market makers, NASD uses a single-mainframe architecture to consolidate and process price quotations. In contrast, NYSE's operations are centralized on a single trading floor. NYSE officials told us that their

trading and quotations systems have used a computer architecture that allows processing to be performed on multiple computers since about 1978. Such an approach allows NYSE to add additional computers, as necessary, to expand capacity.

NYSE also uses various targets that are multiples of its current trading volumes as criteria for ensuring that it has sufficient excess processing capacity. In a June 2000 U.S. House of Representatives testimony, NYSE reported that it can handle transaction rates of 1,000 MPS, which equates to about a daily trading volume of 5 billion shares.¹¹ NYSE officials said that recent capacity modeling has indicated that their system's maximum capacities may be reduced below these levels, depending on how decimal trading affects message traffic levels. By the end of the year, NYSE plans to double its systems' capacity to about 2,000 MPS. In contrast, the Nasdaq market's systems are reportedly already processing 3,000 MPS, and NASD officials said that they plan to expand these rates to be 3 to 6 times these levels.

NYSE's systems development and capacity planning approach reflects its experience with periods of high trading volumes. During the 1987 market crash, high trading volumes occurred on NYSE, NASD, and the other U.S. markets. All markets experienced problems in their information technology systems, including NYSE.¹² As a result, NYSE made various changes, including expanding its systems' capacities. During the recent period of increased trading volume that began in late 1999, NYSE's systems performed as expected, although it did not experience as much of an increase as the Nasdaq market. NYSE's trading volume increased from averaging about 780 million shares a day in September 1999 to an average of 1.1 billion shares during March 2000, which represents a 45-percent increase in 6 months. By contrast, average volumes on the Nasdaq had increased by 80 percent during this period.

¹¹ On Decimals 2000 - Will the Exchanges Convert?, Statement of Richard A. Grasso, Chairman and Chief Executive Officer. Before the Subcommittee on Finance and Hazardous Materials, Committee on Commerce, U.S. House of Representatives (June 13, 2000).

¹² Stock Market Automation: Exchanges Have Increased Systems' Capacities Since the 1987 Market Crash (GAO/IMTEC-91-37, May 10, 1991).

SEC's Decimal-Pricing Oversight Similar to Its Year 2000 Approach

SEC has overseen the securities industry's implementation of decimal pricing using a similar approach to its oversight of the industry's readiness for the Year 2000 date change. As it did for that effort, SEC has primarily relied on industry participants to report their readiness status and has conducted on-site examinations of selected market participants. Although SEC conducted various reviews of NASD that raised capacity concerns, SEC officials relied on NASD's representations regarding its decimal-trading preparations and did not identify in advance the system limitations that caused NASD's delay.

SEC Has Specific Group That Reviews Information Technology Issues

Within SEC, various groups are responsible for oversight of the securities industry. Since 1991, SEC has had a small group within its Division of Market Regulation that oversees information technology issues for the exchanges, NASD, and clearing organizations. This group is responsible for administering SEC's Automation Review Policy (ARP). Under the ARP program, SEC has issued guidance to the self-regulatory organizations (SRO) in the industry regarding their information technology systems. This guidance addresses various issues, such as capacity planning, systems development, and information security. The guidance also indicates that SEC expects SROs to have external reviews done of their information systems. SEC did not initiate the ARP program under its rule-making authority; thus, the program guidance is only voluntary for SROs.

SEC officials said that in addition to performing reviews related to this guidance, SEC's ARP group also monitors information systems issues at SROs, including tracking changes to systems and reviewing rule filings related to automation issues. The ARP group currently has a staff of eight, all of whom have information technology backgrounds as well as other training.

In addition to the SRO reviews conducted by the ARP staff in SEC's Market Regulation Division, other SEC staff also are involved in overseeing information technology issues for the securities industry. SEC's Office of Compliance Inspections and Examinations (OCIE) conducts regular reviews of broker dealers, investment advisers, and other market participants on a variety of issues that sometimes address these firms' information technology systems.

SEC Set Various Deadlines for Decimal Implementation and Surveyed Industry Participants' Readiness

As was the case in the industry's preparations for the Year 2000 date change, SEC's initial efforts regarding decimal pricing involved increasing awareness and assisting in establishing standards and approaches for implementation. Beginning in 1997, SEC organized several meetings with various market participants to address such issues as developing industry standards and strategies for implementing decimal trading. For example, these discussions addressed various topics, such as the appropriate number of decimal places that information technology systems should be capable of processing.

Similar to the milestones it set for its Year 2000 effort, SEC directed the exchanges and NASD to take specific actions and established various deadlines for the industry to meet as part of their efforts in implementing decimal pricing. In September 1999, SEC issued an order to the participants in the options markets requiring them to work cooperatively on options quotation message traffic issues that are expected to arise as a result of decimal trading.¹³ In January and June, 2000, SEC also issued orders directing the exchanges and NASD to work together to prepare implementation plans designed to ensure that the industry implemented decimal trading according to the specific time frames designated in these orders.¹⁴

As part of overseeing the securities industry's Year 2000 efforts, SEC required various market participants, including exchanges, broker-dealers, and others, to periodically provide reports directly to SEC on the progress of their efforts to ready their systems for the date change. SEC advised broker-dealers that failure to adequately ready their system to correctly process date-related information after January 2000 would be considered a violation of the requirements for such firms to maintain accurate customer records.

¹³ Application and Order Pursuant to Section 11A (a)(3)(B), Exchange Act Release Rel. No. 34-41843, 64 Fed. Reg. 50126 (Sept. 8, 1999). The order specifically applied to the American Stock Exchange, LLC; the Chicago Board Options Exchange, Inc.; NYSE; the Options Price Reporting Authority; the Pacific Exchange, Inc.; the Philadelphia Stock Exchange, Inc.; and the Securities Industry Automation Corporation.

¹⁴ Order Directing the Exchanges and National Association of Securities Dealers, Inc., To Submit a Decimalization Implementation Plan Pursuant to Section 11A(a)(3)(B), Exchange Act Release No. 34-42360, 65 Fed. Reg. 5004 (Jan. 28, 2000) and Order Directing the Exchanges and the National Association of Securities Dealers, Inc. To Submit a Phase-In Plan to Implement Decimal Pricing in Equity Securities and Options Pursuant to Section 11A(a)(3)(B), of the Securities Exchange Act of 1934, Release No. 34-42914, 65 Fed. Reg. 5004 (June 8, 2000).

SEC has similarly required certain market participants to report on their progress toward preparing for decimal trading. The ARP staff surveyed the exchanges and NASD regarding their efforts to ready their systems to accommodate decimal trading. These surveys were conducted in January and July, 2000. To ascertain the readiness of broker dealers for decimal trading, OCIE staff worked jointly with NYSE and NASD to prepare surveys that SROs were to administer to their members.

SEC Also Has Conducted Examinations of Decimal-Trading Readiness

In addition, SEC has also conducted examinations to review the readiness of selected industry participants for decimal trading. To assess Year 2000 readiness, OCIE staff had initially conducted on-site examinations of broker-dealer firms using a module containing a brief series of questions. In 1999, it conducted a more detailed series of on-site examinations of about 30 firms in conjunction with staff from various SROs. To review the readiness of SROs themselves, ARP staff conducted on-site reviews that also addressed Year 2000 issues as well as other matters of all SROs at least once. During 1999, SEC also required SROs to submit monthly surveys regarding their progress, and ARP staff used these to select SROs for additional on-site examinations.

Regarding decimal trading's implementation, SEC has also conducted an on-site examination effort as it did to ensure Year 2000 readiness. To assess the readiness of broker-dealers, SEC's OCIE staff conducted on-site examinations of a selected number of broker-dealers beginning in February 2000. Since the new implementation date was established in SEC's June 2000 order, OCIE staff have again worked with SROs to plan a joint series of examinations to follow up on the surveys administered by the SROs. To conduct this effort, an SEC official told us that staff from SEC, NYSE, NASD Regulation, and the Chicago Board Options Exchange have jointly developed an examination module and participated in joint training. These organizations plan to examine a total of 28 broker-dealers, including a majority of the most active trading and clearing firms for stocks and options. Corresponding to various checkpoints in the industry's phased implementation of decimal trading, the preliminary results of these examinations are to be reported by mid-September, and the final results are to be completed by late October. OCIE officials told us that this effort has been modeled on the reviews conducted in 1999 assessing the Year 2000 readiness of large broker-dealers.

During 2000, SEC ARP officials told us that they have conducted examinations that addressed decimal issues at 9 of the 14 SROs that must ready their systems for decimal trading. These examinations were part of the regular ARP inspections of these organizations' information technology

and also address other issues beyond decimal-trading readiness. According to an SEC official, fewer examinations have been conducted focusing on decimal readiness because SEC's resources were initially committed to ensuring participants' readiness for the date change in 2000, which they viewed as a serious risk to market operations.

Although SEC has raised concerns relating to NASD's systems capacities, SEC staff relied on NASD officials' representations about the progress being made to ready the Nasdaq market's systems for decimal trading and did not identify in advance the system limitations that caused NASD's delay. As previously noted, SEC had conducted a recent examination of NASD that addressed various aspects of NASD's operations, including its capacity preparations for decimal trading. This examination work was conducted over a period of 8 days in July, August, and September, 1999, and SEC issued the report that was based on this work in January 2000. In its report, SEC expressed concerns about NASD's systems capacity in light of the likely increased volumes expected from decimal trading and recommended that an independent review of NASD's capacity planning process be performed.¹⁵ In late February 2000, SEC received NASD's response to the first survey SEC had sent to all markets regarding their decimal readiness, in which NASD indicated that its decimal efforts were on schedule. However, within 2 weeks, NASD announced that it would be unable to meet the expected implementation date of July 3, 2000.

Industry Faces Various Challenges in Preparing for Decimal Trading

Although the first phase of decimal trading began August 28, 2000, only a small percentage of securities were converted to decimals, and various challenges remain for the industry as part of implementing such trading for all securities. As required by SEC, the relevant participants submitted a plan for implementing decimal trading. During the phased-in implementation outlined in this plan, the participants are to collect and analyze information on (1) the effects of decimal trading on industry participants' systems operations and (2) the functioning of market rules to ensure that the industry is ready for the next phase in the implementation. The options exchanges will have to continue to work on addressing the capacity concerns facing their markets. Finally, market participants will have to prepare to mitigate the effects on the markets if the decimal trading of all exchange-listed securities begins before such trading for Nasdaq market securities.

¹⁵ We discussed the results of this SEC report in the previous section relating to NASD.

Industry Participants Are Preparing to Implement Decimal Trading

In June 2000, SEC issued its latest order¹⁶ that required the securities exchanges and the Nasdaq market to prepare a plan to begin implementing decimal trading by September 5, 2000.¹⁷ SEC's order also required that such trading be implemented for all securities by April 9, 2001. On July 24, 2000, the relevant market participants submitted the industry's implementation plan to SEC in response to the SEC order. As shown in figure 4, the industry plans to implement decimal trading over four phases. The first phase, which involves the trading of a limited number of exchange-listed securities, began on August 28, 2000. As indicated in the figure, in November 2000, the market participants intend to consider allowing all exchange-listed stocks and their corresponding options to begin trading in decimals while Nasdaq market stocks are trading in fractions. If approved, such trading would begin 30 days later in December.

¹⁶ Order Directing the Exchanges and NASD to Submit a Phase-In Plan to Implement Decimal Pricing in Equity Securities and Options Pursuant to Section 11A(a)(3)(B), Exchange Act Release No. 34-42914 (June 8, 2000).

¹⁷ Named as "Participants" in the order were the American Stock Exchange, LLC; Boston Stock Exchange, Inc.; Chicago Board Options Exchange Inc.; Chicago Stock Exchange, Inc.; Cincinnati Stock Exchange, Inc.; International Securities Exchange, LLC; National Association of Securities Dealers, Inc.; NYSE; Pacific Exchange, Inc.; and Philadelphia Stock Exchange, Inc.

Figure 4: Planned Phases for Implementation of Decimal Trading

2000

Phase 1

► **August 28**

- Decimal trading begins for approximately 10 to 15 exchange-listed securities and options.
- Minimum price variation (MPV) for stocks would be set in pennies.
- MPV for options priced above \$3 will be quoted in dimes; those priced below \$3 will be quoted in nickels.

Phase 2

► **September 25**

- An additional 50 to 100 exchange-listed securities with decimal prices are to begin trading.

2000

2001

Phase 2**Phase 3****Phase 4**

► November 1

► March 12

► April 9

► Participants are to decide if all remaining exchange-listed securities should begin trading with decimal prices.

► Approximately 10 to 15 Nasdaq securities are to begin trading with decimal prices.

► All securities to be priced in decimals.

Source: GAO analysis of securities market participants' plan for decimal implementation.

As part of implementing decimal trading under this phased-in approach, the plan submitted by the securities market participants indicates that they intend to collect and analyze information during the various phases. This information is to be used to determine how decimal trading is affecting the operations of participants' information systems, including the impact on these systems' capacities. In addition, the participants intend to determine how the implementation of decimal trading has affected trading behavior, and this information is to be used as the basis for determining if any changes to exchange or market rules are required. Before the beginning of each subsequent phase of the implementation, the market participants will convene and determine whether the industry is ready to begin the next phase. Overall, the industry's plan indicates that at a minimum of five points in time, its representatives expect to confer with SEC about their readiness to proceed to the next phase.

Options Markets Have Made Limited Progress on Capacity Issues

As we testified in March 2000,¹⁸ the options markets have faced a considerable challenge in preparing for decimal trading. The system that transmits the options market quotations, which is administered by the Options Price Reporting Authority (OPRA), had experienced a peak of about 3,500 MPS as of August 8, 2000. Efforts are under way to expand the OPRA system's capacity to 12,000 MPS by December 2000. However, the consultant that performed the capacity study for the industry indicated

¹⁸ GAO/T-GGD-00-96.

that options message traffic could reach 38,000 MPS by the end of 2001 after decimal trading is implemented.

Because of the potential that the message traffic arising from decimal trading could exceed the OPRA system's capacity, the implementation plan submitted by the various market participants maintains minimum price increments for options trading of between 5 and 10 cents, depending on the price of the underlying stock. These increments are higher than those for stocks, which will trade in penny increments. If lower increments were used, the OPRA system would not have sufficient capacity because too many quotation messages would be automatically generated by the computers that options market makers use to produce their options price quotes.

In response to the concerns over the OPRA system's capacity, the various options markets have also been cooperating with one another to develop strategies for reducing message traffic levels. However, these efforts have made limited progress to date. Currently, the options markets participants have agreed to allocate the capacity of the OPRA system among themselves during peak periods. This allocation is based primarily on the historical peak volume of each market.

However, SEC has urged the options markets to develop a more equitable allocation method. Using an allocation that is based on historical peak volume results in more allocation being awarded to exchanges that historically produced more quotations, regardless of whether these quotations lead to actual trades. Therefore, SEC has sought comments on its own alternative means for allocating the OPRA system capacity during peak usage periods.¹⁹ The alternatives that SEC proposed are designed to provide incentives for the options markets to reduce excessive quoting and would reward those exchanges that quote more efficiently with a larger allocation of the total transmission capacity of the OPRA system.

¹⁹ Proposed Rule: Options Price Reporting Authority: Proposed Amendments to National Market System Plan. Release No. 34-42755; File 4-434 (May 4, 2000).

Steps Could Be Taken to Address Challenges of Implementing Decimal Trading for Exchange-listed Securities Before NASD Listings

Although acknowledging that securities listed on NYSE and the other regional stock exchanges could begin decimal trading before those listed on the Nasdaq market, the market participants that responded to SEC's request for comments, generally did not support such an approach. The primary issues they raised included investor confusion, systems capacity concerns, and increased potential for order entry and other errors. However, market participants also indicated that steps could be taken to mitigate these concerns.

After NASD announced it's inability to meet the originally scheduled July 2000 date, some proponents called for decimal trading in all exchange-listed securities to proceed even though NASD would not be ready to begin such trading in its own listings until the first quarter of 2001. In seeking market participant input on the revised decimal-trading implementation milestones, SEC referred to such trading as "dual pricing." Although some trading of exchange-listed securities is also conducted by NASD market makers using NASD systems, NASD officials have indicated that the systems used for such trading could be decimal-ready by September 2000, which would allow dual pricing for exchange-listed and Nasdaq securities to begin.

The securities industry market, broker-dealer, data vendor, and other officials that provided written comments to SEC, and those that we interviewed, generally acknowledged that it would be technically feasible to begin trading in exchange-listed securities using decimal prices before such trading began for those securities listed by Nasdaq. However, many participants indicated that if a dual-pricing approach is implemented, trading in the same security in both fractional and decimal prices should be avoided. This concern arises because some securities are traded on more than one exchange or market. According to these officials, the reasons that such trading should be avoided included arbitrage on the basis of different price increments,²⁰ investor confusion, and the prevention of industry systems processing limitations. The potential for problems arising from having the same security being traded in both fractional and decimal increments has been reduced as NASD officials have indicated that the systems that it uses to support the decimal trading of those exchange-listed securities traded on its market are currently decimal-ready.

²⁰ Arbitrage is the practice of buying securities in one market and simultaneously selling them in another market to take advantage of a difference in price quotations between the two markets.

Although acknowledging that decimal trading for all exchange-listed securities could begin first, most industry participants raised various issues with such an approach. The most frequently cited issue was that having all exchange-listed securities trade in decimals while those listed on the Nasdaq market traded in fractions would be too confusing to investors. However, two data vendors and two ECNs we spoke with indicated that investor confusion was not likely to be a major problem. For example, officials from one of the ECNs told us that decimal pricing instead should reduce confusion because it is a more rational pricing format and is used in other world markets.

To address possible investor confusion, some market participants suggested that an educational campaign for investors addressing decimal trading in a dual-pricing environment would be required. SIA officials advised SEC that educating investors about dual pricing would require a major campaign. SIA has already developed various literature and press release language that it plans to issue and that can be used by other market participants to help educate their own customers about the transition to decimal trading.

Some market participants also opposed rapidly moving to a dual-pricing environment in the securities markets because of concerns over whether information technology systems would have adequate capacity. For example, the Chicago Board Options Exchange commented to SEC that the impact of decimal trading on systems capacity was likely to be enormous. Therefore, the Chicago Exchange warned that moving too quickly to having all exchange-listed and Nasdaq securities trading with dual pricing would (1) prevent the industry from measuring the impact of decimal trading in a controlled environment and (2) reduce the exchange's ability to take remedial actions before its systems were overwhelmed. Officials from the Securities Industry Automation Corporation, which is the organization that performs information system processing for NYSE, the American Stock Exchange, and the systems that link the stock and options markets, told us that the industry already is facing a considerable challenge in addressing increased trading volumes. As a result, they suggested that waiting to implement decimal trading for all securities until 2001 could provide all market participants with more time to better prepare for the additional volumes expected to result from decimal trading.

However, as previously discussed, the industry plans to implement decimal trading in phases and does not envision allowing all exchange-listed securities to trade in decimals until December 2000 or later, thus reducing

the length of time during which the markets would be trading under dual pricing. This additional delay in implementing such trading would provide more time for market participants to increase the capacities of their information systems. In addition, the industry's plan described above also envisions analyzing the impact of decimal trading on market participants' information systems capacities as part of determining whether to move to the next phase of the implementation plan.

Market participants also expressed concerns that a dual-pricing approach would increase order entry and other operational errors. One broker dealer firm indicated that dual pricing would be confusing for its traders, and that errors made as a result of dual pricing would affect customer confidence. One particular area in which participants indicated that dual pricing could increase errors involved investors' entering orders through on-line trading systems.²¹ For example, a broker-dealer firm commented to SEC that investors may experience problems in conducting trades if they use the wrong pricing format for an order that is later rejected by the market for that security.

Although a dual-pricing trading environment could potentially increase operational errors, some steps could be taken to reduce their occurrence. For example, broker-dealers that accept customer orders using on-line trading systems could program these systems to immediately inform customers entering orders if they use an incorrect pricing format.

Although most participants expressed concerns about an approach involving dual pricing for all securities, some indicated that having decimal pricing begin for exchange-listed and other securities as soon as possible would accelerate the benefits anticipated to result from decimal trading. These officials indicated that rapidly implementing decimal trading would reduce the delay in realizing the reduced spreads and other benefits to investors expected from decimal trading. However, some participants noted that investors would receive the greatest benefit when all Nasdaq securities are trading in decimals because most trades in exchange-listed securities do not involve the payment of a spread to a broker-dealer.

²¹ For additional information, see On-Line Trading: Better Investor Protection Information Needed on Brokers' Web Sites (GAO/GGD-00-43, May 9, 2000).

Conclusions

Although the Nasdaq market experienced an incredible surge of trading volume beginning in late 1999, it was able to process the resulting increased volumes with its existing systems. However, the system NASD developed to process decimal prices for its market had insufficient capacity to process the trading volumes the market was experiencing. The primary limitation affecting the capacity of this system was its inability to use multiple computers to conduct processing.

In recent years, trading and message volumes on the Nasdaq market have grown substantially and have become more volatile. However, NASD's methodology for forecasting such trading volumes and message traffic has not changed to reflect the increasing volatility of this trading. As a result of this new environment, NASD officials acknowledged the need to develop better criteria for determining whether their information systems have sufficient excess capacity in light of their market's trading volatility and how quickly they can expand processing capacity. If NASD had such criteria and applied it during the development of IQMS, the capacity-related limitations of this system may have been apparent earlier, such as when it experienced a peak trading day in 1997 with volume exceeding 1 billion shares.

SEC has overseen the securities industry's progress toward implementing decimal trading using an approach similar to the way it oversaw the industry's efforts to prepare for the Year 2000 date change. As it did for the Year 2000 effort, SEC relied largely on industry participants to report their progress in readying their systems for decimal trading but also conducted examinations of various market participants regarding their readiness for decimal trading. In conducting its oversight of NASD, SEC generally relied on NASD's representations of the progress being made to ready that market's systems for decimal trading. However, SEC did not determine in advance that NASD's systems development efforts would not successfully produce a system that would have adequate processing capacity for decimal trading in time to meet the original implementation deadline. Given NASD's recent decision to modify its existing Legacy System to accommodate decimal pricing, additional on-site examinations of its progress on this revised strategy appear to be warranted. On-site examinations could provide SEC with greater assurance about the specific steps NASD is taking to implement decimal trading in accordance with the SEC-mandated plan, including allowing it to better ensure the validity of representations made by NASD officials.

Although decimal trading has begun for a small number of securities, various challenges remain for the securities industry as part of fully implementing such trading for all securities. The industry participants have a revised schedule to meet and all securities and all markets are to be trading in decimals by April 9, 2001. Over the course of the phased implementation, the market participants will also have to collect and analyze sufficient data to assure themselves and SEC that the industry is ready for each subsequent phase. This analysis is to ensure that market participants' systems have adequate processing capacity and are operating properly. In addition, the participants will have to assess whether market regulations are still functioning as intended in the trading environment involving decimal prices.

Recommendations

We recommend that the Chairman, SEC, take steps to ensure that NASD develops

- a volume forecasting methodology that better incorporates the volatility of the Nasdaq market's trading environment,
- systems that are capable of being quickly expanded to handle increased processing levels, and
- criteria for determining the minimum amount of excess capacity to be maintained for both existing and planned information technology systems that adequately consider its market's trading volatility and speed at which its systems' capacities can be expanded.

The Chairman should also direct SEC staff to conduct more on-site examinations of NASD as a means of collecting and verifying additional information on that market's progress in implementing decimal trading in accordance with the current implementation schedule.

Agency Comments and Our Evaluation

We requested comments on a draft of this report from the heads, or their designees, of SEC and NASD. These organizations provided us with written comments, which appear in appendixes I and II, and also with additional technical comments that were incorporated into this report as appropriate.

In its letter, SEC described the role it has played in supporting and overseeing the industry's progress. SEC stated that our recommendations regarding NASD's systems capacity planning processes were consistent with issues SEC has identified relating to NASD's systems capacities. To address this portion of our recommendation, SEC said they would review the consultant's recommendations to NASD and track NASD's implementation of these recommendations. As long as this results in NASD making the improvements to their volume forecasting and systems

development processes called for in our recommendation, this appears to be a reasonable approach.

SEC said it intends to consider our recommendation that it conduct more on-site examinations of NASD's decimal-trading efforts, but noted that we did not identify what additional information could be obtained through more on-site examinations of NASD. In its letter, SEC acknowledges that on-site examinations are an important element of its ARP program but that it does not primarily rely on them, and it questions whether such an approach would be an effective use of government resources. Although we understand the approach SEC has taken with its ARP program, we believe that there are benefits to be gained from additional on-site examinations of NASD. As we noted in this report, although SEC conducted some examinations of the Nasdaq market's readiness for decimal trading, it also relied on NASD officials' representations of their organization's progress as part of its efforts to monitor NASD's readiness. Such representations indicated that NASD's decimal-trading implementation efforts were on schedule up until the public announcement that it would not be ready.

On-site examinations would provide SEC opportunities to verify, corroborate, and more thoroughly evaluate NASD's progress and readiness. As noted in our published auditing standards,²² evidence obtained through direct physical examination, observation, computations, and inspection is more competent than evidence obtained indirectly. Regarding SEC's concern over whether additional examinations would be an effective use of government resources, the amount of resources required to complete such examinations should be minimal and likely assist in their oversight efforts to a greater degree than activities currently being undertaken by SEC staff. Nevertheless, to address SEC's comments, we have modified our conclusions and recommendation to more specifically discuss what we believe SEC would gain from conducting such examinations.

In its letter, NASD stated that the efforts it is making to implement decimal trading are on schedule. NASD also stated that our report incorrectly characterized as a weakness the way in which its capacity planning process accounts for the volatility of trading volumes on its market. It indicated that referring to this as a weakness implies that it can be remedied, but it stated that accurately predicting the future is notoriously difficult for any organization. NASD further noted that it uses techniques

²² Government Auditing Standards, United States General Accounting Office, June 1994.

standard for the industry but faces a harder task because its market has experienced greater volume growth and greater volatility than other markets.

We agree that the trading environment and market conditions of the Nasdaq market present a difficult challenge for NASD in developing accurate forecasts of its future trading volumes and accompanying message traffic loads. However, ensuring NASD's continued operations will require it to enhance the techniques it employs to better account for the circumstances of its market. Our report describes a possible technique developed by the external consultant that reviewed NASD's capacity planning process that may serve as the basis for incorporating its market's trading volume volatility into its methodology for projecting future volumes. We also acknowledge that this technique will require further development before it could be used to generate forecasts of sufficient length to be useful to NASD. In exploring this area, NASD may find that some other techniques may prove even more applicable. Nevertheless, the soundness of its market operations depends in part on being able to more accurately forecast future trading volumes so as to ensure that it has adequate processing capacity to accommodate such trading activity and, as discussed in the next paragraph, to assist in identifying an adequate level of excess capacity to maintain.

In response to our recommendation that NASD develop consistent criteria for determining how much excess processing capacity to maintain, NASD's letter stated that the criteria it currently uses to size its systems are consistent. It indicated that, instead, its shortcoming could be addressed if it developed a method for calculating the need for excess capacity that incorporates its market trading volume volatility with the capabilities of its system architecture. We agree that the methodology that NASD officials described to us is consistent, and we have revised the text of this report to indicate instead that NASD lacks effective criteria for ensuring that its systems have sufficient excess capacity.

We have also revised the language of the recommendation to indicate the need for NASD to develop criteria that consider its market trading volatility and the speed at which its systems' capacities can be expanded as discussed in a September meeting with NASD officials. As previously noted, NASD faces a considerable challenge in predicting its future trading volumes and implementing systems that can accommodate the growth and volatility of its market. The criteria that NASD uses to assess whether it has sufficient excess capacity in its systems will have to reflect the increasingly volatile nature of its market's trading. In addition, the

flexibility and speed at which NASD can expand its systems' processing capacities will also affect the criteria that it develops. Using the less-flexible mainframe architecture on which it has traditionally relied for processing price quotations will require NASD to plan for larger amounts of excess capacity because expanding the capacity of such architecture is more expensive and requires more time. As NASD transitions to architectures that are more readily capable of using multiple computers to perform processing, the need for larger amounts of excess capacity will likely be reduced.

As agreed with you, unless you publicly release its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will provide copies to Representative W.J. "Billy" Tauzin, Chairman, Subcommittee on Telecommunications, Trade, and Consumer Protection, House Committee on Commerce; Representative John D. Dingell, Ranking Minority Member, House Committee on Commerce; Representative Edolphus Towns, Ranking Minority Member, Subcommittee on Finance and Hazardous Materials, House Committee on Commerce; appropriate congressional committees; Arthur Levitt, Chairman, SEC; Frank G. Zarb, Chairman and Chief Executive Officer, NASD; and Richard A. Grasso, Chairman and Chief Executive Officer, NYSE. We will also make copies available to others on request.

Key contributors to this report are acknowledged in appendix III. If you have any questions, please call Thomas M. McCool at (202) 512-8678.



Thomas M. McCool
Director, Financial Institutions
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Keith Rhodes
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Contents

Letter	1
Appendix I Comments From the Securities and Exchange Commission	38
Appendix II Comments From the Nasdaq Stock Market, Inc.	43
Appendix III GAO Contacts and Staff Acknowledgments	46
Related GAO Products	48
Figures	
Figure 1: Average Daily and Peak Shares Traded on the Nasdaq Market, by Month (1997-2000)	7
Figure 2: Average Daily Quotation Messages on the Nasdaq Market, by Quarter (1993-2000)	8
Figure 3: Average Shares Per Trade on the Nasdaq Market (1993-2000)	9
Figure 4: Planned Phases for Implementation of Decimal Trading	24

Contents

Abbreviations

ARP	Automation Review Policy
ECN	electronic communication network
IQMS	Integrated Quote Management System
MPS	messages per second
MPV	minimum price variation
NASD	National Association of Securities Dealers
NYSE	New York Stock Exchange
OCIE	Office of Compliance Inspections and Examinations
OPRA	Options Price Reporting Authority
SEC	Securities and Exchange Commission
SIA	Securities Industry Association
SRO	self-regulatory organization

Comments From the Securities and Exchange Commission



UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, D.C. 20549

September 6, 2000

Thomas J. McCool
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Washington, D.C. 20548

Dear Mr. McCool:

This letter responds to your letter dated August 31, 2000, requesting our review of the draft Report entitled Securities Pricing: NASD's Decimal Quotation System Limitations and Trading Volumes Led to Decimal Trading Delay, GAO/GGD-00-199.

Thank you for the opportunity to comment on the draft GAO Report. We recognize the considerable efforts of the GAO in investigating this important issue. The GAO Report recommends that the SEC take steps to ensure that the NASD addresses its systems capacity planning process, and recommends that the SEC conduct more on-site examinations to assess the decimal-preparedness of the NASD.

The Commission has supported the move to decimals for several years. For example, in June 1997, the Commission held the first of a series of meetings with the securities industry to discuss the decimals conversion effort. In 1997 and 1998, the Commission corresponded with industry representatives regarding the cost of converting to decimals and the rules that would require amendments to accommodate decimal pricing. In 1998, concurring with the GAO's assessment that decimalization before 2000 was not worth the risk of industry systems failure attributable to Y2K problems, Chairman Levitt recommended that the industry strive to implement decimal pricing by June 30, 2000. In the fall of 1999, the Commission issued the options quote mitigation strategy order and the Division of Market Regulation (Division) sent letters to Self-Regulatory Organizations (SROs) requesting more substantive review of SRO rules that would require changes to accommodate decimal pricing. On January 28, 2000, the Commission issued the first order directing the exchanges and the NASD to work together to develop a decimals implementation plan. The revised order was issued on June 8, 2000. Additionally, the Commission has monitored the industry's efforts to implement decimalization, including testing. On August 28, 2000, the decimals pilot was successfully initiated, and the industry is on track to implement decimals fully by April 9, 2001.

Mr. Thomas J. McCool
September 6, 2000
Page 2

SEC's Oversight of the NASD

As the Report notes, the SEC has raised concerns regarding the NASD's capacity-related problems since 1992. Since that time, Division staff has performed five reviews of NASD systems and, in four of the five, raised concerns and made recommendations to the NASD to improve the NASD's systems capacity and capacity planning process. In particular, last Summer, Division staff examined the NASD's computer operations and identified to the NASD staff concerns about the NASD's capacity planning. In January of this year, the staff's report on its examination to the NASD identified systems capacity as a key concern and recommended that the NASD obtain an independent assessment of its infrastructure capacity and its capacity planning process, and report the results to its governing board prior to June 30, 2000.

In January 2000, Division staff surveyed the NASD (as well as the exchanges) regarding their preparations for decimal pricing. The NASD's response on February 25, 2000 indicated that the NASD would be ready for a decimal pilot by July 3rd, but indicated that it was continuing testing to confirm its readiness. On March 6, 2000, the NASD advised the Commission that the testing revealed unexpected capacity problems stemming, in part, from unprecedented volume surges, and that it would not have sufficient capacity to meet the target dates for decimals implementation.

In response to the NASD's announcement that it would not be decimal ready by July 3rd, Division staff prompted the NASD to accelerate its process for hiring an independent consultant to evaluate NASD systems capacity and capacity planning. That review was recently concluded, and the NASD is evaluating the consultant's recommendations.

Since the NASD's announcement, we have closely monitored the NASD's progress with decimal implementation, including weekly conference calls with the NASD's Chief Information Officer and his staff. Senior Division staff has met with NASD senior management several times over the past six months to review the NASD's readiness for decimals and to discuss the consultant's progress in its assessment of the NASD's systems capacity and capacity planning. Moreover, in early June, Chairman Levitt met with NASD senior management, including its President and Chief Information Officer, to discuss its readiness for decimals and broader capacity issues. On July 21, 2000, we obtained updated information from the NASD on its decimal readiness in response to our second decimals survey.

Mr. Thomas J. McCool
September 6, 2000
Page 3

Response to Specific GAO Recommendations

1. *Improvement in the NASD's Systems Capacity Planning Processes*

The GAO recommends that the Commission take steps to ensure that the NASD develops:

- a volume forecasting methodology that better incorporates the volatility of the Nasdaq market's trading environment,
- systems that are capable of being quickly upgraded to handle increased processing levels, and
- consistent criteria for determining the minimum amount of excess capacity to be maintained for both existing and planned information technology systems.

This GAO recommendation is consistent with the concerns that we have identified about the robustness of the NASD's capacity planning process. As the draft Report notes, the Division's January 2000 examination report raised concerns about the NASD's capacity planning process. In particular, we questioned whether the NASD's infrastructure could provide adequate processing capacity to handle a substantial increase in message traffic resulting from decimalization, particularly in a volatile market.

The Commission's Automation Review Policy Statements (discussed below) recommend that SROs obtain a periodic independent assessment of their systems to determine if they can perform adequately in light of estimated capacity levels. Consistent with this approach and in light of the staff's concerns about the NASD's systems capacity, we recommended in our January report that the NASD obtain an independent assessment of systems capacity and its capacity planning process that would be presented to the NASD board of directors by June 30, 2000. The consultant's report was delivered to the NASD in July, and the consultant is in the final stages of preparing a supplemental report specifically focusing on the capacity of the NASD infrastructure in a decimals environment. The consultant's report addresses the systems capacity planning issues identified in the GAO Report, including volume forecasting methodology, systems infrastructure to handle flexibly the NASD's processing capacity, and criteria for determining excess systems capacity. The NASD is reviewing the consultant's recommendations.

On August 4, 2000, Division staff met with NASD's Chief Information Officer to discuss the NASD's preliminary views of the consultant's report and recommendations. We expect to obtain the NASD's response to the consultant's recommendations, and then track their implementation.

Mr. Thomas J. McCool
September 6, 2000
Page 4

2. *Additional On-Site Examinations of the NASD*

The GAO recommends that the SEC conduct more on-site examinations to assess the decimal-trading efforts of the NASD as a means of collecting additional information on that market's progress in implementing decimal trading in accordance with the current implementation schedule.

A brief discussion of the Commission's technology oversight program for the NASD and other SROs would be useful in this context. The SEC has issued two automation review policy (ARP) statements,¹ and established the automation review program, which is currently staffed by eight individuals with information technology backgrounds. The SEC's oversight role has four principal components: (1) annual meetings with SRO technical staff to obtain reports on recent and prospective developments in automation facilities at each SRO, and to review the status of any outstanding recommendations that resulted from prior independent reviews or SEC inspections; (2) annual automation review plans and audit reports from each SRO after the reviews are conducted; (3) inspections by Division staff of selected automation facilities; and (4) ongoing dialogue with SRO staff about automation systems operation, including significant systems changes and outages.

The SEC has sought to develop a reasonable and cost-effective program that provides assurance that the SROs' automated systems are being rigorously developed and managed with respect to capacity, security, systems development methodology, telecommunications, and contingency planning. To accomplish this, on-site examiners use industry-accepted auditing principles to provide reasonable assurance that the SRO has controls in place that are adequate to meet the goals established by the SRO's management. While on-site examinations are an important element of the ARP program, the program was not designed to rely primarily on them; we believe that such an approach would not be the most effective use of limited government resources. Rather, the SEC's automation review program permits the SEC to respond flexibly to changes in SRO technology and business practices. Through this program, the SEC has been successful in working with the SROs to improve controls over their automated systems, to monitor the safety and soundness of the nation's securities markets in a cost-effective manner. Each year, the staff makes a careful assessment of where it should focus its resources, including the number and scope of on-site examinations.

Division staff has aggressively monitored the decimal readiness of the exchanges and the NASD. Since January 2000, we have completed two decimal surveys. As the GAO Report observes, since January 2000, the Division has conducted nine inspections

¹ Securities Exchange Act Release Nos. 27445 (November 16, 1989) [54 FR 48703] and 29185 (May 9, 1991) [56 FR 22490].

Appendix I
Comments From the Securities and Exchange Commission

Mr. Thomas J. McCool
September 6, 2000
Page 5

of SRO automation facilities that have included a focus on decimal preparedness.² Also, we have monitored the results of the SROs' internal audits covering progress on decimal implementation plans. As indicated above, the Division has taken and continues to take significant steps to see that the NASD remains on schedule for decimalization by April 9, 2001, and has put into place mechanisms to collect information on the NASD's progress in implementing decimal trading. As mentioned previously, the Division has encouraged and is monitoring an independent assessment of NASD systems capacity and capacity planning. Since March 2000, the Division has closely tracked the NASD's progress in preparing for decimalization. This has included weekly telephone conferences to monitor progress on decimals and the work of the consultant.

The Division appreciates the GAO's views on the need for additional on-site examinations to assess the decimalization efforts of the NASD.³ We are already intensively monitoring Nasdaq's progress towards decimals, but will consider the GAO's recommendation in determining the most effective means of overseeing the NASD's decimalization efforts.

* * *

As the GAO Report observes, the securities industry faces various challenges to fully implement decimal pricing by April 9, 2001. The Division is committed to the securities industry's conversion to full decimal pricing in a safe and orderly manner. To accomplish this goal, we will continue to take an appropriate and vigorous approach towards overseeing the exchanges' and the NASD's decimals implementation. We are mindful of the critical importance of decimal conversion to U.S. investors, and the potential for widespread operational problems in the markets and the securities industry, which in turn could adversely affect investors.

Sincerely,



Annette L. Nazareth
Director

² These recent inspections have covered nine of the fourteen SROs and related entities that are part of the decimals change-over.

³ We note, however, that the GAO recommendation does not identify what "additional information" on the NASD's progress would be obtained by conducting more on-site examinations.

Comments From the Nasdaq Stock Market, Inc.



Richard G. Ketchum
President

September 7, 2000

Thomas J. McCool
Director, Financial Institutions and Market Issues
United States General Accounting Office
Washington D.C. 20006

Dear Mr. McCool:

This letter responds to your August 31, 2000 request for comments on the GAO draft report entitled *Securities Pricing: NASD's Decimal Quotation System Limitations and Trading Volumes Led to Decimal Trading Delay*. We appreciate the ability of the GAO to respond to our previous comments thoughtfully, which minimizes the changes that we request to this draft.

Current Schedule – The NASD would like to first of all reiterate that it is on schedule to meet the SEC's April 9, 2001 deadline for decimalization of the Nasdaq Stock Market, and our confidence is underscored by our successes with the interim requirements of this schedule to date. Moreover, we have already decimalized the third market for the initial listed stocks that began trading in decimals on August 28, and are prepared to continue our contribution to full decimalization of that market on schedule as well.

Nasdaq Reliability – We take reliability and availability of the Nasdaq Stock Market very seriously, and the NASD would highlight your report's recognition of this high reliability. In fact, SRI/Atomic Tangerine, the outside consultant cited in your report, found Nasdaq's reliability and availability was the highest it had ever seen, with levels sought in the U.S. space flight program. An important part of this reliability is that we make changes to Nasdaq carefully because we know that while Nasdaq is only one component of the financial system in the U.S., it is a keystone component on which many other major parts of the system must rely.

Capacity Planning – We think it important to add that SRI also found that our capacity planning process, while faced with the difficulty of predicting extreme volatility in the Nasdaq market, ranked above industry standard in the technical knowledge and awareness of senior management of capacity issues, its ability to

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stress test the system to determine its full capacity, and the measurements that it displays online about its capacity.

Volatility Planning – In the report section entitled “NASD Capacity Planning and Systems Development Does Not Adequately Incorporate Trading Volatility,” the report refers to “weakness” in the NASD’s approach to forecasting future trading and transaction volumes. The report describes the weakness by citing the consultant report’s statement that the NASD has not adequately taken into account more recent volatility on Nasdaq. Since your report cites the same consultant as saying that NASD’s forecasting methods are standard for the industry, we believe that GAO has incorrectly characterized the problem that the NASD faces with volatility. “Weakness” means lacking capacity or capability and implies a situation that the NASD could remedy. In fact, predicting the future accurately, especially of a phenomenon as volatile as stock market volume, is notoriously difficult for anyone. The NASD uses the standard for the industry and is unique only in that it has a harder task of prediction because it has experienced greater volume growth and greater volatility than other markets.

Recommendation on Upgradable Systems – The draft report’s second recommendation states that the “SEC should take steps to ensure that the NASD develops ... systems that are capable of being quickly upgraded to handle increased processing levels.” We comment that our SuperMontage system now being planned to start replacing our Legacy system next year will have that capability and will avoid the problems with scalability of our current quotation system.

Recommendation on Consistent Criteria – The draft report’s last recommendation does not reflect the factual predicate that you have established in your report. That recommendation states that the “SEC take steps to ensure that the NASD develops ... consistent criteria for determining the minimum amount of excess capacity to be maintained for both the existing and planned information technology systems.” Our criteria are entirely consistent across all of our systems, and require that we size our systems to meet the peak capacities projected with a 99% confidence level. We believe that your recommendation would fit the facts you have laid out and be of more use to the reader if the underlined language above were replaced with “a method for calculating the need for excess capacity that combines the volume forecast methodology incorporating volatility with the capabilities of the system architecture.”

As we discussed in our meetings with you, we seek to balance the projected need for capacity with the difficulty of replacing particular components of the system. Thus, if we see that the demand on a quickly upgradable component may increase

3

rapidly, we will not need to have it currently installed for all of the additional capacity because its capacity could be increased quickly. Conversely, parts of the system that take a long lead time to upgrade are scaled to the much larger sizes that may be needed in the future because we cannot increase their capacity quickly.

If your recommendation were to be changed as we request, it would combine the first two points of your recommendation – volume forecasting that incorporates volatility and quickly upgradable systems – to direct us to match volume with capacity more precisely. This, we believe, is the focus of your report and should be stated explicitly.

We appreciate the GAO's diligence in the study of this complex area and its willingness to respond to our comments. We would be pleased to meet with you to discuss any of our requested changes further.

Sincerely,



Richard G. Ketchum

GAO Contacts and Staff Acknowledgments

GAO Contacts

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Cody J. Goebel, (202) 512-7329

Acknowledgments

In addition to those named above, Davi D'Agostino, Daniel Goldstein, Edwin Lane, and Jean-Paul Reveyoso made key contributions to the report.

Related GAO Products

On-Line Trading: Better Investor Protection Information Needed on Brokers' Web Sites (GGD-00-43, May 9, 2000).

Securities Pricing: Progress and Challenges in Converting to Decimals (T-GGD-00-96, Mar. 1, 2000).

Securities Operations: Day Trading Requires Continued Oversight (GGD-00-61, Feb. 24, 2000).

Year 2000: Financial Institutions and Regulatory Efforts to Address International Risks (GGD-99-62, Apr. 27, 1999).

Securities Market Operations: The Effects of SOES on the Nasdaq Market (GAO/GGD-98-194, Aug. 1998).

Securities Pricing: Actions Needed for Conversion to Decimals (T-GGD-98-121, May 8, 1998).

SEC Year 2000 Report: Future Reports Could Provide More Detailed Information (GGD-98-51, Mar. 6, 1998).

Stock Market Automation: Exchanges Have Increased Systems' Capacities Since the 1987 Market Crash (GAO/IMTEC-91-37, May 10, 1991).

Financial Markets: Active Oversight of Market Automation by SEC and CFTC Needed (GAO/IMTEC-91-21, Apr. 2, 1991).

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