Item 3.7: Order Types and Attributes

Identify and explain each order type offered by the NMS Stock ATS. In your explanation, include the following:

i. priority, including the order type's priority upon order entry and any subsequent change to priority (if applicable); whether and when the order type can receive a new time stamp; the order type's priority vis-a-vis other orders on the book due to changes in the NBBO or other reference price; and any instance in which the order type could lose execution priority to a later arriving order at the same price;

ii. conditions, including any price conditions (e.g., how price conditions affect the rank and price at which it can be executed; conditions on the display or non-display of an order; or conditions on executability and routability);

iii. order types designed not to remove liquidity (e.g., post-only orders), including what occurs when such order is marketable against trading interest on the NMS Stock ATS when received;

iv. order types that adjust their price as changes to the order book occur (e.g., price sliding orders or pegged orders) or have a discretionary range, including an order's rank and price upon order entry and whether such prices or rank may change based on the NBBO or other market conditions when using such order type; when the order type is executable and at what price the execution would occur; whether the price at which the order type can be executed ever changes; and if the order type can operate in different ways, the default operation of the order type;

v. whether an order type is eligible for routing to other Trading Centers;

vi. the time-in-force instructions that can be used or not used with each order type;

vii. the circumstances under which order types may be combined with another order type, modified, replaced, canceled, rejected, or removed from the NMS Stock ATS; and

viii. the availability of order types across all forms of connectivity to the NMS Stock ATS and differences, if any, in the availability of an order type across those forms of connectivity.

STANDARD ORDER TYPES: The ATS supports the following "Standard Order" types:

1) "Limit Order": an order which (if filled) executes at or above (for an order to sell) or at or below (for an order to buy) the User specified price. Limit Orders must include a security (symbol), a side (buy or sell), a limit price, and a maximum quantity (shares);

2) "Peg Order": a type of Limit Order which (if filled) executes at the NBB, NBO, or midpoint of the NBBO (or better) as indicated by execution instructions. Determination of the NBBO and midpoint price follows in Part III Items 11 and 23.

Peg Orders must include a security (symbol), a side (buy or sell), and a maximum quantity (shares). Peg orders can also optionally include a limit price and/or an offset amount. Offset amounts must be expressed in increments greater than or equal to one penny ($.01). Buy orders will not execute at a price greater than the lowest of: the limit price, the NBO, or the peg price plus or minus the offset amount. Sell orders will not execute at a price lower than the greatest of: the limit price, the NBB, or the peg price plus or minus offset amount.

Limit prices greater than or equal to $1.00 must be expressed in increments of at least $.01 (i.e. sub-penny prices are not permitted). Limit prices less than $1.00 must be expressed in increments of at least $.0001. This applies to limit prices on all order types. If a peg order (including offset amount) would result in an effective price at an impermissible increment for a given auction, then the order will not be eligible to participate in that auction.

EXPRESSIVE ORDERS: The ATS also supports Expressive Orders, an order type unique to OneChronos that allows Subscribers or other External Users entering Bidder Logic to specify execution instructions spanning one or more individual Limit Orders. Any Limit Order or collection of Limit Orders referencing Bidder Logic receives treatment as an Expressive Order.

Expressive Orders have four components: 1) Bidder Logic: static functions that take data and return execution instructions. External Users approved to use the Expressive Bidding Service may provide their Bidder Logic via the mechanism described in Part III Item 5 under "ORDER AND BIDDER LOGIC SUBMISSION"; 2) Bidder Inputs: data provided by Subscribers (for example, notional maximum values or symbol ratios/weightings) for use in Expressive Orders. Bidder Inputs are provided as a FIX tag and may be specified on any Target Order entered in connection with a Expressive Order; 3) Market Inputs: market data (e.g. the NBBO) supplied by the Operator as an input to Bidder Logic (see Part III Item 23); 4) Target Orders: Limit Orders submitted by Subscribers via FIX that reference Submitted Bidder Logic upon which such Bidder Logic acts.

BIDDER LOGIC SUBMISSION: Bidder Logic is expressed via computer code in a general-purpose programming language (e.g. ReasonML). A person using the Expressive Bidding Service must submit its Submitted Bidder Logic in advance of its use in any Expressive Order. Bidder Logic is available for use on the first trading day after the calendar day of its receipt by the ATS. The ATS and the programming language itself are sufficiently flexible to allow External Users to create their own constraints that suit their execution objectives, using common mathematical and Boolean constraints. Examples are provided below. Users of the service, as authors of any Bidder Logic, can submit such code to the ATS through the Portal. As detailed in Part III Item 5, Bidder Logic is not itself an order, and orders themselves can only be submitted directly to the ATS by Subscribers. Examples of computations that may be performed using Bidder Logic (and full examples illustrated below in this section):

- Measurement of bid/ask spread and volume imbalance;
- Computation of midpoint prices with custom volume / venue weightings;

- Selection of a subset of stocks (i.e. underlying Target Orders) for participation or elimination;
- Further constraining of prices / quantities expressed in Target Orders to less aggressive levels;
- Expressing indifference across different quantity levels at different price points;
- Requiring execution in multiple stocks simultaneously, or else none at all;

The output of any Bidder Logic is similar to a collection of Boolean constraints (e.g. "AND," "OR") and algebraic constraints (e.g. +, *, < , =), acting on prices and/or quantities for different symbols. For example, a constraint Quantity(A) > 0 AND Quantity(B) > 0 would require that the quantity filled in symbol "A" must be greater than 0 and the quantity filled in symbol "B" must also be greater than 0. A similar, more restrictive constraint would be Quantity(A) = Quantity(B) meaning the share quantity in both symbols must be equal. Either case would represent an intent to "only execute a trade in A if also executing a trade in B." If the constraint cannot be met in the auction, the Expressive Order will not be filled in either A or B.

Upon acceptance, each Bidder Logic submission is systematically evaluated to confirm its properties (e.g. that it can successfully terminate), then assigned a unique reference ID, which is provided back to the user, for inclusion in Target Orders. The Portal provides tools for analyzing and testing properties of Bidder Logic such as the execution instructions that result from the application of specific simulated Bidder Inputs and Market Inputs to the Bidder Logic. Bidder Inputs and Market Inputs are specific to order entry and matching, and are not managed through the Portal. Target Orders are always sent via FIX and must be received by the ATS from Subscribers.

As an illustrative example of execution instructions that are possible with Expressive Bidding, an order seeking to buy three securities in any ratio, up to a total notional amount, would consist of: 1) Bidder Logic (External User controlled): instructions in the form of a computer program to buy any combination of symbols provided as an input to the program (the Bidder Inputs), each at prices less than or equal to their NBBO midpoints (the Market Inputs) up to a fixed notional cap (also specified as a Bidder Input); 2) Bidder Inputs (External User controlled): a list of symbols e.g. ("A", "B", "C") and a notional cap e.g. $500,000.00 included as a FIX tag on one of the Target Orders; 3) Market Inputs (Operator controlled): The NBBO of "A", "B", and "C" as determined by the procedure described in Part III Item 23; 4) Target Orders (External User controlled): three underlying Limit Orders to buy "A", "B", and "C" respectively with corresponding limit prices and maximum volumes;

The FIX message for entering this order would contain an identifier referencing the pre-submitted Bidder Logic, as well as Bidder Inputs. The Bidder Logic would provide for the computation of midpoint prices for each symbol using the Market Inputs provided by the Operator at the time of auction (as described in Part III Item 23).

Additional examples of trading objectives that may be expressed using Expressive Bidding are given below. These examples include constraints and computations which would, in practice, be constructed and submitted as Bidder Logic. These constraints and

computations are shown in a reduced form analogous to Bidder Logic (i.e. a more easily readable format than the programming language used in actual Bidder Logic) to illustrate how Expressive Bidding may be used. In practice, additional constraints for each example may be included to manage combinations of, for example, price, quantity, and or notional limits.

EXAMPLE A: Basket of Substitutes: A trader may have equal preference for one or more stocks in a Bidder supplied list that similarly satisfy some investment objective, e.g.: buy any combination of A, B, and/or C up to a total notional maximum of $1,000,000.

Constraint 1 (notional maximum):

Quantity(A) * Price(A) + Quantity(B) * Price(B) + Quantity(C) * Price(C) <= $1,000,000

EXAMPLE B: "One out of Many" Basket: A trader may wish to transact in only one out of a list of stocks: buy only stock A or stock B, up to the price and quantity limits specified on the underlying Target Orders. The quantities in Constraint 1 are set at > 0 without an upper limit because the trader is relying on the quantity specified in the Target Orders to establish the maximum size of the order.

Constraint 1 (one out of many):

Quantity(A) > 0 XOR Quantity(B) > 0

Note: "XOR" refers to exclusive-or, a logical operation that can be interpreted as "one or the other, but not both". Sequences of multiple other constraints can be used to create similar behavior for 3 or more stocks.

EXAMPLE C: Basket of Complements: A trader may wish to transact if and only if they can do so in multiple stocks simultaneously, e.g.: sell (A and B and C) in equal quantities as a single basket. In this example, each unit of the basket (i.e. 1 share of A, 1 share of B, and 1 share of C) must be sold for a sum of at least $100, or N units for N * $100 (all units of a given basket will have the same price, as auctions clear each symbol at a single price). Alternatively, the quantities for A, B, and C may be expressed as a desired ratio, e.g. reflecting the market capitalization or price per share of the stocks.

Constraint 1A (equal quantities):

Quantity(A) = Quantity(B) = Quantity(C)

Constraint 1B (quantity ratio):

2 * Quantity(A) = 10 * Quantity(B) = 15 * Quantity(C)

Constraint 2 (minimum price per unit):

Price(A) + Price(B) + Price(C) >= $100

EXAMPLE D: Pairs / Hedge Trade: A trader may wish to transact in two different symbols in similar amounts: buy A if and only if selling an approximately equal (within $1,000) notional amount of B.

Constraint 1 (both A and B simultaneously):

Quantity(A) > 0 AND Quantity(B) > 0

Constraint 2 (maximum net notional of +/- $1,000):

-$1,000 < (Price(A) * Quantity(A) - Price(B) * Quantity(B)) < $1,000

Note: side (buy/sell) for A and B would be expressed in the underlying Target Orders. Additional logic could be constructed to identify and select buy vs. sell side Target Orders for participation if Target Orders were provided for both sides.

EXAMPLE E: Dollar Neutral Basket: A trader may wish to purchase and sell a mix of stocks such that the notional amount sold is equal or approximately equal to the notional amount purchased.

Constraint 1 (maximum net notional of +/- $100)

-$100 <= (Notional(A) + Notional(B) + Notional(C)) - (Notional(D) + Notional(E) + Notional(F)) <= $100

It is assumed for simplicity that A, B, and C have corresponding Target Orders to BUY and D, E, and F have corresponding Target Orders to SELL (or vice versa). This can be validated and asserted by the Bidder Logic, or the Bidder Logic can analyze the input Target Orders and arrange the terms of the constraint according to each Target Order's side.

EXAMPLE F: Price Improvement Size-Up: A trader may wish to transact different volumes at different prices: sell up to 500 shares at $20, or sell up to 1,000 shares if the price is more favorable at $21, but not both (i.e. not 1,500 total). This is an example of a Expressive Order that is employed for a single stock.

Constraint 1:

(0 <= Quantity(A) <= 500 AND Price(A) > $20) XOR (500 < Quantity(A) <= 1,000 AND Price(A) > $21)

EXAMPLE G: Imbalance Discretion: A trader may wish to defer the single stock execution decision between bidding at the midpoint price or at a more aggressive price until the time of auction, based on external market conditions measured by the ATS via the SIP and made available as Market Inputs. For example, a trader might wish to enter an order on the following basis: if there is at least twice as much exogenous volume available at the national best offer (NBO) than is available at the national best bid (NBB), then buy 100 shares up to the NBO. Otherwise, buy 100 only up to the midpoint.

Computation on Market Inputs: IF NBO_Volume(A) / NBB_Volume(A) > 2.0 THEN dynamic_price = NBO(A) OTHERWISE dynamic_price = Midpoint(A)

Constraint 1 (set dynamic limit price):

Price(A) <= dynamic_price

For Expressive Bidding, both the parameters of all constituent Target Orders (e.g. limit price) and the constraints provided in Bidder Logic must be satisfied for an execution to occur. Bidder Logic cannot permit an execution that would violate the parameters of the Target Order(s); likewise, Target Order parameters cannot permit an execution that would violate constraints provided in Bidder Logic. For example: an Expressive Order with Bidder Logic specifying willingness to execute multiple orders at the calculated midpoint or better, will not execute if dependent on inclusion of a Target Order whose limit price is less aggressive than the calculated midpoint and the clearing price of the auction.

ORDER AVAILABILITY: The ATS uses periodic call auctions that make use of mathematical optimization techniques to match buyers and sellers. These auctions take place multiple times per second throughout the trading day. Each auction considers all eligible orders across all symbols simultaneously and seeks an "optimal" matching between buyers and sellers as described in Part III Item 11. All order types, including Expressive Orders, are available to all Subscribers of the ATS, and have the same eligibility criteria and time cut-offs for participation in a given auction. Expressive Orders are evaluated (i.e. Bidder Logic code is processed) in each auction prior to the start of the auction's optimization process. Given that Expressive Orders could allow for varying degrees of complexity, their evaluation is resource constrained. That is, each Expressive Order is allocated a finite amount of computation resources and is evaluated prior to the commencement of the Match Optimization process described in Part III Item 11 under the Auction Procedure heading. These computational constraints apply to all Expressive Orders equally (i.e. regardless of order complexity or from whom the ATS received the order). An Expressive Order and its associated Target Orders will not be eligible for the auction if the Expressive Order exceeds its evaluation constraints. Subscribers can opt-in to receive message alerts via FIX that their orders did not participate in a given auction. The ATS provides tools for analyzing the complexity and resource utilization of Expressive Bidding.

ORDER PRIORITY: The ATS periodically holds auctions (multiple times per second) designed to seek an optimal matching between buyers and sellers across all eligible orders. Each order's eligibility for participation is determined by its time-stamped receipt at one of the Operator's distributed PoPs (the Operator is commencing operation with a single PoP, in Equinix NY5). Executions, allocations, and per symbol clearing prices are determined using mathematical optimization techniques, maximizing Aggregate Price Improvement dollars across eligible orders in a given auction. See Part III Item 11 under the Distributed Point of Presence System and Auction Procedure headings for specific details.

EXECUTION INSTRUCTIONS: The ATS supports a set of execution instructions applicable to both of its Standard Order types (Limit Orders and Peg Orders) at the FIX layer. These execution instructions also apply to the Target Orders that are used in connection with Expressive Bidding. Subscribers may use these execution instructions on a per order basis, subject to system bounds established and imposed by the ATS itself as described in Part III Item 8. The following execution instructions are available: 1) Price Limit (minimum price verification on a per-share basis); 2) Maximum number of shares; 3) Minimum number of shares; 4) Time-in-force: Day, Immediate or Cancel, Fill or Kill, Good 'Til Date (with an expire time not to exceed the end of the current trading session);

These message-layer constraints cannot be overridden by Expressive Bidding and Bidder Logic.

ORDER CANCELLATION, MODIFICATION, AND REPLACEMENT: the ATS does not support modification of resting orders, but Subscribers can cancel and replace orders with either a single cancel-replace request or two separate cancellation and new order entry requests. Order entry and cancellation requests are processed as described in Part III Item 11(c).

ROUTING: The ATS does not route orders to other trading centers.

The ATS does not support any order types designed not to remove liquidity, as the ATS does not distinguish between providing and removing liquidity.

CUSTOM COUNTERPARTY GROUPS: As described in Part III Item 14, the ATS offers functionality for Subscribers to specify custom groups of counterparties against which to execute on an order-by-order basis.

Are the terms and conditions for each order type and attribute the same for all Subscribers and the Broker-Dealer Operator?

Y

If no, identify and explain any differences.

Item 3.11: Trading Services, Facilities and Rules

Provide a summary of the structure of the NMS Stock ATS marketplace (e.g., crossing system, auction market, limit order matching book) and explain the means and facilities for bringing together the orders of multiple buyers and sellers on the NMS Stock ATS.

MATCHING SYSTEM: Rather than matching orders continuously as they arrive at the matching engine (as in a continuous limit order book) the ATS periodically holds auctions designed to seek an optimal matching between buyers and sellers across all eligible orders. As part of this mechanism, Subscribers can enter Limit Orders or Peg Orders in single securities or, by the use of Expressive Bidding, specify execution instructions that span one or more securities. Expressive Bidding allows External Users to express constraints on one order or a group of related orders to fit their business specific execution and or risk management objectives. For example, an Expressive Order may enforce an aggregate limit on notional dollars transacted across simultaneous executions in orders for multiple securities, in addition to price and quantity limits on those individual orders. As explained in Part III Item 7, Expressive Orders are comprised of Target Orders sent via FIX by Subscribers; Bidder Logic (computer code specifying constraints); Bidder Inputs to complement the Bidder Logic as it may apply to a given Target Order, and Market Inputs (i.e. Market Data). Auctions are multilateral: one or more buyers can match against one or more sellers. Within a given auction the mechanism computes per-security uniform transaction prices that apply to all buyers and sellers of that security. The ATS matching mechanism is a call auction in that order matching happens at a specific point in time. All NMS stocks are eligible to trade in the ATS, with the exception of any NMS stocks that cannot be processed by the ATS's clearing or trade reporting partners. Eligibility is subject to procedures described in Part III Item 10 (Opening Procedure).

DISTRIBUTED POINT OF PRESENCE SYSTEM: The Operator maintains a distributed and time-synchronized PoP system at multiple data centers for order entry and market data intake (see also Item III, Part 5 above for further information on the PoP system). Although matching happens at a centralized location, Subscribers can enter orders at any PoP. PoP arrival timestamps dictate order eligibility. Orders received at a PoP by a Cutoff Timestamp (the "Cutoff" or "Cutoff Time") selected by the ATS for a given auction are eligible for matching in that auction; orders received after the Cutoff are not eligible until the next auction. By using PoP arrival timestamps (rather than matching engine arrival timestamp) as described below, the distributed PoP system endeavors to promote equality of access to Subscribers with systems located in different geographies. The Operator is commencing operation of the ATS with a single PoP in Equinix NY5 at 800 Secaucus Road, Secaucus, New Jersey 07094.

ORDER ENTRY AND EXECUTION PROCESS: PoPs apply high precision (recorded in nanoseconds) timestamps to orders as they arrive. After receiving a timestamp, orders proceed to the matching engine located at Equinix NY5 in Secaucus, NJ. Orders are eligible for all auctions with a Cutoff Time greater than or equal to their PoP timestamp. The Cutoff Time is also used as a basis for computing NBBO (see Part III Item 23). Aside from the determination of orders' eligibility, the auctions have no notion of time priority (i.e. all

orders participating in the same auction are on parity from a time perspective). Price priority and share allocation proceeds per the mechanism described in Part III Item 11(c).

Because orders require time to propagate from their entry PoP to the matching engine, the matching engine pauses for a duration (the "Buffer Window" or "Buffer") long enough to allow the arrival of market data from the SIP as well as orders from all PoPs before commencing an auction. The duration of the Buffer Window is calibrated based on measured historical and real-time network latencies and may change over time but will remain on the order of milliseconds or tens of milliseconds. This Buffer seeks to prevent orders entered at PoPs further (in the sense of network transmission time) from the matching engine from experiencing a time disadvantage relative to PoPs closer to the matching engine. Execution report dissemination uses a similar system as described in Part III Item 21.

Are the means and facilities required to be identified in Item 11(a) the same for all Subscribers and the Broker-Dealer Operator?

Y

If no, identify and explain any differences.

Explain the established, non-discretionary rules and procedures of the NMS Stock ATS, including order interaction rules for the priority, pricing methodologies, allocation, matching, and execution of orders and trading interest, and other procedures governing trading, such as price improvement functionality, price protection mechanisms, short sales, locked-crossed markets, the handling of execution errors, and the time-stamping of orders and executions.

The core mechanism underlying execution on the ATS is the combinatorial call auction process. This auction process uses a matching optimization formula that considers orders in all securities in a given auction simultaneously in an effort to identify mutually beneficial matches between buyers and sellers across the ATS's entire market.

AUCTION PROCEDURE: In summary, auctions consist of the following steps: 1) "Initialization Time": an auction Cutoff Time (as defined in the following paragraph) is randomly chosen per the procedure described below as the start of an auction; 2) "Auction Network Buffer" (or "Buffer"): this Buffer is intended to allow orders and market data enough time to arrive from distant PoPs as described in Part III Item 11(a). More specifically, the Buffer allows sufficient time for orders and market data to arrive from the furthest (measured in network transmission time) PoP from the matching engine. The length of the Buffer can vary based on expected transmission times, but would typically be on the order of milliseconds or tens of milliseconds; 3) "Match Optimization": ATS systems evaluate Expressive Orders and run the combinatorial matching process, which determines prices and share allocations across all symbols; 4) "Post Auction Network Buffer": upon completion of the Match Optimization process, the matching engine broadcasts auction results to all PoPs. Each PoP waits until a pre-determined time (which always precedes the following auction's Cutoff), to distribute execution reports, thereby providing a synchronized dissemination of such data externally. As with the Auction Network Buffer, the length of the Post Auction Network Buffer can vary based on expected transmission

times, but would typically be on the order of milliseconds or tens of milliseconds; 5) “Data Dissemination”: at the conclusion of the Post Auction Network Buffer period, PoPs communicate auction results in the form of execution reports to external parties, including Subscribers, the ATS’s direct clearing provider, and the Trade Reporting Facility.

The complete lifecycle of these steps spans a timescale of less than 100 milliseconds. Auctions occur at discrete “Cutoff Times”, following the completion of the prior auction lifecycle, drawn at random within a range of 20 milliseconds to 200 milliseconds from the previous auction. When the Auction Network Buffer has elapsed, the matching engine establishes order eligibility per the PoP arrival timestamps as described in Part III Item 11(a). At this point, Market Inputs used by Expressive Orders and the data used for constructing NBBO is final. See Part III Item 23 under MEASUREMENT OF MARKET DATA AND NBBO for a detailed explanation of NBBO construction. All ATS timestamps, including those that appear on execution/trade reports, are recorded in nanoseconds.

ORDER ELIGIBILITY: Orders entered into the ATS are “firm.” Subscribers can send cancellation requests for resting orders. Cancellation requests received and timestamped before the Cutoff Time have immediate effect. Cancellation requests received after the Cutoff Time but before the completion of the auction cycle do not have effect until the following cycle (and therefore the order may still participate in the auction notwithstanding the cancellation request). The order entry system removes the referenced order from the matching engine as soon as the next auction window opens if the order is still present (not filled) and rejects it otherwise. With regards to a partial fill, the residual quantity is treated as the maximum fill quantity for the order in subsequent auctions, unless its time-in-force instructions dictate that it be cancelled.

RISK CONTROLS: After determining order eligibility (per Part 3 Item 11(a)) and selecting market data (per Part 3 Item 23) upon the completion of the Auction Network Buffer, the ATS carries out a series of pre-match market quality and risk checks. These consist of testing for locked and crossed markets (rules for trading during locked and crossed markets follow later in this section), verifying that user configured risk checks pass, and flagging “clearly erroneous orders” as ineligible. For Subscriber controlled risk checks, the following parameters are configurable within the bounds established by the ATS (see Part III Items 7 and 8 for minimum and maximum values): 1) Total notional value maximums per order; 2) Total quantity maximums per order; 3) Symbol restrictions; 4) Short sale restrictions; 5) Self-Trade prevention by MPID and/or FIX session;

As an additional risk control, orders with External User-supplied prices 10% or more aggressive than the NBBO are not eligible for participation. The ATS rejects orders for which this is true at the time of submission. Subscribers can configure this behavior to be more restrictive (i.e. less than 10%) but not less restrictive (i.e. greater than 10%). The ATS may also enforce share quantity and notional value constraints according to maximums put in place by the ATS’s clearing provider.

MATCH OPTIMIZATION: After identifying a set of eligible, risk checked orders, matching can proceed. Matching is conducted via a uniform clearing price combinatorial auction - a form of mathematical optimization that attempts to match one or more buyers with one or

more sellers in a fashion that maximizes the chosen objective(s) while enforcing constraints. Because orders can include constraints that span securities (e.g., buy A if and only if an accompanying order for B gets filled) the optimization process must run over all securities simultaneously. The optimization procedure includes a rule that the solution found must respect the constraints placed on orders by participants (e.g. price limits, volume ratios) as well as the market wide constraints placed by the ATS (e.g., ensuring that aggregate buy fill volume equals aggregate sell fill volume on a security-by-security basis).

The ATS optimization process consists of multiple optimization techniques (see "Additional Details on Optimization" below) that attempt to maximize the following two objectives:

1) Aggregate Price Improvement: the optimization attempts to maximize the total price improvement realized across all orders eligible to participate in the auction, incorporating both price per share and number of shares filled. For an individual order to buy or sell a single security, "Price Improvement Dollars" refers to the difference between the limit price on the order and the auction clearing price (i.e. the price at which the order is filled) for the given security, times the quantity filled. For an Expressive Order to buy and/or sell multiple securities simultaneously, price improvement refers to differences in limit prices and clearing prices for each respective security, summed across all securities times the quantities filled. See below under "Priority and Price Formation Example" for information on treatment of NBBO. When considering a crossed buy and sell order for a security, Price Improvement Dollars can be calculated as the difference between limit prices for the two orders. Aggregate Price Improvement represents the sum of Price Improvement Dollars across all eligible orders under consideration for a given optimization solution, and across all securities. As a result, it is possible that an order (i.e. Standard Order or Expressive Order) may receive lower match priority in favor of an Expressive Order containing a less aggressively priced Target Order in the same security. This can occur if and only if prioritizing the less aggressive order results in greater Aggregate Price Improvement to a given auction (see a specific example lower in this section under heading: Priority And Price Formation Example). In other words, maximizing Aggregate Price Improvement is the dominant and first objective of the optimization.
2) Volume: as a secondary objective, the optimization attempts to maximize the total share volume cleared in aggregate across all securities.

Each optimization technique evaluates these two objectives in succession, producing one or more sets of potential executions ("solutions"). The solution with the highest value of the first objective is selected. In the event multiple solutions have an equal value for the first objective, the solution with the highest value of the second objective is selected. A solution that represents the largest value of the objective function possible is known as globally optimal. Given finite computing resources obtaining globally optimal solutions is not always possible. Furthermore, globally optimal solutions are not always unique in that multiple solutions might yield identical values for the optimization objective. The ATS is designed such that solutions: a) do not violate constraints placed on orders by users or the global constraints placed by the ATS, such as those described below under "LOCKED AND CROSSED MARKETS" and those in Part III Item 20; and b) are optimal amongst the

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solutions explored during the optimization process. In the event that multiple solutions are equally optimal (i.e., have equal values for both the first and second objectives), any candidate in the set of equally optimal solutions may be selected based on which solution maximizes the average fill size of each execution, or a solution may be chosen randomly. The tie-breaking logic is the same for all Subscribers and in all cases does not consider the identity of Subscribers or the identities of their respective clients.

Once a solution to the optimization is identified, clearing prices are determined for each symbol. A solution to the optimization represents a matching of buyers to sellers for which it is possible to find a list of per-security auction clearing prices (the "price vector"). For a given auction, all orders selected for participation via the solution to the optimization receive fills at the same clearing price on a per-security and, where applicable, a per-Custom Group (see below) basis. A given output to the optimization might yield more than one possible set of clearing prices (solution). When more than one possible set of clearing prices is identified, the ATS then uses a secondary procedure that seeks to identify distinct per-security clearing prices at the middle of the feasible range of clearing prices. In the absence of a two-sided quote (measured as described in Part III Item 23) the optimizer uses the last trade price (also measured as described in Part III Item 23) instead of the midpoint. The optimization solution represents a matching of buyers and sellers and is the mechanism for establishing order priority and share allocation.

When orders with identical sets of constraints enter the auction (e.g. Limit Orders for the same security at the same limit price with no further constraints) an individual optimization technique may treat them as components of a single, larger "synthetic" order. When this approach results in a partially filled synthetic order (i.e. when there is insufficient volume on the contra side to fill the entire synthetic order), allocation to constituent orders happens via a randomized round-robin mechanism. Round-robin allocation is equivalent to: 1) Assigning a random sequencing to all constituent orders; 2) Allocating a random number of shares (up to 100 shares at a time) to constituent orders according to the random sequence, honoring all constraints (e.g. maximum quantity); 3) Repeating step 2 above until the supply of available contra shares runs out.

In the case where only Limit Orders and Peg Orders with no further constraints (i.e. beyond price / quantity constraints) are eligible to participate for a given security (in a given auction), the ATS match process behaves the same as described above.

CUSTOM COUNTERPARTY GROUPS: As described in Part III Item 14, the ATS offers functionality for Subscribers to specify Custom Groups of counterparties against which to execute on an order-by-order basis. The optimization logic for determining which orders execute, and at what price, is the same for orders within a Custom Group as for orders outside the Custom Group. Subscribers may provide an execution instruction on their Custom Group order to specify whether they would like their order to only execute against other orders in the Custom Group (which is also the default behavior if no instruction is provided) or, they may provide an execution instruction to allow residual quantity ("leaves") in a given auction to execute outside of the Custom Group.

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All orders in a given security that do not execute as part of a Custom Group will execute at the same price in a given auction. Given the different set of counterparty liquidity within Custom Groups, Custom Group orders may receive executions at different (i.e. potentially better or worse) prices than orders not in that particular Custom Group. As also discussed in Part III Item 14, orders may participate in multiple Custom Groups simultaneously. In this scenario, an order may be executed at unique prices per Custom Group in which it executes. As discussed in Part III Item 21, the OneChronos ATS submits one trade report per price per symbol per auction.

ADDITIONAL DETAILS ON OPTIMIZATION: Combinatorial auctions belong to a class of computationally intensive search and optimization tasks known as non-deterministic polynomial-time (NP) hard problems. Given that problem instances (auctions) could allow for varying degrees of complexity and therefore computational requirements, they cannot always be exhaustively evaluated. Accordingly, the ATS uses time and resource bounded optimization techniques whereby computational resources are utilized over a period of time lasting on the order of 10s of milliseconds. The amount of resources to be used for a given auction optimization cycle is fixed a priori and arrived at without knowledge of the orders participating in a given auction cycle. Between auctions, the total amount of resources available for optimization may fluctuate as a function of historical and expected future need for computational resources. While these optimization techniques are intended to improve the efficacy of the matching process, they might not identify a globally optimal solution in every scenario. Specifically, the optimizer makes decisions about the allocation of finite computing resources to exploring subsets of the solution space in ways that might leave portions of the search space unexplored.

To ensure that the optimization techniques utilized by the ATS do not result in a "worse" overall outcome for Subscribers than if the ATS utilized individual security-by-security order books for matching securities, every auction includes a "lower bounding" procedure. The lower bounding procedure is deterministic and works by computing the value of the hierarchical objective strictly considering the components of Limit Orders, and Peg Orders. This produces a similar set of outcomes as a traditional per-security call auction would if it were to use a similar matching objective. As such, it places a deterministic lower bound on the performance of the optimization. A solution found through this deterministic search process is selected if it maximizes the objective function more than other solutions found by the optimization process.

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PRIORITY AND PRICE FORMATION EXAMPLE: An illustrative example of the ATS optimization, order priority, and price assignment procedure follows. Expressive Bidding constraints are expressed in a similar reduced form to the examples above.

SELLERS' ORDERS: 1) Seller S1: An Expressive Order (including Target Orders) detailed just below 2) Seller S2: Sell C, LIMIT 500 @ $23

Seller S1 Bidder Logic: - Constraint 1: all quantities must be equal: Quantity(A) = Quantity(B) = Quantity(C) - Constraint 2: total basket price must be at least $110: Price(A) + Price(B) + Price(C) >= $110

Seller S1 Target Orders: 1) Sell A, LIMIT 500 @ $52; 2) Sell B, LIMIT 500 @ $30; 3) Sell C, LIMIT 500 @ $25;

BUYERS' ORDERS: 1) Buyer B1: Buy A, LIMIT 100 @ $54; 2) Buyer B2: Buy B, LIMIT 100 @ $34; 3) Buyer B3: Buy C, LIMIT 100 @ $27;

In this example, Seller S2 would not receive a fill because despite pricing its order more aggressively than Seller S1 ($23 vs. $25), filling Seller S1 would result in greater Aggregate Price Improvement and therefore represents a more optimal solution under the ATS's defined auction procedure. This is demonstrated in the matching arrangement below. See above for more information regarding the matching objective function. Matching would occur as follows: 1) Symbol A: Buyer B1 <> Seller S1, 100 shares; 2) Symbol B: Buyer B2 <> Seller S1, 100 shares; 3) Symbol C: Buyer B3 <> Seller S1, 100 shares;

Aggregate Price Improvement for this arrangement is calculated as:

100 * ($54 - $52) + 100 * ($34 - $30) + 100 * ($27 - $25) = $800

Note that execution prices are not assigned until one or more arrangements maximizing the first optimization objective (Aggregate Price Improvement) has been found. However, this calculation does take into account Bidder Logic constraints. This arrangement will only be considered if it permits potential execution prices that satisfy Bidder Logic constraints. In this case, quantities are equal and there are multiple price vectors that sum to greater than $110, so the arrangement can satisfy Seller S1's Bidder Logic constraints.

Consider an alternative auction outcome in which Seller S2 is included. Including Seller S2 exhausts the 100 shares of demand for C, leaving 0 shares of C for Seller S1. Because Seller S1 must receive equal quantities of each symbol under its first Bidder Logic constraint, Seller S1 is unable to transact in A and B despite having priced its orders such that it may cross with Buyer B1 and Buyer B2 respectively. And because Seller S1's orders in A and B cannot be executed, Buyer B1 and Buyer B2 are also not able to transact, despite having priced their orders such that a cross is possible in A and B.

The matching arrangement including Seller S1 is chosen by the objective function because it provides $800 of Aggregate Price Improvement, which is greater than the $400 (100 * ($27 - $23)) provided in a matching arrangement where Seller S2 does participate (in which case only Symbol C is transacted).

Note: for the purpose of calculating Aggregate Price Improvement, orders with Limit Prices outside the opposite NBBO measured by the ATS as described in Part III Item 23 are considered to be priced at the NBO (for Buy orders) or NBB (for Sell orders).

This example illustrates the property of Aggregate Price Improvement where a more aggressively priced order in a single security (from Seller S2) would, in this example case, receive lower match priority in favor of an order for multiple securities (from Seller S1), despite the latter order offering a less aggressive price in the given security. This is possible in cases where another participating order contributes as much or more Aggregate Price Improvement to the auction. The goal of Aggregate Price Improvement is to encourage overall market-wide liquidity formation by considering both price and quantity across all

orders, in all securities, simultaneously (rather than price alone on a security-by-security basis) as the primary factor dictating priority.

To expand this comparison further, consider an example similar to the above, but in which Seller S1 entered less aggressive prices with only $1 of price improvement between Seller S1's target orders and the Buyers' orders in their respective securities. The aggregate price improvement contributed would be substantially lower: 100 * $1 * 3 = $300. Because the matching arrangement including Seller S2 and not Seller S1 offers $400 of Aggregate Price Improvement, Seller S2's order would be selected to participate and Seller S1 would not participate.

EXECUTION PRICE FORMATION: With regards to execution price selection: after selecting the first matching arrangement in the example above, an execution price for each symbol is determined. Any price in the range between the Seller's limit prices and the respective Buyers' limit prices is equally optimal (i.e. clears the same volume). In such a case, "midpoint affinity", which refers to selecting the middle of the range of feasible clearing prices when all else is equal (i.e. constraints are satisfied and objective function values are equal), is used as a tie-breaker in each symbol. The auction clears as follows: 1) Execute 100 A @ $53; 2) Execute 100 B @ $32; 3) Execute 100 C @ $26;

LOCKED AND CROSSED MARKETS: The ATS flags securities as locked or crossed at the start of each auction using the NBBO "snapshot" created using the procedure described in Part III Item 23(a) "MEASUREMENT OF MARKET DATA AND NBBO." Because the time scales on which auctions run (10s of milliseconds) are much longer than the duration of a typical locked market (< 100 microseconds) the ATS allows Subscribers to specify via a port level setting if their orders for locked securities should remain eligible for the auction. Subscribers making this election might receive executions during a locked market. The default setting permits executions during locked markets. The ATS does not execute trades in crossed securities as measured by the process described in Part III Item 23. Securities that were not crossed at the time of measurement (i.e. at the Cutoff Time) but become crossed during the auction may still receive fills.

EXECUTION ERRORS: The Operator maintains Written Supervisory Procedures that include procedures for handling execution errors. Execution errors may be the result, for example, of an ATS system failure, an error on the part of an ATS Subscriber, or an error in data (e.g. NBBO) provided to the ATS and used in executing a trade. In any of these cases, ATS personnel contact all Subscribers party to the transaction or transactions affected by the error and determine the appropriate course of action. If all Subscribers party to the trade wish to keep the trade in place and applicable FINRA, SEC, and SRO rules allow, no action is taken and the trade is processed. If one or more of the Subscribers wishes to break or correct a trade, the Operator may accordingly cancel or issue corrections for erroneous trades. If the Operator determines a transaction to be a bona fide error, the Operator may in its sole discretion accept erroneous legs of a transaction into an error account maintained with the Operator's clearing provider. The Operator promptly trades out of any positions it takes into the error account via execution services offered by its clearing provider. The CCO reviews all activity in the Operator's error account on a monthly basis to

ensure that the account maintains a zero balance and that the account is only used for bona fide errors.

Are the established, non-discretionary rules and procedures required to be identified in Item 11(c) the same for all Subscribers and the Broker-Dealer Operator?

Y

If no, identify and explain any differences.

Item 3.14: Counter-Party Selection

Can orders or trading interest be designated to interact or not interact with certain orders or trading interest in the NMS Stock ATS (e.g., designated to execute against a specific Subscriber's orders or trading interest or prevent a Subscriber's order from executing against itself)?

Y

If yes, explain the counter-party selection procedures, including how counter-parties can be selected, and whether the designations affect the interaction and priority of trading interest in the ATS.

SELF-TRADE PREVENTION: The ATS provides a "self-trade prevention" mechanism which allows Subscribers to prevent their own orders from matching with one another (i.e. to prevent an order entered by the Subscriber from matching with another order entered by the same Subscriber), as described in Part III Item 11.

CUSTOM COUNTERPARTY GROUPS: The ATS offers functionality for Subscribers to specify Custom Groups of counterparties against which to execute on an order-by-order basis.

OneChronos will set up a specific Custom Group at the request of one or more Subscribers that wish to form a particular grouping, and assign them a particular Group Id. A Subscriber must provide their consent for their orders to participate in a Custom Group. Clients of Subscribers can request that OneChronos set up a Custom Group, in which case the Subscriber routing their orders to OneChronos must be willing to pass through the Group Id pertaining to their client's Custom Group, on the orders that should participate in the Custom Group.

OneChronos also supports combining Custom Groups into a composite group, with its own composite Group Id, and the specification of the composite group on an order via a composite Group Id. When this feature is utilized, the order will be eligible to execute against all Custom Groups in the composite group, where the user is an existing member of those Custom Groups. Which Custom Group or Custom Groups the order executes against will be determined by which set of executions best satisfies the objective function as specified in Part III Item 11. As also discussed in Part III Item 11, orders that participate in multiple Custom Groups may receive fills at distinct prices per Custom Group.

The Custom Group functionality is generally available to any Subscriber or client of a Subscriber that wishes to use it, however, OneChronos in its sole discretion may deny usage of Custom Group functionality to a Subscriber or their client in a manner consistent with the conditions discussed in Part III Item 3.

As detailed in Part III Item 11, executions that occur within a Custom Group may execute at a different price from orders in the same auction that execute outside of the Group.

If yes to Item 14(a), are the procedures for counter-party selection required to be identified in Item 14(a) the same for all Subscribers and the Broker-Dealer Operator?

Y

If no, identify and explain any differences.

Item 3.19: Fees

Identify and describe any fees or charges for use of the NMS Stock ATS services, including the type of fees (e.g., subscription, connectivity), the structure of the fees (e.g., fixed, volume-based, transaction-based), variables that impact the fees (e.g., types of securities traded, block orders, form of connectivity to the ATS), differentiation among types of Subscribers (e.g., broker-dealers, institutional investors, retail) and range of fees (e.g., high and low).

The fees charged for using the ATS are calculated on a per-share basis. The fee is the same for all types of transactions, with discounts available based on a Subscriber's total traded quantity over the course of a calendar month. The base rate fee is $0.0010 per share.

The commission structure is the same for all Subscribers.

The Operator may offer an introductory discount period, pertaining to new Subscribers, new functionality, or existing Subscribers' initial use of existing functionality (see Item 19c) for which the Operator determines the discount amount and length of the discount period. The discounted fees will generally be between $0.0000 and $0.0005 per share. The length of the discount period will generally be 3 to 6 months, subject to revision at the Operator's discretion (e.g. based upon onboarding progress).

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In addition to the ATS's fees, the ATS may pass through clearing and regulatory fees it is assessed (e.g., NSCC, FINRA Section 3 fees, and Trading Activity Fees) to Subscribers.

The ATS does not charge Subscribers for network connectivity, access, or execution data. Nor does the ATS compute different fees based on the type or content of orders executed.

Identify and describe any fees or charges for use of the NMS Stock ATS services that are bundled with the Subscriber's use of non-ATS services or products offered by the Broker-Dealer Operator or its Affiliates, including a summary of the bundled services and products, the structure of the fee, variables that impact the fee, differentiation among types of Subscribers, and range of fees.

No such fees are charged; no additional services are bundled with the use of the ATS.

Identify and describe any rebate or discount of fees or charges required to be identified in Items 19(a) and 19(b), including the type of rebate or discount, structure of the rebate or discount, variables that impact the rebate or discount, differentiation among types of Subscribers, and range of rebate or discount.

INTRODUCTORY DISCOUNTS:

The Operator may offer three types of introductory discounts, at its discretion, as described in Item 19a. Discounts may be available:

1) To new Subscribers to the ATS, in the form of discounted fees on their executions.
2) When the Broker-Dealer Operator introduces new functionality (e.g., order types, order instructions) in the form of discounted fees on executions resulting from the new functionality.

3) When an existing Subscriber is using existing functionality (e.g., order types, order instructions) for the first time.

In all of the above cases, the amount of the discount, and the amount of time for which the discount applies may be negotiated with an individual Subscriber, but will be in line with the ranges discussed in Item 19a. Factors involved in determining the amount of discount and the time for which the discount applies include but are not limited to the Subscribers anticipated volume, the characteristics of their orders (for example the number of symbols traded, average order size, amount of price improvement, duration of orders), and their usage of new ATS functionality.

VOLUME-BASED TIERING:

The Operator offers volume-based tiering where Subscribers can pay lower fees, as follows:

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If a Subscriber's total traded volume for a calendar month is greater than or equal to 5% of OneChronos total matched volume for the calendar month, the Subscriber will incur a fee of $0.0007 per share.

If a Subscriber's total traded volume for a calendar month is greater than or equal to 7% of OneChronos total matched volume for the calendar month, the Subscriber will incur a fee of $0.0005 per share.

The Base Rate is the same for all Subscribers. Any discount will be calculated retroactively on all shares traded for that calendar month. Subscribers' traded volume and OneChronos matched volume are computed as the sum of total shares traded/matched across all securities.

Item 3.21: Trade Reporting

Explain any procedures and material arrangements for reporting transactions on the NMS Stock ATS, including where an ATS reports transactions and under what circumstances.

The ATS reports transactions as follows: 1) Execution reports to Subscribers; 2) Trade Reporting Facility (TRF) reports (sent to the FINRA/NYSE TRF); 3) Clearing reports to the ATS's clearing provider; 4) Rule 605, Rule 606, CAT, and ATS-R Reports (sent to FINRA); 5) Drop Copy reports upon Subscriber request;

After each auction, execution reports are transmitted to each Subscriber reflecting their individual participation (fills, partial fills, "leaves") in the auction. These reports contain, for each order that participated in the auction: symbol, clearing price, volume filled, and side (buy or sell). In the case of a partial fill the execution report contains a "Leaves Quantity" field representing the remaining shares available to be filled for the order.

Modifications made to orders are acknowledged within execution reports. This includes cancellations and automatic adjustments made by the ATS (such as automatically reducing max volume constraints in response a partial fill, as described above).

To foster equal access across all geographies the ATS disseminates execution reports from PoPs at the same time (as detailed in Auction Procedure within Part III Item 11).

Because of the time required for the Buffer Period and match optimization process, some amount of time will elapse between the measurement of NBBO and the dissemination of data to Subscribers and the TRF (i.e. the full completion of the Auction Procedure). This amount of time can vary based on technical factors and limitations but typically falls within 10s of milliseconds.

In compliance with Reg NMS Rule 601 and the FINRA Rule 6000 series, the ATS also promptly transmits aggregate price and volume information for each security matched to the FINRA/NYSE TRF after the Post-Auction Network Buffering period described in Part III Item 11(c) has elapsed at the conclusion of each auction. TRF reports consist of one print per symbol per price per auction.

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Promptly after execution reports and TRF reports are transmitted the ATS transmits fully disclosed clearing reports to its direct clearing provider.

In accordance with Reg NMS Rules 605 and 606 the ATS provides periodic reports to FINRA regarding the composition and timing of orders entered and executed on the ATS. CAT reports are filed on a daily basis, reporting all trades for which the ATS is the designated reporting party. This includes orders received from Subscribers and volume matched internally to the ATS.

Are the procedures and material arrangements for reporting transactions on the NMS Stock ATS the same for all Subscribers and the Broker-Dealer Operator?

Y

If no, identify and explain any differences.