



**Annual Report for 2022**  
**of the Operating Committee of the Plan to Address Extraordinary Market Volatility**



Submitted April 28, 2023

## 1. Executive Summary

The LULD Plan<sup>1</sup> was enacted to minimize excess volatility in individual stocks by preventing trades in NMS stocks from occurring far away from current prices. Price limiting bands are created around the current security Reference Price. If the National Best Bid (“NBB”) equals the upper Price Band, or the National Best Offer (“NBO”) equals the lower Price Band, then a limit state is declared for 15 seconds. If the quote triggering the limit state is not executed or canceled within the 15 seconds, the security enters a five-minute trading pause. Separately, a straddle state occurs when a security’s NBB is below the lower band and the NBO is within the bands, or when a security’s NBO is above the upper band and the NBB is within the bands. In the case of a straddle state, the listing exchange may declare a trading pause.

To evaluate the efficacy of the Plan for the calendar year 2022, the Operating Committee has examined the occurrence of limit states, trading pauses, and straddle states during the year. We compare the occurrences of those events to those for the previous calendar year to detect any changes in occurrence. We also partition our samples by security variables that may impact the number of observed events such as: time of day; LULD pricing tier; whether the security is an exchange-traded product (ETP) or not; and quote volatility.

Our 2021 vs. 2022 comparison shows that more LULD events occurred in 2022 than in 2021. Consistent with our previous annual reports, we find that the number of LULD events in the first 15 minutes of trading is proportionally much larger than other periods. We find that although the percentage of trading pauses that occur in the first 15 minutes of trading in 2022 is roughly the same as in 2021, the percentage of limit states occurring during the first 15 minutes of the trading day was lower in 2022, at 26%, compared to 35% in 2021. We also find that 13% of limit states that occurred during 2022 were not resolved and proceeded to a trading pause, compared to 5% in 2021 and 15% in 2020.

We also examine the distribution of LULD event states partitioned by daily quote volatility, LULD tier, and whether or not the security is an ETP. We examine the distribution of quote volatility within each partition. The evidence suggests that the overall distribution of limit states, trading pauses, and straddle states is more closely related to LULD Tier and whether a security is an ETP.

Finally, we detail straddle state frequency and show that some securities can remain in a straddle state for a significant portion of the day. We study in detail the early part of the day, when spreads tend to be wider, and found a limited number of stocks exhibit this issue, with most of

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<sup>1</sup> The “LULD Plan,” also known as the “Limit Up/Limit Down Plan,” is officially named the Plan to Address Extraordinary Market Volatility Submitted to the Securities and Exchange Commission Pursuant to Rule 608 of Regulation NMS Under the Securities Exchange Act of 1934, and is available at <https://www.luldplan.com/plans>.

those stocks being relatively illiquid.

Overall, our evaluation of the efficacy of the Plan for calendar year 2022 does not suggest the need for any additional calibration of the LULD price bands. We do, however, identify three issues for further study: (1) moving Tier 2 ETPs to Tier 1, which we previewed in the 2019 Annual Report and continue to study; (2) using the LULD price band that triggered the trading pause as the new Reference Price for calculating LULD bands when a security reopens from an LULD trading pause on a quote (as opposed to using the mid-point of the BBO at the time of the reopen, as is presently done); and (3) examining the intersection of the LULD Plan with the 2022 changes to the exchanges' clearly erroneous events rules.<sup>2</sup>

## **II. Background**

On May 31, 2012, the Securities and Exchange Commission ("SEC" or "Commission") approved, on a pilot basis, a National Market System Plan, known as the Limit Up/Limit Down ("LULD") Plan, to address extraordinary market volatility. The Plan was approved by the Commission on a permanent basis on April 11, 2019, as part of the eighteenth amendment ("Amendment 18") to the Plan.<sup>3</sup>

The LULD Plan is administered by the LULD Operating Committee, comprising a representative from each of the Participants. The current Participants are Cboe BYX Exchange, Inc., Cboe BZX Exchange, Inc., Cboe EDGA Exchange, Inc., Cboe EDGX Exchange, Inc., the Financial Industry Regulatory Authority, Inc., Investors Exchange LLC, Long-Term Stock Exchange, MEMX LLC, MIAX Pearl, LLC, NASDAQ BX, Inc., NASDAQ PHLX LLC, The NASDAQ Stock Market LLC, New York Stock Exchange LLC, NYSE Arca, Inc., NYSE American LLC, NYSE Chicago, Inc., and NYSE National, Inc. The Plan and any amendments to it are filed with and approved by the Commission in accordance with Section 11A of the Securities Exchange Act of 1934.

Pursuant to Appendix B.II.A of the Plan, the Operating Committee is submitting this Annual Report for the year 2022.

### **A. OVERVIEW OF THE PLAN**

The Plan is designed to prevent trades in NMS Stocks from occurring outside specified price bands, which are set at a percentage level above and below the Reference Price of a security over the preceding five-minute period. The percentage level is determined by a security's designation

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<sup>2</sup> See, e.g., NYSE Rule 7.10 (Clearly Erroneous Executions).

<sup>3</sup> See Securities Exchange Act Release No. 85623 (April 11, 2019), 84 FR 16086 (April 17, 2019) (File No. 4-631).

as a Tier 1 or Tier 2 security. **Tier 1** comprises all securities in the S&P 500, the Russell 1000, and select ETPs. **Tier 2** comprises all other NMS Stocks, except for rights and warrants, which are specifically excluded from coverage. The Plan does not apply to options. The Plan applies during regular trading hours of 9:30 am ET - 4:00 pm ET.

To determine which ETPs are eligible to be included as Tier 1 securities, the Plan requires that, on January 1 and July 1 of each year, the Participants identify all ETPs across multiple asset classes and issuers, including domestic equity, international equity, fixed income, currency, and commodities and futures. All leveraged ETPs are classified as Tier 2 securities, and the remaining ETPs are then sorted by notional consolidated average daily volume (“CADV”). The period used to measure CADV is from the first day of the previous fiscal half year up until one week before the beginning of the next fiscal half year. Daily volumes are multiplied by closing prices and then averaged over the period. Non-leveraged ETPs (including inverse ETPs) that trade over \$2,000,000 CADV are classified as Tier 1 securities for the six-month period. The remaining ETPs are classified as Tier 2 securities.

#### **B. CALCULATION OF PRICE BANDS**

The two securities information processors (SIPs) – the Securities Industry Automation Corporation (SIAC) and Nasdaq, calculate the Plan’s price bands, consisting of a lower and upper Price Band for each NMS Stock. The SIPs calculate the lower and upper Price Bands by applying a formula to a Reference Price, which is the arithmetic mean price of Eligible Reported Transactions over the prior five-minute period. (The first Reference Price of the day is either the primary market’s opening price or the primary market’s previous day’s closing price/last sale when opening on a quote.) If the primary listing exchange does not open a security in the first five minutes and no eligible trades have occurred during that period from which to calculate a Reference Price, the first eligible trade after 9:35 a.m. becomes the Reference Price. The Reference Price is updated after 30 seconds only if a new Reference Price would be at least 1% away from the current Reference Price.

The Price Bands are calculated by multiplying the current Reference Price by the applicable Percentage Parameter, and then adding or subtracting that value from the Reference Price and rounded to the nearest penny:

$$\text{Price Band} = (\text{Reference Price}) \pm ((\text{Reference Price}) \times (\text{Percentage Parameter}))$$

**Table A** below shows the Percentage Parameters in effect for Tier 1 securities prior to the last 25 minutes of the trading day. The Percentage Parameters are doubled for all Tier 1 securities for the last 25 minutes of the trading day. **Table B** shows the Percentage Parameters that apply to Tier 2 securities except Tier 2 securities below \$3.00 for the last 25 minutes of the trading day, which are doubled.

Table A: Pricing Parameters for Tier 1 Securities	
Previous Closing Price	Percentage Parameter
Greater than \$3.00	5%
\$0.75 up to and including \$3.00	20%
Less than \$0.75	Lesser of \$0.15 or 75%

Table B: Pricing Parameters for Tier 2 Securities	
Previous Closing Price	Percentage Parameter
Greater than \$3.00	10%
\$0.75 up to and including \$3.00	20%
Less than \$0.75	Lesser of \$0.15 or 75%

To illustrate, assume a Tier 1 stock with a current Reference Price of \$25.00. Price bands will be established at  $\$25.00 \pm 5\%$ , resulting in a lower band of \$23.75 and an upper band of \$26.25.

In **Table C** below, we illustrate four possibilities that can trigger an LULD state:

1. If the NBB is equal to the upper band, then a limit state is declared.
2. If the NBO is equal to the lower band, then a limit state is declared.
3. If the NBB is below the lower band and the NBO is within the bands, then a straddle state occurs.
4. If the NBO is above the upper band and the NBB is within the bands, then a straddle state occurs.

Table C : Conditions That Lead To Limit and Straddle States							
Example	Ref Price	Lower Price Band	NBB	NBO	Upper Price Band	State	Condition
1	\$25.00	\$23.75	<b>\$26.25</b>	\$26.75	<b>\$26.25</b>	Limit	NBB resting on upper band

2	\$25.00	<b>\$23.75</b>	\$23.50	<b>\$23.75</b>	\$26.25	Limit	NBO resting on lower band
3	\$25.00	<b>\$23.75</b>	<b>\$23.50</b>	\$26.00	\$26.25	Straddle	NBB crosses the lower band, NBO within bands
4	\$25.00	\$23.75	\$26.00	<b>\$26.75</b>	<b>\$26.25</b>	Straddle	NBO crosses the upper band, NBB within bands

### C. ANNUAL REPORTING OBLIGATION

As required, the Annual Report comprises information concerning the Plan's performance during the preceding calendar year, including:

- (1) an update on the Plan's operations;
- (2) an analysis of any amendment to the Plan implemented during the period covered by the report; and
- (3) an analysis of potential material emerging issues that may directly impact the operation of the Plan.

We address those issues below.

### III. Update on the Plan's Operations in 2022

To provide insight to the current operation of the Plan, we compare measures of LULD events for 2022 to the same measures for 2021. Data for each year includes all trading days during that calendar year.

#### A. TYPE AND NUMBER OF LULD EVENTS

We first examine the number of event types that occur during 2021 and 2022. **Table 1, Panel A** contains the results for 2021, while Panel B reports results for 2022. Comparing the “# of Events” (i.e., “number of events”) column for 2021 (Panel A) with the results for 2022 (Panel B), we find that the total number of limit state events in 2022 (41,847) is less than half of the number of limit states observed in 2021 (83,659). The same tables show that the number of straddle states in 2022 (1,220,388) is more than double the number of straddle states in 2021 (518,078). The number of LULD Trading pauses in 2022 (5,766) is 30% higher than the number observed in 2021 (4,338). Below we address the interaction of limit state and pause states.

As was the case in 2020 and 2021, LULD events in 2022 were more likely to occur during the early part of the trading day. Accordingly, we partition our data into time-of-day partitions: the first 15 minutes of trading; the last 25 minutes of trading; and the intervening period. We then calculate the median, mean, and 90<sup>th</sup> percentile for each LULD event type for each time partition. The measures are contained in columns three through five of each panel. We also report the number of events for each event type – contained in the last column of each panel.

We first examine the number of each event type for each time period. As in 2021, the first 15 minutes of trading in 2022 is important overall. That is, despite accounting for just 4% of the trading day (except short days), the first 15 minutes contained 23% of the total number of LULD trading pauses (1,320 of the total 5,766), 26% of the total number of limit states (10,792 of the total 41,847), and 43% of the total number of straddle states (523,362 of the total 1,220,388). The opposite is true of the end of the day, during which far fewer LULD events occurred in all categories. The last 25 minutes accounts for 6% of the trading day (except short days), but represented just 3% of trading pauses, 3% of limit states, and 4% of straddle states in 2022.

Comparing the 2021 results in Panel A to the 2022 results contained in Panel B produces an interesting finding. The percentage of trading pauses in the first 15 minutes of trading remains basically the same from 2021 (924 of the total 4,338 = 21%) to 2022 (1,320 of the total 5,766 = 23%). Regarding limit states, however, in 2021, 35% (29,061 of the total 83,659) of all limit states occurred in the first 15 minutes of the trading day, while that figure dropped to 26% (10,792 of the total 41,847 = 26%) in 2022.

To further examine the change in the relationship between limit and pause states, we calculate the number of trading pauses during each trading year and divide by the number of limit states over the same period. As shown in our previous annual reports, in 2020, 15% of limit states (13,675 of the total 92,700 = 15%) were not resolved and proceeded to a trading pause, while that number declined in 2021, when only 5% (4,338 of the total 83,659 = 5%) of limit states were not resolved and proceeded to a trading pause. For 2022, the number increased again, with 13% (5,766 of the total 41,847 = 13%) of limit states not resolving and proceeding to a trading pause. The higher volatility in 2022 (as compared to 2021), as equities prices fell amidst inflation and recession concerns, likely explains the increased likelihood in 2022 of a limit state resulting in an LULD trading pause.

Finally, comparing the other statistical measures employed in the report, we find that in all but a few cases, the daily median, mean, and 90<sup>th</sup> percentile are all higher in 2022 than in 2021. For example, examining the medians<sup>4</sup> reported in the last row of Panels A and B we find that there is

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<sup>4</sup> We generally discuss medians instead of averages due to the skew caused by the most volatile periods during the study periods. Medians are a fairer representation of more

a daily median of 1,692 straddle states each day during 2021, but a daily median of 2,962 straddle states in 2022.

**Table 1: Overall Occurrence of LULD Events (Pause, Limit and Straddle)**

**Panel A: All Trading Days 2021**

		Median	Mean	90 %-ile	# Events
<b>9:30 - 9:45</b>	<b>LULD Pauses</b>	3.0	3.7	7.0	924.0
	<b>Limit States</b>	19.0	115.3	128.0	29,061.0
	<b>Straddle States</b>	1,155.0	1,256.6	1,517.0	316,666.0
<b>9:45 - 25 min before close</b>	<b>LULD Pauses</b>	10.0	12.9	26.0	3,251.0
	<b>Limit States</b>	74.5	210.1	419.0	52,952.0
	<b>Straddle States</b>	457.0	744.3	1,684.0	187,561.0
<b>Last 25 minutes</b>	<b>LULD Pauses</b>	0.0	0.6	2.0	163.0
	<b>Limit States</b>	1.0	6.5	17.0	1,646.0
	<b>Straddle States</b>	41.5	55.0	97.0	13,851.0
<b>Total</b>	<b>LULD Pauses</b>	14.0	17.2	31.0	4,338.0
	<b>Limit States</b>	110.5	332.0	708.0	83,659.0
	<b>Straddle States</b>	1,692.5	2,055.9	3,326.0	518,078.0

**Panel B: All Trading Days 2022**

		Median	Mean	90 %-ile	# Events
<b>9:30 - 9:45</b>	<b>LULD Pauses</b>	5.0	5.3	10.0	1,320.0
	<b>Limit States</b>	21.0	43.0	70.0	10,792.0
	<b>Straddle States</b>	1,932.0	2,085.1	2,715.0	523,362.0
<b>9:45 - 25 min before close</b>	<b>LULD Pauses</b>	12.0	16.9	36.0	4,249.0
	<b>Limit States</b>	84.0	118.1	265.0	29,639.0
	<b>Straddle States</b>	756.0	2,597.0	2,841.0	651,857.0
<b>Last 25 minutes</b>	<b>LULD Pauses</b>	0.0	0.68	2.0	197.0
	<b>Limit States</b>	2.0	5.6	13.0	1,416.0
	<b>Straddle States</b>	67.0	180.0	383.00	45,169.0
<b>Total</b>	<b>LULD Pauses</b>	18.0	23.0	44.0	5,766.0
	<b>Limit States</b>	118.5	166.7	336.0	41,847.0
	<b>Straddle States</b>	2,962.0	4,862.1	5,301.0	1,220,388.0

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normal activity, and we refer to the 90th percentile data to exhibit more extreme days. However, we do include some data and discussion on averages for comparison purposes.



## B. IMPACT OF SECURITY CHARACTERISTICS ON LULD EVENTS

Thus far, we have treated all securities equally, regardless of their descriptors. We now examine whether security characteristics have an impact on LULD events. We partition securities according to the following descriptors:

- LULD Price Tier (Tier 1 or Tier 2)
- Exchange Traded Product (Yes or No)
- Leveraged ETP (Yes or No)
- Previous Day's Closing Price

We placed securities into portfolios based on intersections of the above four values. We then calculated the same statistical measures already employed: mean; median; and 90% percentile. The results are found in **Table 2**, with results from 2021 in **Panel A** and 2022 results in **Panel B**.<sup>5</sup> Consistent with what we reported in the 2021 Annual Report, in 2022 there were far more LULD events in Tier 2 symbols than in Tier 1 symbols. For most categories, the median number of LULD pauses in 2022 remained at or near zero.

*[Table 2 appears on the next page.]*

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<sup>5</sup> In this table and the tables below, partitions are not reported if there were only *de minimis* numbers of symbols meeting the requirements.

**Table 2: LULD Summary Statistics by Tier, ETP and Price Groups**

<b>Panel A: 2021</b>							
<b>CATEGORIES:</b>							
<b>Tier</b>	1	1	2	2	2	2	2
<b>ETP Flag</b>	N	Y	N	N	N	Y	Y
<b>Leverage</b>	N	N	N	N	N	N	Y
<b>Close Price</b>	≥ \$3.00	≥ \$3.00	< \$0.75	\$0.75-\$3.00	≥ \$3.00	≥ \$3.00	≥ \$3.00
<b>Avg. # of Symbols</b>	1,023.3	879.1	57.8	480.9	5,918.9	1,520.6	169.8
<b>Avg. Limits Early</b>	7.1	0.6	0.2	0.6	102.5	4.3	0.0
<b>Avg. Limits Midday</b>	11.1	0.2	16.7	6.1	175.8	0.2	0.0
<b>Avg. Limits Late</b>	0.0	0.0	0.5	0.0	6.0	0.0	0.0
<b>Avg. Pauses Early</b>	0.1	0.0	0.1	0.1	3.3	0.1	0.0
<b>Avg. Pauses Midday</b>	0.2	0.0	1.5	0.4	10.7	0.1	0.0
<b>Avg. Pauses Late</b>	0.0	0.0	0.0	0.0	0.6	0.0	0.0
<b>Avg. Straddles Early</b>	38.2	12.4	0.9	3.2	1,030.5	162.8	8.3
<b>Avg. Straddles Midday</b>	24.3	5.5	28.0	13.0	606.8	43.7	22.6
<b>Avg. Straddles Late</b>	0.0	0.4	1.0	0.0	41.5	11.4	0.7
<b>Median Limits Early</b>	0.0	0.0	0.0	0.0	16.5	0.0	0.0
<b>Median Limits Midday</b>	0.0	0.0	0.0	0.0	62.0	0.0	0.0
<b>Median Limits Late</b>	0.0	0.0	0.0	0.0	1.0	0.0	0.0
<b>Median Pauses Early</b>	0.0	0.0	0.0	0.0	3.0	0.0	0.0
<b>Median Pauses Midday</b>	0.0	0.0	0.0	0.0	8.0	0.0	0.0
<b>Median Pauses Late</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Median Straddles Early</b>	24.5	7.0	0.0	2.0	927.5	150.0	6.0
<b>Median Straddles Midday</b>	0.0	0.0	3.0	0.0	348.5	14.0	0.0
<b>Median Straddles Late</b>	0.0	0.0	0.0	0.0	26.5	12.0	0.0
<b>90th %-ile Limits Early</b>	5.0	0.0	0.0	0.0	102.0	1.0	0.0
<b>90th %-ile Limits Midday</b>	12.0	0.0	28.0	8.0	343.0	1.0	0.0
<b>90th %-ile Limits Late</b>	0.0	0.0	0.0	0.0	15.0	0.0	0.0
<b>90th %-ile Pauses Early</b>	0.0	0.0	0.0	0.0	7.0	0.0	0.0
<b>90th %-ile Pauses Midday</b>	0.0	0.0	4.0	1.0	21.0	0.0	0.0
<b>90th %-ile Pauses Late</b>	0.0	0.0	0.0	0.0	2.0	0.0	0.0
<b>90th %-ile Straddles Early</b>	56.0	25.0	2.0	7.0	1,260.0	203.0	18.0
<b>90th %-ile Straddles Midday</b>	25.0	7.0	61.0	21.0	1,313.0	106.0	16.0
<b>90th %-ile Straddles Late</b>	0.0	1.0	1.0	0.0	84.0	17.0	1.0

**Table 2 (continued)**

<b>Panel B: 2022</b>							
<b>CATEGORIES:</b>							
<b>Tier</b>	1	1	2	2	2	2	2
<b>ETP Flag</b>	N	Y	N	N	N	Y	Y
<b>Leverage</b>	N	N	N	N	N	N	Y
<b>Close Price</b>	≥ \$3.00	≥ \$3.00	< \$0.75	\$0.75-\$3.00	≥ \$3.00	≥ \$3.00	≥ \$3.00
<b>Avg. # of Symbols</b>	1,020.0	997.3	306.5	899.8	5,848.0	1,729.0	209.7
<b>Avg. Limits Early</b>	8.0	0.4	1.2	1.9	30.2	1.2	0.0
<b>Avg. Limits Midday</b>	12.0	2.1	17.5	6.8	77.8	1.2	0.0
<b>Avg. Limits Late</b>	0.0	0.0	0.5	0.0	4.7	0.0	0.0
<b>Avg. Pauses Early</b>	0.3	0.1	0.2	0.3	4.1	0.3	0.0
<b>Avg. Pauses Midday</b>	0.5	0.0	27.7	0.9	12.1	0.5	0.0
<b>Avg. Pauses Late</b>	0.0	0.0	0.1	0.0	0.7	0.0	0.0
<b>Avg. Straddles Early</b>	56.4	16.1	7.3	42.3	1,735.7	215.5	15.0
<b>Avg. Straddles Midday</b>	24.4	8.9	133.2	59.7	2,323.4	45.0	261.0
<b>Avg. Straddles Late</b>	0.2	0.0	1.2	4.2	170.1	4.1	0.1
<b>Median Limits Early</b>	0.0	0.0	0.0	0.0	13.0	0.0	0.0
<b>Median Limits Midday</b>	0.0	0.0	1.0	2.0	49.0	0.0	0.0
<b>Median Limits Late</b>	0.0	0.0	0.0	0.0	1.0	0.0	0.0
<b>Median Pauses Early</b>	0.0	0.0	0.0	0.0	4.0	0.0	0.0
<b>Median Pauses Midday</b>	0.0	0.0	0.0	0.0	8.0	0.0	0.0
<b>Median Pauses Late</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Median Straddles Early</b>	38.0	10.0	2.0	39.0	1,559.0	206.0	15.0
<b>Median Straddles Midday</b>	0.0	0.0	7.0	23.0	591.0	26.0	0.0
<b>Median Straddles Late</b>	0.0	0.0	0.0	0.0	58.0	3.0	0.0
<b>90th %-ile Limits Early</b>	22.0	0.0	3.0	4.0	47.0	2.0	0.0
<b>90th %-ile Limits Midday</b>	35.0	0.0	52.0	2.0	193.0	3.0	0.0
<b>90th %-ile Limits Late</b>	0.0	0.0	0.0	0.0	10.0	0.0	0.0
<b>90th %-ile Pauses Early</b>	1.0	0.0	1.0	1.0	8.0	1.0	0.0
<b>90th %-ile Pauses Midday</b>	1.0	0.0	7.0	0.0	26.0	1.0	0.0
<b>90th %-ile Pauses Late</b>	0.0	0.0	0.0	0.0	2.0	0.0	0.0
<b>90th %-ile Straddles Early</b>	110.0	3.0	12.0	84.0	2,302.0	274.0	15.0
<b>90th %-ile Straddles Midday</b>	71.0	11.0	114.0	90.0	2,438.0	98.0	3.0
<b>90th %-ile Straddles Late</b>	0.0	0.0	2.0	2.0	346.0	9.0	0.0

### C. ASSOCIATION BETWEEN QUOTE VOLATILITY AND THE OCCURRENCE OF LULD EVENT

We also examine the relationship between the number of LULD events and the amount of quote volatility a security has. We measure quote volatility as the mean mid-point to mid-point price change for each second. **Table 3** below shows the distribution of daily quote volatility measures, partitioned by (i) whether the security is an ETP and, if so, whether it is leveraged, and (ii) LULD tier.

Results for 2021 are in **Panel A** and results for 2022 are in **Panel B**. We report the mean quote volatility, as well quote volatility at the 10<sup>th</sup> percentile, 25<sup>th</sup> percentile, 50<sup>th</sup> percentile (the median), 75<sup>th</sup> percentile, and 90<sup>th</sup> percentile. In 2022 (Panel B), we find that volatility at the mean and for all of the referenced percentiles for Tier 2 non-ETPs was lower than for Tier 1 non-ETPs. In comparison, 2021's results are slightly different. Volatility at the 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup> (the median), and 75<sup>th</sup> percentiles for Tier 2 non-ETPs was lower than for Tier 1 non-ETPs in 2021, as observed in 2022. However, volatility at the 90<sup>th</sup> percentile for Tier 2 non-ETPs in 2021 was higher than for Tier 1 non-ETPs, in part driving higher mean volatility for Tier 2 non-ETPs relative to Tier 1 non-ETPs in 2021.

In 2021, non-leveraged Tier 2 ETPs exhibited lower volatility than Tier 1 ETPs. This held for all percentiles as well as the median. We reference the median rather than mean since it is less susceptible to outliers and skewness. The same pattern is evidenced in 2022. As expected, leveraged ETPs exhibit noticeably higher volatilities, corroborating the need to continue multiplying band width by their leverage factor.

**Table 3: Quote Volatility**

**Panel A: 2021 (basis points)**

ETP Flag	LULD Tier	Leveraged	Mean	Percentile				
				10	25	50 (Median)	75	90
N	1	N/A	0.258	0.116	0.154	0.212	0.306	0.446
	2	N/A	0.395	0.010	0.039	0.135	0.269	0.495
Y	1	N/A	0.128	0.004	0.028	0.086	0.168	0.279
	2	N	0.217	0.004	0.019	0.062	0.138	0.265
		Y	0.633	0.079	0.188	0.402	0.751	1.240

**Panel B: 2022 (basis points)**

ETP Flag	LULD Tier	Leveraged	Mean	Percentile				
				10	25	50 (Median)	75	90
N	1	N/A	0.369	0.145	0.205	0.303	0.456	0.670
	2	N/A	0.268	0.006	0.035	0.121	0.254	0.439
Y	1	N/A	0.206	0.010	0.053	0.155	0.294	0.459
	2	N	0.236	0.009	0.040	0.116	0.243	0.441
		Y	1.058	0.098	0.250	0.599	1.242	1.985

**D. IMPACT OF QUOTE VOLATILITY ON INDIVIDUAL LULD EVENTS**

We next examine the impact of quote volatility on individual LULD events. We do this by comparing the number of trading pauses, limit states, and straddle states on a per-symbol per-day level at different quote volatility levels. The results are contained in **Table 4. Panel A** contains the results for 2021 and **Panel B** contains the results for 2022. Note that these tables count the *number of events*, which we considered more relevant than the *time spent* in these states.

In addition, **Sub-Panels A1 and B1** delineate the number of events that occur for various levels of quote volatility. Securities are partitioned by intersections of LULD tier and whether securities are ETPs. We can examine the number of days a security had volatility at a given level for the year for each intersection. Examining Sub-Panel A1 (2021) for Tier 1 non-ETFs, we find that 238,949 stock-days occurred in 2021 for securities with quote volatility levels less than 0.5. This represents 93% of the stock-days for this intersection. We find that for each intersection group, there is a preponderance of stock-day combinations that exhibit lower (less than 0.5) quote volatility.

Comparing securities by LULD Tier, ETP, and volatility groupings between 2021 and 2022, we find that 2022 exhibits, almost exclusively, a larger number of events than 2021.<sup>6</sup> Unlike the results reported in the 2021 Annual Report, both calendar periods are 12 months. In the 2021 Report, 2021 is for an entire trading year while 2020 is for just 10 months.

**Sub-Panel A2** contains the average number of LULD events in 2021 per-security per-day relative to the quote volatility level for intersections of LULD Tier and whether it is an ETP. For example, non-ETPs (N) in Tier 1 that have a quote volatility of 2.5 or more have on average 0.345 pauses per trading day for 2021. Further examining the sub-panel, we find that the number of LULD events in Tier 2 non-ETPs is not impacted significantly by increased volatility, suggesting that Tier 2 non-ETPs are more affected by liquidity gaps. We find this for trading pauses, limit states, and

<sup>6</sup> The lone exception is for intersection Tier 1 non-ETP where 2022 has 256,568 events while 2021 had 257,873.

straddle states. We also find that LULD events in Tier 1 ETP are less impacted by volatility than Tier 1 non-ETPs, although trading pause rates generally increase with quote volatility. Because volatility ranges much higher for non-ETPs, at the highest breakout, we do see a substantially greater likelihood of an LULD trading pause in non-ETPs as compared to ETPs, regardless of the security's tier.

**Sub-Panel B2** shows the average number of events per security per day for 2022. There were somewhat more events per day in 2022 than in 2021 for all intersections. We note that Tier 2 Leveraged ETPs have zero limits and pauses (to three decimal places) per symbol day. Non-leveraged Tier 2 ETPs' pauses and limit states are a fraction of those of the Tier 2 non-ETPs, and for most levels of quote volatility are far less common than Tier 1 ETPs. Straddle states are also far less common during more volatile periods.

**Table 4: Per Symbol Pauses, Limits, and Straddles by Daily Quote Volatility**

**Panel A: 2021**

**Sub-Panel A.1: Number and % of Stock-Days by Quote Volatility**

LULD Tier	1		2		1		2			
ETP(Y/N)	N		N		Y		Y			
Leveraged							N		Y	
Quote Volatility	n	%	n	%	n	%	n	%	n	%
< 0.5	238,949	92.66%	1,384,515	90.16%	214,142	97.93%	299,131	96.00%	22,834	58.66%
0.5 - 1.0	16,918	6.56%	84,069	5.47%	4,061	1.86%	6,122	1.96%	9,966	25.60%
1.0 - 1.5	1,595	0.62%	14,293	0.93%	243	0.11%	1,342	0.43%	3,658	9.40%
1.5 - 2.0	277	0.11%	5,762	0.38%	67	0.03%	725	0.23%	1,255	3.22%
2.0 - 2.5	76	0.03%	5,139	0.33%	89	0.04%	576	0.18%	429	1.10%
>= 2.5	58	0.02%	41,840	2.72%	69	0.03%	3,703	1.19%	786	2.02%
Total	257,873	100.00%	1,535,618	100.00%	218,671	100.00%	311,599	100.00%	38,928	100.00%

**Sub-Panel A.2: Average Events Per Security Per Day**

LULD Tier	Quote Volatility	1	2	1	2	
ETP (Y/N)		N	N	Y	Y	
Leveraged					N	Y
<b>Pauses</b>	<b>&lt; 0.5</b>	0.000	0.000	0.000	0.000	0.000
	<b>0.5 - 1.0</b>	0.001	0.004	0.001	0.002	0.000
	<b>1.0 - 1.5</b>	0.007	0.023	0.012	0.004	0.000
	<b>1.5 - 2.0</b>	0.032	0.056	0.000	0.001	0.000
	<b>2.0 - 2.5</b>	0.092	0.054	0.000	0.000	0.000
	<b>&gt;= 2.5</b>	0.345	0.063	0.000	0.002	0.000
<b>Limits</b>	<b>&lt; 0.5</b>	0.000	0.003	0.000	0.004	0.000
	<b>0.5 - 1.0</b>	0.064	0.088	0.005	0.003	0.000
	<b>1.0 - 1.5</b>	0.638	0.384	0.058	0.010	0.000
	<b>1.5 - 2.0</b>	1.166	1.449	0.269	0.004	0.000
	<b>2.0 - 2.5</b>	11.408	0.564	0.000	0.000	0.000
	<b>&gt;= 2.5</b>	20.586	1.166	0.000	0.003	0.000
<b>Straddles</b>	<b>&lt; 0.5</b>	0.025	0.118	0.012	0.092	0.014
	<b>0.5 - 1.0</b>	0.132	0.391	0.073	0.138	0.012
	<b>1.0 - 1.5</b>	1.337	1.870	0.531	0.349	0.022
	<b>1.5 - 2.0</b>	3.282	2.512	0.552	0.338	0.016
	<b>2.0 - 2.5</b>	23.237	1.873	0.000	1.036	0.075
	<b>&gt;= 2.5</b>	47.155	3.053	0.303	1.422	0.277

**Table 4 (continued)**

**Panel B: 2022**

**Sub-Panel B.1: Number and % of Stock-Days by Quote Volatility**

LULD Tier	1		2		1		2			
ETP(Y/N)	N		N		Y		Y			
Leveraged							N		Y	
Quote Volatility	n	%	n	%	n	%	n	%	n	%
< 0.5	203,823	79.44%	1,627,904	92.27%	230,174	92.17%	399,249	92.00%	23,747	44.43%
0.5 - 1.0	45,479	17.73%	99,095	5.62%	17,972	7.20%	23,226	5.35%	12,127	22.69%
1.0 - 1.5	6,068	2.37%	15,314	0.87%	1,246	0.50%	4,802	1.11%	7,847	14.68%
1.5 - 2.0	992	0.39%	4,785	0.27%	178	0.07%	2023	0.47%	4,470	8.36%
2.0 - 2.5	145	0.06%	2,284	0.13%	54	0.02%	1076	0.25%	1921	3.59%
>= 2.5	61	0.02%	14,946	0.85%	102	0.04%	3,591	0.83%	3,339	6.25%
Total	256,568	100.00%	1,764,328	100.00%	249,726	100.00%	433,967	100.00%	53,451	100.00%

**Sub Panel B2: Average Events Per Security Per Day**

LULD Tier	Quote Volatility	1	2	1	2	
ETP (Y/N)		N	N	Y	Y	
Leveraged					N	Y
<b>Pauses</b>	< 0.5	0.000	0.000	0.000	0.000	0.000
	0.5 - 1.0	0.001	0.006	0.000	0.003	0.000
	1.0 - 1.5	0.006	0.026	0.006	0.006	0.000
	1.5 - 2.0	0.038	0.071	0.028	0.012	0.000
	2.0 - 2.5	0.138	0.135	0.074	0.007	0.000
	>= 2.5	1.279	0.224	0.294	0.009	0.002
<b>Limits</b>	< 0.5	0.000	0.001	0.000	0.001	0.000
	0.5 - 1.0	0.026	0.023	0.004	0.005	0.000
	1.0 - 1.5	0.155	0.203	0.051	0.011	0.000
	1.5 - 2.0	0.926	0.386	0.303	0.043	0.000
	2.0 - 2.5	4.000	0.620	0.370	0.032	0.000
	>= 2.5	24.295	1.650	3.882	0.023	0.008
<b>Straddles</b>	< 0.5	0.038	0.288	0.016	0.124	0.022
	0.5 - 1.0	0.095	0.995	0.031	0.291	0.033
	1.0 - 1.5	0.385	2.633	0.402	0.514	0.063
	1.5 - 2.0	1.875	3.382	1.927	0.993	0.034
	2.0 - 2.5	8.407	10.35	1.444	0.856	0.047
	>= 2.5	4.049	31.84	11.402	1273	0.476



Continuing our examination of the distribution of LULD event states partitioned by daily quote volatility, LULD Tier, and whether the security is an ETP, we examine the distribution of quote volatility within each partition examined. The results are contained in **Table 5**. We first examine the overall distribution of trading pauses, limit states, and straddle states for 2022 (Panel B). Comparing the results in Panel B to those of the per symbol results from Table 4, we find that the distribution across quote volatility levels is less linear with respect to volatility than on a per symbol basis,. This is made clear by the fact that the distribution of trading pauses, limits states, and straddle states in **Table 5** does not consistently rise as quote volatility increases. There appears to be a greater impact from high volatility on Tier 2 non-ETPs than on the other categories of securities. Interestingly, for Tier 2 non-ETPs, the lowest volatility periods also result in a large share of LULD events. This is likely tied to liquidity gaps, where after a period of quiescence, the quote moves, resulting in a straddle state, limit state, or trading pause. Comparing 2021 to 2022, we find no discernable pattern for any of the partitions. Therefore, these findings do not suggest any additional calibration of the LULD bands.

**Table 5: LULD Event Distribution by Quote Volatility, Tier and ETP Flag**

**Panel A: 2021**

LULD Tier		1	2	1	2
ETP (Y/N)	Quote Volatility	N	N	Y	Y
<b>Pauses</b>	< 0.5	3.2%	4.7%	42.9%	28.3%
	0.5 - 1.0	22.2%	9.1%	21.4%	37.0%
	1.0 - 1.5	17.5%	8.3%	28.6%	13.0%
	1.5 - 2.0	14.3%	7.9%	7.1%	2.2%
	2.0 - 2.5	11.1%	6.6%	0.0%	0.0%
	>= 2.5	31.7%	63.3%	0.0%	19.6%
<b>Limits</b>	< 0.5	2.0%	5.8%	8.9%	95.4%
	0.5 - 1.0	23.6%	9.6%	9.9%	2.0%
	1.0 - 1.5	22.2%	7.2%	12.5%	1.1%
	1.5 - 2.0	7.1%	10.8%	68.8%	0.3%
	2.0 - 2.5	19.0%	3.8%	0.0%	0.0%
	>= 2.5	26.1%	62.9%	0.0%	1.2%
<b>Straddles</b>	< 0.5	37.92%	47.26%	64.0%	67.11%
	0.5 - 1.0	14.18%	8.45%	8.0%	3.56%
	1.0 - 1.5	13.54%	6.59%	3.5%	2.29%
	1.5 - 2.0	5.77%	3.64%	3.6%	7.80%
	2.0 - 2.5	11.21%	2.59%	0.3%	1.32%
	>= 2.5	17.37%	31.47%	20.5%	17.92%

**Table 5 (continued)**

**Panel B: 2022**

LULD Tier		1	2	1	2
ETP (Y/N)	Quote Volatility	N	N	Y	Y
<b>Pauses</b>	<b>&lt; 0.5</b>	0.5%	5.9%	18.5%	21.3%
	<b>0.5 - 1.0</b>	16.3%	11.0%	9.2%	29.7%
	<b>1.0 - 1.5</b>	18.2%	7.6%	12.3%	14.4%
	<b>1.5 - 2.0</b>	18.2%	6.5%	7.7%	12.4%
	<b>2.0 - 2.5</b>	9.6%	5.8%	6.2%	4.0%
	<b>&gt;= 2.5</b>	37.3%	63.2%	46.2%	18.3%
<b>Limits</b>	<b>&lt; 0.5</b>	1.7%	5.8%	5.5%	41.7%
	<b>0.5 - 1.0</b>	22.5%	6.4%	10.8%	17.5%
	<b>1.0 - 1.5</b>	18.2%	8.8%	10.0%	8.0%
	<b>1.5 - 2.0</b>	17.8%	5.2%	8.5%	12.5%
	<b>2.0 - 2.5</b>	11.2%	4.0%	3.1%	4.8%
	<b>&gt;= 2.5</b>	28.6%	69.8%	62.1%	15.4%
<b>Straddles</b>	<b>&lt; 0.5</b>	38.0%	41.7%	58.0%	71.9%
	<b>0.5 - 1.0</b>	21.0%	8.8%	8.9%	10.3%
	<b>1.0 - 1.5</b>	11.4%	3.6%	8.0%	4.3%
	<b>1.5 - 2.0</b>	9.1%	1.4%	5.5%	3.1%
	<b>2.0 - 2.5</b>	5.9%	2.1%	1.2%	1.5%
	<b>&gt;= 2.5</b>	14.6%	42.4%	18.5%	8.9%

**E. STRADDLE STATES**

Pursuant to the Commission's request, we review the occurrence of straddle states in 2022. At the outset, we note that the straddle states have much less significance than either LULD limit states or trading pauses. Unlike limit states, which involve stopping an order from trading, or trading pauses, which entirely halt trading in the affected security for five minutes, a straddle state simply indicates the existence of a wide quote at a time where there is no order interaction. Additionally, as shown below, straddle states occur overwhelmingly at the opening of trading and are likely caused by wide quotes at the beginning of the day, which tend to subsequently tighten as trading commences. As such, the existence of straddle states is more of a comment on the availability of liquidity at the beginning of the trading day than on the proper functioning of the LULD Plan.

Below, we calculate the percentage of time that a stock not in an LULD trading pause or regulatory pause spends in a straddle state. The statistic is calculated for each date and equal weighted for each day and each symbol. For this review, we focused only on the fourth quarter of 2021 and 2022, and only the first 15 minutes of regular trading hours (9:30 a.m. - 9:45 a.m.). The percentages are shown in **Table 6** below and reveal nothing remarkable. However, in examining the individual security results, we find that in 2021, 273 securities were in a straddle state for more than 10% of the trading time (defined as 64 days x 900 seconds = 57,600 seconds). For 2022, that number increased to 441 securities.

**Table 6: Time in Straddle State During 9:30 - 9:45 a.m. Period**

Tier	ETP	Q4 2021	Q4 2022
1	N	0.02%	0.03%
2	N	0.73%	0.22%
1	Y	0.01%	0.03%
2	Y	0.20%	0.69%

A more detailed review of securities that spent at least 10% of the first 15 minutes of the day during Q4 2022 in a straddle state revealed several common themes. Most of the stocks were low volume. The median volume for these securities was 326 shares per day, with an average volume of 30,041 shares. All such securities had a median daily volume of less than 39,000 shares.

In addition, we found that many of the stocks were illiquid and had very wide quotes. We believe that such securities remaining in a straddle state for extended periods of time limits volatility and protects investors.

#### **IV. Analysis of Amendments Implemented**

No LULD Plan amendments were implemented in 2022.

#### **V. Analysis of Emerging Issues**

##### **A. PROPOSAL TO MOVE TIER 2 ETPs TO TIER 1**

As the Commission is aware, and as noted in previous Annual Reports, the Operating Committee continues to evaluate whether Tier 2 ETPs should be included in Tier 1. As previewed in the 2019 Annual Report, the Operating Committee began reviewing this issue at the request of issuers who were concerned about price divergence from indicative index valuations that occur within the twice-as-wide Tier 2 Price Band boundaries. Based on industry and issuer feedback, the Operating Committee feels that the LULD mechanism can improve investor protection by moving

ETPs in Tier 2 to Tier 1, making all ETPs subject to the same LULD bands. The Operating Committee has expanded its study of the issue and will present it to the Commission when completed.

## **B. POTENTIAL CHANGE TO REFERENCE PRICE WHEN REOPENING ON A QUOTE**

As noted in the 2021 Annual Report, the Operating Committee has identified as a potential emerging issue the handling of LULD trading pauses that reopen on a quote vs. an auction. In Amendment 10, the Operating Committee changed the process for establishing the first Reference Price for a security opening in an auction but for which there is not a Reference Price at 9:30 a.m. While the Plan previously used the mid-point of the opening BBO to establish the Reference Price in that instance, Amendment 10 changed that process to instead use the prior day's closing price to establish the Reference Price. The change dramatically reduced the frequency of trading pauses caused by mid-point Reference Prices in the early part of the trading day.

Amendment 10, however, did not change the process for establishing the Reference Price after LULD trading pauses that reopen on a quote. That process still uses the mid-point of the BBO at the time of the reopen -- but in cases where the BBO is wide, this may result in inaccurate LULD bands. Similar to the change made in Amendment 10, the Participants are now considering amending the Plan to instead use the LULD price band that triggered the trading pause as the new Reference Price for calculating LULD bands when a security opens on a quote. Doing so would be more reflective of the current pricing of the security and would improve protections for the security.

## **C. REVIEW OF THE INTERSECTION OF THE LULD PLAN WITH THE 2022 REVISIONS TO THE CLEARLY ERRONEOUS EXECUTIONS RULES**

At the Commission's request, in 2022, the Participants jointly revised their rules pertaining to clearly erroneous executions (CEEs) to make CEE review largely unavailable when LULD price bands are in place.<sup>7</sup> Subsequent to this change, on January 24, 2023, the New York Stock Exchange LLC experienced a technology issue which caused it to send incorrect reference prices to the SIPs, which in turn caused the SIPs to calculate price bands on those incorrect reference prices. The Participants intend to consider whether to propose any changes to the LULD Plan or the CEE rules in response.

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<sup>7</sup> See, e.g., NYSE Rule 7.10(c).