

MIAx Pearl Options Exchange

Top of Market Feed ToM Interface Specification

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Version: 1.2

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1. Overview

MIAX Pearl Top of Market (ToM) is a data feed that allows subscribers to receive real-time updates of the following information from the Pearl Options Market

- Pearl Best Bid or Offer (PBBO): Best Bid or Offer price with aggregate orders and quote size of contracts that can be displayed. For purposes of this document, PBBOs are subject to quote mitigation processing (details of Quote mitigation on MIAX website).
- Display of Public Customer interest at PBBO.
- Display of Priority Customer interest at the PBBO.
- MIAX Pearl Last Sale (trades)

ToM Features:

ToM messaging and the system architecture are designed for low latency and high throughput messaging. Some of the key features of the interface are:

- ToM uses binary numeric fields, fixed length ASCII fields and single sided top of market messages in order to utilize bandwidth efficiently and assist in achieving **low latency**.
- Message formats are designed to use **less bandwidth**. Some examples: ToM disseminates top of Pearl Bid separate from top of Pearl Offer. ToM also uses a compact version of the Top of Market message for most quotes with small prices/sizes and uses the larger message only when necessary. ToM disseminates a separate Seconds message instead of sending this with every message. ToM messages use Product IDs in each message in place of a full canonical symbol.
- ToM uses binary message formats and bundles multiple application messages into a single packet in order to facilitate **high throughput**.
- ToM is offered with redundant multicast feeds (A Feed & B Feed) to provide single point of failure hardware and network fault tolerance and to provide an opportunity for recipients to arbitrate the two feeds to auto-fill gaps.
- ToM real-time messages are disseminated over multicast to achieve a fair delivery mechanism.
- ToM requires the use of MIAX proprietary SesM over TCP/IP protocol for retransmission lines in order to provide a **guaranteed delivery** mechanism for gap fills.
- The ToM retransmission service also provides a Last Value Refresh Service to facilitate fast intra-day recovery without a full day gap fill.
- ToM notifications provide current **electronic system status** allowing the subscribers to take necessary actions immediately.

This specification is intended to be used by MIAX Pearl ToM subscribers only. MIAX Pearl will be referred to as Pearl for the rest of the document.

1.1 Exchange Related Information

1.1.1 Hours of Operation for Pearl Options Exchange

Please refer to MIAX website at <http://www.MIAXGlobal.com> for details about times for each of these events.

Note: Times specified below are in United States Eastern Time zone.

Start of Session: Start of dissemination of messages. After 5:00 a.m.

Trading Session for Equity Options: 9:30 a.m. to 4:00 p.m. (ends at 1:00 p.m. on early closing days). Pearl may send trade related data following the end of trading session due to the issuance of manual trades, trade cancels, trade corrections or for various operational reasons as needed.

Trading Session for ETF and Index Options: 9:30 a.m. to 4:15 p.m. (ends at 1:15 p.m. on early closing days). Pearl may send trade related data following the end of trading session due to the issuance of manual trades, trade cancels, trade corrections or for various operational reasons as needed.

1.1.2 Obtaining More Information

Information such as (but not limited to) membership, rules, data feeds, fees and support can be obtained by sending an email to Trading Operations or by referring to MIAX website at <http://www.MIAXGlobal.com>.

1.2 Testing of ToM Subscription

Pearl can provide testing assistance on Pearl testing area for the retransmission interface. Please contact MIAX Trading Operations to obtain more information about the aforementioned.

1.3 Answers to FAQs

Subscription: Please contact Trading Operations for details about subscribing to ToM.

Symbol management: Subscribers to the data feed will get a list of all option symbols that will be traded and sourced on that feed at the start of every session. If firms cannot start listening to the feed in time for the normal symbol broadcast, they can connect to the ToM Retransmission service and request for all messages published and then subsequently process only the symbol messages to build their symbol list. The Pearl assigned Product ID of each option in this symbol list will be sent in every message so that firms can tie each message to an option symbol.

Quote Mitigation: Pearl Best Bid or Offer disseminated on this feed is subject to quote mitigation processing at Pearl. Please refer to Pearl website in order to understand the quote mitigation processing.

Retransmission: Gap-fill packets generated as a response to retransmission requests are only disseminated on the retransmission TCP channels and not on the real-time multicast feeds.

Redundant Feeds: In order to achieve higher availability, Pearl offers the real-time ToM feed in two separate redundant and identical feeds named “A Feed” and “B Feed”. Firms are advised to arbitrate between the two feeds in order to mitigate gaps and achieve higher availability. “A Feed” is the primary feed from the primary data center and “B Feed” is the secondary feed from the secondary data center.

Trading Status: The first “regular” trade or “regular (automatic execution eligible)” MBBO quote of the day or “regular” PBBO after a halt indicates that the given product (option symbol) is open for trading at Pearl. Halts are communicated as top of market messages with a condition of ‘T’.

Refresh Service: Refresh service is provided only on the retransmission TCP channels and does not affect the real-time ToM feed.

1.4 Data Types

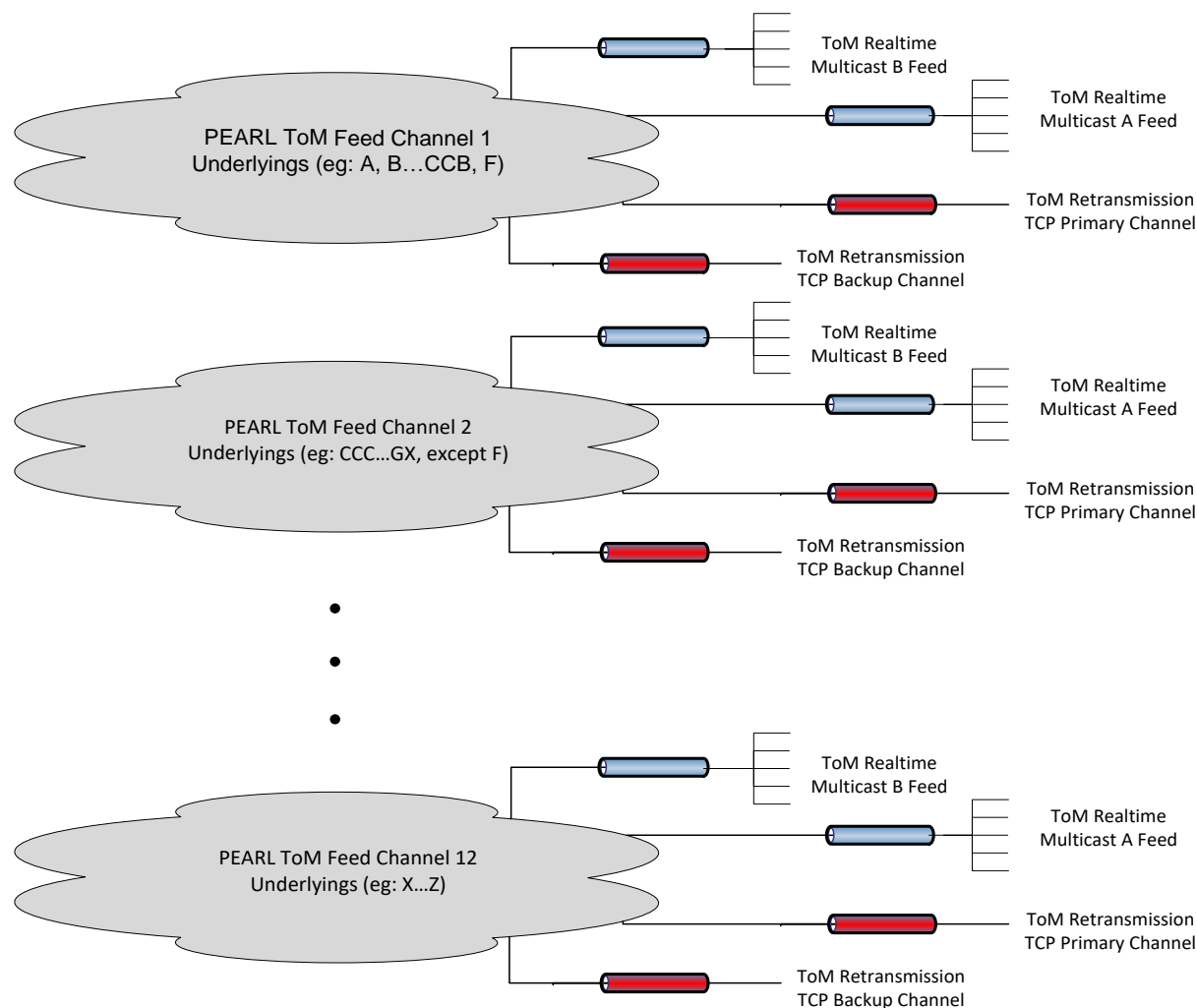
The following table describes the data types used in ToM messaging:

Note: Time fields in all messages are as per timings of United States Eastern Time zone unless specified otherwise.

| Data Type | Description |
|---------------------|--|
| BinaryU | Unsigned, Intel x86 byte-ordered (little-endian), binary encoded numbers |
| BinaryPrc4U | BinaryU Field with the last 4 (right most) digit places being decimal places |
| BinaryPrc2U | BinaryU Field with the last 2 (right most) digit places being decimal places |
| SecTime | BinaryU field that contain transaction time in seconds since Epoch (January 1, 1970, 00:00:00 UTC) |
| NanoTime | BinaryU field that contain transaction time in nanoseconds since past second |
| Alphanumeric | Each place can contain characters or numbers. Left justified and space-padded on the right |

2. ToM Architecture

PEARL Top of Market (ToM) Architecture



Highlights:

- Real-time dissemination is separated out on to 12 separate Feed channels.
- A Feed channel will contain sourced data for all options for a single underlying.
- Any options for any given underlying will only be sourced by a single feed channel on any given day.
- Each Feed channel sources independently from the other groups and hence has independent sequence numbers.
- All the messages on each feed channel will be published in FIFO sequence.
- PBBO data is disseminated on same multicast group as Trades in each of these Feeds.
- High availability is achieved by disseminating identical data on an “A Feed” and “B Feed” for each Feed channel

- Underlyings may not be contiguously distributed according to symbol ranges in each Feed channel.
- Two separate TCP based retransmission channels for each Feed channel supply ToM retransmission via the 3.2 ToM Retransmission Interface.

3. Session Level Protocol

3.1 Real-time ToM Feed

ToM real-time feed uses MIAX's proprietary **MACH protocol**. Each ToM Packet may have multiple application messages and each application message is encapsulated in a MACH protocol packet. Hence a single ToM packet may contain 1 or more sequenced MACH protocol packets.

Please refer to MACH document (available at the [MIAX website](#)) for details about MACH protocol. This protocol layer offers low latency application messaging over multicast, sequencing of messages and heartbeats.

3.2 ToM Retransmission Interface

ToM Retransmission Interface uses MIAX's proprietary **SesM – TCP Session Management Protocol**. Please refer to the latest SesM TCP Session Management document (available at the [MIAX website](#)) for details about SesM session management protocol. This protocol layer offers session management capabilities such as authentication, application messaging over TCP/IP, sequencing of messages, heartbeats and gap fills.

Firms must first use the `Login Request` with a requested sequence number of **zero** to login to the Interface. After receiving a successful `Login Response`, the firm can choose either the 3.2.1 SesM Gap Fill Service or Last Value Refresh Service.

3.2.1 SesM Gap Fill Service

Firms can use the **Retransmission Request** session management message, available in the SesM protocol, to request retransmission of a specific range of packets, identified by sequence numbers.

3.2.2 Last Value Refresh Service

3.2.2.1 Request Message to Pearl

Firms can use the **Unsequenced Data Packet**, available in the SesM protocol, to request a last value refresh of various PBBO market data and status information. The Refresh Request has the following format:

| Field Name | Length | Data Type | Notes |
|-----------------------------|--------|--------------|--|
| SesM Packet Length | 2 | Binary | |
| SesM Packet Type | 1 | Alphanumeric | 'U' – SesM Unsequenced Packet |
| Request Type | 1 | Alphanumeric | "R" – Refresh |
| Refresh Message Type | 1 | Alphanumeric | "P" - Series Update Refresh "Q" –Top of Market Refresh "U" – Underlying Trading Status Refresh |

| Field Name | Length | Data Type | Notes |
|------------|--------|-----------|----------------------------|
| | | | "S" – System State Refresh |

3.2.2.2 Response Message from Pearl

The Retransmission feed will respond to the Refresh request with a series of SesM-TCP “unsequenced packets” based on the Refresh Message Type. Each response message will have the *following format*:

| Field Name | Length | Data Type | Notes |
|----------------------------|--------|---------------|--|
| SesM Packet Length | 2 | Binary | |
| SesM Packet Type | 1 | Alphanumeric | 'U' – SesM Unsequenced Packet |
| Response Type | 1 | Alphanumeric | "R" – TOM Refresh |
| Sequence Number | 8 | BinaryU | Original sequence number from live feed. |
| Application Message | varies | See section 0 | Based on the message type requested. |

The first SesM-TCP packet to be received by the firms will be the 4.1 Pearl System Time Message (See section 4.1 Pearl System Time Message). The timestamp (combined with the nanosecond part in the subsequent messages) represents the most recent Matching Engine transaction time. It is **not** the original timestamp from the MACH sequenced messages in the live feed. *The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).*

3.2.2.3 End of Refresh Notification from Pearl

When the refresh is complete Pearl will send the following message.

| Field Name | Length | Data Type | Notes |
|-----------------------------|--------|--------------|-------------------------------|
| SesM Packet Length | 2 | Binary | |
| SesM Packet Type | 1 | Alphanumeric | 'U' – SesM Unsequenced Packet |
| Response Type | 1 | Alphanumeric | "E" – End of Request. |
| Refresh Message Type | 1 | Alphanumeric | from Refresh Request |

3.2.3 Session Termination

After satisfying the retransmission request, ToM Retransmission Interface will send a Goodbye Packet and disconnect the TCP connection.

Note: Upon receipt of an unknown, malformed or illegal session message, Pearl will send a SesM “Goodbye Packet” with a human readable reason text string and Pearl will disconnect the line.

4. Application Message Formats

This section consists of format of messages sent over the ToM feed.

The time specified in the *Timestamp* field in all the messages below is the time at which the Matching Engine associated with that underlying group published the message. This is the same timestamp that will get included in the messages transmitted on the retransmission interface.

4.1 Pearl System Time Message

This is the message format that will be used to disseminate the “seconds” part of the timestamp that is applicable to all messages that are sent in the current second.

| Field Name | Length | Data Type | Notes |
|---------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | “1” |
| Time Stamp | 4 | SecTime | Seconds part of the time that applies to all messages that gets disseminated until this message gets sent again. |

Points to note:

- Note that this message is only sent when there are any application messages that are going to be sent during any second. Firms are advised to not assume that there will be a message for every second of the day.

4.2 Series Update

This is the message format that will be used to disseminate all Option series traded on Pearl for the current session. The product ID sent in this message is what will be disseminated in Top of Market BBO and Last Sale messages.

| Field Name | Length | Data Type | Notes |
|--------------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | “P” |
| Product Add/Update Time | 4 | NanoTime | Time at which this product is added/updated on Pearl system today. |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| Underlying Symbol | 11 | Alphanumeric | Stock Symbol for the option. |
| Security Symbol | 6 | Alphanumeric | Option Security Symbol |

| Field Name | Length | Data Type | Notes | | | | | | | | | | | | | | |
|---|--------------------|---------------|---|-----------|--------------------|--|--------------|-------------|-----|--------------|--------------|-----|--------------|---------------|-----|---------------|-------------|
| Expiration Date | 8 | Alphanumeric | Expiration date of the option in YYYYMMDD format | | | | | | | | | | | | | | |
| Strike Price | 4 | BinaryPrc4U | Explicit strike price of the option. Refer to data types for field processing notes | | | | | | | | | | | | | | |
| Call or Put | 1 | Alphanumeric | Option Type "C" = Call "P" = Put | | | | | | | | | | | | | | |
| Opening Time | 8 | Alphanumeric | Expressed in HH:MM:SS format. Eg: 09:30:00 | | | | | | | | | | | | | | |
| Closing Time | 8 | Alphanumeric | Expressed in HH:MM:SS format. Eg: 16:15:00 | | | | | | | | | | | | | | |
| Restricted Option | 1 | Alphanumeric | "Y" = Pearl will accept position closing orders only "N" = Pearl will accept open and close positions | | | | | | | | | | | | | | |
| Long Term Option | 1 | Alphanumeric | "Y" = Far month expiration (as defined by Pearl rules) "N" = Near month expiration (as defined by Pearl rules) | | | | | | | | | | | | | | |
| Active on Pearl | 1 | Alphanumeric | Indicates if this symbol is tradable on Pearl in the current session: "A" = Active (tradable) on Pearl "I" = Inactive (not tradable) on Pearl | | | | | | | | | | | | | | |
| Pearl BBO Posting Increment Indicator | 1 | Alphanumeric | This is the Minimum Price Variation as agreed to by the Options industry (penny pilot program) and as published by Pearl <table border="1" data-bbox="824 1024 1386 1220"> <thead> <tr> <th rowspan="2">Indicator</th> <th colspan="2">BBO Increments</th> </tr> <tr> <th>Price <= \$3</th> <th>Price > \$3</th> </tr> </thead> <tbody> <tr> <td>"P"</td> <td>Penny (0.01)</td> <td>Penny (0.01)</td> </tr> <tr> <td>"N"</td> <td>Penny (0.01)</td> <td>Nickel (0.05)</td> </tr> <tr> <td>"D"</td> <td>Nickel (0.05)</td> <td>Dime (0.10)</td> </tr> </tbody> </table> | Indicator | BBO Increments | | Price <= \$3 | Price > \$3 | "P" | Penny (0.01) | Penny (0.01) | "N" | Penny (0.01) | Nickel (0.05) | "D" | Nickel (0.05) | Dime (0.10) |
| Indicator | BBO Increments | | | | | | | | | | | | | | | | |
| | Price <= \$3 | Price > \$3 | | | | | | | | | | | | | | | |
| "P" | Penny (0.01) | Penny (0.01) | | | | | | | | | | | | | | | |
| "N" | Penny (0.01) | Nickel (0.05) | | | | | | | | | | | | | | | |
| "D" | Nickel (0.05) | Dime (0.10) | | | | | | | | | | | | | | | |
| Liquidity Acceptance Increment Indicator | 1 | Alphanumeric | This is the Minimum Price Variation for Quote/Order acceptance as per Pearl rules <table border="1" data-bbox="824 1297 1386 1493"> <thead> <tr> <th rowspan="2">Indicator</th> <th colspan="2">Quoting Increments</th> </tr> <tr> <th>Price <= \$3</th> <th>Price > \$3</th> </tr> </thead> <tbody> <tr> <td>"P"</td> <td>Penny (0.01)</td> <td>Penny (0.01)</td> </tr> <tr> <td>"N"</td> <td>Penny (0.01)</td> <td>Nickel (0.05)</td> </tr> <tr> <td>"D"</td> <td>Nickel (0.05)</td> <td>Dime (0.10)</td> </tr> </tbody> </table> | Indicator | Quoting Increments | | Price <= \$3 | Price > \$3 | "P" | Penny (0.01) | Penny (0.01) | "N" | Penny (0.01) | Nickel (0.05) | "D" | Nickel (0.05) | Dime (0.10) |
| Indicator | Quoting Increments | | | | | | | | | | | | | | | | |
| | Price <= \$3 | Price > \$3 | | | | | | | | | | | | | | | |
| "P" | Penny (0.01) | Penny (0.01) | | | | | | | | | | | | | | | |
| "N" | Penny (0.01) | Nickel (0.05) | | | | | | | | | | | | | | | |
| "D" | Nickel (0.05) | Dime (0.10) | | | | | | | | | | | | | | | |

| Field Name | Length | Data Type | Notes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------------------|----------------------------|--------------|---|--|-------------|----------|-----------|----------|---------------|----------|-------------------------|----------|-----------|----------|--|----------|---------------------|----------|-----------------------------------|----------|--------------------|----------|--------------------|----------|------|----------|------------------------|----------|---------------|----------|--------------------|----------|---------------------------|----------|---------------------------|----------|------|----------|-----|----------|----------------------------|----------|-----------------|----------|----------------------|----------|-------------------|
| Opening Underlying Market Code | 1 | Alphanumeric | Options opening will be triggered on receipt of Opening quote/trade from this Underlying market: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | <table border="1"> <thead> <tr> <th>Market Code</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>NYSE Amex</td> </tr> <tr> <td>B</td> <td>NASDAQ OMX BX</td> </tr> <tr> <td>C</td> <td>National Stock Exchange</td> </tr> <tr> <td>D</td> <td>FINRA ADF</td> </tr> <tr> <td>E</td> <td>Market Independent (Any market that opens first)</td> </tr> <tr> <td>H</td> <td>MIAX Pearl Equities</td> </tr> <tr> <td>I</td> <td>International Securities Exchange</td> </tr> <tr> <td>J</td> <td>EDGA Exchange, Inc</td> </tr> <tr> <td>K</td> <td>EDGX Exchange, Inc</td> </tr> <tr> <td>L</td> <td>LTSE</td> </tr> <tr> <td>M</td> <td>Chicago Stock Exchange</td> </tr> <tr> <td>N</td> <td>NYSE Euronext</td> </tr> <tr> <td>P</td> <td>NYSE Arca Exchange</td> </tr> <tr> <td>Q</td> <td>NASDAQ OMX (via UTP Feed)</td> </tr> <tr> <td>T</td> <td>NASDAQ OMX (via CTA Feed)</td> </tr> <tr> <td>U</td> <td>MEMX</td> </tr> <tr> <td>V</td> <td>IEX</td> </tr> <tr> <td>W</td> <td>CBOE Stock Exchange (CBSX)</td> </tr> <tr> <td>X</td> <td>NASDAQ OMX PHLX</td> </tr> <tr> <td>Y</td> <td>BATS Y-Exchange, Inc</td> </tr> <tr> <td>Z</td> <td>BATS Exchange Inc</td> </tr> </tbody> </table> | Market Code | Description | A | NYSE Amex | B | NASDAQ OMX BX | C | National Stock Exchange | D | FINRA ADF | E | Market Independent (Any market that opens first) | H | MIAX Pearl Equities | I | International Securities Exchange | J | EDGA Exchange, Inc | K | EDGX Exchange, Inc | L | LTSE | M | Chicago Stock Exchange | N | NYSE Euronext | P | NYSE Arca Exchange | Q | NASDAQ OMX (via UTP Feed) | T | NASDAQ OMX (via CTA Feed) | U | MEMX | V | IEX | W | CBOE Stock Exchange (CBSX) | X | NASDAQ OMX PHLX | Y | BATS Y-Exchange, Inc | Z | BATS Exchange Inc |
| | | | Market Code | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | A | NYSE Amex | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | B | NASDAQ OMX BX | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | C | National Stock Exchange | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | D | FINRA ADF | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | E | Market Independent (Any market that opens first) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | H | MIAX Pearl Equities | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | I | International Securities Exchange | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | J | EDGA Exchange, Inc | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | K | EDGX Exchange, Inc | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | L | LTSE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | M | Chicago Stock Exchange | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | N | NYSE Euronext | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | P | NYSE Arca Exchange | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | Q | NASDAQ OMX (via UTP Feed) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | T | NASDAQ OMX (via CTA Feed) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | U | MEMX | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | V | IEX | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| W | CBOE Stock Exchange (CBSX) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | NASDAQ OMX PHLX | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Y | BATS Y-Exchange, Inc | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Z | BATS Exchange Inc | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserved | 12 | BinaryU | ** Reserved for future use ** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Points to note:

- Entire Options list will be disseminated at the start of day.
- In each channel, firms will only receive the series associated with the Engine that is servicing that channel.
- Intra-day updates will also be published as they occur.
- In case of an intra-day reconnection, users can request all Options series data from the ToM retransmission line.

4.3 System State

This message format is used to notify the firms of the state changes of the system. This is a notification that applies to each Underlying group. Firms can use notifications as triggers in their system to ensure electronic synchronization of systems.

| Field Name | Length | Data Type | Notes |
|---------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | "S" |
| Notification Time | 4 | NanoTime | Time at which this was generated by Pearl system. |
| ToM Version | 8 | Alphanumeric | Eg: TOM1.0 |
| Session ID | 4 | BinaryU | Pearl assigned ID for the current trading session |
| System Status | 1 | Alphanumeric | Current system status: "S" = Start of System hours "C" = End of System hours "1" = Start of Test Session (sent before tests). "2" = End of Test Session. |

Points to note:

- Firms must ensure that messages sent on the ToM Feed from the beginning of "start of test session" to the end of "end of test session" will not affect their production session while allowing the firms to still be involved in production tests and dry runs.
- A change in Session ID will mean that restarting at MACH sequence number 1 for that Underlying group. Refer to MACH protocol specification for details about this. Firms must be able to handle more than one trading session in a single trading day.

4.4 Top of Market (Best Bid or Offer) Message – Compact Format

This is the message format that will be used to disseminate each side of the Pearl Top of Market for options with low premiums and small aggregate Pearl Best Bid or Offer (PBBO) size.

| Field Name | Length | Data Type | Notes |
|------------------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | "B" = Top of Market on Bid side "h" = Simple Top of Market on Bid side with Priority Customer establishing new aggressive price "O" = Top of Market on Offer side "I" = Simple Top of Market on Offer side with Priority Customer establishing new aggressive price |
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| PBBO Price | 2 | BinaryPrc2U | Pearl Best price at the time stated in Timestamp and side specified in Message Type |
| PBBO Size | 2 | BinaryU | Aggregate size at Pearl Best Price at the time stated in Timestamp and side specified in Message Type |
| PBBO Priority Customer Size | 2 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Price |

| Field Name | Length | Data Type | Notes | |
|----------------|--------------|--------------|-----------------------|---|
| PBBO Condition | 1 | Alphanumeric | Valid Values: | |
| | | | Condition Code | Description |
| | | | A | Regular (Eligible for Automatic Execution) |
| | | | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) |
| | | | C | Quote is not firm on this side |
| | | | R | ** Reserved for future use ** |
| T | Trading Halt | | | |

Points to note:

- Pearl will only disseminate the side on which the PBBO changed. Firms must preserve the PBBO for the other side until an update is sent for that side.
- PBBO Condition B is sent when there is any Public Customer Interest at the PBBO price.
- Note that Message Type “h” and “i” will be used only when a new Priority customer order establishes a new aggressive BBO price. With all other BBO updates, “B” and “O” will be used as appropriate.

4.5 Top of Market (Best Bid or Offer) Message – Wide Format

This is the message format that will be used to disseminate Pearl Top of Market for options with high premiums or large aggregate Pearl Best Bid or Offer (PBBO) size.

| Field Name | Length | Data Type | Notes |
|-----------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | “W” = Top of Market on Bid side “J” = Simple Top of Market on Bid side with Priority Customer establishing new aggressive price “A” = Top of Market on Offer side “K” = Simple Top of Market on Offer side with Priority Customer establishing new aggressive price |
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| PBBO Price | 4 | BinaryPrc4U | Pearl Best price at the time stated in Timestamp and side specified in Message Type |
| PBBO Size | 4 | BinaryU | Aggregate size at Pearl Best Price at the time stated in Timestamp and side specified in Message Type |
| PBBO Priority Customer Size | 4 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Price |

| Field Name | Length | Data Type | Notes | |
|----------------|--------------|--------------|-----------------------|---|
| PBBO Condition | 1 | Alphanumeric | Valid Values: | |
| | | | Condition Code | Description |
| | | | A | Regular (Eligible for Automatic Execution) |
| | | | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) |
| | | | C | Quote is not firm on this side |
| | | | R | ** Reserved for future use ** |
| T | Trading Halt | | | |

Points to note:

- Pearl will only disseminate the side on which the PBBO changed. Firms must preserve the PBBO for the other side until an update is sent for that side.
- PBBO Condition B is sent when there is any Public Customer Interest at the PBBO price.
- Note that Message Type “j” and “k” will be used only when a new Priority customer order establishes a new aggressive BBO price. With all other BBO updates, “W” and “A” will be used as appropriate.

4.6 Double-Sided Top of Market (Best Bid or Offer) Message – Compact Format

This is the message format that will be used, in the refresh service and during trading hours, to disseminate both sides of the Pearl Top of Market for options with low premiums and small aggregate Pearl Best Bid or Offer (PBBO) size.

| Field Name | Length | Data Type | Notes |
|----------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | “d” (lower case ‘D’) |
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| Bid Price | 2 | BinaryPrc2U | Pearl best bid price at the time stated in Timestamp and side specified in Message Type |
| Bid Size | 2 | BinaryU | Aggregate size at Pearl best bid Price at the time stated in Timestamp and side specified in Message Type |
| Bid Priority Customer Size | 2 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Bid Price |

| Field Name | Length | Data Type | Notes | |
|-------------------------------------|--------------|--------------|---|---|
| Bid Condition | 1 | Alphanumeric | Valid Values: | |
| | | | Condition Code | Description |
| | | | A | Regular (Eligible for Automatic Execution) |
| | | | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) |
| | | | C | Quote is not firm on this side |
| | | | R | ** Reserved for future use ** |
| T | Trading Halt | | | |
| Offer Price | 2 | BinaryPrc2U | Pearl best offer price at the time stated in Timestamp and side specified in Message Type | |
| Offer Size | 2 | BinaryU | Aggregate size at Pearl best offer Price at the time stated in Timestamp and side specified in Message Type | |
| Offer Priority Customer Size | 2 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Offer Price | |
| Offer Condition | 1 | Alphanumeric | Valid Values: | |
| | | | Condition Code | Description |
| | | | A | Regular (Eligible for Automatic Execution) |
| | | | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) |
| | | | C | Quote is not firm on this side |
| | | | R | ** Reserved for future use ** |
| T | Trading Halt | | | |

Points to note:

- PBBO Condition B is sent when there is any Public Customer Interest at the PBBO price.
- *Refresh: The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).*

4.7 Double-Sided Top of Market (Best Bid or Offer) Message – Wide Format

This is the message format that will be used, in the refresh service and during trading hours, to disseminate both sides of the Pearl Top of Market for options with high premiums or large aggregate Pearl Best Bid or Offer (PBBO) sizes.

| Field Name | Length | Data Type | Notes |
|---------------------------|--------|--------------|---|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | “D” |

| Field Name | Length | Data Type | Notes | | | | | | | | | | | | |
|-------------------------------------|---|--------------|---|----------------|-------------|----------|--|----------|---|----------|--------------------------------|----------|-------------------------------|----------|--------------|
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp | | | | | | | | | | | | |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. | | | | | | | | | | | | |
| Bid Price | 4 | BinaryPrc4U | Pearl best bid price at the time stated in Timestamp and side specified in Message Type | | | | | | | | | | | | |
| Bid Size | 4 | BinaryU | Aggregate size at Pearl best bid Price at the time stated in Timestamp and side specified in Message Type | | | | | | | | | | | | |
| Bid Priority Customer Size | 4 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Bid Price | | | | | | | | | | | | |
| Bid Condition | 1 | Alphanumeric | Valid Values: <table border="1" data-bbox="824 722 1424 1079"> <thead> <tr> <th>Condition Code</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Regular (Eligible for Automatic Execution)</td> </tr> <tr> <td>B</td> <td>Quote contains Public Customer interest (Priority & Non-Priority Customer Interest)</td> </tr> <tr> <td>C</td> <td>Quote is not firm on this side</td> </tr> <tr> <td>R</td> <td>** Reserved for future use **</td> </tr> <tr> <td>T</td> <td>Trading Halt</td> </tr> </tbody> </table> | Condition Code | Description | A | Regular (Eligible for Automatic Execution) | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) | C | Quote is not firm on this side | R | ** Reserved for future use ** | T | Trading Halt |
| Condition Code | Description | | | | | | | | | | | | | | |
| A | Regular (Eligible for Automatic Execution) | | | | | | | | | | | | | | |
| B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) | | | | | | | | | | | | | | |
| C | Quote is not firm on this side | | | | | | | | | | | | | | |
| R | ** Reserved for future use ** | | | | | | | | | | | | | | |
| T | Trading Halt | | | | | | | | | | | | | | |
| Offer Price | 4 | BinaryPrc4U | Pearl best offer price at the time stated in Timestamp and side specified in Message Type | | | | | | | | | | | | |
| Offer Size | 4 | BinaryU | Aggregate size at Pearl best offer Price at the time stated in Timestamp and side specified in Message Type | | | | | | | | | | | | |
| Offer Priority Customer Size | 4 | BinaryU | Aggregate size of Priority Customer contracts at the Pearl Best Offer Price | | | | | | | | | | | | |
| Offer Condition | 1 | Alphanumeric | Valid Values: <table border="1" data-bbox="824 1367 1424 1724"> <thead> <tr> <th>Condition Code</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Regular (Eligible for Automatic Execution)</td> </tr> <tr> <td>B</td> <td>Quote contains Public Customer interest (Priority & Non-Priority Customer Interest)</td> </tr> <tr> <td>C</td> <td>Quote is not firm on this side</td> </tr> <tr> <td>R</td> <td>** Reserved for future use **</td> </tr> <tr> <td>T</td> <td>Trading Halt</td> </tr> </tbody> </table> | Condition Code | Description | A | Regular (Eligible for Automatic Execution) | B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) | C | Quote is not firm on this side | R | ** Reserved for future use ** | T | Trading Halt |
| Condition Code | Description | | | | | | | | | | | | | | |
| A | Regular (Eligible for Automatic Execution) | | | | | | | | | | | | | | |
| B | Quote contains Public Customer interest (Priority & Non-Priority Customer Interest) | | | | | | | | | | | | | | |
| C | Quote is not firm on this side | | | | | | | | | | | | | | |
| R | ** Reserved for future use ** | | | | | | | | | | | | | | |
| T | Trading Halt | | | | | | | | | | | | | | |

Points to note:

- PBBO Condition B is sent when there is any Public Customer Interest at the PBBO price.

- *Refresh: The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).*

4.8 Last Sale (Trade) Message

This is the message format that will be used to disseminate Trades that are resulting from executions on Pearl during the current trading session.

| Field Name | Length | Data Type | Notes |
|------------------------------------|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | "T" |
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| Trade ID | 4 | BinaryU | Unique Trade ID assigned to every Trade. |
| Correction Number | 1 | BinaryU | Trade correction number. 0 for New trades. Greater than or equal to 0 for trades resulting from corrections/adjustments. |
| Reference Trade ID | 4 | BinaryU | 0 (zero) if new trade. Trade ID of the original trade if this trade originated as a correction of the original trade. |
| Reference Correction Number | 1 | BinaryU | Correction Number of the trade that was just corrected/adjusted. 0 for new trades. |
| Trade Price | 4 | BinaryPrc4U | Price at which this product traded |
| Trade Size | 4 | BinaryU | Number of contracts executed in this trade |
| Trade Condition | 1 | Alphanumeric | Valid Values: Please refer to Appendix A |

Points to note:

- Most trades generated from Trade corrections will have the same Trade ID and Reference Trade ID. But the correction number of the newer trade is 1 more than that of the reference trade. Some new trades generated from certain types of trade corrections can have a Trade ID different than the original trade and hence they will have correction number of 0.

4.9 Trade Cancel Message

This is the message format that will be used to disseminate canceled Trades that are resulting from Trade cancellations or corrections on Pearl during the current trading session.

| Field Name | Length | Data Type | Notes |
|---------------------------|--------|--------------|---|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | "X" |

| Field Name | Length | Data Type | Notes |
|--------------------------|--------|--------------|--|
| Timestamp | 4 | NanoTime | Nanoseconds part of the timestamp |
| Product ID | 4 | BinaryU | Pearl Product ID mapped to a given option. It is assigned per trading session and is valid for that session. |
| Trade ID | 4 | BinaryU | Trade ID of the Canceled Trade |
| Correction Number | 1 | BinaryU | Trade correction number of the trade being canceled. 0 for New trades being canceled. >=0 if this is cancel of a trade that resulted from corrections/adjustments. |
| Trade Price | 4 | BinaryPrc4U | Trade price of the Canceled Trade |
| Trade Size | 4 | BinaryU | Trade volume of the Canceled Trade |
| Trade Condition | 1 | Alphanumeric | Trade condition of the Canceled Trade Valid Values: Please refer to Appendix A |

4.10 Underlying Trading Status Notification

This message format will be used to notify firms of changes to the trading status of all the options of an underlying.

| Field Name | Length | Data Type | Notes |
|---|--------|--------------|--|
| <i>MACH Protocol Data</i> | | | <i>Refer to MACH Protocol Specification</i> |
| Message Type | 1 | Alphanumeric | "H" |
| Timestamp | 4 | NanoTime | Time at which this was generated by Pearl system. |
| Underlying Symbol | 11 | Alphanumeric | Underlying Symbol |
| Trading Status | 1 | Alphanumeric | "H" = Pearl has halted trading for this Underlying Symbol "R" = Pearl will resume trading (reopen) for this Underlying Symbol "O" = Pearl will open trading for this Underlying Symbol |
| Event Reason | 1 | Alphanumeric | "A" = This event resulted from automatic/market driven event "M" = Pearl manually initiated this event |
| Expected Event Time: Seconds Part | 4 | SecTime | Seconds portion of the expected time of the event. Always use in conjunction with the Nano-seconds part field. |
| Expected Event Time: Nano-Seconds Part | 4 | BinaryU | Nano-seconds portion of the expected time of the event. Specifies number of nano-seconds since the seconds specified in "Expected Event Time Seconds" field. |

Points to note:

- When underlying trading status = "H", Expected Event Time Seconds/Nano-Seconds will be set to 0 (zero).
- When underlying trading status = "R" or "O", Expected Event Time (Seconds/Nano-Seconds Parts) will be set to the time at which the opening/reopening process will start for this Underlying Symbol.

Appendix A: Trade Conditions

Note that the trade conditions below are intended to be aligned with the OPRA trade conditions as a convenience. However, this is not a fixed requirement and, as such, they may digress at times.

Trade conditions sent in the Last Sale and Trade cancel message:

| Condition Code | Description |
|----------------|---|
| Space | Regular |
| A | Cancel of Trade previously reported other than as the last or opening for the particular Option |
| B | Trade that is Late and is out of sequence |
| C | Cancel of the last reported Trade for the particular Option |
| D | Trade that is Late and is in correct sequence |
| E | Cancel of the first (opening) reported Trade for the particular Option |
| F | Trade that is late report of the opening trade and is out of sequence |
| G | Cancel of the only reported Trade for the particular Option |
| H | Trade that is late report of the opening trade and is in correct sequence |
| I | Auto |
| J | Trade due to reopening of an Option in which trading has been previously halted; process as a regular transaction. |
| K | * Reserved for future use * |
| L | * Reserved for future use * |
| M | * Reserved for future use * |
| N | * Reserved for future use * |
| O | * Reserved for future use * |
| P | * Reserved for future use * |
| Q | * Reserved for future use * |
| R | Trade was the execution of an order which was “stopped” at a price that did not constitute a Trade-Through on another market at the time of the stop. Process like a normal transaction except don’t update “last”. |
| S | Trade was the execution of an order identified as an Intermarket Sweep Order (ISO). |
| T | * Reserved for future use * |
| X | Trade that is Trade Through Exempt. The trade should be treated like a regular sale. |
| a | Trade from a Paired PRIME transaction |
| b | * Reserved for future use * |
| c | Trade from PRIME Customer to Customer Cross or PRIME QCC transaction |
| d | * Reserved for future use * |
| e | * Reserved for future use * |
| f | Trade from a Complex transaction that is not Complex stock-tied and does not involve legging |
| g | Trade from a Complex PRIME transaction that is not Complex stock-tied and does not involve legging |

| | |
|----------|---|
| h | Trade from a Complex PRIME Customer to Customer Cross or Complex PRIME QCC transaction that is not Complex stock-tied |
| i | * Reserved for future use * |
| j | Trade from a Complex legging transaction that is not Complex stock-tied |
| k | Trade from a Complex PRIME stock-tied transaction that does not involve legging |
| l | Trade from a Complex PRIME legging transaction that is not Complex stock-tied |
| m | * Reserved for future use * |
| n | Trade from a Complex stock-tied transaction that does not involve legging |
| o | Trade from Complex Customer to Customer Cross stock-tied or Complex QCC stock-tied transaction |
| p | * Reserved for future use * |
| q | * Reserved for future use * |
| r | * Reserved for future use * |
| s | * Reserved for future use * |
| t | * Reserved for future use * |

NOTE: The list of trade conditions above is a superset of those supported by the MIAX Exchange Group for Options. Individual exchanges may or may not emit certain trade conditions depending on the related supported functionality.

Appendix B: Pearl ToM Subscription/Connectivity Information

Please visit MIAx website at <http://www.MIAXGlobal.com> to obtain the most up-to-date information about the following:

- Real-time Feed multicast groups, ports for A feed and B Feed
- Retransmission IP addresses and ports for primary and backup channels.

Appendix C: Contact List

Please visit MIA X website at <http://www.MIAXGlobal.com> to obtain the most up-to-date contact list and other such information.

Appendix D: Revision History

| Revision Date | Version | Description |
|---------------------------|---------|---|
| Sep 30, 2016 | 1.0 | First release. |
| Jan 31, 2017 | 1.0a | Fixed Typo in DataType column of BidPrice and OfferPrice in Double-sided top of market – wide format message. |
| Feb 27 th 2017 | 1.0b | System startup time moved up |
| Jun 10, 2019 | 1.1 | Added new trade conditions to Appendix A. |
| July 25, 2019 | 1.1a | Corrected Appendix A |
| Aug 12, 2020 | 1.1b | Added new Equities exchanges |
| Jul 25, 2023 | 1.2 | Added support for new priority customer indicator |

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