

PRESS RELEASE

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Tokyo Stock Exchange, Inc.

Launch of arrowhead Upgrade

Tokyo Stock Exchange, Inc. (TSE) has started production operations of arrowhead Upgrade today. TSE and Fujitsu Limited jointly made an announcement of the launch of the new arrowhead as attached.

Upgraded Version of Tokyo Stock Exchange's "arrowhead" Trading System

Operations start for new system, creating a safe and secure market

Tokyo, November 5, 2019 - Tokyo Stock Exchange, Inc. (TSE) and Fujitsu Limited today announced that TSE has completely overhauled its "arrowhead" trading system for the first time in four years, leveraging the latest technology from Fujitsu to enhance functionality and improve performance. The new version begins operation today.

The TSE "arrowhead" trading system is a world leading solution that delivers high performance and reliability, offering users the power of a large-scale mission critical system that combines a variety of cutting-edge technologies. After nearly ten years of stable operations, the system remains an integral part of trade at the Tokyo Stock Exchange since entering service in 2010.

Newly introduced features that prevent sudden fluctuations in stock prices, improve the opportunity to conclude contracts based on closing prices, and stabilize system performance mean that traders using the upgraded version of "arrowhead" will enjoy the chance to conduct their transactions in a market with greater peace of mind.

1. Overview of the new version "arrowhead"

The new version of "arrowhead" uses the existing system as a base for an upgraded technology that offers users the familiar, high speed, high reliability experience, while delivering even greater convenience. The trading system and transaction services have been improved in order to respond to changes in the business environment and better meet the needs of users, providing stronger overall market functionality.

1. Reducing cases in which trades are not executed at closing

For closing (the final trades at the end of the day), this version doubles the renewal price interval (*1). This will make it easier to execute trades at closing, when trading needs are quite high.

2. Preventing sudden and sharp changes in prices

TSE has deployed a system called sequential trade quotes, as part of an effort to improve control over sudden and sharp changes in price. When the system was deployed, it would display a sequential trade quote (STQ) to notify users of a sudden price change for cases in which a string of executions results from a single large order. This would attract counter orders, but in light of market trends, the system was improved in September 2015 to also

display an STQ when a string of executions results from multiple small orders arrive at the same time.

Now, the system is being further improved to prevent excessive price fluctuations beyond a certain price range (double the update price range of the Special Quotes) until a certain amount of time (60 seconds) has passed from the reference execution.

3. Improving processing capability

The system's processing capability is being improved to process trades in a stable fashion even when orders from participants are concentrated at certain times or when the number of orders suddenly increases. In particular, the new "arrowhead" will provide a stable environment for transactions by limiting the degree of instability in processing performance when orders are concentrated (*2).

Table: Comparison of Processing Performance

Processing Capability	Previous System	New System
Order response time	0.3 milliseconds	0.2 milliseconds
Information delivery time	1.0 millisecond	0.5 milliseconds

4. Enhancing the test environment

In order to increase opportunities for developers of trading systems that connect users with "arrowhead" to check the functionality of their products in TSE's test environment, TSE will now be providing an environment where developers can run tests from early morning to late night on all working days, where tests previously had to be conducted on specific days. This will contribute to greater safety and improved convenience for the market as a whole.

2. The Highly Reliable Technology and Support Behind "arrowhead"

The overhaul of "arrowhead" is improving both reliability and processing performance, combining the latest products, including Fujitsu's high reliability, high performance servers and middleware incorporating new technology to improve speed and reliability, with the full strength of the know-how and technical abilities of Fujitsu's engineers, built up over many years of system building.

1. The latest high reliability, high performance products

The new "arrowhead" consists of 400 Fujitsu Server PRIMERGY RX2540 M4 servers, Fujitsu's latest high performance, high reliability x86 server.

Fujitsu Software Primesoft Server, Fujitsu's high-speed in-memory data management software, enables nanosecond-level ultra-high-speed data access by storing all data necessary for processing in memory, providing high response and throughput performance. In addition, for data stored in memory, data integrity is ensured through constant mirroring to triply-redundant standby servers, enabling the system to switch servers in seconds when there is a fault.

Moreover, this update also delivers new functions that increase processing efficiency, such as a batch processing function.

2. Operations and support services for stable marketplace operations

With this new version, TSE and Fujitsu have used Fujitsu's many years of experience in developing and operating mission-critical systems, as well as its cutting-edge technology research capabilities, to jointly research applications of field-programmable gate array (FPGA) (*3) technology, developing the ultra-high-speed order test tool. This tool enables TSE to repeatedly conduct tests that place a burden on the system that significantly exceeds actual market levels, contributing to improved reliability for "arrowhead."

Fujitsu's personnel, including system engineers with excellent technical capabilities and many years of know-how in mission-critical systems, along with other personnel responsible for product development and support, will come together to provide advanced operations and support services, thereby contributing to stable market operations.

TSE and Fujitsu will take the opportunity of the launch of the new "arrowhead" to commit themselves to the further development of cash markets, continuing to improve convenience for a wide range of users going forward.

Notes

1. Refers to the price range between a previous price and the price at which the immediate next trade is completed. It is defined so as to control sudden and sharp price changes, and trades cannot be immediately executed if they exceed this price range.

2. Field-programmable gate array (FPGA): Refers to a semiconductor chip whose logic circuits can be programmed. Particularly good at simple processing programs, these chips are capable of extremely large volumes, high speed computations compared to CPUs. They are extensively used in technical fields that require high real-time capabilities, such as IoT.

About Tokyo Stock Exchange (TSE)

Tokyo Stock Exchange is licensed as a financial instruments exchange under the Financial Instruments and Exchange Act and operates financial instruments markets.

The market capitalization of companies listed on the Tokyo Stock Exchange is the third largest in the world and the largest in Asia, and we have established our position as the central market in Japanese securities.

Tokyo Stock Exchange is a wholly owned subsidiary of Japan Exchange Group, Inc. (Code: 8697).

About Fujitsu

Fujitsu is the leading Japanese information and communication technology (ICT) company, offering a full range of technology products, solutions, and services. Approximately 132,000 Fujitsu people support customers in more than 100 countries. We use our experience and the power of ICT to shape the future of society with our customers. Fujitsu Limited (Code: 6702) reported consolidated revenues of 4.0 trillion yen (US \$36 billion) for the fiscal year ended March 31, 2019. For more information, please see www.fujitsu.com.