

# VOLATILITY FITTING APP User Guide

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### **Table of Contents**

Change History	2
Introduction	3
Implementation Approach	4
Functionality Highlights	5
Purchasing and Installing	6
Configuring and Setting Up	7
Generating Volatility Curves (Fitting the Market)	12
Additional Considerations	15
Max ATM Vol Change	15
Publishes Via the Model Control	15
Using the Auto determine Wing Slopes Functionality	15
Theos and Theoretical Cache	16

## **Change History**

Date	Changes
12/23/2016	Version 1.0



Volatility Fitting App User Guide

### Introduction

The Volatility Fitting App is a Metro Widget that allows for the automated management of Volatility Curves. The functionality fits the market by creating and updating Assigned Volatility Curves based on the implied volatilities of the Live Options markets.

The Volatility Fitting App leverages the powerful, yet simple to use Metro APIs, the Freeway API and Widget API, in providing new functionality that complements the rich out-of-the-box functionality inherent in Vela's flagship Metro platform.

This document outlines the usages of the app and covers several topics. It captures the typical user's workflow along with everything that user needs to leverage the functionality: configuration settings, job interactions, a walkthrough of the different GUIs and their purpose.



### **Implementation Approach**

The Volatility Fitting App uses the Assigned Volatility Curve type offered by the Metro platform. The Assigned Volatility Curve allows for volatility values to be specified on a strike-by-strike basis.

The functionality is currently implemented via back-end components only, as Freeway Jobs (VolatilityFitterJob). The configuration of the functionality is done via the standard Freeway Job Configuration screen, and the functionality does not present any additional front-end components.



## **Functionality Highlights**

- The Volatility Fitting App provides the user with the ability to automatically fit volatility curves to the market for one or more expirations on one or more products. This fit can be employed manually (with enhancements over the out-of-the-box fitting), or on a configurable schedule.
- The volatility fitting functionality fits the market by calculating the implied volatilities of the bid and offer prices for all the strikes within an option expiration and setting the volatility value for a strike to be the average between the bid implied volatility and offer implied volatility.
- The volatility fitting app breaks up an option expiration's strike range into segments to capture market behavior local to certain parts of the curve. The average implied bid-offer vol spread (difference) of strikes within the segment is calculated and used to determine vols at strikes where only one side of data (bid or offer) is available. Outlier vols within the segment are removed from the average computation.
  - The skew is segmented by the wing cutoffs, and 1, 2, 3 standard deviation points by default.
  - An alternative segmentation method is configurable (BYMONOTONICVOLS), which segments the skew at points where the bid or offer skew slope changes signs.
- In the case of strikes for which there is no price, or for strikes whose prices were determined to be outliers, the functionality employs a linear interpolation between the adjacent strike prices in order to determine the volatility.
- Wing segments are determined to start at a user-provided cutoff point, specified in delta terms. These deltas leverage the current vol skew and model being used at each fit. The first fit will use flat atm vol Black-Scholes deltas to determine equivalent strikes.
- The Volatility Fitter App can also automatically determine the wing segment cutoff points as being the lowest strike, for the put side, and highest Strike, for the call side, having with a bid price.
- Users can also specify a wing slope for each side (in vol/strike) or choose to have both wings automatically determine their slope. The Volatility Fitter automatically determines wing slopes by examining the slope between the atm strike, respective wing cutoff strike, and the available data.
- For option expirations for which there is only sparse market data (sparsity determined by user-specified threshold), an alternative method applying an offset to the volatility curve of a liquid front-month will be leveraged, shifting the entire curve by the offset (the offset will be the difference of the atm implied vol of the two strikes).
- The Volatility Fitter Job only publishes a new fitted skew if the skew is sufficiently different from the existing skew for the instrument month being fitted, or if the existing skew is off the market. This throttling behavior is intended to reduce unnecessary stress on the Metro NOW theoretical center.



## **Purchasing and Installing**

The Volatility Fitting App will be available on the Metro App Store via this <u>link</u>. During the checkout process, the users will have the opportunity to choose the Metro installation (instance) against which to deploy the functionality.

Upon restarting the Metro front-end, the widget will be installed.



Figure: Install dialog upon a new app purchase or app version update



## **Configuring and Setting Up**

At least 1 (one) instance of the Volatility Fitting Job needs to be created, as an execution unit before being able to use the fitting functionality. This is accomplished via the Freeway Jobs Window, with the "New" button.

Start Stop		New Rom	Augura Configura				
Server	Job	Description					
receiver	AdvancedOrderWidgetBack	Advanced Order Io	derRouter				
receiver	BboOrderRouter.1	BBO Trading Job v1	ertBackend				
receiver	CmeMarginCalcJob.1	CME Margin Calculat	ncReceiverJob				
receiver	FastFutures.1	FFA UZB MAR1/					
receiver	FastFutures.2	FFA OZB DEC16 TradeSyncSenderJob					
receiver	FastFutures.3	FFA UZB JUN1/	ngOffsetControllerJob				
receiver	FastFutures.4	FFA OZB SEP17 Volatility					
receiver	FastFutures.5	Calculate Fast Futur	/ktDepthData				
receiver	FastFutures.6	Calculate Fast Futures Algo	•				
receiver	FastFutures.7	Calculate Fast Futures Algo	•				
receiver	ModelSyncReceiverJob.1		•				
receiver	OrderExtractor.1	Order Extractor Job v0.1	•				
receiver	TWAPOrderRouter.1	TWAP Order Router Job v0.7	•				
receiver	TradeSyncReceiverJob.1	Trade receiver job	•				
receiver	UnderlyingOffsetControllerJo	Underlying Offset Controller					
receiver	VolatilityFitterJob.1	VolatilityFitterJob 1.0	•				
receiver	VolatilityFitterJob.2	VolatilityFitterJob 1.0					
receiver	testGenMktDepthData.1		•				
receiver	testGenMktDepthData.2		•				

Figure: Job Instantiation



Configuring the Volatility Fitting App is accomplished via the Job Configuration Screen.

Name	Desc.		Value							
dynamic	job	1								
owner	job	1								
ownergroup	job									
autostart	auto									
autostop	auto	1								
group	job	Assign	edAutoFitter							
description	desc	ES Vol	atilityFitterJob1.0							
priority	job	norma								
orderoptions	confi									
limits	confi	orders	PerSec=1;modifiesPerSec=1;openOrders=1;tra	desPerSec=	=l;crossT	icks=99	9999			
testmode	in 't									
debugmode	in 'd									
timer	how	20000								
services	com						_			
	-									
Job Defined			Description		Value	2	-12			
Job Defined	-		Description	FS	Value					
Job Defined N Symbols	ame		Comma-delimited list of symbols to filter on		Value					
Job Defined	ame		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav	0-250	Value		-0			
Job Defined N Symbols Days Until Exp	ame		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i	0-250 17:00	Value					
Job Defined N Symbols Days Until Exp Start time	ame o Range	shold	Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser	0-250 17:00 17:00	Value					
Job Defined N Symbols Days Until Exp Start time End time	ame o Range	shold	Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i	0-250 17:00 17:00	Value					
Job Defined N Symbols Days Until Exp Start time End time Sparse Min D	ame o Range ata Thre	shold	Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to	0-250 17:00 17:00 90						
Job Defined N Symbols Days Until Exp Start time End time Sparse Min D One-Shot Fit	ame o Range ata Thre ff Delta		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to f true, job will stop after initial fit Delta of cutoff strike on put side of skew. If l	0-250 17:00 17:00 90						
Job Defined N Symbols Days Until Exp Start time End time Sparse Min D One-Shot Fit Put Wing Cuto	ame o Range ata Thre ff Delta off Delta		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to If true, job will stop after initial fit Delta of cutoff strike on put side of skew. If l	0-250 17:00 17:00 90 2.5						
Job Defined N Symbols Days Until Exp Start time End time Sparse Min D One-Shot Fit Put Wing Cuto Call Wing Cuto	ame o Range ata Thre ff Delta off Delta e		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to If true, job will stop after initial fit Delta of cutoff strike on put side of skew. If l Delta of cutoff strike on call side of skew. If l	0-250 17:00 17:00 90 2.5 0.75						
Job Defined N. Symbols Days Until Exp Start time End time Sparse Min D One-Shot Fit Put Wing Cuto Call Wing Cuto Put Wing Slop	ame o Range ata Thre ff Delta off Delta e oe		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to If true, job will stop after initial fit Delta of cutoff strike on put side of skew. If I Delta of cutoff strike on call side of skew. If I Slope (vol/strike) of vols past put wing cutoff.	0-250 17:00 17:00 90 2.5 0.75 0.0						
Job Defined N. Symbols Days Until Exp Start time End time Sparse Min D One-Shot Fit Put Wing Cuto Call Wing Slop Call Wing Slop	ame o Range ata Thre off Delta off Delta e oe e Wing S		Comma-delimited list of symbols to filter on Start days until exp - end days until exp; leav Time after which the job can run; in hh:mm (i Time after which job stops; in hh:mm (in ser % of Strikes with Missing Data Necessary to If true, job will stop after initial fit Delta of cutoff strike on put side of skew. If I Slope (vol/strike) of vols past put wing cutoff. Slope (vol/strike) of vols past call wing cutoff.	0-250 17:00 17:00 90 2.5 0.75 0.0	r					

Figure: Volatility Fitting App Job Configuration Screen

The Job Configuration Screen can be brought up by accessing the "Job Control" under the Freeway icon within the Metro toolbar.



Figure: Freeway Icon and Job Control menu



Start Stop		New Remov	configure
Server	Job	Description	Status
receiver	AdvancedOrderWidgetBack	Advanced Order Job 1.5	•
receiver	BboOrderRouter.1	BBO Trading Job v1.2	0
receiver	CmeMarginCalcJob.1	CME Margin Calculator Job	•
receiver	FastFutures.1	FFA OZB MAR17	
receiver	FastFutures.2	FFA OZB DEC16	
receiver	FastFutures.3	FFA OZB JUN17	•
receiver	FastFutures.4	FFA OZB SEP17	
receiver	FastFutures.5	Calculate Fast Futures Algo	•
receiver	FastFutures.6	Calculate Fast Futures Algo	•
receiver	FastFutures.7	Calculate Fast Futures Algo	•
receiver	ModelSyncReceiverJob.1		•
receiver	OrderExtractor.1	Order Extractor Job v0.1	•
receiver	TWAPOrderRouter.1	TWAP Order Router Job v0.7	•
receiver	TradeSyncReceiverJob.1	Trade receiver job	•
receiver	UnderlyingOffsetControllerJo	Underlying Offset Controller	0
receiver	VolatilityFitterJob.1	VolatilityFitterJob 1.0	
receiver	VolatilityFitterJob.2	VolatilityFitterJob 1.0	
receiver	testGenMktDepthData.1		•
receiver	testGenMktDepthData.2		•

Figure: (Instantiated) Freeway Jobs Window

The Job configurations available are:

Configuration	Description
Timer	Interval, in milliseconds, at which the job should generate volatility curves (fit the market).
AutoStart	If checked, the job will start up when your server starts up.
test mode	If checked, the job will determine fitted skews, but not publish them. This is largely a debugging tool.
debug mode	If checked, the job will produce extra, detailed logging. This is largely a debugging tool.
Symbols	Symbols (products), as comma-delimited list, for which the job should generate Volatility Curves.
Days Until Exp Range	An expression of the form <i>min days until exp - max days until exp</i> , specifying all option expirations for which the job shall generate volatility curves. If left blank all expirations will be fit.
	Example: 0-100, where any option expirations with days to expiration between 0 and 100, would be included.
Start Time and End Time	Start and end times defining the session during which the job shall generate volatility curves.

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Configuration	Description
	Example: Start Time: 17:00, End Time: 16:00 would cover the typical CME trading session.
Sparse Min Data Threshold	The percentage of strikes within an option expiration lacking market data, which would categorize the expiration as an illiquid expiration and therefore use an alternate algorithm for generating a volatility curve. The threshold does not include outliers and one-sided markets.
One-Shot Fit	If enabled, the Job shall generate only one set of Volatility Curves and cease execution.
Put/Call Wing Cut- off Delta	The cutoff point, defined in delta terms, where the wing segments of the volatility curve shall start; the wing has a curvature of 0 and a consistent slope. Deltas specified will always be positive and typically be between 0 and 100. If the cutoff point is specified as 0 (zero), the job automatically determines the cutoff point to be the last strike (lowest for the put side, highest for the call side of the curve) with a bid price.
Put/Call Wing Slope	The slope for the wing segment of the Volatility Curve. The slope is specified in terms of increase in volatility (as a percentage) for 1- point increase in the Strike price. For example, if the current volatility at Strike 2000 is 19% (or 19 vol), if the desired volatility at Strike 2100 is 20% (or 20 vol), the slope shall be specified as 0.01 ((20-19)/(2100-2000) ).
Auto determine Wing Slope	The slope of the wing segments would be automatically determined by the job by being the slope determined by the ATM strike and the last strike with a bid price. Note that this will override any slopes set in the configuration.
Send Notifications	Check to receive client-side notifications when skews publish.
Segmentation Method	<ul> <li>BYSTANDARDDEV (default): The skew is segmented at the 1, 2 and 3 standard deviation points and at the specified wing cutoff points.</li> <li>BYMONOTONICVOLS: The skew is segmented at points where the bid or offer boll is not monotonic (switches from nondecreasing to decreasing on the call side, or nonincreasing to increasing on the put side).</li> </ul>

Note: The ability to fit the market for several distinct Symbols or Expirations, which may require distinct sets of configuration values, can be accomplished by creating multiple instances of the Volatility Fitting Job and having each instance generate Volatility Curves for a subset of Expirations.

For example, a Job instance with a certain set of configuration values can be used for the front Expirations for a product, while a different Job with a distinct set of configuration values can be used for the back Expirations of the same product.

Similarly, if increased performance is desired, multiple Job instances may be created, each generating Volatility Curves for a smaller subset of Expirations.



The only Volatility Curve type applicable for the Volatility Fitting logic is the Assigned Volatility Curve, which allows for the setting of volatility on a per Strike basis. The selection of a Volatility Curve Type is made via the Theoretical Model Wizard.

All ES					
Model Type	Whaley (American)				
Calendar	ACT_365		Expiration		
Intra-Day Decay					
Skew Options					
Skew type	Assigned	Pivot type		Fixed Skew	
Point type		Wing shape			
Skew dimensior		Apply point	type to center	Yes No	

Figure: Theoretical Model Wizard



## **Generating Volatility Curves (Fitting the Market)**

Upon successful configuration of a Job instance, the volatility fitting logic is activated by starting the Job. This is accomplished by the Freeway Job window, via the "Start" button. The Job will proceed to generate an Assigned Volatility Curve that best fits the market, based on the implemented logic. Some of the relevant highlights of the implementation details can be found in the "Functionality Highlights" section.

The generated Volatility Curve can be viewed within the Metro Model Controller, which can be brought up via the Trade Sheet. It is recommended that the Trade Sheet is Configured to "Auto-Accept" in order to allow for the Volatility Curve changes made by the volatility fitting logic to be automatically accepted within the Trade Sheet widgets without user intervention.

										Trade Sheet Configuration -					_ □ ×
								Trac	de Sh	e 🔽	ell Configuration Trad	e Sheet Configuratio	Product Strike Configuration		
	-	-	-							D	isplay Settings			Underlying Bar / Ticke	r Settings
Second Second	Setting	100 million		odel E			0.005				Collapse Empty Strikes			Ruler Increments	1
2250.0	000	1 2	251.000	2252.000	225	3.000	2254	.000	2255.0		adal Cattinua Iladata			Decimal Places	3
Clear	Cli	ck on	a Strike to Be	gin							lodel Settings Update				
Ma	17	2255	500 Jun	17 2255	500	Sen17	2255.	500	Dec17		Auto-Accept			Spinner Tick Incremen	nt 0.010
	0.5		47.305 98.93	2	00 400	129.432	LLUU	113.932	155.628	S	pread Box			Underyling Source	
55.7		40.00	-44.294 54.72			54.723	2240.00	-45.277	54.945	l r	Multiply delta by Leg C	oust	Enable Quantity Slider	C Last	O Bid
59.5 54.2		45.00	49.057 95.80		85.308						manipity down by Log o	ount			0.00
54.2 56.3		_	-45.719 53.85		-46.149	100 100		447.000		L L	Legs increments have	0.5 quantity		Average Ask/Bid	C Least Quantity
52.8		50.00	50.809 92.68 -47.179 52.96		47 033	123.183	2250.00	117.683							
Contraction and	12		52.712 89.68	e .	00 105	55.551		-40.003	33.001	Т	heta and Vega Display			O Settle	
53.2 51.3 50.1 49.7 47.1 48.2 44.3		55.00	-48.676 52.07		.47 928					0	Per-Tick	O Per-Point	Raw		
50.1		60.00	54.688 81.31		85.811	107.810	2280.00	112.310						Market Source	
49.7	94	.00.00	-50.206 50.99	4	-49.000	51.788	2200.00	-48.212	52.413	т	rade Accounts			Actual Market	
47.1		65.00	56.690 78.31		87.812			and the second se		Г	All Trade Accounts			O Implied Market	
48.2 44.3			-51.772 50.01 58.817 75.31	4	-49.985	101.937		116.437	125 157		Air muut Accounts				
		70.00	-53.367 49.02			50.296	2270.00	-49.704			TEST			Strip Pricing Mode	
41.4 44.9 38.8	44	75.00	60.944 72.56	E.	92 085	99.045		119 545			TEST2				
44.9	97 22	75.00	-55.003 48.02	4 2275.00	-51.976	49.538	2275.00	-50.462	50.560					O Average	Sum
38.8		80.00	63.321 69.69			96.189	2280.00	120.689			TEST3			SmartComplete	
43.3	57		-56.643 47.00	8	-52.994	48.774		-51.226	49.937		TEST4				
36.1 41.6		85.00	65.698 66.81 -58.320 45.97		96.318 -54.030									Enable SmartComplet	e
337	00		68.200 64.19	4	00 804	90.691		125.191	114 064	c	olumn Header Config	uration			
39.9 31.4 38.3 29.0 36.5		90.00	-60.011 44.94			47.233	2290.00	-52.767		w	hen I click on the Colu	mn Header while	building a Spread, I want to	Call Christmas Tree	Box
31.4		95.00	70.952 61.57		101.070									Put Christmas Tree	Call Butterfly
38.3	27		-61.673 43.89	9	-56.101						Do Nothing		Create a Strip	Diagonal Straddle	Put Butterfly
29.0		00.00	73.579 59.07		103.571		2300.00	129.943		C	Create a Calendar Spr	ead		Horizontal Straddle	Call Diagonal
	58		-83.407 42.85 76.456 56.44	0	105 040	45.677		-54.323	47.397		Joreate a Galeridar Opr	cuu		Iron Butterfly	Put Diagonal
34.9 24.7 33.1 22.9		05.00	-65.098 41.78		-58.217					т	hirdParty Chat Config	uration		Iron Condor	Call Horizontal
24.7	08 22	10.00	79.208 54.07		108.574	80.195	2310.00	134.695	103.443		ONE			Jelly Roll	Put Horizontal
33.1	22	10.00	-66.878 40.73	0	-59.270	44.087	2510.00	-55.913	46.106		UNE			Call 1x3 Ratio	Call Condor
22.9		15.00	82.460 51.57		111.075					s	hare List Configuratio				
31.5			-68.484 39.64 85.463 49.20		-60.359	76 197		139.697	00 210						· · · ·
20.5		20.00	-70.236 38.55		-61.443	42.488	2320.00	-57.512			Enable Share List				
19.2	15	25.00	88.715 46.95		118 452		2225.00	142 100			ser Interface Configu	ration			
28.0	98 23.	20.00	-71.902 37.48	1 2325.00	-62.519	41.674	2325.00	-58.326	44.145						
17.7		30.00	92.216 44.70		119.204		2330.00	144.825			Center ATM when sw	tching products			
26.5	48		-73.454 38.38		100.004	40.867		-59.133	43.483						
16.2 24.9		35.00	95.718 42.58 -75.028 35.31		122.081										Done Can
14.7	20	40.00	99.220 40.58		105 000	65.701		150.201	88.507						
23.3		40.00	-76.630 34.24			39.245	2340.00	-60.755		2340.0	-57.839				
13.4		45.00	102.972 38.58		128.083										
21.9	17		-78.083 33.17		-66.826						170.004				
12.2		50.00	106.724 36.58		131.085	61.203 37.607	2350.00	155.703		2350.0	0 178.324				
11.2	25		110.725 34.71	4	404.044	37.007		-02.393	40.829		-50.171				
19.1		55.00	-80.843 31.01		-68.986										
10.2	27 22	80.00	114.727 32.96	2 2280.00	137.462		2360.00	161.455		2360.0	183.575				
17.8	61 23	00.00	-82.139 29.97	1	-70.029	35.977	2000.00	-64.023	39.465	2000.0	-80.535				
			Source												

Figure: Trade Sheet with Configuration Dialog





Figure: Viewing Generated Volatility Curve in Trade Sheet Model Controller





Figure: Detail of Generated Volatility Curve in Trade Sheet Model Controller



### **Additional Considerations**

Due to the wide-variety of use-cases of the Metro platform, users may have different expectations, requirements, and experiences of/with the Volatility Fitter. This section aims to highlight and address those concerns and expectations.

#### Max ATM Vol Change

MaxAtmVolChange is a Vela Metro App Store safety setting that can be applied to a product, preventing any server-side volatility change in any of the product's expirations if the atm strike volatility changes by more than the specified percentage. To ensure that the Atm Vol Change solution can make publishes, set this number to a very high value.

The MaxAtmVolChange safety can be found in Metro *City Center*  $\rightarrow$  click the *Settings* button  $\rightarrow$  select the Product you are Fitting from the drop-down  $\rightarrow$  click on the *Quote Settings* tab  $\rightarrow$  click on the *Class Settings* tab underneath.



#### **Publishes Via the Model Control**

While the Volatility Fitter job is running, users will still can fit and publish the model via the OC Metro mode control. Doing so will not prevent the Volatility Fitter job from fitting per its configured schedule. Note that in some versions of Metro, fitting an Assigned-type skew via the model control may be difficult as strikes with missing data are fit to 0 vol. To get some level of manual intervention without using the model control, you may consider having one Volatility Fitter job instance configured to run in One-Shot-Fit mode. In such a case, starting the job will be the equivalent of fitting to implied and publishing via the model control, but will gain the logic of the Volatility Fitter job.

#### Using the Auto determine Wing Slopes Functionality

The Volatility Fitter App only supports linear wings currently, meaning that it may be impossible to find such a linear wing that can fit all the implied bids and offers, especially if there is concavity in the market data. For this reason, the *Auto determine Wing Slopes* configuration was intended to be used with the automatically-determined wing cutoff points (setting wing cutoff deltas to 0) as it is easiest to determine the wing slope when there is only one set of volatilities (offers) to worry about. Users may set the wing cutoff points to any delta and use the *Auto determine Wing Slopes* configuration, but the user should note that this can result in wing vols being off the market.



#### **Theos and Theoretical Cache**

The Theo Cache is an internal structure to the Vela Metro platform that stores pre-calculated theo values at different potential underlying prices with the purpose of avoiding costly real-time calculations. Any model publish purges the cache and prompts a recalculation of the theos, which can be costly. The Volatility Fitter Job is designed to minimize stress on the theoretical cache, but certain usages of the job may require additional server-side/job configuration to ensure this. If you plan on running the Volatility Fitter job with a frequency higher than 5000 Millis or plan on fitting more than 30 instrument months, please consult with the Metro App Store support on your use-case.