Cboe European Risk Management Conference:

OCC Update on Margins and Renaissance Risk Architecture

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THE FOUNDATION FOR SECURE MARKETS

Options Clearing Corporation Overview

- OCC is the world's largest equity derivatives clearing organization and the foundation for secure markets. Founded in 1973, OCC operates under the jurisdiction of both the U.S. Securities and Exchange Commission (SEC) as a registered clearing agency and the U.S. Commodity Futures Trading Commission (CFTC) as a Derivatives Clearing Organization. We provide clearing services for the sixteen US securities options exchanges and three futures exchanges. OCC cleared 5.24 billion contracts in 2018 and through August is only 3.2% below that record setting pace for 2019.
- As the 'central counterparty' for these markets, OCC assures the financial performance of the derivatives contracts it clears with respect to its 115 clearing members. Consistent with global industry standards, OCC utilizes three fundamental tools in providing these services, which it has done successfully every business day for forty-six years:
  - Stringent financial and operations standards for admission to and continuation of clearing membership based around periodic financial reporting and on-premises risk and operations inspections.
  - A rigorous margin methodology requiring liquid financial resources in place to cover a very conservative estimate of the probable change in the value of clearing member portfolios. Details of OCC's approach follow.
  - A risk mutualizing clearing fund (currently at $10.8 Billion) based on stress tests that examine 'extreme but plausible' market and liquidity changes bolstered by assessment powers of up to twice that amount.

Renaissance Initiative Overview

- In January 2019, OCC launched our Renaissance Initiative, an ambitious, multi-year investment to modernize OCC's legacy 'Encore' risk management, clearing and data systems to better serve market participants. This will enhance OCC's resiliency, improve our compliance posture, and help us operate in a more effective and efficient manner so we can best serve market participants and the investing public.
- The risk management elements of the Renaissance Initiative will expand and strengthen our current capabilities, providing an environment for intra-day risk management, intra-day computations, pricing and revaluation. It will enhance the efficiency and speed of margin, stress-testing and back-testing capabilities.
- Our core clearing system will deliver many advantages, including enhanced functionality to procure and submit data to and from the system for external and internal users, stronger ad hoc reporting capabilities, enhanced control and information security mechanisms throughout the systems, improved industry-standard futures processing, and greater flexibility in processing clearing member trade agreements.
- The development of our data platform, which will be independent from our clearing and risk systems, enhances OCC's ability to process and manage data. We will have self-service capability for data discovery, search and historical analysis as well as a scalable and secure centralized enterprise repository that can serve data to concurrent processing needs, including report generation, back-testing and stress-testing.

STANS Margin Methodology-1

Under the STANS methodology, which went into effect in August 2006, the daily margin calculation for each account is based on full portfolio Monte Carlo simulations and - as set out in more detail below - is constructed conservatively to ensure a very high level of assurance that the overall value of cleared products in the account, plus collateral posted to meet margin requirements, will not be appreciably negative at a two-day horizon.

Until February 2010, securities posted as collateral were not included in the Monte Carlo simulations, but were subjected to traditional "haircuts." Since then, the "collateral in margins" approach has taken effect, whereby some collateral securities - specifically equity securities and, more recently, U.S. Treasury securities (excluding TIPS) - have instead been included in the Monte Carlo simulations. Thus, the margin calculations now reflect the scope for price movements in these forms of collateral to exacerbate or mitigate losses on the cleared products on the account.

STANS Margin Methodology-2

The Monte Carlo simulations are based on econometric models of the joint behavior of the risk factors affecting values of CM accounts at OCC. The majority of risk factors pertain to the prices and option-implied volatilities of individual equity securities. The modeling of each risk factor allows for volatility clustering and fat-tailed innovations. The joint behavior is addressed by combining the marginal behaviors of individual risk factors by means of a copula function that takes account of correlations and allows for tail-dependence.

The Monte Carlo simulations use the greater of the short-term level and longer-term level for the volatility of each risk factor as an Anti-Procyclicality tool.

STANS Margin Methodology-3

The base component of the margin requirement for each account is obtained from the risk measure known as 99% Expected Shortfall. A 99% Expected Shortfall averages all of the base theoretical losses from the 99% Value-at-Risk (VAR) point to 100%. This approach is inherently more conservative than a straight VAR approach.

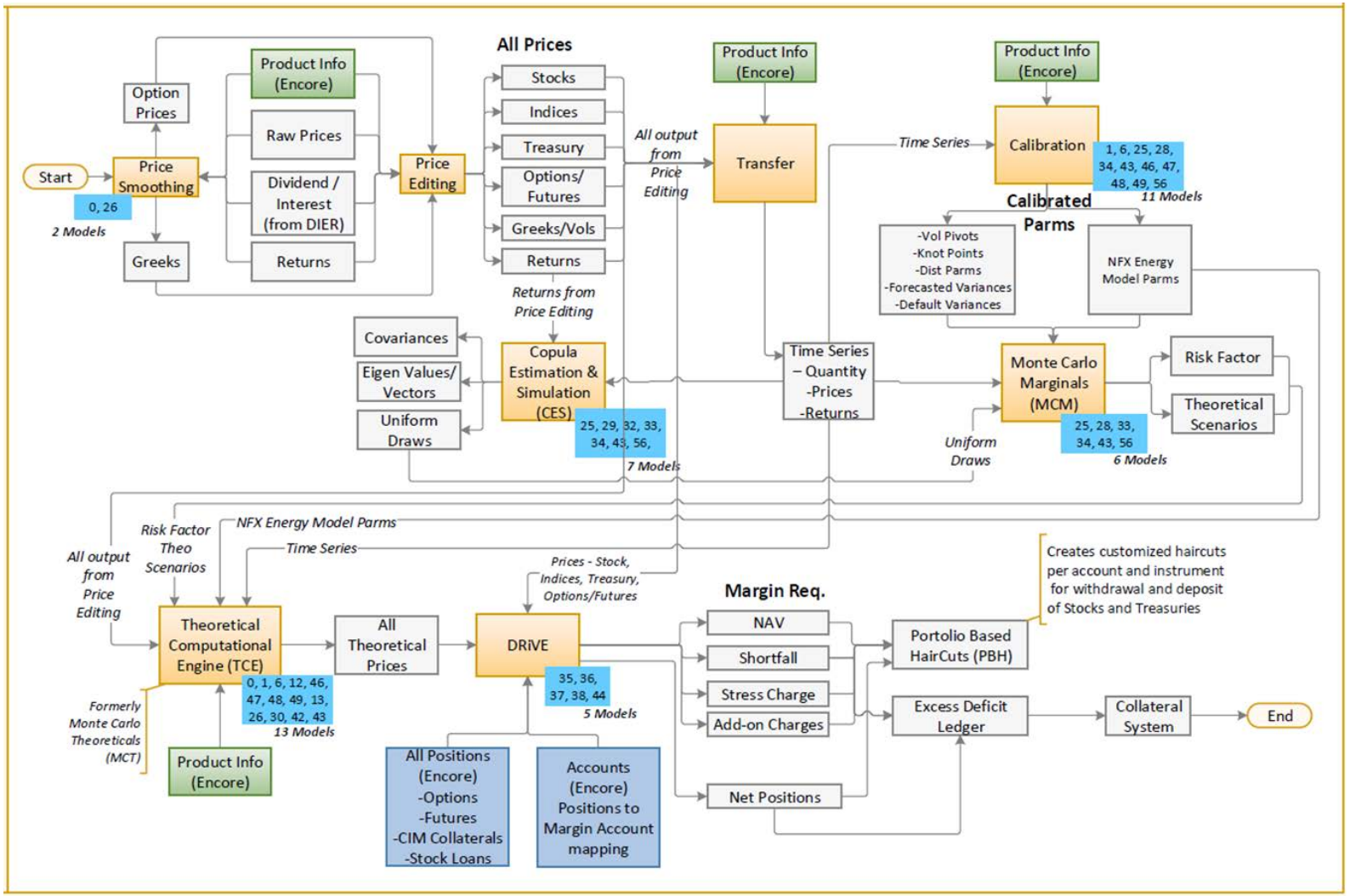
The base component is adjusted by the addition of a stress test component. The stress test component is a de-correlation scenario utilizing zero correlation, observed historical correlation, and perfect correlation, as well as an examination of extreme adverse idiosyncratic movements in individual risk factors to which the clearing level account is particularly exposed.

Several other components of the overall margin requirement exist, but are typically considerably smaller than the base and stress test components. These are modeled at a higher confidence level than the above and many of them affect only a minority of accounts.

All models require validation, monitoring, adjustment of parameters and as products and markets evolve, potential replacement.

Encore Margin Calculation Process and System Overview

The simplified illustration below captures the complexity of daily margin process and system environment



Legacy Encore Margin Processing:

ENCORE systems run sequentially in a batch process on large Linux servers accessing and storing data to an IBM mainframe utilizing DB2. Data outputs from one system have to be loaded as inputs to the next system with excess run time and potential points of failure

- **Calibration & Transfer** – 60 minutes/day, calibrate volatility forecasting parameters from historical data; fit options implied volatility surfaces; generate futures synthetic time series; calibrate parameters in specialized pricing models (calculation intensive)
- **Copula Estimation & Simulation** – 30 minutes/day, generate theoretical scenarios of all risk factors that reflect the actual historically observed correlation between their movements (calculation intensive)
- **Monte Carlo Marginals** – 50 minutes/day, create a large sample of theoretical market scenarios for each underlying and specialized risk factor, using current close prices and volatility forecasts (I/O and calculation intensive)
- **Theoretical Computation Engine** – 90 minutes/day, uses underlying price scenarios and implied volatility surface scenarios, product-specific pricing models to create theoretical instrument price scenarios, outputs a 42GB file (I/O and calculation intensive)
- **DRiVE** – 150 minutes/day, aggregates equity and derivative price scenarios to produce portfolio P&L, uses Extreme Value Theory for margin calculation. 85% of elapsed time is spent reading inputs and writing results (I/O and calculation intensive)

Recent Enhancements to STANS

- Responding to input from OCC's on-going monitoring of coverage, parameters, input from our 'second line of defense' Model Validation Group, as well as from our regulators (SEC, FRB and CFTC) we have made a number of enhancements.
- Anti-procyclicality measures: '**Daily Univariate**' enhancements moved our parameter updates from monthly to daily and utilized the higher of the most recent or a 10-year lookback for volatility.
- **Liquidation Cost Model** enhancements (coming mid-October) examines stressed period bid/offer spreads on options and adds to the margin requirement to account for the cost of liquidating portfolios in the event of clearing member default. Also included is a concentration scalar that increases requirements for low liquidity instruments.
- A position **Specific Wrong Way Risk** enhancement accounts for stock positions going to zero and bond positions (including ETNs) going to a recovery rate (pending regulatory approval). OCC has long had 'wrong way risk' protections built into its collateral acceptance policies.
- Additional enhancements will move certain of the modeling techniques closer to those utilized by banks for their CVA/IMM models which should facilitate replication by clearing members.
- These changes are initially developed by OCC's 'quants' in our Quantitative Risk Management group, and then independently validated by our Model Validation Group in our 'second line of defense' control team. They are also responsible for the annual validation of all risk models at OCC.

Renaissance Initiative Objectives

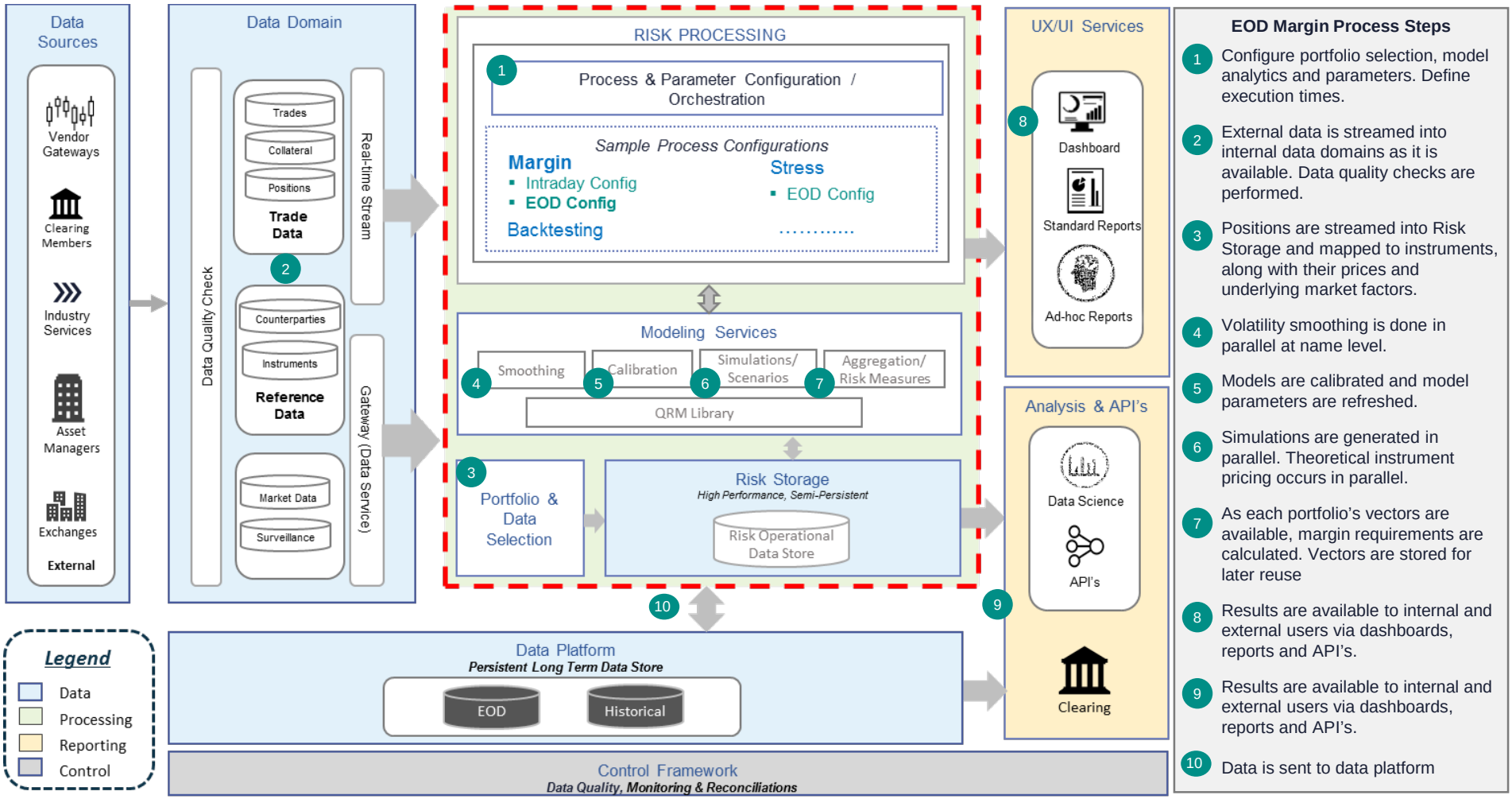
With the information on our robust STANS margin methodology operating in our legacy Encore technology environment as background, it is useful to use margin processing as an example of how the Renaissance Initiative will fundamentally alter both our technology, but also all of the operational processes that have grown up at OCC as we have utilized that environment for the past twenty years.

Renaissance Risk: Target State Architecture Design Principles

Current State		Target State	
Batch Driven	Sequential processing, limiting real-time analysis	**Event Driven**	Processing occurs as data inputs are available or updated, supporting real-time analysis
Limited Configurability	Restrictive process configurations	**Highly Configurable**	Parameter driven process configuration, improving flexibility and time to market
Monolithic	Tightly coupled architecture. Replacing or invoking components and models not easy	**Modular**	Microservice architecture enabling easier replacement and invocation of components and models
Limited Scalability	Fixed computing resources	**Horizontally Scalable**	Elastic cloud resources, enabling flexible computing allocations
Slow Data Throughput	File and DB data transfers slowing overall performance	**High Data Throughput**	Leverage high performance in-memory data architecture
Static Reporting	No self service business intelligence reporting	**Business Intelligence**	Self service ad-hoc reporting. What-if analysis.

Renaissance Logical Target Risk Architecture

Margin Process for Illustration



EOD Margin Process Steps

1. Configure portfolio selection, model analytics and parameters. Define execution times.
2. External data is streamed into internal data domains as it is available. Data quality checks are performed.
3. Positions are streamed into Risk Storage and mapped to instruments, along with their prices and underlying market factors.
4. Volatility smoothing is done in parallel at name level.
5. Models are calibrated and model parameters are refreshed.
6. Simulations are generated in parallel. Theoretical instrument pricing occurs in parallel.
7. As each portfolio's vectors are available, margin requirements are calculated. Vectors are stored for later reuse
8. Results are available to internal and external users via dashboards, reports and API's.
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10. Data is sent to data platform

Questions?

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