J.P.Morgan

**J.P. Morgan Private Bank Algorithmic Trading Guide
(European Markets)**

August 2018

J. P. Morgan
Algorithmic Trading

Efficient execution and liquidity access through a wide variety of sophisticated, customisable algorithms.

J.P. Morgan is committed to providing global access, excellent service and quantitative content to our clients. A consultative approach to electronic trading enables us to partner with clients, understand their needs and deliver tailored solutions. Our global suite of algorithms, analytics, trading research and liquidity products is designed to combine and cover the breadth of our clients' requirements.

J.P. Morgan focusses on four core competencies:

Transparency

- We are open with our clients

Quantitative Approach

- We employ a disciplined, research-driven approach to product innovation and delivery

Operational Excellence

- We strive to build and maintain the best, most efficient systems and operations

Exceptional Client Service

- We focus on the customer

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Algorithmic Trading

Efficient execution and liquidity access through a wide variety of sophisticated, customisable algorithms.

The J.P. Morgan suite of algorithms deliver model driven, optimal behaviour with benchmark targets. Clients can target VWAP, TWAP, arrival/strike and Close using different algorithms. Tactical strategies such as "Peg" and "Iceberg" (described in more detail in this document) allow more targeted behaviour when required.

The J.P. Morgan flagship liquidity algorithm, Aqua, combines a host of favourable attributes of the whole suite. It trades an optimised trade schedule using a participation based strategy while taking full advantage of dark order placement and well-priced lit opportunities. It includes proprietary quantitative models to manage market impact and opportunity risk, while striving to prevent dark crossing at inopportune times.

Model Driven Trading

AQUA → CLOSE → ICEBERG → IS → LADDER → PEG → POV → TWAP → VWAP

Through a range of sophisticated global algorithms J. P. Morgan offers market leading execution services to our clients and internal trading desks. The underlying quantitative models are constantly evolved based on performance analysis, including many personalised custom algorithms.
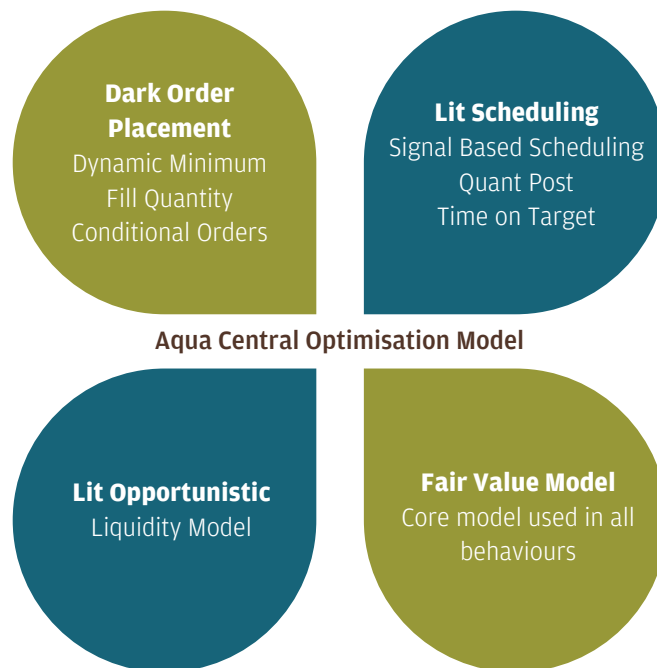
Optimisation & Scheduling

- **Centralised Optimisation Model:** The model evaluates market impact cost and timing risk to determine trading rates throughout the order. Combining lit and dark trading, the Centralised Optimisation Model is utilised by AQUA to forecast likely fill sizes in dark to reduce lit trading and therefore market impact.

- **Fair Value Model (FVM):** Stock over-or under-performance is assessed against a stock specific index to identify value and hence optimal trading times, with signals to trade based on an assumption of reversion to the market price. Signals are used by the Signal Based Scheduling to determine trade timing and in lit and dark opportunistic models to take advantage of good value prices.

Lit Order Placement

- **Signal Based Scheduling (SBS):** SBS allocates volume within the specified schedule with trading urgency dependent on schedule position and Fair Value Signals on price favourability.

- **Limit Order Placement Model (LOPM):** The LOPM determines whether to trade passively or aggressively on the order book based on current position within schedule, order book imbalance, snapshot momentum and spread. Orders across price levels are placed within the limit price to ensure queue priority when the price moves favorably.

- **Lit Opportunistic:** Additional liquidity is taken in lit markets when there is sufficient volume on the far touch coupled with a tight spread and Fair Value Model signals of underperformance.

Routing Logic

- **Quant Post:** Child orders with a passive limit price are posted to venues based on predictions of queue length and speed to maximise fill potential.

- **Time on Target:** Child orders with an aggressive limit price are staggered when sent to multiple exchanges ensuring simultaneous arrival to minimise signaling to the market.

Dark Placement

- **Dark Order Placement Model (DOPM):** Dark trading venues are selected based on historical fill probability, with other venues explored continuously for unexpected liquidity. Trading is only undertaken in dark when signals from the FVM show the stock is not overpriced.

- **Dynamic Minimum Quantity (DMQ):** Information exposure is protected by reducing the number of executions of sub optimal size by foregoing a small amount of poor quality liquidity. DMQ adjusts based on FVM signals on stock value and trade sizes to capture the largest amount of liquidity in a reduced number of trades.

- **Conditional Orders** A non-firm order for the remaining parent size is simultaneously placed in all qualifying dark venues alongside child orders. When confirmation of a counterparty is received all child orders are cancelled and the conditional order is executed, minimising market impact.

- **JPSI:** J. P. Morgan's systematic internaliser offers a controlled environment to source large blocks of liquidity, reducing market impact while achieving advantageous prices using FVM.

AQUA

Our flagship liquidity seeking algorithm intelligently finds high quality, price favourable liquidity by combining model driven lit, dark and opportunistic trading.

Strategy Behaviour

- Aqua unifies the J.P. Morgan suite of dark and lit quantitative models to optimise placement across all sources of liquidity.

- The Centralised Optimisation Model estimates an expected volume to be traded in dark by the Dark Order Placement Model using Dynamic Minimum Fill protection, while the Lit Order Placement Model and Signal Based Scheduling trade the residual simultaneously in lit venues.

- The Fair Value Model determines the local value of the stock, aggressing on lit venues when stock is cheap. This only happens when there is sufficient size and tightness of spread to execute.

Dark Order Placement
Dynamic Minimum Fill Quantity
Conditional Orders

Lit Scheduling
Signal Based Scheduling
Quant Post
Time on Target

Aqua Central Optimisation Model

Lit Opportunistic
Liquidity Model

Fair Value Model
Core model used in all behaviours

Aqua uses a combination of a wide universe of quantitative models. The Fair Value Model is used in all three behaviours.

Urgency	Expected Lit Participation	Passive-Aggressive Ratio % in Lit	Average Dark Crossing
LOW	0-10%	62%	79%
MEDIUM	10-20%	58%	61%
HIGH	33-100%	38%	32%

Minimum and maximum percentages are indicative only. For example with less liquid names the algorithm may execute at higher fractions of the traded volume.

AQUA (continued)

Considerations

- For each urgency level participation levels in lit are fully customisable in-house.

Market Impact Control for Higher Urgency Trading

- The high volume participation rates of Higher Urgency (High and Get Done) trading can potentially cause unforeseen price movements. Users should assess market conditions before deciding whether a Higher Urgency setting is appropriate.

- Lit participation is capped at 50% for orders submitted without limit prices in order to restrict price impact of Higher Urgency orders.

Parameter Name	Type	Default	Mandatory parameter?	Comments
Urgency	Text	"Medium"	Yes	"Low" or "1", "Medium" or "2", "High" or "3"
Limit Price	Number			
Maximum Percentage of Volume	Percent	50		Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Would Price	Number			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

Clients may have these fields (or other fields) available on their OMS as editable. However, parameters not listed above as supported will not be handled.
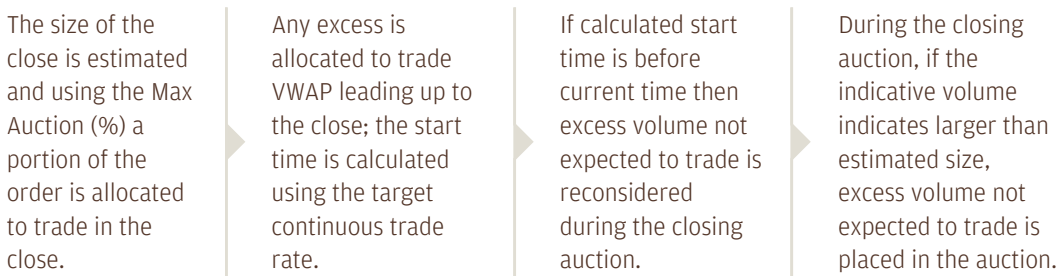
CLOSE

This strategy targets the close price. The Close Algorithm attempts to trade the order in the closing auction, with any excess volume traded leading up to the auction. Indicative auction volumes are monitored to trade as much as possible up to the order limits.
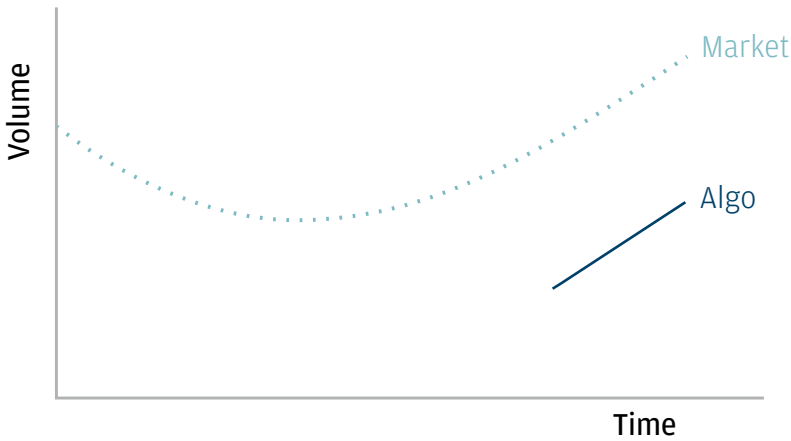
Strategy Behaviour

- The amount to trade in the close is calculated using a forecast of the closing auction size and the user specified Max Auction %.

- If the client allows, any volume to be traded outside of the closing auction is traded directly before the close, starting at the calculated time required to trade this excess before the close (if possible).

- The algorithm will place the order size up to the Max Auction (%) of the indicative close volume in the closing auction.

Allocation Process

The size of the close is estimated and using the Max Auction (%) a portion of the order is allocated to trade in the close.	Any excess is allocated to trade VWAP leading up to the close; the start time is calculated using the target continuous trade rate.	If calculated start time is before current time then excess volume not expected to trade is reconsidered during the closing auction.	During the closing auction, if the indicative volume indicates larger than estimated size, excess volume not expected to trade is placed in the auction.

Volume Profile

CLOSE (continued)

Key Considerations

- A large order may cause deviation from the close price due to pre-close trading.

- Close auction size is volatile so orders risk not getting done due to Max Auction (%) is set without trading before the auction.

- Limit price for volume placed in the auction tracks the indicative price up to the limit tolerance to achieve best price possible.

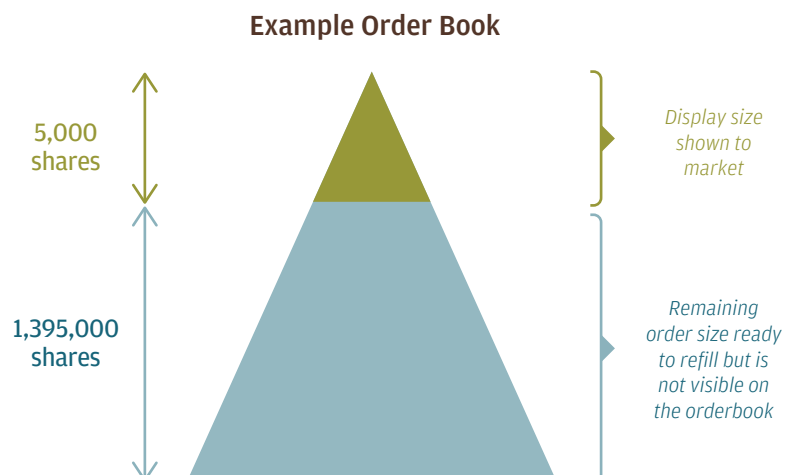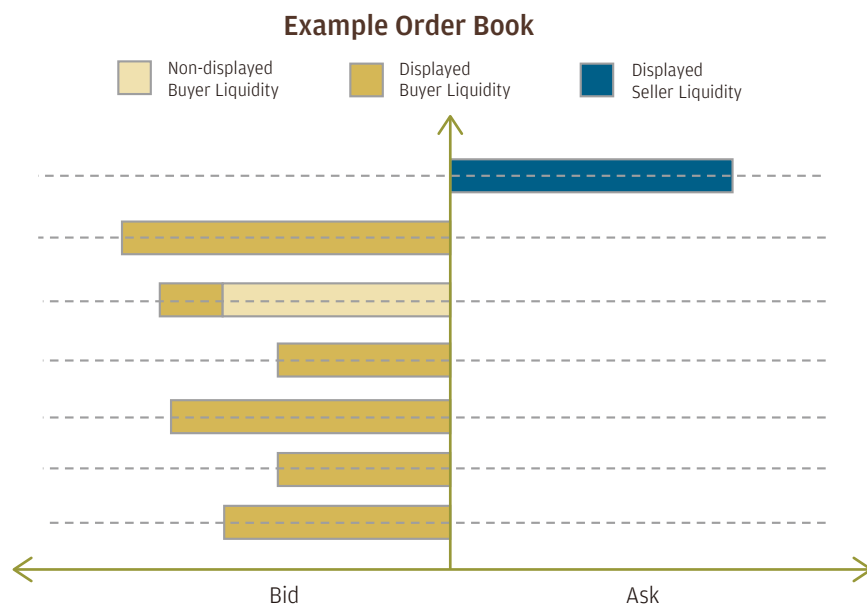| Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Urgency	Text	"Medium"		"Low" or "1", "Medium" or "2", "High" or "3",
Maximum Percentage of Volume	Percent	50		Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Only Trade at Close	Y/N	No		
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			

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ICEBERG

An algorithm used across exchanges to automatically execute large orders with reduced market impact. The synthetic iceberg is created by repeatedly reloading child orders at the same price after the previous one fully fills. Child orders are smart routed across multiple venues providing a key advantage over native icebergs.

Strategy Behaviour

- Either an automatically calculated appropriate display size or user specified size is placed in the market and reloaded when the liquidity is taken.

- Provides a constant market presence within a predefined price level until fully filled.

- Customised aggression based on limit price.

Example Order Book

Non-displayed Buyer Liquidity   Displayed Buyer Liquidity   Displayed Seller Liquidity

Bid   Ask

Example Order Book

5,000 shares

1,395,000 shares

Display size shown to market

Remaining order size ready to refill but is not visible on the orderbook

ICEBERG (continued)

Key Considerations

- Scope for allocation across multiple exchanges to reduce quantities on individual exchanges.

- Participation level is unpredictable.

- May not execute whole of order if there is low liquidity. Equally may fill early in the trading window if volumes are high.

- Does not offer exchange native queue priority on the non-displayed quantity but does allow any display size regardless of exchange specific settings.

- Algorithm should not be used for opening or closing auction.

Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number		Yes	
Refill Size	Number			
Display Size	Number			
Participate on Open*	Default to "No", no other values supported.			
Participate on Close*	Default to "No", no other values supported.			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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Private Bank Equity Desk Annotation:

Possibility to use DMA instead of Iceberg (Places display size shown in market)

IS

The IS algorithm minimises the combination of market impact cost and the risk of the market moving away from the benchmark price. Higher urgencies trade faster at the start of the order to maximise liquidity capture at the current price whereas a low urgency will prioritise minimising market impact and take on more timing risk by trading over a longer duration.

Strategy Behaviour

- Front-loads the trading schedule to target the arrival price in the market.

- Urgency level in the market can also be determined by the price relative to a user specified level, with either aggressive-in-the-money or passive in-the-money views.
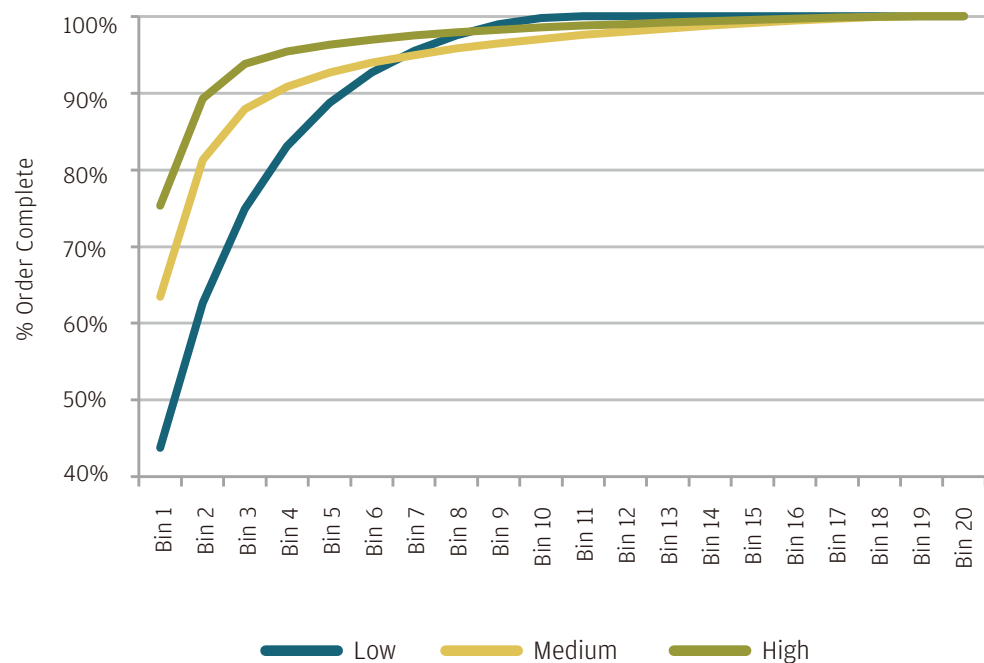
Example trading trajectories for different urgency levels. "Bins" are sections of the day with equal amounts of volume traded: the bins are short during high volume periods of the day and long during quiet periods.

IS (continued)

Key Considerations

- Trading schedule is highly affected by urgency level.

- If market moves in your favour, timing risk will capture alpha rather than contribute to cost and a more passive strategy might perform better.

Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Urgency	Text	"Medium"		"Low" or "1", "Medium" or "2", "High" or "3"
Maximum Percentage of Volume	Percent	50		Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Strike Price	Number			
Price Adaptation	Text	"None"		"None" or "AIM" or "PIM"
Would Price	Number			
Benchmark	Text	"Arrival"		"Arrival" or "Open" or "PrevClose" or "UserStrike"
Start Time*		Default to "now" or "start of trading section" (whichever later), no other values supported.		
End Time*		Default to "End of trading section" of respective exchanges, no other values supported.		

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Private Bank Equity Desk Annotation:

Possibility to use AQUA algorithm instead of IS.

LADDER

An adaptation of the POV algorithm, this strategy adjusts participation levels depending on the price. Instead of just a limit price there is a 'ladder' of participation levels as the price changes.

Strategy Behaviour

- Based on a POV algorithm with adaptations for price variation.

- As the price transitions through user specified levels the participation rate changes to user specified values.

- Enables aggressive- or passive-in-the money views to be accommodated.
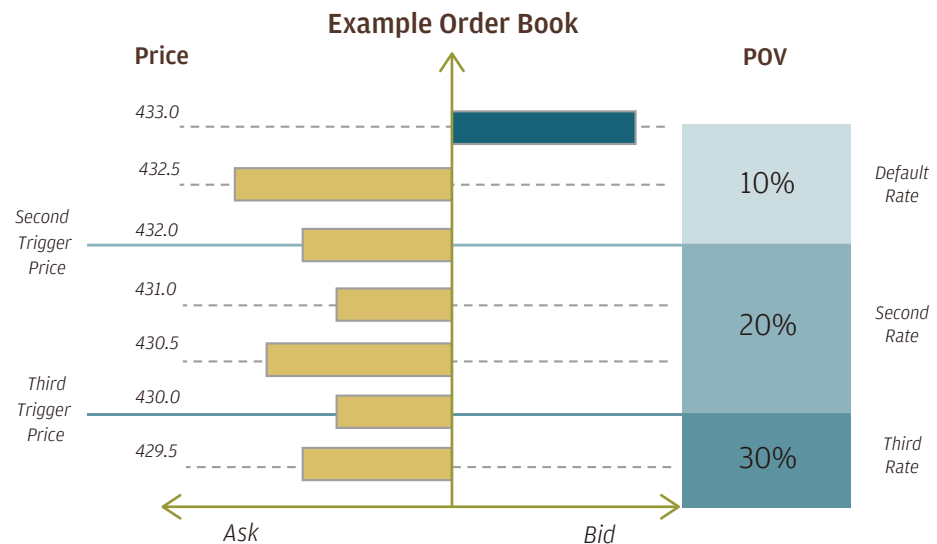
Example Order Book with quantity on bid (yellow) and ask (blue) shown.
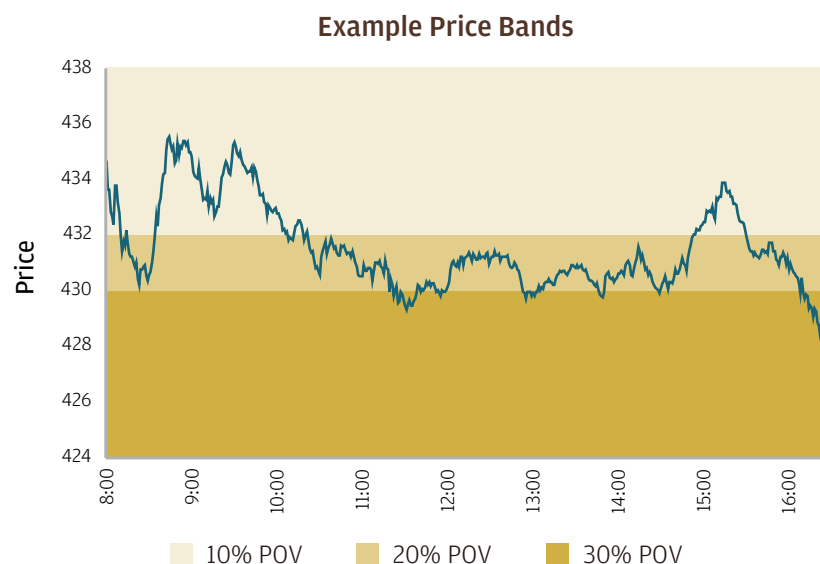
LADDER (continued)

Key Considerations

- Less straightforward to track participation rate when compared to the POV algorithm due to adaptive market sensitive participation.

- Participation level is determined by the user specified price level.

| Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Base Rate	Percent		Yes	
Second Step Price	Number			
Second Step Rate	Percent			Max Rate capped at 50%
Third Step Price	Number			
Third Step Rate	Percent			Max Rate capped at 50%
Would Price	Number			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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PEG

A passive algorithm which places orders on the near side of the order book to collect the spread when other market participants aggress. The Peg algorithm is suitable for clients who wish to take advantage of spread capture with no urgency to fill.

Strategy Behaviour

• Places orders of either an algorithm calculated appropriate size or user specified size passively; the spread is never crossed.

• In-built anti-gaming controls only allow placing at prices where material volume has been present for at least an expected duration.

• A very passive strategy with unpredictable participation rate.
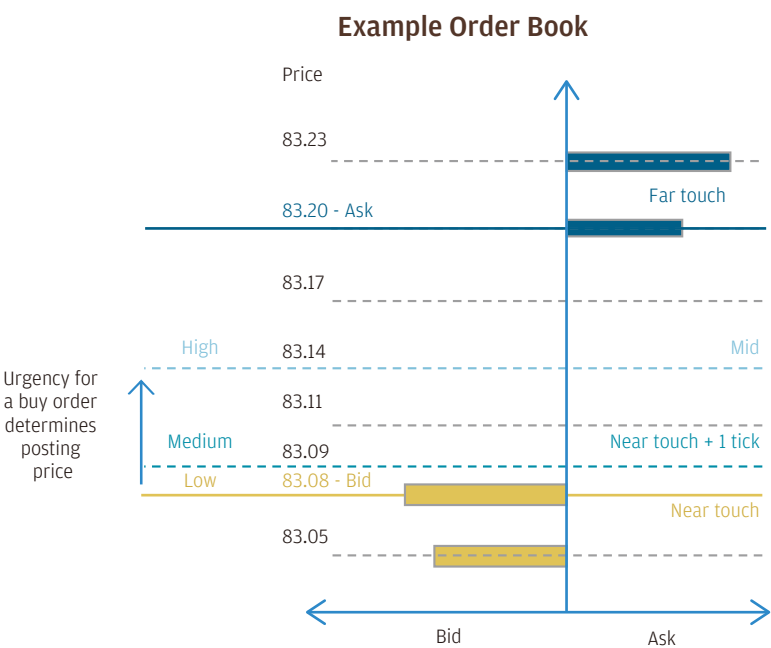
Example Order Book

Example Order Book with quantity on bid (yellow) and ask (blue) shown.

Order Placement by Urgency			
Order	**Low**	**Medium**	**High**
Buy	Bid	Bid + 1 tick	Mid
Sell	Ask	Ask -1 tick	Mid

PEG (continued)

Key Considerations

- If market moves unfavourably, spread capture may not exceed losses from price movements.

- A "Would" should be set to benefit from advantageous prices.

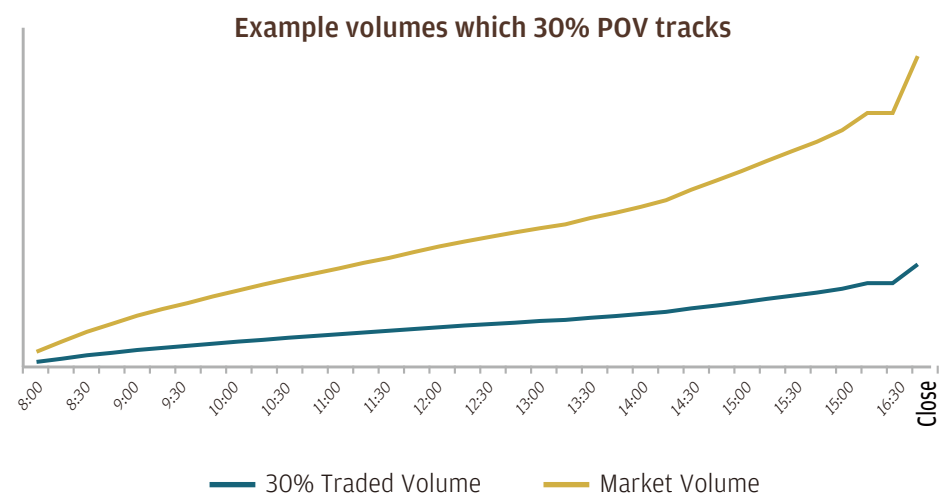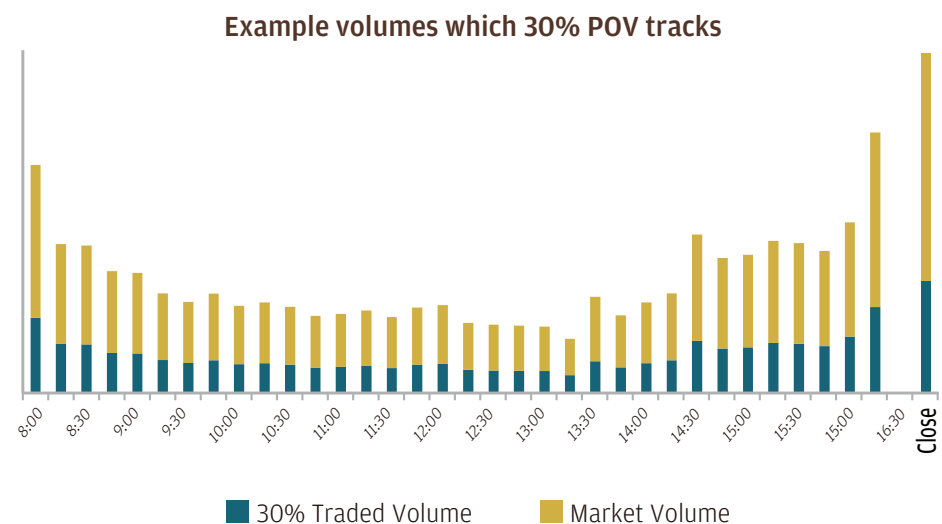| Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Urgency	Text	"Low"		"Low" or "1", "Medium" or "2", "High" or "3"
Display Size	Number			
Would Price	Number			
Participate on Open	Default to "No", no other values supported.			
Participate on Close	Default to "No", no other values supported.			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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POV

POV is a widely-used strategy that trades in-line with market volumes to complete the order while limiting market impact. This dynamic algorithm trades a user specified percentage of real-time traded volumes.

Strategy Behaviour

• Passive or aggressive based on participation rate allows management of impact and risk.

• POV incorporates market events, participating in all liquidity generated by other market participants.

• Works for liquid and illiquid stocks as automatically accounts for high or low volumes.

Example volumes which 30% POV tracks

■ 30% Traded Volume   ■ Market Volume

Example volumes which 30% POV tracks

── 30% Traded Volume   ── Market Volume

POV (continued)

Key Considerations

- If market moves unfavourably, spread capture may not exceed losses from price movements.

- A "Would" should be set to benefit from advantageous prices.

Parameter Name	Type	Default	Mandatory parameter?	Comments
Target Percentage of Volume	Percent		Yes	Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Limit Price	Number			
Would Price	Number			
Participate on Open	Y/N			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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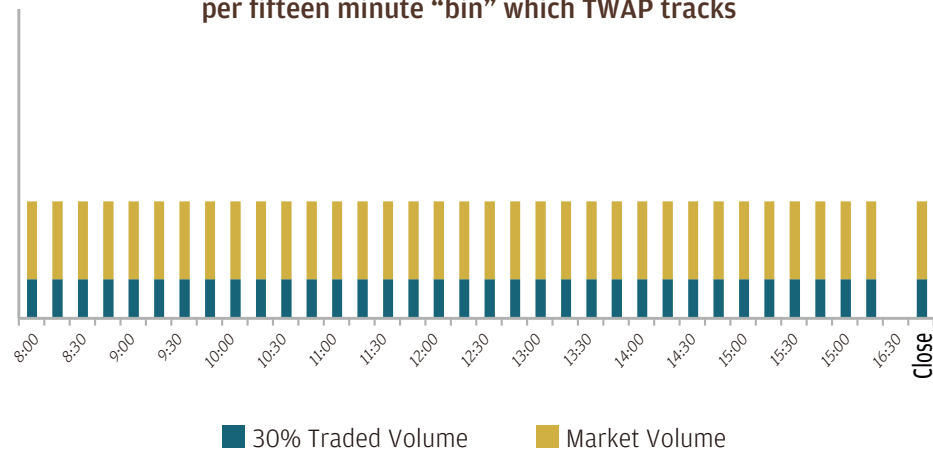
TWAP

A strategy suited to clients who want to trade evenly over the day. TWAP will trade linearly throughout the day with micro-order placement modelled quantitatively to trade passively when possible.
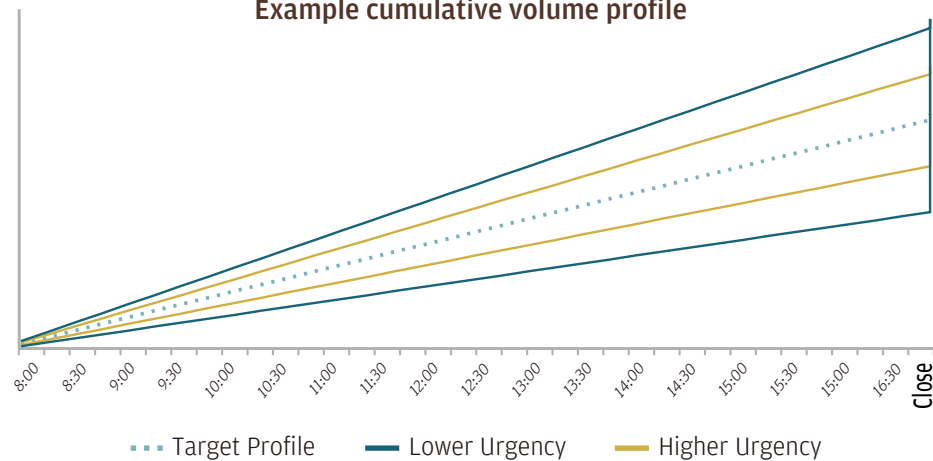
Strategy Behaviour

- Enables trading of balanced baskets keeping them neutral throughout the trade.

- Typically a passive strategy used for low participation rate orders.

- Limit Order Placement Model (LOPM) and Signal Based Scheduling (SBS) ensure optimal execution along the volume profile.

- Appropriate for stocks with unpredictable volume profiles such as small caps or ETFs.

**Example volume profile
per fifteen minute "bin" which TWAP tracks**

■ 30% Traded Volume   ■ Market Volume

Example cumulative volume profile

···· Target Profile   — Lower Urgency   — Higher Urgency

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TWAP (continued)

Key Considerations

- Liquidity may be missed by ignoring unpredictable volume spikes.

- Trade size as a percentage of volume varies as market volumes likely to follow daily trends of peaking towards the start and end of day.

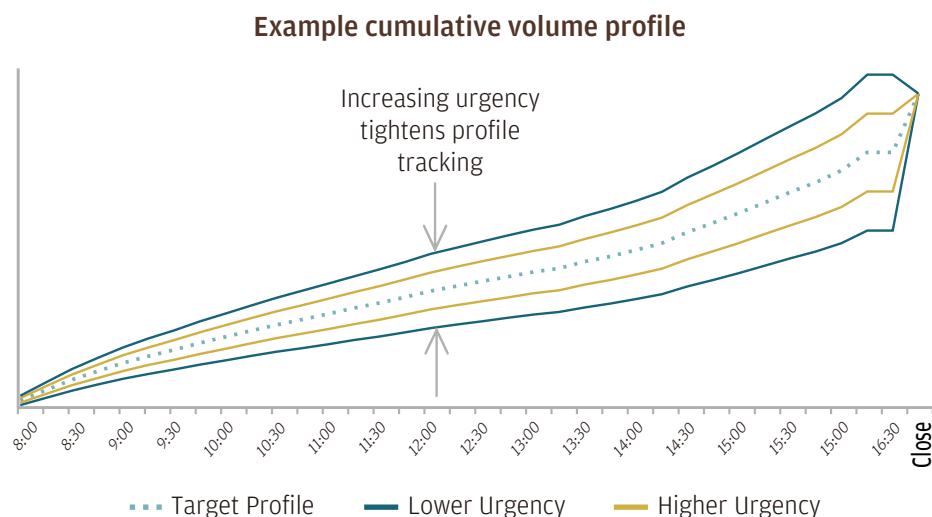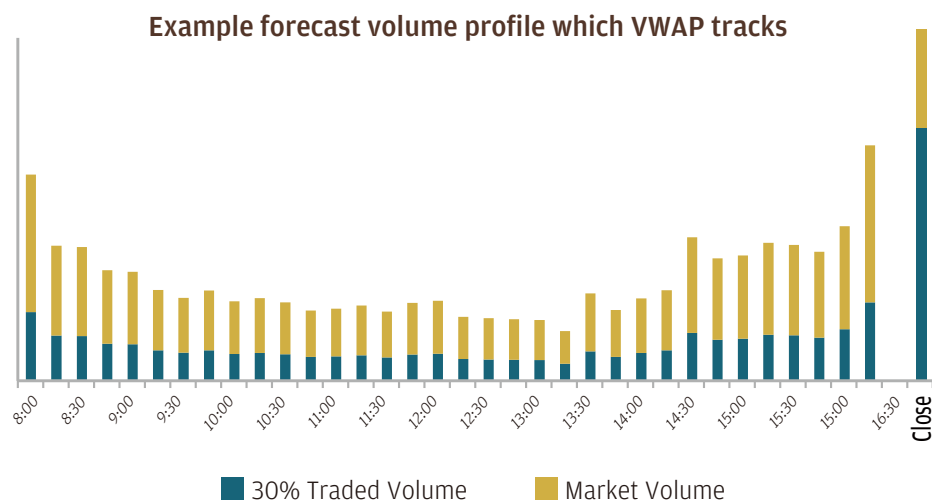| Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Maximum Percentage of Volume	Percent	50		Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Would Price	Number			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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VWAP

One of the most widely-used strategies, the algorithm trades in-line with the expected market volume. The VWAP algorithm uses volume profiles created from proprietary quantitative models considering stock, sector and market characteristics, with adjustments made on index rebalance days.

Strategy Behaviour

- Typically a passive strategy used for low participation rate orders.

- Stock specific volume models maximise performance.

- Limit Order Placement Model (LOPM) and Signal Based Scheduling (SBS) ensure optimal execution along the volume profile.

- VWAP targets trading to the End Time regardless of market activity.

Example forecast volume profile which VWAP tracks

■ 30% Traded Volume   ■ Market Volume

Example cumulative volume profile

Increasing urgency
tightens profile
tracking

····· Target Profile   — Lower Urgency   — Higher Urgency

VWAP (continued)

Key Considerations

- Does not adapt to unpredictable volume spikes.

- Trading small volumes passively over long durations can cause excessive timing risk.

Parameter Name	Type	Default	Mandatory parameter?	Comments
Limit Price	Number			
Maximum Percentage of Volume	Percent	50		Orders will be subject to a max of 50% of Volume. Order submitted for this parameter higher than 50% will be rejected.
Would Price	Number			
Participate on Open	Y/N			
Participate on Close	Y/N			
Start Time*	Default to "now" or "start of trading section" (whichever later), no other values supported.			
End Time*	Default to "End of trading section" of respective exchanges, no other values supported.			

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While our internally managed strategies generally align well with our forward-looking views, and we are familiar with the investment processes as well as the risk and compliance philosophy of the firm, it is important to note that J.P. Morgan receives more overall fees when internally managed strategies are included. We offer the option of choosing to exclude J.P. Morgan managed strategies (other than cash and liquidity products) in certain portfolios.

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