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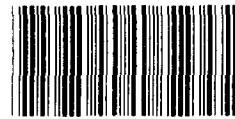
GAO

Report to Congressional Requesters

April 1988

FINANCIAL MARKETS

Status of Computer Improvements at the New York Stock Exchange



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**Information Management and
Technology Division**

B-229471

April 27, 1988

The Honorable Edward J. Markey
Chairman, Subcommittee on Telecommunications
and Finance
Committee on Energy and Commerce
House of Representatives

The Honorable Doug Barnard, Jr.
Chairman, Subcommittee on Commerce, Consumer
and Monetary Affairs
Committee on Government Operations
House of Representatives

The Honorable William Proxmire
Chairman, Committee on Banking, Housing, and
Urban Affairs
United States Senate

The Honorable Patrick J. Leahy
Chairman, Committee on Agriculture, Nutrition,
and Forestry
United States Senate

The Honorable Fernand J. St. Germain
Chairman, Committee on Banking, Finance, and
Urban Affairs
House of Representatives

The Honorable Edward R. Madigan
House of Representatives

This report is in further response to your requests and provides an update on the New York Stock Exchange's improvements to its automated order processing systems since our January 1988 report.¹ In that report, we pointed out that during the week of October 19, 1987, the Exchange experienced an unprecedented and unanticipated volume of stock trades (about 600 million shares on both October 19 and 20, 1987) that caused some of its automated order processing systems to significantly delay routing some trading orders to the Exchange's trading floor

¹Financial Markets: Preliminary Observations on the October 1987 Crash (GAO/GGD-88-38, Jan. 26, 1988).

for execution. These problems included limitations in the ability of some systems' software to handle the volume of transactions, antiquated equipment that could not handle the volume of odd lot orders,² and backups on card printers that print orders and administrative messages on the trading floor from member firms and other exchanges. The Exchange's problems with its automated systems were believed by some to have contributed to an inability to maintain orderly markets and raised questions about their capability to provide fair and equitable treatment to all market participants during these unprecedented trading volumes.

In our January 1988 report, we identified a number of changes that had either been made to the systems or were planned to improve performance. For example, immediately after October 19, 1987 the Exchange increased various systems' ability to store and process orders by adding additional disk drives and minicomputers. We also pointed out that the Exchange was planning to replace the entire system that handled odd lot orders; reduce the card printers' work load by moving administrative data not directly associated with executing orders to other printers; reduce reliance on card printers to print orders on the trading floor by increasing the number of electronic display books; and add trading floor space and related equipment. At the time of our January 1988 report, the Exchange anticipated that the systems would be capable of routinely handling a 600-million share trading day by December 1988.

We pointed out, however, that the Exchange's computer problems raised questions regarding whether planned system upgrades would be able to handle anticipated and unanticipated trading volumes, as well as the Exchange's ability to accurately forecast trading volumes and related system requirements.

We also reported in January 1988 that the SEC did not have the technical resources to independently evaluate the specific capabilities of automated trading systems. We expressed our belief that the SEC should expand its capabilities in this area, and obtain the necessary resources to determine whether the exchanges adequately plan for, design, and develop systems necessary to function smoothly.

In this review, we found that since January 1988, the Exchange (1) has made additional upgrades to its major automated order processing systems that encountered problems in October 1987 and, on April 30, 1988,

²Odd lot orders are trades of fewer than 100 shares.

plans a full-scale test of the systems in a 600-million share trading day similar to that encountered in October 1987; (2) plans to obtain an independent assessment of its automated systems; and (3) has improved its process for estimating the computer resources needed to handle anticipated future trading volumes.

The SEC plans to review the results of the independent assessment of the Exchange's automated trading systems, but has no plans to develop the technical capability to independently conduct such assessments. We continue to believe that the SEC needs to expand its technical capability to review exchanges' independent assessments and conduct its own assessments, as necessary.

Status of Automated Systems Improvements

Eleven major computer systems now support stock trading at the Exchange.³ Members of the Exchange can place orders through about 600 dedicated communications lines, then the systems route the orders to the Exchange's trading floor for execution. Orders routed through the systems reach the floor two ways. They are (1) printed by card printers located on the trading floor, or (2) displayed on terminals called electronic display books. Specialists on the trading floor use printed or electronically displayed orders to execute trades. As of October 19, 1987, about 60 percent of the traffic through the automated systems was routed to the trading floor through card printers.

Since our January 1988 report, the Exchange has completed several enhancements to its automated order processing systems. The Exchange has phased out the old equipment that handled odd lot orders and added new equipment to another system to handle odd lot processing. The Exchange has also placed 17 more printers on the trading floor to handle administrative messages during heavy trading periods, thus freeing other card printers to print only orders. The number of electronic display books has also been increased from 215 on October 19, 1987, to 361, as of March 31, 1988. The Exchange estimates that this has increased the amount of order traffic displayed electronically from 40 to 78 percent, thus reducing the reliance on card printers to print orders. To spread the work load on the trading floor, two and one half specialist trading posts, including 30 additional card printers and readers, were added.

³In October 1987, the Exchange used 12 major order processing systems to support stock trading. Since then, the system that handled odd lot orders has been removed and its work load consolidated with that of another system. New equipment has been added to the consolidated system to handle the odd lot work load.

According to Exchange officials, these system changes, combined with those discussed in our January report, will allow the routine processing of a 600-million share trading day that has similar order flow patterns as those that occurred on October 19 and 20, 1987, when the daily volumes of shares traded reached about 604 million and 608 million shares, respectively. Although individual systems had been tested to ensure that they met or exceeded this capacity level, the entire automated order processing system is not scheduled to be tested until April 30, 1988. At that time, the Exchange plans to test the systems' ability to handle a work load similar to that experienced the week of October 19, 1987. However, the plans for this test have not yet been finalized.

Although the Exchange has upgraded the capability of its automated trading systems to handle increasing trading volumes, a great deal will depend on the success of the test, scheduled for April 30, 1988, to help ensure that all systems will work smoothly under high order volume processing conditions. In this regard, it would be reasonable to expect that testing would include measures to successfully demonstrate that the Exchange's trading systems are capable of overcoming the processing problems experienced in October 1987. Such tests, therefore, should include measures to determine whether (1) floor devices, such as card printers and electronic display books, can efficiently deliver orders to the Exchange's trading floor under high volume conditions, (2) odd lot orders can be processed in a timely manner on the Exchange's upgraded equipment, (3) orders from other exchanges can be executed within specified time limits, and (4) software and hardware limitations have been overcome.

In our January 1988 report on the October 1987 crash, we pointed out that problems in automated trading systems created uncertainties in each individual market they served and may have created problems in others that depend on those markets. Thus, future tests designed to stress the automated systems and electronic linkages of the New York Stock Exchange, its member firms, regional stock exchanges, and intermarket components would be desirable. Such testing could serve to enhance public confidence that all parts of the nation's trading system are capable of performing under various kinds of anticipated trading patterns and associated volumes.

Status of the Exchange's Plans for an Independent Assessment of Its Automated Systems

On February 5, 1988, the Exchange's Chairman and Chief Executive Officer testified before the Senate Committee on Banking, Housing, and Urban Affairs that the Exchange intended to initiate an audit of its automated trading systems every 12 to 18 months to help ensure proper operation.

Exchange officials stated that they are in the early stages of initiating an independent assessment of their automated order processing systems. As of March 31, 1988, the Exchange had contacted three firms that perform computer systems reviews and have obtained proposals from each of them. The scope of the review is anticipated to include (1) an evaluation of the Exchange's computer capacity planning process, (2) a detailed evaluation of the capacity of each major order processing system, and (3) an evaluation of the Exchange's ability to monitor processing work loads on its major systems during operation. The Exchange anticipates selecting a firm by the end of April 1988.

Enhancements to the Exchange's Systems Capacity Planning Process

As discussed in our January 1988 report, the Exchange's automated order processing systems were not designed to handle the high trading volumes that occurred during the week of October 19, 1987. At the time of the October 1987 crash, the Exchange was updating its systems to routinely handle a 400-million share trading day by the end of 1987. A volume of 400-million shares is roughly two and one half times the average daily trading volume during 1986, and 1.6 times the highest volume day during 1986. Prior to October 1987, the Exchange believed that this amount of computing capacity would be sufficient to handle any peak trading day.

Since October 1987, however, the Exchange has modified its overall systems capacity targets and is planning to have its systems capable of routinely handling a 600-million share trading day by May 1988 and a 1-billion share trading day by December 1989. Assuming present rates of volume growth, Exchange officials said that this represents the development of a system that can process roughly 5 times the average daily trading volume the Exchange expects to receive. Exchange officials consider this target to be conservative, since, on an average day, the systems would operate at 20 percent of total capacity.

In addition to raising its overall computer capacity goals, the Exchange has also refined how it translates anticipated trading volumes into associated systems requirements. For example, the Exchange now will estimate the capability of subsystems supporting individual trading posts to

handle anticipated trading volumes. Prior to October 1987, it estimated the effect of volume only on the entire system that supports all trading posts. This is a significant change because during October 1987, the volume of orders overwhelmed the ability of some subsystems to print orders at some trading posts. In addition, the Exchange has established system performance goals, such as those for delivering orders to the Exchange floor and reporting executed trades to member firms. These goals will be considered as part of an overall assessment of the systems' capabilities to meet the Exchange's needs.

SEC's Plans to Expand Its Review of the Exchange's Computer Systems

In our January 1988 report, we pointed out that the SEC did not independently evaluate the specific capabilities of the automated stock trading systems or assess the extent to which the New York Stock Exchange and other exchanges purchased sufficient computer resources to efficiently process stock trades. We also pointed out that the SEC did not have the resources to determine whether systems are designed to effectively handle increasing trading volumes. We expressed our belief that given the intermarket consequences of trading systems breakdowns, the SEC should expand its capabilities in this area.

According to the Director of SEC's Division of Market Regulation, the SEC has no current plans to acquire additional technical resources to independently assess the Exchange's trading systems. However, the Director agrees with the need for an independent assessment of the trading systems and the Exchange's plans to contract for an assessment. The Director said that the SEC plans to review the results of the Exchange's independent assessment and believes this review fulfills the SEC's regulatory responsibilities. We agree that the SEC should review the Exchange's independent assessment of their automated systems, but continue to believe that the SEC needs the technical capability to evaluate the operations of automated trading systems. The SEC needs sufficient technical ability to review independent assessments, such as the one planned by the New York Stock Exchange, and to conduct its own assessments when independent assessments have not been made or are inadequate.

Objectives, Scope, and Methodology

Our objectives were to determine the status of the Exchange's (1) corrective actions to its automated order processing systems since January 1988, (2) plans for an independent assessment of its computer operations, and (3) efforts to improve its systems capacity planning process.

In addition, we determined the SEC's plans to review the adequacy of the Exchange's automated order processing systems.

Our review was limited to only those automated systems that support the execution of stocks traded on the floor of the New York Stock Exchange. We did not review other methods with which stocks are traded on the Exchange floor, the Exchange's post-trading settlement or clearance functions, and computer systems that did not experience difficulties in October 1987.

At the New York Stock Exchange, we met with the Executive Vice President for Capital Markets and the Senior Vice President for Equities to obtain updated information on planned or completed improvements made to the Exchange's order processing systems since January 1988. We also met with the Securities Industry Automation Corporation's President and the Vice President of Computer Operations to obtain detailed information and available documentation on upgrades to the Exchange's automated order processing systems.⁴

We also toured the floor of the Exchange to observe improvements such as the addition of two and one half trading posts and more electronic display books and card printers. In addition, we toured the Exchange's computer facility to observe upgrades made to computer hardware, such as the removal of the Automated Pricing and Reporting System, which was used to process odd lot orders, and the expansion of the Limit Order System to handle both limit and odd lot orders.

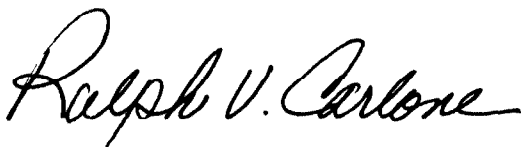
To understand the methodology followed at the New York Stock Exchange to estimate future trading volumes and associated system requirements, we met with the Exchange's Executive Vice President and Chief Administrative Officer, and the Senior Vice President for Technology and Product Development. We also obtained and reviewed available documents from officials in the Operations, Research and Analysis Division on the Exchange's computer capacity modeling process.

At the Securities and Exchange Commission, we met with the Director, Division of Market Regulation, and the Associate Director of the Office of Self-Regulatory Oversight and Market Structure to determine the Commission's plans for reviewing the adequacy of the Exchange's automated order processing systems.

⁴The Corporation is wholly owned by the New York and American Stock Exchanges and operates these exchanges' automated trading systems.

Our review was conducted between March 7, 1988, and April 19, 1988. Because detailed data on systems' performance after the upgrades were not available during our review, we were unable to independently evaluate the current performance capabilities of the Exchange's computer systems. Our work was performed in accordance with generally accepted government auditing standards.

We discussed the facts contained in this report with senior officials of the New York Stock Exchange, Securities Industry Automation Corporation, and the SEC, who agreed with the facts presented. We are providing copies of this report to other interested Members of Congress, executive branch agencies, and the public.



Ralph V. Carlone
Director

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