



## CME CF CRYPTOCURRENCY REAL TIME INDICES

Methodology Guide

Version: 15.0

Version Date: 31<sup>st</sup> October 2022

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# 1 Version History

| Version | Version Date                    | Changes to Previous   |
|---------|---------------------------------|---|
| 1       | 10 <sup>th</sup> November 2016  | N/A   |
| 2       | 6 <sup>th</sup> March 2017      | Added description of treatment of erroneous data.<br>Changed calculation methodology from static to dynamic depth. <b>Effective: 18 March 2017, 16:30:00 London time.</b>                             |
| 3       | 14 <sup>th</sup> May 2018       | Clarified use of spacing parameter. Generalised methodology to support multiple real time indices.  |
| 3.1     | 17 <sup>th</sup> October 2018   | Changed ETH_RTI_USD ticker symbol to ETHUSD_RTI.<br>Specified usage of spacing parameter for utilized depth fallback.   |
| 4       | 3 <sup>rd</sup> January 2019    | Parameterisation of Rule 5.3 for different Real Time Indices  |
| 4.1     | 14 <sup>th</sup> March 2019     | Change of order size cap for ETHUSD_RTI   |
| 4.2     | 16 July 2019                    | Remove constituent list (documented separately)   |
| 5       | 16 <sup>th</sup> July 2019      | Rebrand for CF Benchmarks   |
| 6       | 11 <sup>th</sup> September 2019 | Update legal text with BMR registration   |
| 7       | 2 <sup>nd</sup> December 2019   | Change order size cap from static to dynamic  |
| 8       | 10 <sup>th</sup> February 2020  | Change potentially erroneous data parameter   |
| 9       | 20 <sup>th</sup> May 2020       | Clarify use of orderbook price levels   |
| 10      | 31 <sup>st</sup> July 2020      | Addition of: <ul style="list-style-type: none"> <li>• Underlying Economic Reality in Section 2</li> <li>• Expert Judgement in Section 5</li> <li>• Methodology Review and Change Section 8</li> </ul> |

| Version | Version Date                  | Changes to Previous   |
|---------|-------------------------------|---|
| 11      | 14th September 2020           | Change to the implementation of the <b>Potentially Erroneous Data Parameter</b>   |
| 12      | 25 <sup>th</sup> April 2022   | Addition of Relevant Pairs: <ul style="list-style-type: none"><li>• Cardano – U.S. Dollar</li><li>• Solana – U.S. Dollar</li><li>• Stellar Lumens – U.S. Dollar</li><li>• Algorand – U.S. Dollar</li><li>• Bitcoin Cash – U.S. Dollar</li><li>• Litecoin – U.S. Dollar</li><li>• Chainlink – U.S. Dollar</li><li>• Cosmos – U.S. Dollar</li><li>• Stellar Lumens – U.S. Dollar</li><li>• Uniswap – U.S. Dollar</li><li>• Polkadot – U.S. Dollar</li></ul> |
| 13      | 6 <sup>th</sup> June 2022     | Addition of Relevant Pairs: <ul style="list-style-type: none"><li>• Bitcoin – Euro</li><li>• Ether - Euro</li></ul>   |
| 14      | 13 <sup>th</sup> July 2022    | Addition of definition and reference to Accepted Assets   |
| 15      | 31 <sup>st</sup> October 2022 | Addition of Relevant Pairs: <ul style="list-style-type: none"><li>• Avalanche – U.S. Dollar</li><li>• Filecoin – U.S. Dollar</li><li>• Tezos - U.S. Dollar</li></ul>  |

## 2 Overview

Responding to the need for enhanced pricing information on the rapidly growing cryptocurrency asset class, CME Group and CF Benchmarks have developed standardized cryptocurrency reference rates and real time indices.

Each reference rate and real time index represent transparent indicators with independent governance and oversight and build on our experience to accelerate the professionalization of cryptocurrency trading.

This document covers the CME CF Cryptocurrency Real Time Indices. A summary of specifications is provided in Section 7.

### **Underlying Economic Reality**

The CME CF Reference Rates are intended to measure the underlying economic reality of the exchange of the base asset for the quote asset and vice versa. This is accomplished by the use of order input data from markets that facilitate the trading of the base asset for the quote asset, including markets where the quote asset is fungible with Accepted Assets, operated by Constituent Exchanges, the criteria for eligibility for which are available in the CME CF Constituent Exchange Criteria.

### 3 Definitions

**Accepted Asset:** a digital asset that is a fully reserve backed digital token, commonly referred to as a “stablecoin”, that seeks to peg its value to that of the quote asset, where the issuer operates a 1:1 redemption facility and solely holds reserve assets that are in line with the prevailing regulations enforced for government security money market funds in major jurisdiction such as the US, UK and EU. All Accepted Assets must be approved by the CME CF Cryptocurrency Oversight Committee before inclusion in the calculation of a CME CF Cryptocurrency Reference Rate.

**API:** Application programming interface.

**Calculation Time:** Any time as of which a CME CF Cryptocurrency Real Time Index is published.

**Constituent Exchange:** A cryptocurrency trading venue approved by the CME CF Cryptocurrency Indices Oversight Committee to serve as pricing source for the calculation of a CME CF Cryptocurrency Real Time Index.<sup>1</sup>

**Relevant Pair:** The cryptocurrency base asset versus the quote asset referenced by a CME CF Cryptocurrency Real Time Index, as defined in Section 6.

**Relevant Order Book:** The universe of the currently unmatched limit orders to buy or sell a unit of the cryptocurrency base asset versus the quote asset on a Constituent Exchange in the Relevant Pair, aggregated by price, that is reported through its API to the Calculation Agent.

**Retrieval Time:** The time, as given by the server clock of the Calculation Agent, as of which the Relevant Order Book of a Constituent Exchange is requested by the Calculation Agent through the API of the Constituent Exchange.

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<sup>1</sup> Constituent Exchanges and the Criteria for inclusion are published on the Administrator’s website <https://www.cfbenchmarks.com>.

## 4 Methodology and Rules

### 4.1 Methodology

#### 4.1.1 Qualitative Description

CME CF Cryptocurrency Real Time Indices are calculated in real time based on the Relevant Order Books of all Constituent Exchanges. An order book is a list of buy and sell orders with associated limit prices and sizes that have not yet been matched due to lack of supply or demand to trade at that price. It therefore informs about the price at which a trader can buy or sell a certain amount of cryptocurrency as of now. In line with existing cryptocurrency market practises, the "order size" refers to the aggregated sizes of all orders at the same price, the price/sizes tuples of buy orders ("bids") descend by price and the price/size tuples of sell orders ("asks") ascend by price.

Calculation steps are as follows:

1. At the Effective Time, the Relevant Order Book of each Constituent Exchange is added to a joint list of order books.
2. The joint list of order books is aggregated into one consolidated order book. If the size at the bid or ask order price level exceeds the order size cap, it enters the consolidated order book with a size equal to the order size cap.
3. The cumulative bid price-volume curve, ask price-volume curve, mid price-volume curve and mid spread-volume curve are calculated from the consolidated order book at a granularity equal to the spacing parameter.
  - a. The bid price-volume curve maps transaction volume to the marginal price per cryptocurrency unit a seller is required to accept in order to sell this volume to the consolidated order book.
  - b. The ask price-volume curve maps a transaction volume to the marginal price per cryptocurrency unit a buyer is required to pay in order to purchase this volume from the consolidated order book.
  - c. The mid price-volume curve represents the average of the bid price-volume curve and the ask price-volume curve.
  - d. The mid spread-volume curve represents the percentage deviation of the ask price-volume curve from the mid price-volume curve.
4. The utilized depth is calculated as the maximum cumulative volume for which the mid spread-volume curve does not exceed a certain percentage deviation from the mid price. If this volume is less than the spacing parameter, the utilized depth is set to the spacing parameter.

5. The mid price-volume curve is weighted by the normalized probability density of the exponential distribution up to the utilized depth.
6. The CME CF Cryptocurrency Real Time Index is then given by the sum of the weighted mid price-volume curve obtained in the previous step.

#### 4.1.2 Mathematical Representation

The following table shows the symbols used in the mathematical representation of CME CF Cryptocurrency Real Time Indices.

| Symbol   | Name               | Description  | Type                                 |
|--|--------------------|--|--------------------------------------|
| $T$  | Effective time     | The time at which a CME CF Cryptocurrency Real Time Index is calculated  | Parameter, see Section 6             |
| $C_T$  | Order size cap     | The size above which any excess size of a bid or ask order price level is discarded  | Internal variable, see Section 4.1.3 |
| $D$  | Deviation from mid | The maximum percentage deviation of a limit order price level from the mid price-volume curve, until which that limit order price level is used for the calculation of a CME CF Cryptocurrency Real Time Index | Parameter, see Section 6             |
| $\lambda$  | Lambda             | A parameter that determines the shape of the probability density function of the exponential distribution  | Parameter, see Section 6             |
| $s$  | Spacing            | The spacing granularity of a price-volume curve  | Parameter, see Section 6             |
| $v$  | Volume             | The independent variable of a price-volume curve   | Internal variable                    |
| $A_T$  | Ask orders         | The ask order price levels of the consolidated order book as of the effective time, ordered ascending by price   | Input                                |
| $a_{T,i}$<br>with $a_{T,i} = (ap_{T,i}, as_{T,i})$ ,<br>$a_{T,i} \in A_T$ , $as_{T,i} = \min\{as_{T,i}, C\}$ | Ask order          | The $i$ th price/size ask order pair of the consolidated order book  | Input                                |



|   |                      |   |        |
|---|----------------------|---|--------|
| $B_T$   | Bid orders           | The bid order price levels of the consolidated order book as of the effective time, ordered descending by price | Input  |
| $b_{T,i}$<br>with $b_{T,i} = (bp_{T,i}, bs_{T,i})$ ,<br>$b_{T,i} \in B, bs_{T,i} = \min\{bs_{T,i}, C\}$ | Bid order            | The $i$ th price/size bid order pair of the consolidated order book   | Input  |
| $NF$  | Normalization factor | A parameter chosen such that $\frac{1}{NF} \sum_{v \in \{s, 2s, \dots, \bar{v}_T\}} \lambda e^{-\lambda v} = 1$ | Output |
| $CCRTI_T$   | CCRTI                | The CME CF Cryptocurrency Real Time Index at time $T$   | Output |

Using the above notation, we define the ask price-volume curve,  $askPV_T$ , the bid price-volume curve,  $bidPV_T$ , the mid-price volume curve,  $midPV_T$ , and the mid spread-volume curve,  $midSV_T$ , in each case as of the effective time  $T$ , as:

|  |        |
|--|--------|
| $ask\widehat{PV}_T(v) = ap_{T,j+1}$ where $\sum_{i=1}^j as_{T,i} < v$ and $\sum_{i=1}^{j+1} as_{T,i} \geq v$ | Eq. 1a |
| $bid\widehat{PV}_T(v) = bp_{T,j+1}$ where $\sum_{i=1}^j bs_{T,i} < v$ and $\sum_{i=1}^{j+1} bs_{T,i} \geq v$ | Eq. 1b |
| $askPV_T(v) = ask\widehat{PV}_T\left(s \left\lfloor \frac{v}{s} \right\rfloor\right)$                        | Eq. 1c |
| $bidPV_T(v) = bid\widehat{PV}_T\left(s \left\lfloor \frac{v}{s} \right\rfloor\right)$                        | Eq. 1d |
| $midPV_T(v) = \frac{askPV_T(v) + bidPV_T(v)}{2}$   | Eq. 1e |
| $midSV_T(v) = \frac{askPV_T(v)}{midPV_T(v)} - 1$   | Eq. 1f |

The utilized depth,  $\bar{v}_T$ , is calculated as:

|   |       |
|---|-------|
| $\bar{v}_T = \max(v_i \text{ where } midSV_T(v_i) \leq D \text{ and } midSV_T(v_{i+1}) > D, s)$ | Eq. 2 |
|---|-------|

The CME CF Cryptocurrency Real Time Index as of the effective time  $T$ ,  $CCRTI_T$ , is then given by:

$$CCRTI_T = \sum_{v \in \{s, 2s, \dots, \bar{v}_T\}} midPV_T(v) \frac{1}{NF} \lambda e^{-\lambda v} \quad \text{Eq. 3}$$

### 4.1.3 Dynamic Order Size Cap

The order size cap is calculated from the uncapped consolidated order book. The following symbols are used in the calculation of the order size cap:

| Symbol   | Name                                 | Description   |
|--|--------------------------------------|---|
| $ac_T$   | Ask sample size                      | The number of samples used for ask-side sizes                     |
| $bc_T$   | Bid sample size                      | The number of samples used for bid-side sizes                     |
| $S_T = \{s_{T,1}, s_{T,2}, \dots, s_{T,n_T}\}$     | Size sample set                      | The consolidated set of sizes, ordered by ascending size          |
| $k$  | Trimming / winsorizing size          | The number of samples to trim or winsorize from $S_T$             |
| $\bar{s}$  | Trimmed mean                         | The trimmed mean of the sample set $S_T$                          |
| $S'_T = \{s'_{T,1}, s'_{T,2}, \dots, s'_{T,n_T}\}$ | Winsorized sample set                | The winsorized sample set of $S_T$                                |
| $\bar{s}'$   | Winsorized mean                      | The mean of the winsorized sample set $S'_T$                      |
| $\sigma$   | Winsorized sample standard deviation | The sample standard deviation of the winsorized sample set $S'_T$ |

Using the above notation, the dynamic order size cap is derived as follows:

|   |        |
|---|--------|
| $ac_T = \max\left(\max_{1 \leq i \leq  A_T } \{i \mid ap_{T,i} \leq 1.05ap_{T,1}\}, \min( A_T , 50)\right)$   | Eq. 4a |
| $bc_T = \max\left(\max_{1 \leq i \leq  B_T } \{i \mid bp_{T,i} \geq 0.95bp_{T,1}\}, \min( B_T , 50)\right)$   | Eq. 4b |
| $S_T = [bs_{T,1}, bs_{T,2}, \dots, bs_{T,bc_T}] \cup [as_{T,1}, as_{T,2}, \dots, as_{T,ac_T}]$ $S_T = [s_{T,1}, s_{T,2}, \dots, s_{T,n_T}] \text{ where } s_{T,1} \leq s_{T,2} \leq \dots \leq s_{T,n_T}$ | Eq. 4c |
| $k = \lfloor 0.01n_T \rfloor$   | Eq. 4d |
| $\bar{s} = \frac{1}{n_T - 2k} \sum_{i=k+1}^{n_T-k} s_{T,i}$   | Eq. 4e |
| $s'_{T,i} = s_{T,k+1} \text{ if } i \leq k$ $s'_{T,i} = s_{T,n-k} \text{ if } i > n - k$ $s'_{T,i} = s_{T,i} \text{ otherwise}$   | Eq. 4f |
| $\bar{s}' = \frac{1}{n_T} \sum_{i=1}^{n_T} s'_{T,i}$  | Eq. 4g |
| $\sigma = \sqrt{\frac{1}{n_T - 1} \sum_{i=1}^{n_T} (s'_{T,i} - \bar{s}')^2}$  | Eq. 4h |

The order size cap as of the effective time  $T$ ,  $C_T$ , is then given by:

|                           |       |
|---------------------------|-------|
| $C_T = \bar{s} + 5\sigma$ | Eq. 5 |
|---------------------------|-------|

## 4.2 A Note on Properties

CME CF Cryptocurrency Real Time Indices reflect the instantaneous supply and demand of a given cryptocurrency and result in a robust, yet highly timely indication of the current price. This is achieved through the following design choices:

### Order Book Data

CME CF Cryptocurrency Real Time Indices are calculated from order book data, as opposed to, for instance, trade data. Order book data is composed of unmatched limit orders to buy or sell cryptocurrency. The order books retrieved from the constituent exchanges are aggregated by price. They inform about the price at which a trader can buy or sell cryptocurrency now or in the future and are therefore forward-looking by nature. Further, absent retrieval constraints, order book data is always up to date. This

is in contrast to trade data, which is produced in stochastic intervals only and informs about the price at which the cryptocurrency has traded in the past.

### Mid Price Volume Curve

The mid price-volume curve represents the average of the marginal price at which a certain amount of cryptocurrency can be sold and bought. By averaging across the mid price-volume curve, CME CF Cryptocurrency Real Time Indices represent a blend of such (hypothetical) transactions at various transaction sizes.

### Utilized Depth

CME CF Cryptocurrency Real Time Indices are calculated from the section of the mid price-volume curve for which ask limit order price levels at a certain depth diverge by no more than a certain percentage from the mid-price at that depth. It therefore reflects a significant portion of the top of the consolidated order book (as opposed to, for instance, the best bid and ask prices only) but discards limit order price levels that are less likely to be matched. This makes it a meaningful representation of true liquidity and robust to local changes in order books.

Note that utilized depth will always include any crossing section of the consolidated order book, as well as the non-crossing section with limit orders up to a certain percentage away from the crossing point. If zero size resides in both these sections, utilized depth is set to the spacing parameter. The CME CF Cryptocurrency Real Time Indices is then effectively equal to the mid-price of the consolidated order book.

### Exponential Weighting

The mid price-volume curve is weighted by the normalized probability density of the exponential distribution. The exponential distribution and its first derivative are monotonically decreasing, resulting in a higher emphasis on the initial section of the mid price-volume curve, i.e. bid and ask prices that are closest to the global best bid and ask price.

### Markov Process and Martingale

Indices are frequently based on historical data, such as recent trade prices or volumes. This can result in certain predictability, for instance due to the expectation that stale prices will be updated or that a price will drop out of a weighting window.

By relying solely on order book data, CME CF Cryptocurrency Real Time Indices are both a Markov process and a martingale. A Markov process is a stochastic process with a probability distribution that depends only on the current information set, not on historical information sets. The martingale property implies that the best prediction of the next CME CF Cryptocurrency Real Time Index value is its current value:

$$E(CCRTI_{t+1} | CCRTI_1, CCRTI_2, \dots, CCRTI_t) = CCRTI_t$$

This makes CME CF Cryptocurrency Real Time Indices useful for applications that require an unbiased estimator of the future price.

# 5 Contingency Calculation Rules

## 5.1 Delayed Data

Delayed data is treated according to the following rules:

1. If the Retrieval Time of the Relevant Order Book of a Constituent Exchange is at least 30 seconds older than the Calculation Time, the Constituent Exchange is disregarded in the calculation of the CME CF Cryptocurrency Real Time Index for that Calculation Time.

If the Retrieval Times of the Relevant Order Books of all Constituent Exchanges are each at least 30 seconds older than the Calculation Time, a CME CF Cryptocurrency Real Time Index calculation failure occurs for that Calculation Time (see Section 5.5).

## 5.2 Erroneous Data

### 5.2.1 Erroneous Books

All Relevant Order Books are subject to an automated screening for erroneous data according to the following rules:

1. If the format of a Relevant Order Book deviates from the expected format such that it cannot be parsed, it is flagged as erroneous.
2. If the Relevant Order Book contains no bid orders or no ask orders, it is flagged as erroneous.
3. If the Relevant Order Book crosses, it is flagged as erroneous.

Relevant Order Books flagged as erroneous for a given Calculation Time are disregarded in the calculation of the CME CF Cryptocurrency Real Time Index for that Calculation Time.

If the Relevant Order Books of all Constituent Exchanges are flagged as erroneous for a given Calculation Time, a CME CF Cryptocurrency Real Time Index calculation failure occurs for that Calculation Time (see Section 5.5).

### 5.2.2 Erroneous Prices

All Relevant Order Books are subject to an automated filtering process according to the following rule.

1. If a Relevant Order Book contains any entries with a non-numeric or non-positive limit price or size then any such entries are flagged as erroneous.

All entries in a Relevant Order Book which are flagged as erroneous for a given Calculation Time are disregarded in the calculation of the CME CF Cryptocurrency Real Time Index for that Calculation Time.

### 5.3 Potentially Erroneous Data

All Relevant Order Books are subject to an automated screening for potentially erroneous data according to the following rules:

1. For each Constituent Exchange individually, the current mid-price is calculated as the average of the highest bid price and the lowest ask price of the Relevant Order Book.
2. For each Constituent Exchange, the absolute percentage deviation of the mid-price, as calculated in the previous step, from the median of the mid prices of all Constituent Exchanges is calculated.
3. If for any Constituent Exchange the absolute percentage deviation, as calculated in the previous step, exceeds the Potentially Erroneous Data Parameter for the respective Real Time Index represented in Real Time Index Parameters (section 6) then the Relevant Order Book of that Constituent Exchange for the affected Real Time Index is flagged as potentially erroneous. Relevant Order Books flagged as potentially erroneous for a given Calculation Time are disregarded in the calculation of the CME CF Cryptocurrency Real Time Index for that Calculation Time. The occurrence of any such flag is reported to the Oversight Committee.
4. Upon an orderbook of a Constituent Exchange having been disregarded in the calculation as described in the previous step, its orderbook shall continue to be disregarded from the calculation of the affected index until the absolute deviation of the mid-price of its orderbook as calculated in step 2 is less than 50% of the Potentially Erroneous Data Parameter. At this point it shall be re-instated to the calculation for that Calculation Time and all subsequent Calculation Times unless it is removed from the calculation for any of the reasons as described in section 5.

If the Relevant Order Books of all Constituent Exchanges are flagged as potentially erroneous for a given Calculation Time, a CME CF Cryptocurrency Real Time Index calculation failure occurs for that Calculation Time (see Section 5.5).

### 5.4 Expert Judgement

The Administrator does not utilise expert judgment in the day to day calculation of the Reference Rates. In extraordinary circumstances Expert Judgement may be exercised by the Administrator in accordance with its codified policies and processes which are available upon request.

## 5.5 Calculation Failure

If a CME CF Cryptocurrency Real Time Index cannot be calculated for a given Calculation Time, for instance because:

- the Retrieval Times of the Relevant Order Books of all Constituent Exchanges are each at least 30 seconds older than the Calculation Time, or
- all Relevant Order Books are flagged as erroneous or potentially erroneous (see Section 5.2); or
- any other reason or circumstance that prevents the orderly calculation of a CME CF Cryptocurrency Real Time Index,

then the CME CF Cryptocurrency Real Time Index for that Calculation Time is not published. The occurrence of any CME CF Cryptocurrency Real Time Index calculation failure is reported to the Oversight Committee.



## 6 Real Time Index Parameters

### 6.1 Constants

|  |   |
|--|---|
| <b>Effective Time (<math>T</math>)</b> | Approximately every second of each day for the entire year including weekends and holidays. |
| <b>Lambda (<math>\lambda</math>)</b>   | $\frac{1}{0.3\bar{v}_T}$  |

### 6.2 Index Specific Parameters

The following table summarizes the parameters for the currently supported CME CF Real Time Indices:

|   | <b>Spacing<br/>(<math>s</math>)</b> | <b>Deviation<br/>from Mid<br/>(<math>D</math>)</b> | <b>Potentially<br/>Erroneous Data<br/>Parameter</b> | <b>Order<br/>Size Cap<br/>(<math>C_T</math>)</b> |
|---|-------------------------------------|--|---|--|
| <b>CME CF Bitcoin Real Time Index</b>         | 1                                   | 0.5%   | 10%   | Dynamic  |
| <b>CME CF Ether–Dollar Real Time Index</b>    | 25                                  | 1%   | 10%   | Dynamic  |
| <b>CME CF Litecoin-Dollar Real Time Index</b> | 50                                  | 1%   | 10%   | Dynamic  |

|   |        |      |     |         |
|---|--------|------|-----|---------|
| <b>CME CF Bitcoin Cash-Dollar Real Time Index</b>   | 10     | 1%   | 10% | Dynamic |
| <b>CME CF Stellar Lumens-Dollar Real Time Index</b> | 100000 | 1%   | 10% | Dynamic |
| <b>CME CF Chainlink-Dollar Real Time Index</b>      | 1000   | 1%   | 10% | Dynamic |
| <b>CME CF Algorand-Dollar Real Time Index</b>       | 15000  | 1%   | 10% | Dynamic |
| <b>CME CF Cosmos-Dollar Real Time Index</b>         | 900    | 1%   | 10% | Dynamic |
| <b>CME CF Cardano-Dollar Real Time Index</b>        | 1000   | 1%   | 10% | Dynamic |
| <b>CME CF Uniswap-Dollar Real Time Index</b>        | 100    | 1%   | 10% | Dynamic |
| <b>CME CF Polkadot-Dollar Real Time Index</b>       | 100    | 1%   | 10% | Dynamic |
| <b>CME CF Polygon-Dollar Real Time Index</b>        | 1000   | 1%   | 10% | Dynamic |
| <b>CME CF Solana-Dollar Real Time Index</b>         | 100    | 1%   | 10% | Dynamic |
| <b>CME CF Bitcoin- Euro Real Time Index</b>         | 1      | 0.5% | 10% | Dynamic |
| <b>CME CF Ether – Euro Real Time Index</b>          | 25     | 1%   | 10% | Dynamic |
| <b>CME CF Avalanche – Dollar Real Time Index</b>    | 10     | 1%   | 10% | Dynamic |
| <b>CME CF Filecoin – Dollar Real Time Index</b>     | 10     | 1%   | 10% | Dynamic |
| <b>CME CF Tezos – Dollar Real Time Index</b>        | 1000   | 1%   | 10% | Dynamic |

## 7 Real Time Index Specifications

|                                | <b>CME CF Bitcoin Real Time Index</b>   | <b>CME CF Ether-Dollar Real Time Index</b>   | <b>CME CF Cardano – Dollar Real Time Index</b> |
|--------------------------------|---|--|--|
| <b>Ticker Symbol</b>           | BRTI  | ETHUSD_RTI                                   | ADAUSD_RTI                                     |
| <b>Administrator</b>           | CF Benchmarks Ltd   |  |  |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |  |  |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Bitcoin  | Instantaneous U.S. Dollar price of one Ether | Instantaneous U.S. Dollar price of one Cardano |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges                           |  |  |
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |  |  |
| <b>Dissemination Precision</b> | 0.01 U.S. Dollars   | 0.01 U.S. Dollars                            | 0.0001 U.S. Dollars                            |

|                                | <b>CME CF Solana - Dollar Real Time Index</b>   | <b>CME CF Algorand - Dollar Real Time Index</b> | <b>CME CF Stellar Lumens – Dollar Real Time Index</b> |
|--------------------------------|---|---|---|
| <b>Ticker Symbol</b>           | SOLUSD_RTI  | ALGOUSD_RTI                                     | XMLUSD_RTI  |
| <b>Administrator</b>           | CF Benchmarks Ltd   |   |   |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |   |   |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Solana   | Instantaneous U.S. Dollar price of one Algorand | Instantaneous U.S. Dollar price of one stellar Lumens |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges                           |   |   |
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |   |   |

|                                |                   |                     |                      |
|--------------------------------|-------------------|---------------------|----------------------|
| <b>Dissemination Precision</b> | 0.01 U.S. Dollars | 0.0001 U.S. Dollars | 0.00001 U.S. Dollars |
|--------------------------------|-------------------|---------------------|----------------------|

|                                | <b>CME CF Bitcoin Cash - Dollar Time Index</b>  | <b>CME CF Litecoin - Dollar Real Time Index</b> | <b>CME CF Chainlink – Dollar Real Time Index</b> |
|--------------------------------|---|---|--|
| <b>Ticker Symbol</b>           | BCHUSD_RTI  | LTCUSD_RTI                                      | LINKUSD_RTI                                      |
| <b>Administrator</b>           | CF Benchmarks Ltd   |   |  |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |   |  |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Bitcoin Cash   | Instantaneous U.S. Dollar price of one Litecoin | Instantaneous U.S. Dollar price of one Chainlink |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges                           |   |  |
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |   |  |
| <b>Dissemination Precision</b> | 0.01 U.S. Dollars   | 0.01 U.S. Dollars                               | 0.01 U.S. Dollars                                |

|                                | <b>CME CF Polkadot - Dollar Time Index</b>                        | <b>CME CF Polygon - Dollar Real Time Index</b> | <b>CME CF Uniswap – Dollar Real Time Index</b> |
|--------------------------------|---|--|--|
| <b>Ticker Symbol</b>           | DOTUSD_RTI  | MATICUSD_RTI                                   | UNIUSD_RTI                                     |
| <b>Administrator</b>           | CF Benchmarks Ltd   |  |  |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |  |  |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Polkadot                   | Instantaneous U.S. Dollar price of one Polygon | Instantaneous U.S. Dollar price of one Uniswap |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges |  |  |

|                                |   |                    |                     |
|--------------------------------|---|--------------------|---------------------|
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |                    |                     |
| <b>Dissemination Precision</b> | 0.001 U.S. Dollars  | 0.001 U.S. Dollars | 0.0001 U.S. Dollars |

|                                | <b>CME CF Cosmos - Dollar Real Time Index</b>   | <b>CME CF Bitcoin - Euro Real Time Index</b> | <b>CME CF Ether - Euro Real Time Index</b> |
|--------------------------------|---|--|--|
| <b>Ticker Symbol</b>           | ATOMUSD_RTI   | BTCEUR_RTI                                   | ETHEUR_RTI                                 |
| <b>Administrator</b>           | CF Benchmarks Ltd   |  |  |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |  |  |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Cosmos   | Instantaneous Euro price of one Bitcoin      | Instantaneous Euro price of one Ether      |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges                           |  |  |
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |  |  |
| <b>Dissemination Precision</b> | 0.001 U.S. Dollars  | 0.01 Euro                                    | 0.01 Euro                                  |

|                                | <b>CME CF Avalanche - Dollar Real Time Index</b>                  | <b>CME CF Filecoin - Dollar Real Time Index</b> | <b>CME CF Tezos - Dollar Real Time Index</b> |
|--------------------------------|---|---|--|
| <b>Ticker Symbol</b>           | AVAXUSD_RTI   | FILUSD_RTI                                      | XTZUSD_RTI                                   |
| <b>Administrator</b>           | CF Benchmarks Ltd   |   |  |
| <b>Calculation Agent</b>       | CF Benchmarks Ltd   |   |  |
| <b>Description</b>             | Instantaneous U.S. Dollar price of one Avalanche                  | Instantaneous U.S. Dollar price of one Filecoin | Instantaneous U.S. Dollar price of one Tezos |
| <b>Calculation Methodology</b> | Real time aggregation of order book data of Constituent Exchanges |   |  |

|                                |   |                    |                     |
|--------------------------------|---|--------------------|---------------------|
| <b>Dissemination Time</b>      | Approximately every second of each day for the entire year including weekends and holidays. |                    |                     |
| <b>Dissemination Precision</b> | 0.01 U.S. Dollars   | 0.001 U.S. Dollars | 0.0001 U.S. Dollars |

## 8 Methodology Review and Changes to the Real Time Indices

This methodology is subject to internal review by the Administrator and the CME CF Oversight Committee at least annually.

Any changes to this methodology are overseen by the CME CF Oversight Committee, and In accordance with EU BMR Article 13.

All *material* changes to the methodology shall only be implemented after a consultation process with users and relevant stakeholders that shall be conducted according to the Administrator's policies and overseen by the CME CF Oversight Committee.

Should the Administrator deem it necessary to cease providing any of the Reference Rates it shall only do so after a consultation process with users and relevant stakeholders that shall be conducted according to the Administrator's policies and overseen by the CME CF Oversight Committee

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