Annual Report for 2021

of the Operating Committee of the Plan to Address Extraordinary Market Volatility

Submitted May 12, 2022

I.   Executive Summary

The LULD Plan[1] was enacted to minimize excess volatility 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 calendar year 2021, 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. Note, however, that we define the previous calendar year as February 24, 2020 to December 31, 2020, due to a change in the pricing band rules in February of 2020.[2] As a result, our two samples have identical pricing band rules. 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); and quote volatility.

Our 2020 vs. 2021 comparison shows that fewer LULD events occurred in 2021 than in 2020. 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 in other periods. We find that although the percentage of trading pauses that occur in the first 15 minutes of trading in 2021 is roughly the same as in 2020, the percentage of limit states occurring in the first 15 minutes of the trading day was higher in 2021, at 34%, compared to 23% in 2020. We also find that 15% of limit states that occurred during 2020 were not resolved and proceeded to a trading pause, while only 5% of limit states proceeded to a trading pause in 2021. We believe this may be due

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[1]   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.

[2]   Effective February 24, 2020, Amendment 18 to the Plan eliminated double-wide bands from 9:30 a.m. to 9:45 a.m. for all securities, and eliminated double-wide bands from 3:35 p.m. to 4:00 p.m. for all Tier 2 securities priced above $3.00.

to lower volatility resulting in fewer extended price moves, allowing market makers to provide liquidity in expectation of prices reverting.

Further, our analysis shows that, even when looking only at the least volatile periods of 2020 and 2021, there were markedly fewer LULD events in 2021. However, even the least volatile periods of 2020 featured a higher VIX ® level than almost any day in 2021.

We also examine 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. 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.

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 those stocks being relatively illiquid.

We also examine the so-called "meme stock" event in early 2021, where several stocks traded with extreme price volatility. We find that unlike other recent bouts of volatility, only the stocks directly affected by the event exhibited an increase in LULD events. Our analysis suggests that the LULD Plan worked as intended for these stocks during this event.

Additionally, we review the November 2016 recommendations of the EMSAC Market Quality Subcommittee regarding the LULD Plan, and conclude that the Subcommittee's recommendations have all either been addressed by Plan amendments since 2016 or will be addressed by currently pending rule filings.

Overall, our evaluation of the efficacy of the Plan for calendar year 2021 does not suggest the need for any additional calibration of the LULD price bands. We do, however, identify two issues for further study: (1) 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 (2) moving Tier 2 ETPs to Tier 1, which we previewed in the 2019 Annual Report and continue to study.

II.   **Background**

On May 31, 2012, the Securities and Exchange Commission ("SEC" or "Commission") approved, on a pilot basis, the 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.[3]

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, Inc., MEMXLLC, 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 Commissionin 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 2021.

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 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 a.m. - 4:00 p.m.

In order 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.

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

B. CALCULATION OF PRICE BANDS

The two securities information processors ("SIPs") – the Securities Industry Automation Corporation 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:

Price Band = (Reference Price) ± ((Reference Price) x (Percentage Parameter))

Table A below shows the Percentage Parameters in effect for Tier 1 securities. **Table B** shows the Percentage Parameters that apply to Tier 2 securities. Price Bands are doubled during the last 25 minutes of the regular trading day for all Tier 1 securities and for Tier 2 securities at or below $3.00.

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 ± 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.

Example	Ref Price	Lower Price Band	NBB	NBO	Upper Price Band	State	Condition
		Table C: Conditions that Lead to Limit and Straddle States					
1	$25.00	$23.75	*$26.25*	$26.75	*$26.25*	Limit	NBB resting on upper band
2	$25.00	*$23.75*	$23.50	*$23.75*	$26.25	Limit	NBO resting on lower band
3	$25.00	*$23.75*	*$23.50*	$26.00	$26.25	Straddle	NBB crosses the lower band, NBO within bands
4	$25.00	$23.75	$26.00	*$26.75*	*$26.25*	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 2021

To provide insight to the current operation of the Plan, we compare measures of LULD events for 2021 to the same measures for 2020. Prior to February 24, 2020, Price Bands were doubled for all securities during the first 15 minutes and the last 25 minutes of trading for the day. Beginning February 24, 2020, only single-wide bands were used to calculate upper and lower Price Bands during the first 15 minutes of trading, and for securities above $3 only Tier 1 securities' bands were doubled for the last 25 minutes. For the sake of comparability, we exclude data for January 1 to February 23, 2020.[4] When we speak of "2020 data," we are therefore referring to data for the period February 24 through December 31, 2020. Data for 2021 includes all trading days during the calendar year.

A. TYPE AND NUMBER OF LULD EVENTS

We first examine the number of event types that occur during the abbreviated trading year of 2020 and the full trading year of 2021. **Table 1, Panel A** contains the results for February 24 - December 31, 2020, while **Panel B** reports results for 2021. Comparing the "# of Events" (i.e., "number of events") column for 2020 (Panel A) with the results for 2021 (Panel B), we find that although Panel B is for a full trading year while Panel A is for about 10 months, the aggregate number of events in all periods is smaller in 2021 than it was in 2020. In particular, the 518,078 LULD events that occur in 2021 are only about 55% of the 934,626 events that occurred in the abbreviated 2020 year.

As was the case in 2020, LULD events in 2021 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 daily median, mean, and 90th 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.

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4   The 2020 Annual Report included the full trading year for 2020. In addition, while compiling the 2021 Annual Report, we discovered certain errors in the 2020 Annual Report that have been corrected for the 2021 Annual Report. (Specifically, some of the data used to compile the 2020 Annual Report was incorrectly labeled, and due to a programming error, securities that did not trade on a given day were erroneously dropped from the calculations for that day.) For these reasons, the numbers for 2020 found in this report are not directly comparable to the figures in the 2020 Annual Report.

We first examine the number of each event type for each time period. The data show that the first 15 minutes of trading is important overall. That is, despite accounting for just 4% of the trading day (except shortened trading days), the first 15 minutes contained 22% of limit states, 21% of LULD trading pauses, and 43% of straddle states. The opposite is true of the end of the day, during which far fewer LULD events occurred in all categories. The last 25 minutes accounted for 6% of the trading day (except short days), but represented just 4% of trading pauses and 3% of limit and straddle states.

Comparing the 2020 results in Panel A to the 2021 results contained in Panel B produces an interesting finding. For 2020, 15% of the limit states (13,647 / 92,700 = 15%) were not resolved and proceeded to a trading pause. For 2021, the same calculation shows that only 5% of the limit states were not resolved and proceeded to a trading pause (i.e., 4,338 / 83,659 = 5%). This decline in the percentage of limit states that proceeded to trading pauses suggests either that market participants were simply better able to "cure" limit states in 2021, or that price volatility was more ephemeral in 2021 and not as reflective of fundamental uncertainty about securities' fair values.

Finally, comparing the other statistical measures employed in the report, we find that in all but a few cases, the daily median, mean, and 90th percentile are all smaller in 2021 than in 2020. For example, examining the medians[5] reported in the last row of Panels A and B we find that there is a daily median of 2,467 straddle states in each day during 2020, but only a daily median of 1,692 straddle states in 2021.

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

Panel A: February 24 to December 31, 2020

		Median	Mean	90 %-ile	# of Events
9:30 - 9:45	**LULD Pauses**	6.0	13.0	26	2,832
	Limit States	38.0	92.7	216	20,216
	Straddle States	1,417.0	1,762.3	2,747	384,186
9:45 - 25 min before close	**LULD Pauses**	16.0	47.0	74	10,247
	Limit States	117.0	320.6	577	69,886
	Straddle States	1,077.5	2,362.8	3,942	515,092

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[5] 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 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.

Last 25 minutes	LULD Pauses	1.0	2.6	4	568
	Limit States	2.0	11.9	30	2,598
	Straddle States	78.0	162.1	297	35,348
Total	LULD Pauses	23.0	62.6	97	13,647
	Limit States	172.0	425.2	772	92,700
	Straddle States	2,466.5	4,287.3	7,161	934,626

Panel B: 2021

		Median	Mean	90 %-ile	# of Events
9:30 - 9:45	LULD Pauses	3.0	3.7	7	924
	Limit States	19.0	115.3	128	29,061
	Straddle States	1,155.0	1,256.6	1,517	316,666
9:45 - 25 min before close	LULD Pauses	10.0	12.9	26	3,251
	Limit States	74.5	210.1	419	52,952
	Straddle States	457.0	744.3	1,684	187,561
Last 25 minutes	LULD Pauses	0.0	0.6	2	163
	Limit States	1.0	6.5	17	1,646
	Straddle States	41.5	55.0	97	13,851
Total	LULD Pauses	14.0	17.2	31	4,338
	Limit States	110.5	332.0	708	83,659
	Straddle States	1,692.5	2,055.9	3,326	518,078

The exceptional volatility in early 2020, which started on February 24, may be driving the differences found for our 2020 and 2021 samples. To test if this is the case, we recalculated the statistics for Table 1, Panel A but exclude all data before May 1, 2020. The results for the period May 1 - December 31, 2020 are contained in **Panel C** below.

Examining Panel C reveals that the median daily number of events reported during the May 1 - December 31, 2020 period is lower than those reported in Panel A (February 24 - December 31, 2020), but still higher than those reported in Panel B (2021). In particular, the median number of straddle states occurring in a day for February 24 to December 31, 2020 (Panel A) is 2,467. Redefining the sample length as May 1 to December 31, 2020 (Panel C) reduces the number of median daily straddle states slightly to 2,345, which is lower than 2,467, but still higher than the median daily straddle states for the full year 2021 (Panel B) of 1,693. Put differently, even excluding the most volatile period of 2020 (i.e., from February 24 - April 30), there were still more straddle states in the remaining portion of 2020 than in all of 2021.

For the Panel A period (February 24 - December 31, 2020), 14.7% of limit states that occurred became trading pauses (i.e., 13,647 / 92,700 = 14.7%). For the Panel C period (May 1 -

December 31, 2020), the percentage was lower, at 10.7% (i.e., 4,218 / 39,592 = 10.7%). In 2021, the Panel B period, the percentage was lower still, at 5.1% (i.e., 4,338 / 83,659 = 5.1%). These results may reflect the overall higher volatility in 2020, even in the latter part of that year, as compared to 2021.

Panel C: May 1 to December 31, 2020

		Median	Mean	90 %-ile	# of Events
9:30 - 9:45	LULD Pauses	4.0	6.0	13	1022
	Limit States	29.0	67.6	132	11,428
	Straddle States	1,340.0	1434.9	1,878	242,501
9:45 - 25 min before close	LULD Pauses	13.0	18.1	38	3,051
	Limit States	93.0	160.3	384	27,098
	Straddle States	903.0	1152.0	2,141	194,684
Last 25 minutes	LULD Pauses	0.0	0.9	2	145
	Limit States	2.0	6.3	19	1,066
	Straddle States	60.0	80.1	148	13,543
Total	LULD Pauses	20.0	25.0	46	4,218
	Limit States	145.0	234.3	511	39,592
	Straddle States	2,345.0	2,667.0	4,248	450,728

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 combinations of the above four values. We then calculated the same statistical measures already employed: daily mean, median, and 90th percentile. The results are found below in **Table 2**, with results for February 24 - December 31, 2020 in **Panel A**, and 2021 results in **Panel B**.[6] A review of the details shows some interesting

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[6]   In this table and the tables below, categories are not reported if there were only *de minimis* numbers of symbols meeting the requirements.

observations for 2020, which were reported in the 2020 Annual Report. As expected, in 2020, there were far more LULD events in Tier 2 symbols than in Tier 1 symbols. For most categories, the median number of LULD trading pauses in 2020, despite the high volatility, remained at or near zero. However, the skew caused by the initial reaction to the COVID-19 pandemic resulted in noticeable differences in mean daily and 90th percentile figures.

Comparing those 2020 results (Panel A) with the 2021 results (Panel B) reveals nothing remarkable. The medians for given portfolios in 2021 are almost all smaller than the same portfolio for 2020. This suggests that none of the security descriptors employed can fully explain why the number of median daily LULD events for the full year 2021 are uniformly smaller than in the partial 2020 year.

[Table 2 appears on the next page.]

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

	Panel A: February 24 to December 31, 2020						
CATEGORIES:							
Tier	1	1	2	2	2	2	2
ETP Flag	N	Y	N	N	N	Y	Y
Leverage	N	N	N	N	N	N	Y
Close Price	≥ $3.00	≥ $3.00	< $0.75	$0.75-$3.00	≥ $3.00	≥ $3.00	≥ $3.00
Avg. # of Symbols	1002.9	753.0	172.3	675.9	4,570.0	1,397.9	181.2
Avg. Limits Early	20.3	1.1	2.8	8.4	54.8	4.8	0.5
Avg. Limits Midday	48.2	4.2	21.5	29.0	200.1	14.2	3.0
Avg. Limits Late	0.3	0.1	0.4	0.0	10.2	0.7	0.1
Avg. Pauses Early	1.4	0.3	0.6	1.1	8.8	0.7	0.1
Avg. Pauses Midday	4.9	1.0	3.0	2.9	32.7	2.0	0.3
Avg. Pauses Late	0.1	0.0	0.0	0.0	2.3	0.1	0.0
Avg. Straddles Early	115.5	27.3	7.7	37.3	1,165.8	384.9	22.7
Avg. Straddles Midday	145.9	29.8	46.1	72.6	1,369.4	632.7	61.7
Avg. Straddles Late	0.9	0.2	1.3	0.5	115.0	42.6	1.4
Median Limits Early	0.0	0.0	0.0	1.0	11.0	0.0	0.0
Median Limits Midday	0.0	0.0	2.0	4.0	69.5	0.0	0.0
Median Limits Late	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Median Pauses Early	0.0	0.0	0.0	0.0	4.0	0.0	0.0
Median Pauses Midday	0.0	0.0	1.0	1.0	12.0	0.0	0.0
Median Pauses Late	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Median Straddles Early	52.0	10.0	1.0	14.5	1,034.5	209.0	5.0
Median Straddles Midday	10.0	0.0	7.5	15.5	735.0	125.5	0.0
Median Straddles Late	0.0	0.0	0.0	0.0	57.0	10.0	0.0
90th %-ile Limits Early	42.0	1.0	9.0	20.0	123.0	7.0	0.0
90th %-ile Limits Midday	75.0	1.0	64.0	68.0	285.0	9.0	1.0
90th %-ile Limits Late	0.0	0.0	0.0	0.0	30.0	1.0	0.0
90th %-ile Pauses Early	4.0	1.0	2.0	3.0	17.0	2.0	0.0
90th %-ile Pauses Midday	5.0	0.0	9.0	8.0	47.0	3.0	0.0
90th %-ile Pauses Late	0.0	0.0	0.0	0.0	4.0	0.0	0.0
90th %-ile Straddles Early	244.0	63.0	24.0	115.0	1,765.0	767.0	23.0
90th %-ile Straddles Midday	265.0	21.0	143	194.0	2,392.0	1,196	20.0
90th %-ile Straddles Late	0.0	0.0	1.0	2.0	226.0	90.0	2.0

Table 2 (continued)

CATEGORIES:	Panel B: All Trading Days 2021						
Tier	1	1	2	2	2	2	2
ETP Flag	N	Y	N	N	N	Y	Y
Leverage	N	N	N	N	N	N	Y
Close Price	≥ $3.00	≥ $3.00	< $0.75	$0.75-$3.00	≥ $3.00	≥ $3.00	≥ $3.00
Avg. # of Symbols	1023.3	879.1	57.8	480.9	5,918.9	1,520.6	169.8
Avg. Limits Early	7.1	0.6	0.2	0.6	102.5	4.3	0.0
Avg. Limits Midday	11.1	0.2	16.7	6.1	175.8	0.2	0.0
Avg. Limits Late	0.0	0.0	0.5	0.0	6.0	0.0	0.0
Avg. Pauses Early	0.1	0.0	0.1	0.1	3.3	0.1	0.0
Avg. Pauses Midday	0.2	0.0	1.5	0.4	10.7	0.1	0.0
Avg. Pauses Late	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Avg. Straddles Early	38.2	12.4	0.9	3.2	1,030.5	162.8	8.3
Avg. Straddles Midday	24.3	5.5	28.0	13.0	606.8	43.7	22.6
Avg. Straddles Late	0.0	0.4	1.0	0.0	41.5	11.4	0.7
Median Limits Early	0.0	0.0	0.0	0.0	16.5	0.0	0.0
Median Limits Midday	0.0	0.0	0.0	0.0	62.0	0.0	0.0
Median Limits Late	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Median Pauses Early	0.0	0.0	0.0	0.0	3.0	0.0	0.0
Median Pauses Midday	0.0	0.0	0.0	0.0	8.0	0.0	0.0
Median Pauses Late	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Median Straddles Early	24.5	7.0	0.0	2.0	927.5	150.0	6.0
Median Straddles Midday	0.0	0.0	3.0	0.0	348.5	14.0	0.0
Median Straddles Late	0.0	0.0	0.0	0.0	26.5	12.0	0.0
90th %-ile Limits Early	5.0	0.0	0.0	0.0	102.0	1.0	0.0
90th %-ile Limits Midday	12.0	0.0	28.0	8.0	343.0	1.0	0.0
90th %-ile Limits Late	0.0	0.0	0.0	0.0	15.0	0.0	0.0
90th %-ile Pauses Early	0.0	0.0	0.0	0.0	7.0	0.0	0.0
90th %-ile Pauses Midday	0.0	0.0	4.0	1.0	21.0	0.0	0.0
90th %-ile Pauses Late	0.0	0.0	0.0	0.0	2.0	0.0	0.0
90th %-ile Straddles Early	56.0	25.0	2.0	7.0	1,260.0	203.0	18.0
90th %-ile Straddles Midday	25.0	7.0	61.0	21.0	1,313.0	106.0	16.0
90th %-ile Straddles Late	0.0	1.0	1.0	0.0	84.0	17.0	1.0

C. IMPACT OF QUOTE VOLATILITY ON LULD EVENTS

We also examine the relationship between the number of LULD events and a security's quote volatility. 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 (ii) LULD tier.

Results for February 24 - December 31, 2020 are contained in **Panel A** and results for 2021 are in **Panel B**. We report the mean quote volatility as well as the 10th percentile, 25th percentile, 50th percentile, 75th percentile, and 90th percentile. Examining the results for non-ETPs in 2020 (Panel A), we find that Tier 2 non-ETPs exhibit somewhat higher volatility than Tier 1 non-ETPs. This is probably due to the skew for the most volatile periods. At the lowest part of the distribution (e.g., 10th percentile), quote volatility for Tier 2 non-ETPs was lower than quote volatility for Tier 1 non-ETPs, but at higher parts of the distribution (e.g., 90th percentile), this result was flipped and quote volatility for Tier 2 non-ETPs was higher than quote volatility for Tier 1 non-ETPs. This stands to reason, since at lower percentiles, Tier 2 non-ETPs have fewer quote updates, so their quote volatility is lower. However, when less-liquid securities become more actively traded, it results in a concomitant larger increase in quote volatility. The results for 2021 (Panel B) are qualitatively similar to those for 2020.

Regarding ETPs, we do not find the disparity in quote volatility that we found for non-ETPs. In particular, quote volatility did not flip between the lower and higher ends of the distribution. We also find that quote volatility for ETPs was well below that of non-ETPs. Turning to the 2021 results reported in Panel B, we find that for all percentiles, quote volatility was much lower in 2021 than it was in 2020.

Table 3: Quote Volatility

Panel A: February 24 to December 31, 2020
(Basis points)

ETP Flag	LULD Tier	Mean	Percentile 10	25	50	75	90
N	1	0.420	0.152	0.208	0.312	0.500	0.796
	2	1.966	0.025	0.084	0.199	0.416	1.130
Y	1	0.268	0.007	0.044	0.137	0.268	0.472
	2	0.775	0.010	0.040	0.126	0.339	0.946

Panel B: 2021
(Basis points)

			Percentile				
ETP Flag	LULD Tier	Average	10	25	50	75	90
N	1	0.258	0.116	0.154	0.212	0.306	0.446
	2	1.182	0.008	0.033	0.128	0.264	0.502
Y	1	0.128	0.004	0.028	0.086	0.168	0.279
	2	0.292	0.005	0.022	0.073	0.173	0.413

Finally, we note that Table 3 shows that Tier 2 ETPs, at every percentile level except the 90th percentile in 2020, had lower quote volatility than Tier 1 non-ETPs. Additionally, Tier 2 ETPs had similar quote volatility to Tier 1 ETPs, and in some cases lower volatilities in both 2020 and 2021. Tier 2 ETPs only had noticeably higher volatility compared to Tier 1 at the 90th percentile. These observations support shifting all Tier 2 ETPs to Tier 1.

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 February 24 through December 31, 2020 and **Panel B** the results for 2021. Note that these tables count the *number of events*, which we consider more relevant than the *time spent* in these states. As Panels A and B show, increases in limit and straddle states are more obvious as volatility rises.

In addition, **Sub-Panels A1 and B1** delineate the number of days any given security had its quote volatility average in the range described.[7] Securities are partitioned by intersections of LULD tier and whether or not 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 for Tier 1 non-ETFs, we find that 164,515 stock-days occurred in 2020 for securities with quote volatility levels less than 0.5. This represents 75% 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.

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[7] For example, Tier 1 non-ETPs had 649 "stock-days" where quote volatility was at least 2.5. Any given symbol may have had days during the study period where its quote volatility was in each of the volatility categories.

Sub-Panel A2 contains the average number of LULD events in the February 24 - December 31, 2020 period relative to 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 0.626 pauses per trading day. Further examining the sub-panel, we find that the number of limit states and trading pauses is relatively low in Tier 2 ETPs and is not significantly impacted by increased volatility, suggesting that Tier 2 non-ETPs are relatively more affected by liquidity gaps. We find this for trading pauses, limit states, and straddle states. We also find that Tier 1 ETP events 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 our highest breakout,we do see a substantially greater likelihood of an LULD trading pause in non-ETPs, regardless of the security's tier.

The combination of Sub-panels A1 and A2, as well as B1 and B2, show how likely a security is to pause, hit a limit state, or go into a straddle state under various volatility regimes. As expected, LULD events are more likely when volatility increases, and ETPs are less likely to trigger an event than same-tier individual stocks. It is also worth noting that Tier 2 ETPs are generally less likely, under all volatility states, to trigger an LULD event than Tier 1 non-ETPs, providing support for shifting all Tier 2 ETPs to Tier 1.

The average number of events per security per day for 2021 is contained in **Sub-Panel B2**. It is interesting that there are far fewer trading pause events per day in 2021 than in 2020.

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

Panel A: February 24 to December 31, 2020

Sub-Panel A.1: Quote Volatility Membership

LULD Tier	1		2		1		2	
ETP(Y/N)	N		N		Y		Y	
Quote Volatility	n	%	n	%	n	%	n	%
< 0.5	164,515	75.02%	940,537	79.67%	148,698	90.99%	282,468	81.95%
0.5 - 1.0	42,055	19.18%	113,400	9.61%	11,101	6.79%	29,703	8.62%
1.0 - 1.5	8,682	3.96%	22,158	1.88%	2,422	1.48%	11,241	3.26%
1.5 - 2.0	2,533	1.16%	10,351	0.88%	642	0.39%	5,628	1.63%
2.0 - 2.5	847	0.39%	9,404	0.80%	221	0.14%	3,265	0.95%
>= 2.5	649	0.30%	84,711	7.18%	334	0.20%	12,390	3.59%
Total	219,281	100.00%	1,180,561	100.00%	163,418	100.00%	344,695	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
Pauses	< 0.5	0.000	0.002	0.000	0.000
	0.5 - 1.0	0.005	0.018	0.005	0.005
	1.0 - 1.5	0.035	0.063	0.032	0.008
	1.5 - 2.0	0.098	0.083	0.069	0.011
	2.0 - 2.5	0.256	0.062	0.118	0.012
	>= 2.5	0.626	0.056	0.102	0.023
Limits	< 0.5	0.001	0.006	0.001	0.003
	0.5 - 1.0	0.053	0.073	0.024	0.014
	1.0 - 1.5	0.296	0.332	0.104	0.039
	1.5 - 2.0	0.979	0.692	0.235	0.051
	2.0 - 2.5	3.204	0.243	0.466	0.079
	>= 2.5	7.488	0.479	0.527	0.226
Straddles	< 0.5	0.047	0.168	0.030	0.137
	0.5 - 1.0	0.273	0.710	0.274	0.713
	1.0 - 1.5	1.178	2.124	0.823	1.229
	1.5 - 2.0	2.959	2.743	1.294	2.099
	2.0 - 2.5	9.144	2.622	3.321	3.592
	>= 2.5	19.438	3.045	4.078	12.264

Table 4 (continued)

Panel B: 2021

Sub-Panel B.1: Quote Volatility Membership

LULD Tier	1		2		1		2	
ETP(Y/N)	N		N		Y		Y	
Quote Volatility	n	%	n	%	n	%	n	%
< 0.5	238,949	92.66%	1,384,515	90.16%	214,142	97.93%	321,965	91.85%
0.5 - 1.0	16,918	6.56%	84,069	5.47%	4,061	1.86%	16,088	4.59%
1.0 - 1.5	1,595	0.62%	14,293	0.93%	243	0.11%	5,000	1.43%
1.5 - 2.0	277	0.11%	5,762	0.38%	67	0.03%	1,980	0.56%
2.0 - 2.5	76	0.03%	5,139	0.33%	89	0.04%	1,005	0.29%
>= 2.5	58	0.02%	41,840	2.72%	69	0.03%	4,489	1.28%
Total	257,873	100.00%	1,535,618	100.00%	218,671	100.00%	350,527	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
Pauses	**< 0.5**	0.000	0.000	0.000	0.000
	0.5 - 1.0	0.001	0.004	0.001	0.001
	1.0 - 1.5	0.007	0.023	0.012	0.001
	1.5 - 2.0	0.032	0.056	0.000	0.001
	2.0 - 2.5	0.092	0.054	0.000	0.000
	>= 2.5	0.345	0.063	0.000	0.002
Limits	**< 0.5**	0.000	0.003	0.000	0.003
	0.5 - 1.0	0.064	0.088	0.005	0.001
	1.0 - 1.5	0.638	0.384	0.058	0.003
	1.5 - 2.0	1.166	1.449	0.269	0.002
	2.0 - 2.5	11.408	0.564	0.000	0.000
	>= 2.5	20.586	1.166	0.000	0.0021
Straddles	**< 0.5**	0.025	0.118	0.012	0.087
	0.5 - 1.0	0.132	0.391	0.073	0.060
	1.0 - 1.5	1.337	1.870	0.531	0.1102
	1.5 - 2.0	3.282	2.512	0.552	0.134
	2.0 - 2.5	23.237	1.873	0.000	0.626
	>= 2.5	47.155	3.053	0.303	1.221

To continue 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**. The overall distributionof pauses, limit states, and straddle states is less closely tied to volatility than a symbol's tier or ETP categorization. This is made clear by the fact that the distribution of pauses, limits and straddles in **Table 5, Panels A and B** do 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, limit, or pause. Comparing 2020 to 2021 we find no discernable pattern for any of the partitions.

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

Panel A: February 24 to December 31, 2020

LULD Tier		1	2	1	2
ETP (Y/N)	Quote Volatility	N	N	Y	Y
Pauses	**< 0.5**	1.8%	13.9%	15.0%	12.9%

	Quote Volatility	1 N	2 N	1 Y	2 Y
	0.5 - 1.0	14.6%	18.3%	21.3%	21.0%
	1.0 - 1.5	21.5%	12.4%	27.3%	12.8%
	1.5 - 2.0	17.7%	7.6%	15.4%	8.7%
	2.0 - 2.5	15.5%	5.2%	9.1%	5.4%
	>= 2.5	28.9%	42.6%	11.9%	39.2%
Limits	< 0.5	1.4%	8.0%	18.4%	17.5%
	0.5 - 1.0	14.8%	11.6%	23.2%	8.4%
	1.0 - 1.5	17.0%	10.3%	21.5%	8.5%
	1.5 - 2.0	16.5%	10.0%	13.0%	5.6%
	2.0 - 2.5	18.0%	3.2%	8.8%	5.0%
	>= 2.5	32.2%	56.9%	15.1%	55.0%
Straddles	< 0.5	13.51%	28.55%	36.19%	15.49%
	0.5 - 1.0	20.03%	13.12%	24.39%	8.50%
	1.0 - 1.5	17.85%	7.67%	15.97%	5.55%
	1.5 - 2.0	13.08%	4.63%	6.66%	4.74%
	2.0 - 2.5	13.51%	4.02%	5.88%	4.71%
	>= 2.5	22.01%	42.03%	10.91%	61.01%

Panel B: 2021

LULD Tier		1	2	1	2
ETP (Y/N)	Quote Volatility	N	N	Y	Y
Pauses	< 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%
Limits	< 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%
Straddles	< 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%

E. STRADDLE STATES

Pursuant to the Commission's request, we review the occurrence of straddle states in 2021. At the outset, we must 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 2020 and 2021, 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 2020, 184 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 2021, that number increased to 273 securities.

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

Tier	ETP	Q4 2020	Q4 2021
1	N	0.04%	0.02%
2	N	0.67%	0.73%
1	Y	0.02%	0.01%
2	Y	0.21%	0.20%

A more detailed review of securities that spent at least 10% of the first 15 minutes of the day during Q4 2021 in a straddle state revealed several common themes. Most of the stocks were low volume. The median volume for these securities was 7,284 shares per day, with an average volume of 41,787 shares. All such securities had a median daily volume of less than 275,000 shares.

In addition, we found that many of the stocks were illiquid and had very wide quotes. One security that we analyzed closely was listed for twelve days during Q4 2021. On one day, the stock was in a straddle state for the entire first 15 minutes of the day. At that time, the NBB was $0.01 below the lower LULD band, while the NBO was at the mid-point of the band. During that time, this Tier-2 security had a spread of roughly 10%. The spread narrowed later in the day and averaged 1.63% for the full day and traded for most of the day at a price 10% above its

lower LULD band. By staying in a straddle state in the early part of the day, it prevented market orders, for example, from receiving a bad fill.

We find these results to be generally representative of trading in illiquid stocks and believe that such securities remaining in a straddle state for extended periods of time limits volatility and protects investors.


F. FOCUS ON MEME STOCK EVENTS

Finally, we examine the "meme stock" phenomenon in early 2021. The extreme volatility in several stocks during January and February 2021 offers the opportunity to study the functioning of the LULD Plan when general volatility was subdued, apart from a limited number of securities. This contrasts with the pandemic-related market wide volatility during March through May 2020.[8]

Table 7: Trading Pause and Limit State Count Per Symbol in 2021

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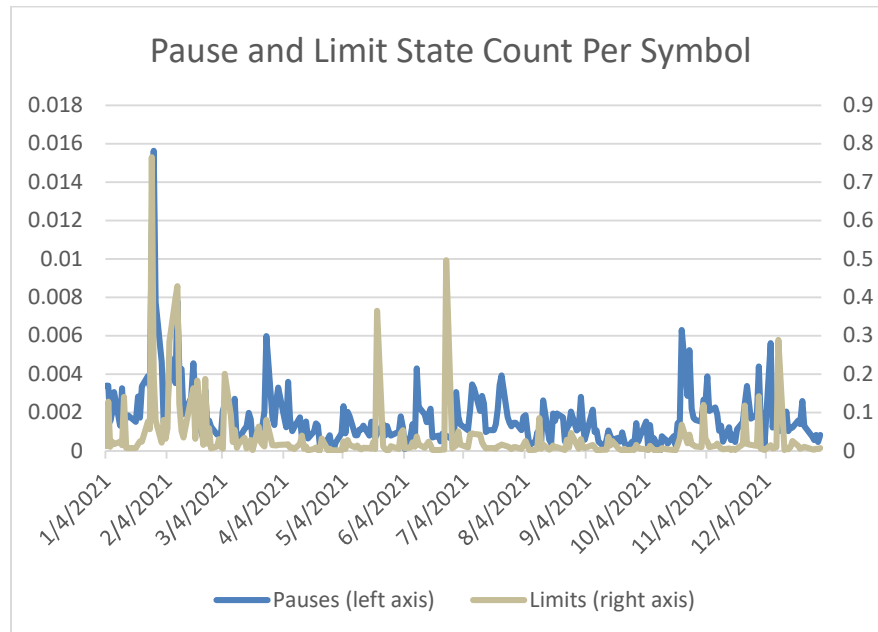
[8]   We find a higher percentage of limit states resulting in a trading pause for some securities impacted by the decision to restrict trading on January 28, 2021. While volatility could theoretically be a cause, further study is needed to separate out the impact of volatility versus singular price directionality.

Table 8: Seconds Paused and in Limit States Per Symbol

Seconds Paused and in Limit States Per Symbol. Legend: Time Paused (left axis); Seconds in Limit State (right axis).
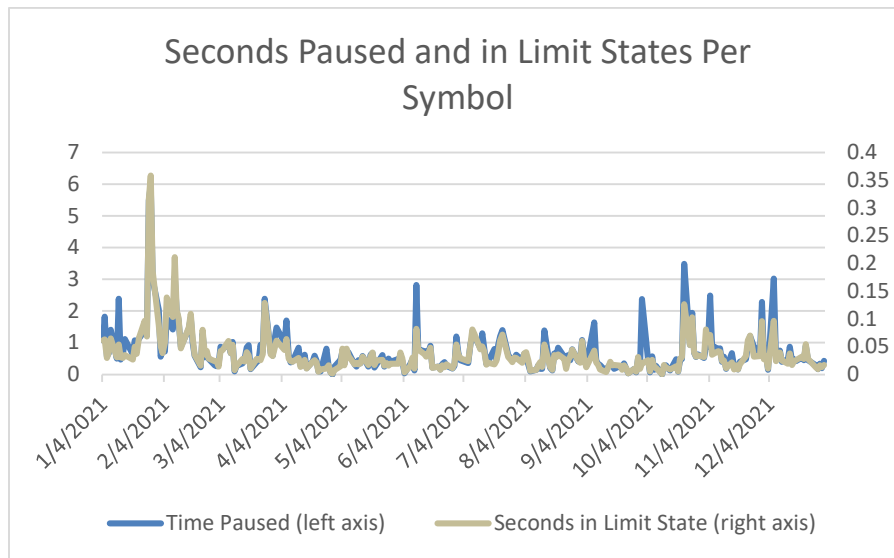
The tight focus of the meme stock activity becomes clear from the **Tables 7 and 8** above. While the count of limit states and trading pauses did jump in late January, even at their peak on January 28, 2021, there was an average of only 0.016 trading pauses per symbol and 0.765 limit states per symbol on that day. While these figures are well above the 2021 averages of 0.002 and 0.034 per symbol, overall impact was limited. The average amount of time any symbols was in an LULD trading pause on January 28 was 5.97 seconds versus an average of 0.71 seconds for the full year. The average amount of time a symbol was in a limit state on that day was 0.36 seconds, versus 0.04 for the full year. Even at the 99th percentile, time in a limit state and time in an LULD trading pause were zero for every day in 2021.

Between January 15 and March 31, 2021, there were 40 symbol-days where a stock entered an LULD trading pause at least five times in a single day; there were 106 such days across the whole year. The peak day was January 28, when seven symbols paused at least five times. During that same time period (January 15 - March 31, 2021), there were 185 stocks that had at least 25 limit states on a single day, versus 406 stocks with at least 25 limit states on a single day for all of 2021. January 27, 2021 had 20 such occurrences, and January 28 had 14. Many of these limit states resolved without triggering a pause; the average time for each limit state was 0.44 seconds.

On January 28, 2021, multiple retail-oriented brokers restricted transactions in AMC, BB, BBBY, EXPR, GME, KOSS, NAKD, and NOK. As shown in **Table 9** below, of these eight symbols, two never entered a limit state, and three did not pause. Only Koss had extended trading pauses. Although AMC had the most limit states with 358, its ten pauses trailed GameStop's 19 and Koss's 21. AMC's average limit state was only 0.80 seconds. Although Koss and GameStop

cleared nearly 90% of their limit states without entering a trading pause, their average time in a limit state was longer, at 1.83 and 2.92 seconds respectively.

Table 9: Robinhood Restricted Stocks on January 28, 2021 LULD Data Summary

	Robinhood Restricted Stocks on January 28, 2021 LULD Data Summary							% Limits
		Limit	Seconds in Limit	Seconds	Pause	Time	Time per	Resulting
Symbol	Company Name	Count	State	per Limit	Count	Paused	Pause*	in Pause
AMC	AMC Entertainment Holdings, Inc.	358	285.43	0.80	13	3,951.5	304.0	3.6%
BB	BlackBerry Limited	37	7.82	0.21	0	0.0	N/A	0.0%
BBBY	Bed Bath & Beyond Inc	0	0.00	N/A	0	0.0	N/A	N/A
EXPR	Express, Inc.	63	186.90	2.97	10	3,122.9	312.3	15.9%
GME	GameStop Corp. Class A	176	321.97	1.83	19	5,554.9	307.6	10.8%
KOSS	Koss Corp	175	511.32	2.92	21	10,352.0	493.0	12.0%
NAKD	Naked Brand Group Limited Ordinary Shares	5	30.29	6.06	2	600.0	300.0	40.0%
NOK	Nokia Corporation	0	0.00	N/A	0	0	N/A	N/A

* GME's last halt was just before the close and is not included in the average time per pause.

We now look at KOSS and GME trading on January 28, 2021. Although volatility dissipated as the day unfolded, this did not prevent the triggering of several halts for each security in the afternoon. GME halted less than 20 seconds prior to the close of regular trading hours at 4:00 p.m. Twelve of 19 GameStop and 16 of 21 Koss trading pauses occurred within five minutes of a reopen, with several triggering within seconds after the stock reopened.

Below, **Table 10** shows the distribution of LULD trading pauses throughout the day on January 28, 2021, for GME and KOSS. **Table 11** shows activity around trading pauses for GameStop and Koss on January 28, 2021.

Table 10: Distribution of LULD Trading Pauses for GME and KOSS on January 28, 2021

LULD Pause Time Distribution		
	GME	KOSS
09:30 - 09:59	2	4
10:00 - 10:29	2	4
10:30 - 10:59	3	1
11:00 - 11:29	5	1
11:30 - 11:59	3	4
12:00 - 12:29	2	3
12:30 - 12:59	1	2
13:00 - 13:29	0	0
13:30 - 13:59	0	0
14:00 - 14:29	0	1
14:30 - 14:59	0	1
15:00 - 15:29	0	0
15:30 - 15:59	1	0

Table 11: Distribution of LULD Trading Pauses for GME and KOSS on January 28, 2021

Activity Around LULD Trading Pauses for Gamestop and Koss on January 28, 2021

Symbol	Pause	Last Before Pause	Reopen Auction Price	Reopen Auction Shares	Next 5-Min High	Next 5-Min Low	Next 5-Min Shares Traded	Halt in Next 5-Min?	Last to Auction Chg.+	Next 5-Min Range	Max Chg. From Auction	Distance from High/Low
GME	9:31:29	$300.16	$309.82	63,771	$351.82	$279.60	902,343	Yes	3.2%	22.9%	13.6%	41.8%
GME	9:39:34	$351.82	$362.00	109,162	$405.00	$351.00	1,811,950	No	2.9%	14.3%	11.9%	20.4%
GME	10:03:23	$403.45	$403.00	72,607	$430.00	$400.01	971,119	No	-0.1%	7.2%	6.7%	10.0%
GME	10:17:08	$369.75	$369.75	62,697	$419.00	$365.00	1,086,199	No	0.0%	13.8%	13.3%	8.8%
GME	10:40:01	$330.66	$330.00	86,810	$363.00	$297.00	391,769	Yes	-0.2%	20.0%	10.0%	50.0%
GME	10:45:45	$297.00	$290.00	123,081	$319.00	$264.01	1,287,319	Yes	-2.4%	18.9%	10.0%	47.3%
GME	10:54:39	$264.01	$265.00	114,431	$282.55	$237.86	1,135,149	Yes	0.4%	17.2%	10.2%	39.3%
GME	11:02:19	$237.86	$226.05	115,233	$241.50	$196.05	934,113	Yes	-5.0%	20.8%	13.3%	34.0%
GME	11:08:22	$196.05	$170.00	287,530	$187.00	$152.94	676,071	Yes	-13.3%	20.0%	10.0%	49.9%
GME	11:13:59	$152.94	$140.01	347,695	$154.01	$126.01	728,857	Yes	-8.5%	20.0%	10.0%	50.0%
GME	11:19:34	$126.01	$120.00	443,302	$132.00	$108.00	995,930	Yes	-4.8%	20.0%	10.0%	50.0%
GME	11:24:59	$132.00	$141.00	167,279	$155.11	$132.00	803,188	Yes	6.8%	16.1%	10.0%	38.9%
GME	11:30:45	$155.10	$169.97	113,597	$196.26	$155.10	873,881	Yes	9.6%	23.4%	15.5%	36.1%
GME	11:36:57	$196.24	$210.00	117,587	$249.00	$196.15	2,453,432	Yes	7.0%	23.7%	18.6%	26.2%
GME	11:46:19	$207.90	$216.00	46,887	$239.64	$201.99	1,364,784	No	3.9%	17.1%	10.9%	37.2%
GME	12:01:47	$273.28	$275.00	44,967	$324.00	$265.07	1,651,665	Yes	0.6%	20.0%	17.8%	16.9%
GME	12:11:26	$265.28	$270.00	48,683	$300.00	$260.00	885,143	No	1.8%	14.3%	11.1%	25.0%
GME	12:38:48	$238.00	$240.00	36,422	$270.00	$238.53	593,420	No	0.8%	12.4%	12.5%	4.7%
GME	15:59:42	$197.44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Average			133,430				1,085,907		4.0%	17.9%	12.0%	32.6%
Median			111,380				952,616		3.1%	19.4%	11.0%	36.7%

Symbol	Pause	Last Before Pause	Reopen Auction Price	Reopen Auction Shares	Next 5-Min High	Next 5-Min Low	Next 5-Min Shares Traded	Halt in Next 5-Min?	Last to Auction Chg.+	Next 5-Min Range	Max Chg. From Auction	Distance from High/Low
KOSS	9:31:24	$82.22	$84.60	32,814	$93.09	$80.00	178,800	Yes	2.9%	15.1%	10.0%	35.1%
KOSS	9:38:25	$93.09	$95.25	32,143	$112.84	$94.00	268,928	Yes	2.3%	18.2%	18.5%	6.6%
KOSS	9:45:34	$112.84	$115.86	26,272	$127.45	$106.45	372,249	Yes	2.7%	18.0%	10.0%	44.8%
KOSS	9:52:58	$106.45	$106.00	32,000	$118.00	$100.79	293,540	Yes	-0.4%	15.7%	11.3%	30.3%
KOSS	10:01:24	$100.79	$98.24	29,357	$100.00	$88.42	87,961	Yes	-2.5%	12.3%	10.0%	15.2%
KOSS	10:07:04	$88.42	$81.92	52,623	$88.41	$72.26	192,968	Yes*	-7.4%	20.1%	11.8%	40.2%
KOSS	10:17:54	$72.26	$66.66	49,848	$76.74	$66.00	248,416	Yes*	-7.7%	15.0%	15.1%	6.1%
KOSS	10:28:49	$76.74	$72.00	23,417	$73.35	$64.80	55,264	Yes	-6.2%	12.4%	10.0%	15.8%
KOSS	10:34:18	$64.80	$42.30	134,524	$46.53	$42.30	181,148	Yes**	-34.7%	9.5%	10.0%	0.0%
KOSS	11:07:03	$46.53	$28.00	202,611	$30.80	$28.00	262,493	Yes**	-39.8%	9.5%	10.0%	0.0%
KOSS	11:32:19	$30.80	$27.34	69,217	$31.16	$26.00	387,435	Yes	-11.2%	18.1%	14.0%	26.0%
KOSS	11:38:41	$26.31	$25.75	51,406	$28.33	$25.00	119,799	Yes	-2.1%	12.5%	10.0%	22.5%
KOSS	11:44:00	$28.33	$31.20	47,543	$34.32	$31.17	86,402	Yes*	10.1%	9.6%	10.0%	1.0%
KOSS	11:54:21	$34.32	$36.03	23,319	$40.38	$34.50	262,389	Yes	5.0%	15.7%	12.1%	26.0%
KOSS	12:00:15	$40.38	$36.95	23,816	$38.49	$33.26	65,480	Yes	-8.5%	14.6%	10.0%	29.4%
KOSS	12:05:36	$33.26	$33.33	21,653	$36.66	$31.95	125,319	Yes	0.2%	13.7%	10.0%	29.3%
KOSS	12:11:45	$31.95	$32.50	13,424	$40.64	$32.00	268,484	No	1.7%	23.8%	25.0%	5.8%
KOSS	12:35:38	$41.52	$39.00	11,411	$41.50	$33.40	187,363	No	-6.1%	21.6%	14.4%	30.9%
KOSS	12:51:11	$40.52	$40.52	4,924	$40.53	$37.00	54,496	No	0.0%	9.1%	8.7%	0.3%
KOSS	14:03:28	$41.27	$41.00	4,160	$44.00	$39.00	79,201	No	-0.7%	12.0%	7.3%	40.0%
KOSS	14:54:31	$42.09	$41.00	5,289	$45.00	$41.00	69,428	No	-2.6%	9.3%	9.8%	0.0%
Average			45,640				185,023		8.2%	14.6%	11.6%	20.2%
Median			27,815				184,256		5.5%	14.2%	10.0%	24.2%

* - Reopened after one extension (5-minutes)

** - Reopened after multiple extensions

As Tables 10 and 11 show, both stocks traded in a very wide range on January 28. KOSS ranged between $25.00 and $127.46, closing at $41.96, down 27.7% from the prior day's close. GME traded in a range of $108 to $483, closing at $193.60, down 44.3% from the prior day. Although the stocks closed sharply lower, GameStop and Koss rallied sharply in early trading. Five of Koss's trading pauses required extensions, as the auction process could not zero in on an acceptable price within Nasdaq's auction collars. (GME trades on NYSE and does not have collars, but the DMM can take more time to reopen the stock.) The extended auctions averaged a 20.0% price change from the last trade prior to the trading pause, compared to 3.4% for the other 16 auctions, close to the 4.0% average last sale to reopen change for GME.

Both stocks traded in a wide range following the reopens, despite, in several cases, pausing again within seconds of reopening. The average trading range following a trading pause in the next five minutes (or until the next pause, if it did not stay open for five minutes) was 17.9% for GameStop and 14.6% for Koss.

We note that the reopening process implemented in Amendment 12 worked well in KOSS by allowing more effective price discovery through wider price moves, instead of artificially constraining the reopening price only to prompt subsequent LULD pauses. We also note that Amendment 18's elimination of double-wide price bands after the opening helped to permit a more symmetric application of LULD bands, as prices rallied and then sold off in the morning; without that change, we might have seen more halts after 9:45 a.m. as the stocks gave up their early gains.

Overall, this evidence suggests that the LULD Plan worked as it should have worked with respect to these securities on January 28, 2021. While Koss and GameStop continued to display extreme volatility, the LULD trading pauses helped to aggregate substantial liquidity in the reopening auctions. This is consistent with the purpose of the LULD Plan, which is not to prevent a stock price from rising or falling, but rather to dampen the price movements and to aggregate supply and demand in an auction when trading resumes. GameStop's average reopening auction size was more than 100,000 shares and the equivalent average for Koss was a respectable 45,640 shares.

Price discovery was mixed, as several auctions did open at or near the high or low of the ensuing five minute time period (recall that the majority of trading pauses were followed quickly by another LULD trading pause). In most cases, the stock was in the middle of a period of extreme gains or losses, so this is not surprising. For instance, GME, on high volume, started the day at $265, nearly doubled to $483 and then dropped by more than 75% to $112.24, followed by the stock nearly tripling to $324. It finally closed at $193.60, down roughly 40% from that level. Overall, the stock's price traversed $931 in gross price action during the day. In that context, the number of pauses the stock experienced (19 in total) does not seem surprising

or troublesome. It is worth noting that the kind of price swings that occurred in these stocks cannot be prevented by the Plan, nor is it meant to.

IV.   Analysis of Amendments Implemented

No LULD Plan amendments were implemented in 2021.

V.   Review of EMSAC Recommendations

In November 2016, the Equity Market Structure Advisory Committee (EMSAC) Market Quality Subcommittee ("Subcommittee") issued several recommendations regarding potential changes to the LULD Plan in the wake of the August 24, 2015 "flash crash." Specifically, the Subcommittee recommended:

"1. When a stock is 'stuck' in limit up or limit down that there be no traditional halt to the trading of the stock. Trading would continue within the limit price. However if the limit condition remains after four minutes, instead of a halt, new price bands for LU/LD would be established using the limit condition price as the new reference price for the bands. In this way, stocks would not halt, runaway stocks would be prevented and market participants would have sufficient time and opportunity to 'correct' prices and respond if the market felt the stock should trade inside the current bands.

2. The Clearly Erroneous rules at each exchange should conform to the LU/LD bands. In other words, any trade that takes place within the band would stand and not be broken and trades outside the LU/LD bands would be eligible for the consideration of the Clearly Erroneous rules.

3. The LU/LD bands should include the concept of mean reversion, that is that a stock be allowed to trade back to its original price without triggering bands on the way back up. As an example, if a stock trades for $100 and trades down to its LD band of $80 (double wide in the first 15 minutes) the bands 'reset' so that the stock is able to trade back to $100 without hitting LU states on the way back up. Under current conditions, exacerbated by the bands narrowing after the first 15 mins, the LU band would be triggered at $88, and then again at $96. In particular, this should mitigate a large number of LU/LD conditions where stocks trigger multiple conditions around the same price. These effects were clearly driving some of the halts on August 24th."[9]

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[9]   See https://www.sec.gov/spotlight/emsac/emsac-recommendations-rulemaking-

The Commission has asked the Operating Committee for its present views on these Subcommittee recommendations.

With respect to the Subcommittee's first recommendation, the Operating Committee believes that several changes that have been implemented since 2016 have addressed the issues the Subcommittee identified. First, in mid-2016, Amendment 10 to the Plan was implemented,[10] revising the Reference Price used to establish bands in the absence of an opening auction and leading to a sharp decline in unintended trading pauses.[11] Second, in late 2017, Amendment 12[12] was implemented, which widens price collars by 5% of the price of the Price Band that triggered a trading pause in the direction of the band that invoked the trading pause, and continues to widen that collar every five minutes if the security does not reopen within the five-minute halt period. The Participants agree that these changes to the Plan have addressed the Subcommittee's concerns.

With respect to the Subcommittee's second recommendation, the Participants are currently pursuing changes to their rules regarding Clearly Erroneous Executions that are in line with the Subcommittee's recommendations, which should be finalized in the near future.[13]

With respect to the Subcommittee's third recommendation, the Operating Committee believes that the mechanism implemented in Amendment 12, which continually widens price collars in the direction of the Price Band that triggers a trading pause until the security reopens, as well as Amendment 18 to the Plan,[14] which, among other things, eliminated double-wide bands for

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market-quality.pdf.

10   See Securities Exchange Act Release No. 77679 (April 21, 2016), 81 FR 24908 (April 27, 2016) (File No. 4-631) (approving Amendment 10 to the Plan).

11   DERA agreed, finding that pauses for both Tier 1 and Tier 2 securities were less frequent following the implementation of Amendment 10. See DERA White Paper, "The Effect of Amendment 10 of the 'Limit Up-Limit Down' Pilot Plan," dated December 2017, available at https://www.sec.gov/files/dera_wp_the_effect_of_amendment_10_of_the_luld_plan.pdf.

12   See Securities Exchange Act Release No. 79845 (January 19, 2017), 82 FR 8551 (File No. 4-631) (approving Amendment 12 to the Plan).

13   See Securities Exchange Act Release No. 94374 (March 7, 2022), 87 FR 14062 (SR-CboeBZX-2022-017).

14   See Securities Exchange Act Release No. 85623 (April 11, 2019), 84 FR 16086 (April 17, 2019) (File No. 4-631) (approving Amendment 18 to the Plan).

all securities from 9:30 a.m. to 9:45 a.m., have addressed the concerns underlying the Subcommittee's recommendation.

VI.   Analysis of Emerging Issues

A. POTENTIAL CHANGE TO REFERENCE PRICE WHEN REOPENING ON A QUOTE

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.

B. PROPOSAL TO MOVE TIER 2 ETPS TO TIER 1

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.