ASX Trade Outage - 19 September 2016

23 SEPTEMBER 2016

1. ASX Trade Outage

1.1 Introduction

On Monday 19 September 2016, a hardware failure in the main database used to operate the ASX market triggered a number of events that meant the ASX market did not open at 10am. The market was also closed early.

The faulty hardware was replaced that evening. The ASX market opened as usual the next day and has since functioned normally.

It is very unusual for ASX to close the market. The ASX market has been closed on only 3 previous occasions in the last 10 years.

The ASX market plays a pivotal role in the Australian financial system. A decision to close the ASX market is not one that ASX takes lightly. We deeply apologise for the disruption this has caused.

The first section of this document provides a high-level overview. More technical detail follows in section 1.3 on page 4, and a timeline of market events is provided in section 2 on page 7.

1.2 Overview

Problems with hardware do happen from time to time and typically do not disrupt the proper functioning of the market. This is because ASX maintains a full replication of its systems in a backup datacentre (the disaster recovery site - DRS), and has automated processes (known as 'failover') that enable faulty hardware within the primary datacentre to be seamlessly replaced. ASX regularly tests this failover – including testing hardware components every time there is an upgrade to ASX Trade. ASX also conducts business continuity tests with industry participants and includes testing failover processes. This was last performed and successfully completed on 27 July 2016.

On Monday an unprecedented hardware malfunction triggered a complete database failover to DRS and not all parts of ASX Trade successfully connected to the DRS database. As a result, ASX could not open the market until 11.30am and took action to close the market at 2.05pm.

The nature of the hardware malfunction caused the failover process to respond in an unprecedented way. Put simply, there was inconsistency: the broken database hardware failed-over to the backup datacentre correctly and most parts of ASX Trade failed-over and connected to the new database. However, some parts remained connected to the original database, thinking it was operating normally. ASX operators were initially unaware of this anomaly. The issue was identified before the normal market open and most of the consequences were manually rectified. The market was then opened at 11.30am.

At 1.42pm a reference data inconsistency emerged for a group of securities. As a result, the system stopped functioning properly for those securities. After investigation, it became apparent that the data inconsistency had been caused by the original hardware malfunction and partial failover. ASX then halted the market in a controlled manner.

The data inconsistency could not be resolved before the scheduled close of trading, and the market was not re-opened. ASX has a responsibility to ensure that the ASX market is fair, orderly and transparent. As the trading platform was not functioning properly, ASX closed the market.

ASX Actions

Overnight, the failed hardware was replaced, ASX Trade was reset to its standard operating configuration, and the system was validated as being ready for market open. The market opened as normal at 10.00am on Tuesday 20 September and has operated without incident since.

The CEO and senior management commenced consultations to understand how these events affected market participants. In particular, ASX has received feedback on the communication process and will continue to engage on the forms of communication that would be most helpful during these types of events. This engagement remains an ongoing process.

A detailed investigation by ASX and its technology vendors has commenced to identify why the hardware malfunction caused the failover issues. At this stage, neither ASX nor its vendors can confirm having ever seen this malfunction before. ASX has updated its procedures to address this unprecedented scenario, were it to recur. Further actions include enhanced hardware monitoring, and continued investigation with vendors to improve the resilience of the system and the orderliness of the market recovery process.

ASX is fully cooperating with ASIC as it reviews the events that occurred and the decisions made by ASX.

1.3 ASX Trade

ASX Trade is comprised of a range of sub-systems that process and disseminate, among other things, public market data, private confirmations, clearing code allocations and securities reference data. A number of these sub-systems read from, and write to, the database which has real-time replication to a secondary database at the backup datacentre, or DRS.

The platform is logically segmented into 5 Partitions. The Partitions support load-balancing across the platform and are not the same as the Equity Groups. The Equity Groups are distributed across the Partitions and support the staggered and alphabetical opening of securities for trading each day.

ASX maintains a fully redundant system across the Primary Site (PS) at the Australian Liquidity Centre (ALC) and the DRS, which is in a different location. A number of these sub-systems, including the matching engine, have redundancy within the PS as well as at the DRS. Within each Partition of ASX Trade there is a primary and 'hot' standby matching engine at the PS, and a backup at the DRS.

1.4 Detail of Events

From 6.57am there was a degradation, and ultimately failure, of the physical database that supports ASX Trade. As designed, the backup database at the DRS successfully became the new primary database.

The sub-systems that comprise ASX Trade and that utilise the database are designed to automatically reconnect to the new primary database. This reconnection process was only partially successful. A number of sub-systems incorrectly maintained connection to the failed database. These included a number of common sub-systems and sub-systems relating to Partitions 2, 3 and 5 specifically. This malfunction created a series of technical issues.

The impact of the failed reconnection of the common sub-systems was visible to participants primarily as unsuccessful log-ons due to incomplete queries. This meant that some participants could not log-on or connect trading applications. Similarly, ASX Trading Operations was not able to log-on and perform certain market functions, although alternative control mechanisms were available. The market did not open as scheduled at 10.00am.

ASX failed over these common sub-systems to force a reconnection to the new primary database and opened the market at 11.30am.

> **MARKET ACTIONS**
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> - At 9.45am, ASX announced that the market would not open on schedule and was placed into Enquire.
> - At 10:54am, ASX announced that the market would be placed in Pre-Open at 11.10am with a staggered opening commencing at 11.30am.

The impact of the failed reconnection of the Partition-specific services (2, 3 and 5) was that on the market open private (directed to participants) and public market data broadcasts for securities in those Partitions were not published.

ASX failed over a Partition-specific service (not including the matching engine) of Partitions 2 and 3 to force a reconnection to the new primary database. This resolved the broadcast issue at 11.40am.

The market operated until 1.42pm when there was a reference data inconsistency, and as a result invalid order acknowledgments were disseminated on Partition 2. ASX subsequently placed the market into Enquire, and recovery and validation procedures commenced.

> **MARKET ACTIONS**
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> - At 2.05pm, ASX placed the entire market into Enquire.
> - At 3.35pm, ASX announced that the market would not re-open and that there would be no Closing Single Price Auction (CSPA).
> - At 5.20pm, ASX announced that closing prices were the last prices traded on the ASX market.

1.5 What Happened at 11.10am

At 11.10am Groups 1-3 (securities in the alphabet range A-M) transitioned into Pre-Open and Open as expected. The opening of Group 4 (securities N-R) and Group 5 (securities S-Z) were impacted due to an operational error.

Group 4 incorrectly opened at 11.10am and remained open until 11.11am during which time a number of trades occurred.

Group 5 did not open as advised and was rescheduled to Pre-Open at 11.40am and Open at 12.00 noon.

> **MARKET ACTIONS**
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> - Group 4 was placed into Enquire at 11.11am, and was placed in Pre-Open at 1.00pm and Open at 1.20pm.
> - Group 5 was rescheduled to Pre-Open at 11.40am and Open at 12.00 noon.

1.6 Other Actions

Some trades and invalid transactions were cancelled.

11.10am to 11.11am – Securities opened ahead of announced schedule

Trading in this period was not orderly. All trades executed between 11.10am and 11.11am were cancelled.

1.42pm to 2.05pm – Partition 2 not properly functioning

Partition 2 of the trading platform was not properly functioning during this time. Any messages which appeared to provide details of executions were invalid and later cancelled.

> **MARKET ACTIONS**
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> - On Tuesday 20 September, any acknowledgements market participants received for orders in Partition 2 securities on 19 September after matching engine timestamp 13:42:42.3679418 and up until the market was placed into Enquire (2.05pm) were invalid. ASX communicated with all participants impacted.
> - At 12.47pm on Tuesday 20 September, ASX published notice 1114.16.09 confirming that the invalid transactions were cancelled.

2. Timeline of Market Events

DATE/TIME	DESCRIPTION
Monday 19 September	
09:44	ASX market placed into Enquire.
09:45	ASX Trade publishes that ASX markets have been placed into Enquire.
09:47	ASX publishes via email that ASX markets have been placed into Enquire.
10:22	ASX restarts services to resolve internal and external user access issues.
10:32	ASX confirms normal access re-established to its Trading Operations application.
10:36	ASX confirms log-on access issues resolved for some external users.
10:54	ASX communicates to the market Pre-Open at 11:10 and Open at 11:30.
11:10	ASX transitions Groups 1, 2 and 3 to Pre-Open. ASX transitions Group 4 to Open (11:10) incorrectly. ASX did not transition Group 5 to Pre-Open and it remained in Enquire.
11:11	ASX transitions Group 4 into Enquire (11:11).
11:22	ASX publishes to the market via ASX Trade that "All trades at 11:10 are under investigation".
11:29	ASX publishes via ASX Trade that Group 5 securities will Pre-Open at 11:40 and Open at 12:00.
11:30	ASX transitions Groups 1, 2 and 3 to Open, as communicated (11:30, 11:32, 11:34 respectively).
11:33	Participants report that public and private trade report messages are not being disseminated for securities in Partitions 2 and 3.
11:35	ASX publishes an email that Group 5 securities will Pre-Open at 11:40 and Open at 12:00.
11:36	ASX identifies that trade confirmations are not being disseminated.
11:40	ASX transition Group 5 securities to Pre-Open.
11:40	ASX resolves the trade confirmation issue by failing over the effected sub-systems on Partitions 2 and 3.
11:49	ASX publishes via ASX Trade that "All trades in Equity Market Group 4 b/w 11:10.53-11:36 to be cancelled".
12:00	ASX transitions Group 5 securities to Open.

12:40	ASX publishes via ASX Trade and email that "Pre-Open Group 4 13:00 and Open 13:20".
13:00	ASX transitions Group 4 securities to Pre-Open.
13:20	ASX transitions Group 4 securities to Open.
13:42	ASX Trade Partition 2 processes fail due to an inconsistency in security reference data.
13:55	ASX publishes to market that Partition 2 is not available.
14:05	ASX transitions markets to Close by placing ASX Trade into Enquire.
14:06	ASX publishes via ASX Trade and email, that "All markets have been placed into Enquire".
15:31	ASX publishes via ASX Trade and email, that: • ASX Trade markets will not re-open for trading for trade date 19 September. • There will be no Closing Single Price Auction (CSPA). • ASX advises the process for determining closing prices, remaining session states and status of orders.
16:36	ASX publishes via ASX Trade on the purge of orders and close events, and advises participants to download order books for full validation in the morning.
17:10	ASX publishes via ASX Trade confirmation of the closing price determination: • Last traded price or the midpoint of the bid/offer on ASX Trade, whichever is the most recent. • ASX Margining prices will be available through the usual distribution methods.
20:00	ASX publishes via ASX Trade a file of the last trade price and/or previous close price information for all equity, interest rate, structured and listed fund products as at close of trading. The prices within this file were used for end of day processing.
Tuesday 20 September	
12:47	ASX publishes notice 1114.16.09 confirming that the invalid transactions between 13:42 and up until the market was placed into Enquire (14:05) were cancelled.

3. Related Documents

ASX Notice 1111.16.09 ASX Trade Outage - 19 September 2016

ASX Notice 1114.16.09 Invalid Acknowledgements for Partition 2 Securities - 19 September 2016