



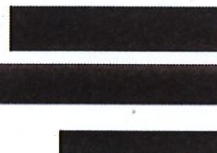
## Kentucky Teachers' Retirement System



### Proposal for QED Platform as a Service System Capabilities Upgrade

21 August 2013

Prepared by



## Contents

1. Executive Summary-----	3
2. Fulfilling Your Primary Business Requirements-----	10
3. Your QED Platform Deployment-----	12
4. Description of QED Platform Features -----	14
5. Terms -----	18
6. System Architecture -----	21
7. Next Steps & Rollout-----	26
8. Confirmation to Proceed -----	27

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## 1. Executive Summary

QED has prepared this proposal for PaaS (Platform as a Service) migration, system enhancements and ongoing maintenance of the QED portfolio accounting and investment management platform. Based on the current platform (Version 2 Revision 11.3) in use by Kentucky Teachers' Retirement System (KTRS) and additional QED provided capabilities, execution of this proposal will make the following capabilities available to KTRS via internet connectivity to QED's hosting facility. As proposed this project addresses migration and ASP support for currently implemented platform capabilities.

<p><b>Portfolio Accounting Foundation</b></p>	<p>QED's global multi-currency platform will provide portfolio accounting, securities workflow support, and financial data management to support the investment business for the Kentucky Teachers' Retirement System.</p> <p>The platform will be delivered as a hosted solution accessed by Retirement System staff via the Internet from any approved location (office, and/or remote locations in accordance with security guidelines established by the State of Kentucky).</p> <p>The QED solution is a multi-basis, multi-currency system that processes events (e.g., trading, settlement, security master, reconciliation, general ledger accounting, performance measurement, reporting and analysis) in real-time ensuring users have access to data delivered within a "single version of the truth paradigm," regardless of role, function, or location.</p> <p>QED's platform also provides advanced and automated workflow processes minimizing the need to augment your investment operation with manual tasks, custom applications, or data management outside the QED application framework. QED's portfolio accounting foundation serves as the financial data management center facilitating internal access to data across KTRS front, middle, and back offices.</p> <p><i>** The QED General Ledger is a separately licensed module not included as part of this proposal.</i></p>
<p><b>Securities Movement &amp; Control</b></p>	<p>The QED platform automates straight through processing through the receipt and processing of bi-directional trade traffic between third parties, trading systems, broker, manager, and custody bank notifications. This integrated feature enables electronic delivery of trade advices to clients, depositories, regulatory agencies, banks, and</p>

**Market Data Management**

third party systems for fully automated trade recordkeeping.

In addition, the QED platform incorporates automated transaction, position, and cash activity captured from custody banks for automated reconciliation, full confirmation/affirmation processing with the DTCC, settlement/delivery instruction advices with custody banks, and real-time settlement of cash with multiple depositories.

Integration of multi-vendor market pricing, corporate action notifications and security master services across global asset classes comprise a robust global market data management capability for KTRS investment operation.

The QED platform provides a hierarchical multi-vendor infrastructure for the automated receipt and recording of pricing, quality ratings, securities (issue level) events, and security terms and conditions coupling transaction activity between the issue ledger, investment sub-ledger and general ledger for life cycle position investment management.

Integration of multiple market data sources combined with controls associated with security level data provide "Gold Copy" security master assets for your investment business. Full context integration throughout the QED platform provides immediate reference and navigation between the security master, position record, position transaction ledger (investment sub-ledger), issue event ledger, and general ledger journal transactions. These tools allow you to conduct research and trace securities events within and across portfolios while maintaining full control of your financial assets.

**Reconciliation**

The QED platform includes integrated reconciliation tools that facilitate the automated resolution of investment accounting data activity and balances with third party sources such as custody banks, prime brokers, trading systems, settlement banks, and the DTCC.

The business rules driven reconciliation process, enabled by straight through processing interfaces to multiple third party sources, will allow KTRS to manage position, transaction, and cash reconciliations on a proactive exception basis and address identified variances through direct access to financial information within the accounting system foundation.

Aligned with KTRS investment business, the QED platform will be configured to automatically gather data from defined third party



	<p>sources for reconciliation directly against KTRS book of record maintained on the system. Users may define reconciliation business rules templates that specify data elements and reconciliation tolerances. Further supporting the reconciliation workflow are standard and user-defined reports that provide detailed information on unmatched, near-matched, and matched records. The online views and reports highlight breaks (unmatched fields) and can be configured to display specified data as well as the defined matching criteria for each reconciliation task.</p>
<p><b>Portfolio Analytics and Performance Measurement</b></p>	<p>The QED platform fulfills an essential role in the management of KTRS investment portfolio through the accurate and reliable evaluation of portfolio statistics and rates of return providing insight and transparency across numerous dimensions and scenarios.</p> <p>Enhanced analysis features include the daily evaluation of investment rates of return and net asset value including securities market values on trade date, settlement date, cash, or ex-date basis with earned and accrued income, securities receivables and payables, and accrued fees.</p> <p>Rates of return measurements include evaluations by account (fund), GIPS segment, asset type, economic sector, industry classification, country, currency; user defined groups, and many other dimensions as well as the individual security level.</p> <p>Integrated performance measurement and analysis features allow for the creation of unlimited composites, including automatic entry and exit rules for constituents. Backed by accounting controls and a secure audit trail, performance measurement evaluations are linked to underlying securities and accounting records for effective drill-down analysis over user-selected time horizons (date ranges).</p>
<p><b>••Business Intelligence Reporting Suite</b></p>	<p>The QED platform allows KTRS to produce and publish reports and analysis views directly from the portfolio accounting environment through the QED Business Intelligence reporting portal (QBI) and the Quantum Financial Desktop.</p> <p>These integrated features provide visualization of real-time investment activity within your business including trading activity, transaction details, running balances, inventories, cash management, and performance measures. The QED platform includes a library of pre-defined industry standard reports for internal and external information consumers.</p>

	<p>QED reports provide summary and detailed views for client, account, composite, agency, and bank relationships. The platform includes report writers that allow creation of branded, user-defined reports using a drag-and-drop interface. All system data elements are available in real-time and work with macro editors that enable inclusion of user-defined data elements, calculations, weighted averages, percentages, headers and footers, data from other databases, etc.</p> <p>System reports can be generated in various forms depending on the options selected at the point of generation (run-time). These run-time options are specific to each report and are defined by the user in a graphical selection window. This window allows users to selectively include or exclude specific entries or groups of entries within categories of portfolios, funds, asset-types, countries, currencies, custodians, advisors, etc. Based on these report parameters (including any "as-of" date or date range) results are evaluated in real time and report output generated in the form and format selected for the report. Additional reporting criteria are also provided according to the specific focus of the report.</p> <p><i>** QED Business Intelligence and Quantum Financial Desktop are separately licensed module which are available but not currently in use within KTRS.</i></p>
<b>Audit Control &amp; Configuration</b>	<p>The QED platform is built on a secure, multi-tiered work environment that provides mandatory user authentication and security features such as the ability to assign privileges at the file, module, function, data group, fund, and business unit level. Based on detailed logs, real-time audit trails include: User Access, Security Master Referential Data, Funds (Accounts) and Portfolios, Position Holdings and Cash Accounts, Transaction Capture &amp; Modification, Transaction Posting Errors and Warnings, Invocation of Automatic Posting Procedures, Client Business Rule Definition Tables, Report Processing and Interactive Queries, and System Administration Tasks.</p> <p>This extensive set of system controls, audit logs, and reports ensures the safety and integrity of the financial data managed within your investment business.</p>
<b>••Securities (Corporate) Actions Processing</b>	<p>Securities actions processing within the QED platform implements a transaction register that records mandatory and discretionary actions include identity changes (e.g., security identifier, name, and ticker symbol), mergers, acquisitions, splits, distributions, spinoffs, redemptions, dividends, recapitalizations, and fixed income security</p>



	<p>life-cycle events. Even news events such as shareholder meetings, approvals, and resolutions are received and recorded for review. Discrete events are recorded as a ledger transaction at the issue level (security master events ledger) and actionable events can be automatically processed across all portfolio holdings on a specific entitlement basis. Corporate action announcements are automatically received on a daily basis as part of the QED market data services powered by Interactive Data, Ixshare Financial, and Xcitek (an Interactive Data-owned company) and include the terms and conditions of each event as well as full text narrative descriptions of the events.</p> <p>The QED platform automates transaction processing for mandatory corporate actions, administrative tasks, and routine portfolio maintenance operations. Corporate actions can be processed globally across a set of funds defined by client-specific business rules. Full automation support is provided in the QED platform for mandatory corporate actions.</p> <p>The system contains completely integrated and automated procedures for processing corporate actions and events pertinent to the security at the issue level. The transaction engine is real-time and completely self-balancing. Transaction ledgers contain cumulative balances at each transaction event date that are automatically updated upon transaction entry, modifications, and deletions preventing point-to-point out of balance situations. The system allows clients to process block commitment trades and allocate trades across funds. The system maintains investment accounting data elements for position, transaction, cash and general ledger and journal records with complete running accounts of position size (par, shares, units, contracts, etc.), original mortgage securities pool value, unamortized cost, amortized book value, lifetime earnings to date, lifetime income to date, purchased and sold interest balance to date, weighted average yield to maturity, and other values.</p> <p><i>**Automated Corporate Actions Processing is a separately licensed module which is available but will not be activated as part of this project.</i></p>
<b>Relational DataMart</b>	<p>In today's business environment, it's no longer optional to have a single, enterprise-wide and integrated view of financial data – it's mandatory. New regulatory requirements for financial institutions mandate that data across the enterprise be centralized, integrated, accurate, and auditable. The practice of data warehousing is steadily</p>

pushing analytics from the executive level down to the tactical and operational levels throughout the enterprise. Data warehousing has become a mission critical facet of businesses simply because its absence or degradation affects the ability of an organization to focus on achieving its fiscal responsibilities and revenue generation goals.

By extracting all data relevant to the business decision-making processes from the QED platform production system and protecting the production environment from the impact of organizational data mining and data analysis, the QED DataMart promotes data centrality and enables organizations to easily share investment data across their enterprises. The QED DataMart aggregates and summarizes enterprise investment data in a dimensional model – a hierarchical composition of facts presented using multiple views across dynamic dimensions. The extraction process copies relevant data from the system, scrubbing the data to remove anomalies, inconsistencies, and unnecessary information, and enriches the data by translating numeric codes and acronyms into easy-to-understand textual information.

The QED DataMart enhances a client's ability to perform routine data analysis and complex data mining without causing degradation to time-sensitive operational business processes, such as data entry and data communications. Additionally, the QED DataMart protects the integrity and security of proprietary investment data by selectively separating data for analysis into an ODBC-compliant environment specifically designed for access by a variety of reporting tools such as Oracle Discoverer, Microsoft Access, Crystal Reports, and other SQL query tools.

The QED platform provides the following strategic benefits to your organization:

- ✓ Enhanced levels of automation for management of critical information within a fully integrated multi-currency portfolio management and investment accounting platform for both current and future business initiatives
- ✓ Straight through processing workflow enhancing efficiency and transparency to front, middle and back office operations
- ✓ Centralized control and audit of investment data and activities within a single, secure database library accessible from multiple office locations and providing consistent real time investment information to your team
- ✓ Sophisticated automation for management of security master reference data, market pricing, trading activity, custodial and accounting records, elimination of manual processes and reduction of data management and reconciliation workloads



- ✓ On-demand access to robust reporting features and content generated in real-time based on "last action" data, thereby eliminating the need to export and reprocess data to obtain reporting results
- ✓ Consistent treatment and evaluation of global investment data for calculations according to industry standards and guidelines while providing GIPS-compliant reporting evaluations of performance rates of return consistently across from the security level up through user-defined (or client-defined) composites
- ✓ Production, testing, and daily synchronized disaster recovery environments for the QED platform

Our proposal includes a term sheet with an itemization of recurring license and maintenance fees, market data costs, and non-recurring hardware, customization, and deployment charges. Estimating based on our deployment process and understanding of the requirements for this effort; we believe this project will require approximately three months from proposal acceptance.

Subject to acceptance of this proposal, the next steps are written confirmation to proceed and formal implementation planning.

## 2. Fulfilling Your Primary Business Requirements

Based on our conversations to date, this upgrade and PaaS migration of the QED platform will fulfill the following strategic business requirements:

Strategic Business Requirement	QED Feature	Business Outcome
Straight through processing framework to streamline workflow between front, middle and back office operations	QED Portfolio Accounting Foundation and Financial Data Management Tools	Integrated real-time data exchange throughout the investment business cycle from receipt of trade execution through trade settlement of investment activity with on-demand access and data visualization to facilitate decision making, execution and operational business activities.
Provide a secure and controlled investment accounting platform that can support KTRS's current and future business initiatives including expansion in global investment strategies and asset classes across multiple business office locations.	PAAS Hosted QED Accounting Foundation	The Kentucky Teachers' Retirement System will coordinate control of the definition of user profiles and enjoy the ability to conduct business from authorized locations in real-time with complete confidence of secure information access and control, system scalability, and support for current and future investment management initiatives. Future requirements for application hosting, technical infrastructure procurement and support, disaster recovery and business continuity planning will be provided via this PaaS implementation.
Provide efficient and reliable management of reference data in support of KTRS investment management, trading and accounting business functions.	QED Accounting Foundation Universal Data Exchange	Automated processing of security master reference data, market pricing and trade activity records in support of daily KTRS investment business operations. Market and custody bank data import will be utilized as needed to validate the KTRS book-of-record based on business rules configured in accordance with KTRS's business practices.



Provide integrated support for capture of trading activity including receipt of trade executions to reflect current trading activity, trade settlement and real time evaluations.

QED Accounting Foundation Trade Import and Reconciliation Features

Cross-platform connectivity and integration for efficient and automated securities processing and management, including easy-to-use tools to facilitate data exchange with external sources.

### 3. Your QED Platform Deployment

QED will undertake the migration to stage, configure, and implement the QED platform within its hosting facilities based on your stated requirements. The solution will consist of:

Feature	Configuration Notes
<b>Portfolio Accounting Foundation</b>	The QED team will configure and deploy the current version of the QED platform as a PaaS Hosted platform in accordance with the needs and requirements of the Kentucky Teachers' Retirement System. This implementation project will include migration and reconciliation of the QED core database library to the schema defined for the current software version. Execution of this migration will include QED supported steps to systematically transition existing KTRS production capabilities onto QED provided hardware platforms. QED will also provide Disaster Recovery services in support of KTRS business continuity objectives.
<b>Securities Movement &amp; Control</b>	Configuration of QED order management, trade match, and affirmation features in accordance with capabilities of KTRS's selected trading processes and custody bank systems to the extent that such systems support the automation of straight through transaction processing.
<b>Market Data Management</b>	KTRS's implementation will include configuration and automated delivery and integration of Interactive Data security master reference data and market pricing.
<b>Reconciliation</b>	As part of the QED implementation project, KTRS's reconciliation requirements will be configured for automated exception processing of data received from third-party sources including reconciliation business rules, tolerances, and reports.
<b>Securities (Corporate) Actions Processing and Portfolio Maintenance Tasks</b>	The QED team will work with KTRS staff to configure securities actions processing and portfolio maintenance tasks to automate daily and periodic transaction processing workflows in accordance with KTRS standard operating procedures.



<b>Business Intelligence Analysis and Reporting</b>	Implementation of the current QED software version will provide the QED standard reporting library and graphical report writer studio and tools for development of operational analysis and branded, enterprise and constituent-ready reports. In addition, QED will work with KTRS staff to upgrade and validate reporting applications previously developed by KTRS in accordance with KTRS business needs.
<b>DataMart</b>	Integral to the implementation of the current QED software version, the QED team will stage and configure a relational investment database schema (QED DataMart) to support the development and publishing of business intelligence reports, and the near real-time data mining and information analysis requirements of KTRS. The DataMart configuration will be staged in a manner that will facilitate existing data extracts in support of third party reporting tools managed internally by KTRS using Crystal Report.

## 4. Description of QED Platform Features

Deployment of the QED platform will include the Portfolio Accounting Foundation and additional features selected to meet the specific requirements of your investment operation. The following overview of system capabilities represent a summary of functionality supported by platform. As your financial managements needs evolve QED is available to work with KTRS to leverage additional system modules and functionality in support of growing business requirements.

### Portfolio Accounting Foundation

Central to the deployment of the QED solution, the Portfolio Accounting Foundation will provide the data integrity needed for effective portfolio management including automated transaction processing, reconciliation, financial data management, reporting, and investment analysis. The Portfolio Accounting Foundation will benefit your business through:

- ✓ Implementation of an efficient and scalable business solution for current and future business requirements.
- ✓ Integrated straight through processing facilitating seamless workflow between front, middle and back office investment management functions.
- ✓ Efficient tools for application of investment strategies through model construction, rebalancing, order generation and execution in response to dynamic market conditions.
- ✓ Reliable and scalable facilities for the timely and accurate management of critical investment data in support of each aspect of portfolio management and investment accounting operations.
- ✓ On demand access to business information delivered through robust reporting tools delivering up to the minute transparency for decision makers throughout the organization.

Over the past twenty-four years, our clients have relied upon QED and the QED platform to provide the functionality necessary to meet their investment business requirements. And, while no clients use the QED platform in an identical manner, they rely on QED to provide a reliable, scalable software platform that includes, among many other features:

- ✓ Extensive Global Fixed Income, Equity, Derivatives and Alternatives Coverage
- ✓ Multi-Currency and International Securities Processing and Reporting
- ✓ Internal and External Straight Through Processing Conduits and APIs
- ✓ Book-of-Record Investment Accounting
- ✓ Extensive Portfolio Management Features including Risk Management and Rebalancing
- ✓ Real-time, Parallel Cash Management and Cash Track Intra-day Cash Sweep and Settlement
- ✓ Common Fund Accounting and Participant Investment Management
- ✓ Real-Time Position and Trade Evaluations
- ✓ Multi-Vendor Pricing and Corporate Actions Feeds
- ✓ Automated Global Corporate Actions Events Processing
- ✓ Automated Collateral Processing and Real-time Sufficiency Analysis



- ✓ Rules-Based Reconciliation and Settlement Control
- ✓ Real-time DTCC Trade Match (Confirmation) and Affirmation Processing
- ✓ AIMR/GIPS Performance Measurement Presentation
- ✓ Multi-Currency, Multi-Portfolio, Dual-Entry Investment General Ledger
- ✓ Controlled and Automated General Ledger Hard Close
- ✓ Compliance Monitoring of Investment Policy and Approved Lists
- ✓ Multiple Vendor Market Data Management (including hierarchical rules for market price sources)
- ✓ Advanced User Profile and Security model
- ✓ Reconciliation Tools for cash, position and transaction activity from multiple third party sources
- ✓ Universal Third-Party Import and Export Message-based Conduits (including extended capabilities for data import and export tasks including reusable, rules-based extraction, translation and loading templates)
- ✓ Expanded Business Rules Tables (including hierarchical account aggregation for parent and child plans)
- ✓ Real-time, Interactive Portfolio Holdings Dashboard (including user-customizable views)
- ✓ Real-time, Interactive Investment Transactions Dashboard (including user-customizable views)
- ✓ Efficient and Accurate Software Implementation and System Conversion
- ✓ Open and Extensible Relational Database Model
- ✓ Branded, Customizable Business Intelligence Reporting Portal
- ✓ Integrated User Collaboration and Data Sharing
- ✓ Powerful, Scalable, Easily Maintained Architecture
- ✓ Operator-Friendly, Personalized Software Interface
- ✓ Industry-Leading Customer Support and Professional Services Organizations

We are confident that KTRS will continue to benefit from QED's experience with our institutional investment and asset management clients and that the QED platform will continue to be the best solution for KTRS's portfolio accounting and investment management system needs as defined through our discussions to date.

Brief summaries of key features of the Portfolio Accounting Foundation are below:

#### **Securities Movement & Control**

The QED platform offers straight through processing based on bi-directional trade traffic to and from third party or proprietary trading systems including position refreshes. This allows electronic delivery of trade notifications to clients, depositories, regulatory agencies, and third party applications in addition to handling trade advices from external managers for fully automated trade postings.

The QED platform provides access to automated transaction, position, and cash activity captured from custody banks for automated reconciliation, full download confirmation, and upload affirmation with depositories, and settlement/delivery instructions advices for custody banks.



### Reference Data Management

Integration of market pricing, corporate actions, and security master services provides the foundation for global market asset data management. The QED platform supports multi-vendor pricing, bond ratings, and security terms and conditions detail coupled with data management for esoteric asset classes.

Integration of market data sources combined with controls associated with security level data provides a "Gold Copy" security master asset. Full integration throughout the application provides navigation directly from the security master to positions, transactions, issue transaction ledgers, and journals for investments within your portfolios. The QED platform includes tools to conduct research and trace securities throughout your portfolios while maintaining control of data assets.

### Cash Management

The cash movement and settlement control system manages intra-day cash balances, disbursements, and receipts across multiple financial institutions. The system provides verification for all payment flows from deposits, withdrawals, security settlements, and transfers by individual account, payment type, netting basket, and institution.

The cash management functionality can reduce wire transfer costs by netting movements between settlement locations, based on criteria set by your operations team. Cash flows can be categorized based on specific business practices and reporting requirements. The platform can also automatically redirect income and corpus items from one internal fund to another or external sources upon receipt of cash.

### Investment General Ledger

The integrated investment general ledger feature supports automatic journal posting of investment activity, integration with enterprise general ledger systems, and financial statement reporting. This provides single entity and consolidated financial accounting statements such as trial balance, income statement, and flow of funds reporting.

The general ledger accommodates multiple charts of account, hierarchical entity roll-ups, and multiple fiscal accounting periods. The platform supports GAAP, FASB, IFRS, and business rule specific evaluations.

As an example, the QED general ledger charts of account may include:

- Change in Value (market, par, book, cost)
- Amortization and Accretion
- Realized/Unrealized Gains and Losses
- Currency Revaluation Gains and Losses
- Payables/Receivables
- Deferred Gains and Losses
- Accrued Income and Fee Income
- Equity and Retained Earnings
- Capital Contributions and Withdrawals
- Cash Balances

### Performance Measurement

The QED platform provides calculation of net asset value including securities market values based on a trade date basis, cash, ex-date basis earned and accrued income, securities receivables and payables, and



accrued fees. Rates of return measurements include calculations by account (fund), GIPS segment, asset type, economic sector, industry classification, country, currency, user defined groups, and many other dimensions including at the individual security level.

The performance measurement feature allows for the creation unlimited composites, including automatic entry and exit rules for constituents. All performance measurements are backed by accounting controls and a secure audit trail that links to underlying securities and accounting records for effective drill-down.

#### **Dashboards & Reporting**

Key activities of your investment management operation are available for real-time viewing including transaction details and running balances. The QED platform includes a library of over 600 pre-defined industry standard reports for internal and external information consumers.

This will provide summary and detailed reporting for fund, agency, and bank relationships. The platform includes a report writer that allows the creation of custom reports using a drag-and-drop interface. All system data elements are available in real-time and work with a macro editor that allows the addition of extra data elements, weighted averages, percentages, headers and footers, etc.

#### **Audit Control & Configuration**

The QED platform is built on a secure, multi-tiered work environment that provides mandatory user authentication and security features such as the ability to assign privileges at the file, module, function, data group, fund, and business unit level. Based on detailed logs, real-time audit trails include:




- |                                       |  |
|---------------------------------------|--|
| ■ User Access                         | ■ Transaction Posting Errors And Warnings    |
| ■ Security Master Referential Data    | ■ Invocation Of Automatic Posting Procedures |
| ■ Funds (Accounts) and Portfolios     | ■ Client Business Rule Definition Tables     |
| ■ Position Holdings and Cash Accounts | ■ Report Processing And Interactive Queries  |
| ■ Transaction Capture & Modification  | ■ System Administration Tasks                |

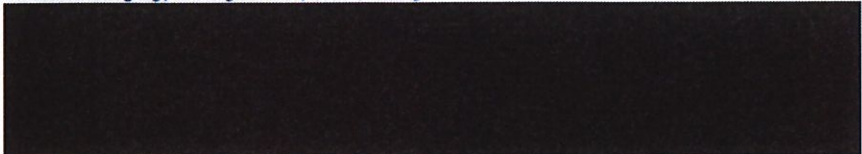

This extensive set of system controls, audit logs, and reports ensures the safety and integrity of the financial data managed within the business.

## 5. Terms

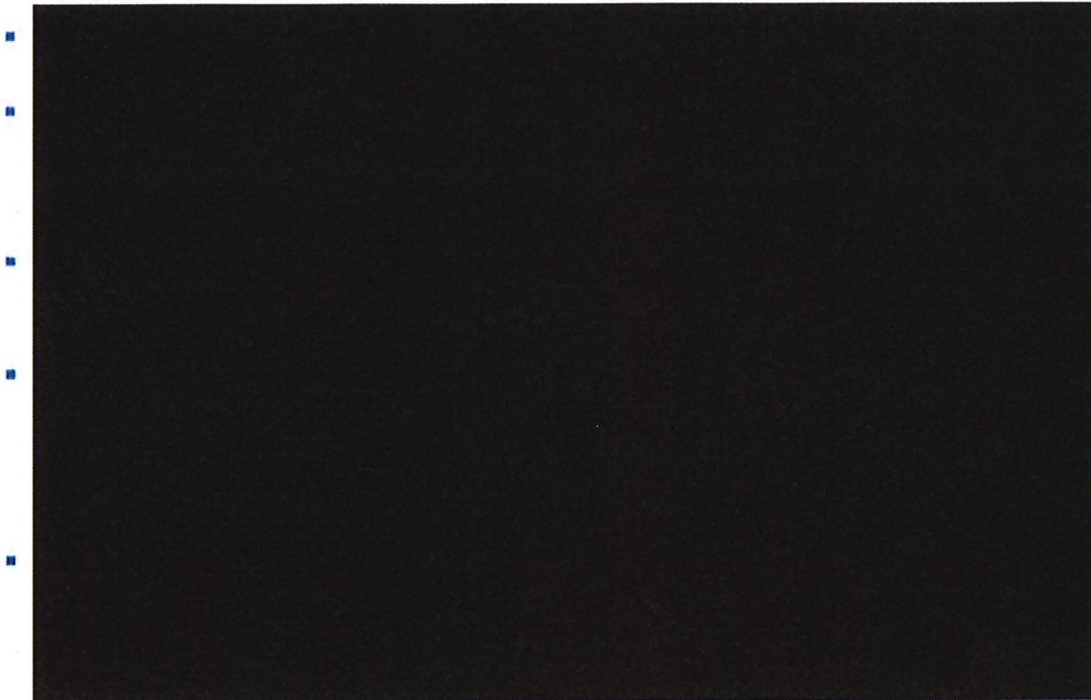
### QED Platform as a Service (PAAS)

The cost (U.S. dollars) of for licensing and implementing the QED platform as a service as outlined within this proposal is below:

QED Platform PaaS License	Annual, Recurring Cost
Portfolio Accounting Foundation, Including the following features as described in this proposal 	<div> <div>           Production Software            PaaS Hosting            Staging/DR         </div>  </div>
	Total      \$ 101,671.00

Development, Configuration, Training and Implementation Services	Non-recurring Cost
Platform Staging, Configuration, and Testing 	



**Training****Additional Engagement Codicils**

The 2011 QED Professional Services hourly rate schedule is (reviewed annually and are subject to change):

Senior Executive		Technology Engineer		Training Specialist	
Senior Systems Analyst		Business Analyst		Interface Specialist	
Financial Engineer		Programmer		Reports Specialist	
Applications Developer		Project Manager		Technical Writer	

All software developed by QED in conjunction with this or other projects will remain the intellectual property of QED under the terms and conditions of the existing agreements between QED and the client for the license and maintenance of the QED platform and no rights to such software whatsoever shall be inferred to be the property of any other entity.

Any additional work desired by the client beyond the scope defined in the agreement between QED and the client shall be provided under the terms of a separate statement of work and subject to the prior authorization of the client.



## 6. System Architecture

### QED Platform Architecture Overview

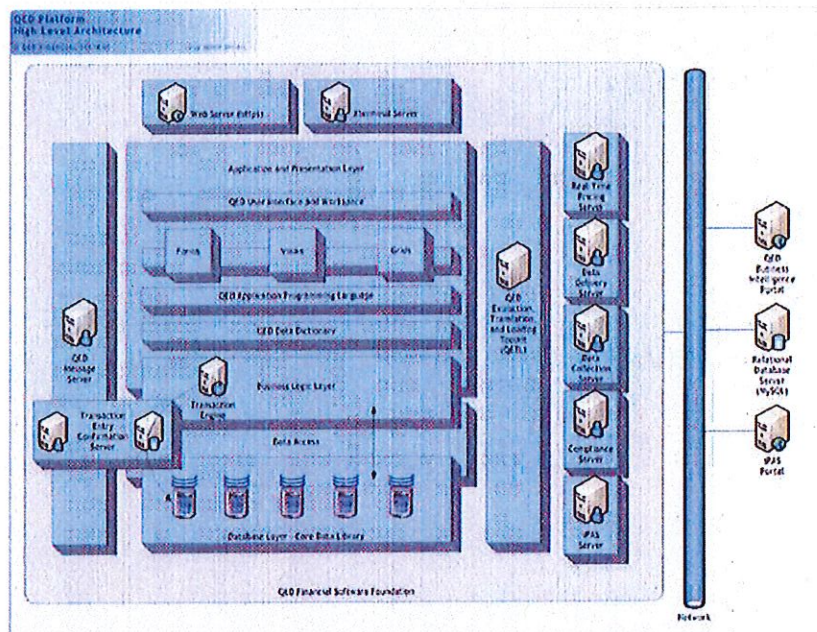
The QED platform has a sophisticated foundation with a real-time messaging backbone facilitating communication between the database, application logic, and client presentation layers.

### Development Environment

The integrated development environments (IDE) for the QED platform consist of Nokia/Trolltech Qt cross-platform application framework, JetBrains IntelliJIDEA, and the Sun Microsystems Studio12.

Application platform development and programming languages include Java, C++, and the QED Applications Programming Language (QAPL). The QED presentation layer is developed in both C++ and Java. The application logic layer is developed in C++ and is

extended with the QAPL. The QAPL is a proprietary development toolkit that enables QED team members and clients to design, develop, compile, and implement customized reports and data queries within the application logic layer of the system. The physical development hardware environment exists on an enterprise-class Sun Microsystems SPARC server under the Solaris operating system.



### Database Environment

QED employs several database storage engines within the database layer for the management of system level, production level, and customer level data within the architecture of the QED platform.

The primary repository for relationally validated data (protected and audited data library privately accessible only to authorized QED users) is the MySQL InnoDB and MyISAM record manager. Secure and embedded (non-server) database storage managers are implemented for system-level and system configuration data management.

The QED DataMart, the repository for publicly accessible views of investment data for enterprise reporting, market data libraries, and extended customer business data, can be deployed using the MySQL, Microsoft SQL Server, Postgres, or Oracle database servers depending on site preferences. Read access to this



repository is enabled by default while write access is restricted to application-level interfaces (and approved third party client systems) to ensure data integrity and security.

#### Application Programming Interface Environment

The QED platform is a secure, reliable, and highly scalable relational repository for the recording and retention of the data from third party sources. The QED database library contains a schema configured to the specifications that define electronic data communication formats. Data interface applications are configured to perform the retrieval (or receipt) of the file(s) on a schedule (with fail-safe notification and retry capability), translation of the file data, and storage of the data (as well as the source data file). The data repository is exposed for interrogation by QED report and data query tools (QAPL, VisualQED, Quantum) as well as third-party data interrogation and reporting tools allowing business users to develop standard and ad-hoc views of data that relate and combine transaction detail and other relevant data provided by third party sources.

The predominate force behind QED development and engineering efforts is system inter-connectivity and user collaboration that includes:

- electronic transaction-clearing using initiatives and standards such as DTC-ID, SID, SWIFT/I.S.I.T.C and XML messaging standards;
- on-line/real-time access to fundamental market data;
- electronic interfaces to external advisors and managers;
- electronic interfaces to custodian banks for transaction, position, cash, and collateral matching and reconciliations;
- electronic interfaces to front office trading and analytical systems; and
- electronic interfaces to other interested third party internal systems, regulatory systems, and general ledger systems.

The QED platform includes a robust data extraction, translation and loading toolkit (ETL) to facilitate the institutionalization of cross-system data transport and communication by business users. QED ETL is a flexible and configurable template and rules-set editor that includes such features as data element and record-level data translation mapping, static data assignment, data manipulation rules editing, conditional logic operators, and data type conversion. QED ETL supports native input and output formats including SWIFT, XML, CSV, tab-delimited, pipe-delimited, and fixed field.

The QED platform includes a variety of standard system-to-system interfaces, and the versatile, integrated QED Extraction Translation and Loading (QETL) import/export toolkit that allows clients to easily create and maintain custom interfaces for any external third party source from which data is received or sent. System interfaces support the exporting of detail and summary journal data to proprietary and third-party general ledger systems.

The QED platform contains system-level interfaces that have been developed, and are supported, with the following types of systems, services, and applications:



- General Ledger Systems
- Trading Systems
- Compliance Systems
- Performance Systems
- Attribution Systems
- Other Back Office Systems
- Third-party Custodial Systems
- Third-party Reconciliation Systems
- SWIFT
- DTC/Clearing Services
- Pricing Services
- Security Master Services
- Corporate Actions Notification Services
- Domestic and International Ratings Service Providers
- Third-party Analytics Systems (both equity and fixed-income)
- Middleware or Message Routing Applications

Current QED interfaces support:

- Transaction importing/exporting and transaction, position and cash reconciliation for custodian bank reconciliation.
- Transaction loading, exporting, and reconciliation with the DTC, including import of raw DTC data, advisor trade/DTC file reconciliation, and affirmation upload and reconciliation (Omgeo).
- The delivery of securities market data via Interactive Data and Standard & Poor's for more than 3.5 million securities, commodities, and derivative instruments, including daily evaluations for more than 2.5 million fixed income issues.
- The importing of transaction and security master file data and the exporting of positions to proprietary and third-party trading systems, including Macgregor, FlexTrade, INDATA, Bloomberg Trading, EZE Castle Software, Charles River, and Tradeware.
- The exporting of detail and summary journal data to proprietary and third-party general ledger systems, including Oracle, PeopleSoft, Sungard, and Great Plains.
- The exporting of data to third-party analytical systems, including CMS BondEdge, Barra, Salomon YieldBook, Quantal International, Advisor Software, Inc., Factset, and Investment Metrics.
- Loading and reconciliation procedures for domestic and global brokers, such as JP Morgan, Merrill Lynch, American Express, Schwab, Brown Brothers Harriman, Bank of New York/Mellon, Brinson Partners, and other advisors, such as Putnam Financial, Marathon, Capital International, Walter Scott, S G Pacific, Newgate Management Associates, and others.

QED's professional services team has created interfaces such as those listed above for our clients. Additional interfaces can be created as requested, or clients can use our integrated import/export utility to exchange data with outside entities, in-house applications, and third-party software packages and trading systems.

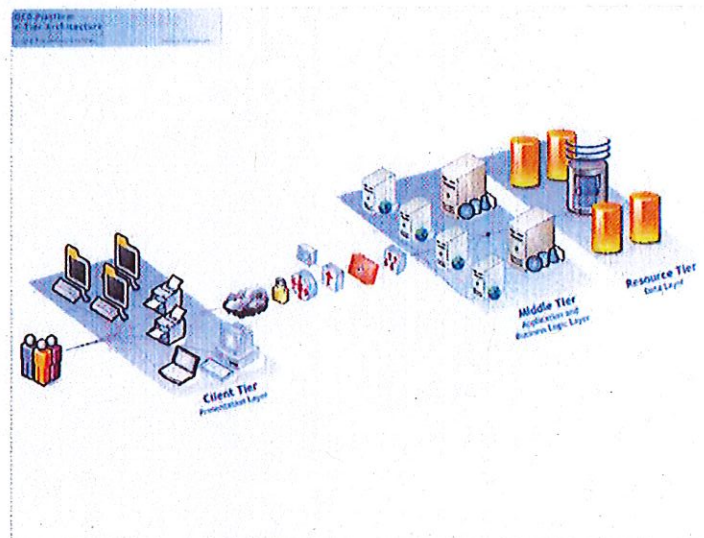


### System Deployment

QED will deploy and manage the QED platform as a service (PAAS) from our datacenter facilities. The following information is intended only to provide highlights of the various technologies that comprise the platform architecture and deployment.

The QED platform is developed for deployment on Sun Microsystems SPARC-based servers under the Sun Solaris operating system with transparent interfaces to Microsoft Windows clients (XP, Vista, and Windows7), Sun Solaris X86 clients, Linux clients, and Macintosh clients.

The QED platform is engineered under a services-oriented architecture that utilizes separate presentation, application, and database layers residing on a centralized applications server. Clients use two methods of accessing the system: X-emulation and Internet browser agents for access to the platform in either local area network (LAN) or QED facilities management hosted (Application Service Provider) scenarios respectfully where the QED team provides system administration support or system administration services for the management of the solution environment.



### Managed PAAS Deployment

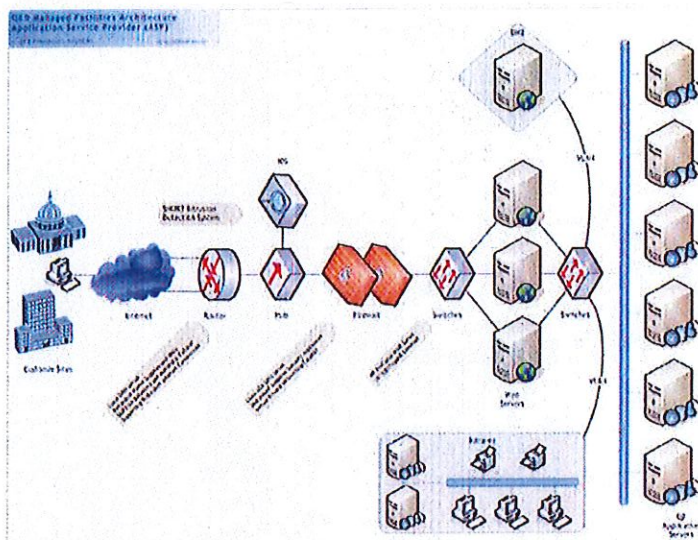
Within the managed PAAS environment, (see diagram below) the client Internet browser-based interface connects via a web server running the Oracle Secure Global Desktop (SGD) portal under the Apache Tomcat Web Server. The SGD portal marshals authenticated user traffic through secure connections directly to each client's target application server. Access to the QED platform from a user's workstation under the PAAS model is conducted using an Internet browser (e.g., Microsoft Internet Explorer (v7 or above), Mozilla Firefox (v3 or above), Apple Safari (v3.2 or above)). Internet browser configuration must include the Sun Microsystems Java Plug-in for Java Run-time Environment (JRE) version 1.6 or later.

On initial connection to the SGD portal server a Java Applet is moved to the user desktop computer as a browser applet to manage the secure connection and the user session. The SGD, along with Apache, provides both; encryption of the session and compression that allows for safe and speedy data movement. The SGD portal provides integration with Lightweight Directory Application Protocol (LDAP) and Microsoft Windows Server operating systems Active Directory for single-point user account administration and management. Under this deployment model, the application server also acts as the print server for user



sessions. Upon connection to the SGD portal, the user's desktop computer registry is interrogated for two items; the default desktop presentation size and the currently selected default printer.

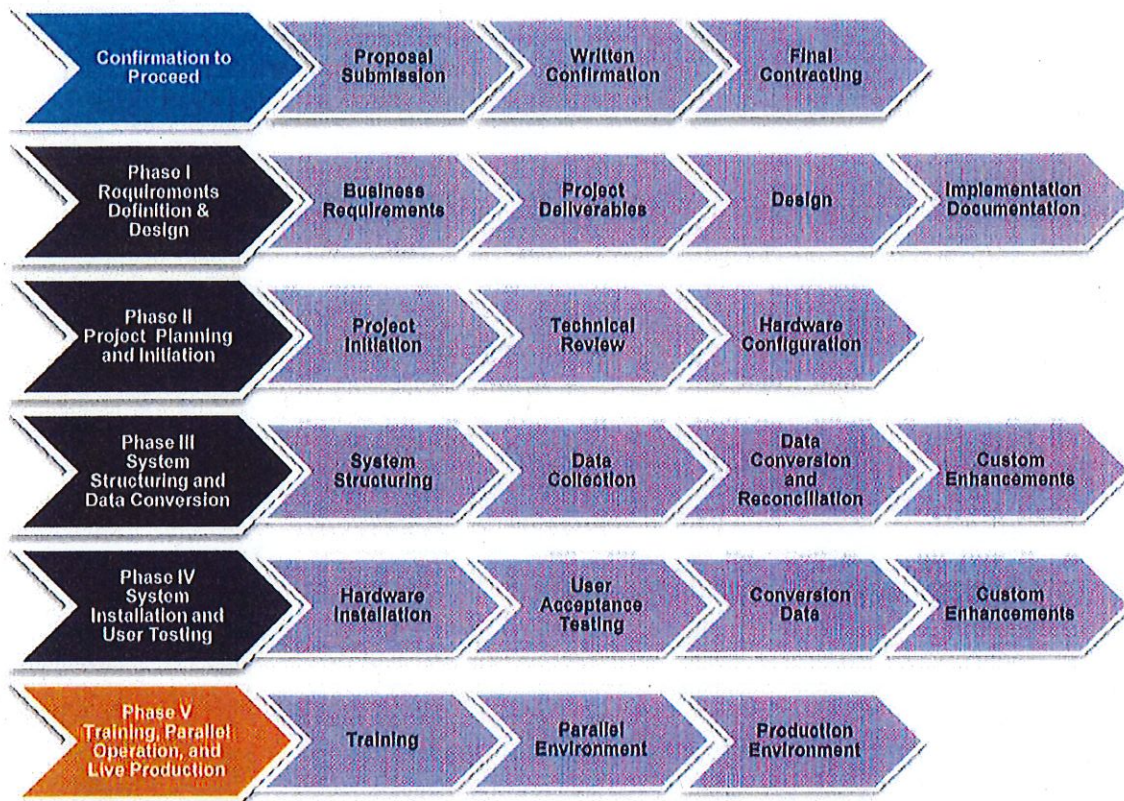
Under the PAAS deployment, the QED team will manage the QED platform on dedicated or zoned application servers within QED's secure datacenter facility. QED will manage border security, virtual networks, web servers, power, and Internet access for your solution. The use of Oracle Sun server technology realizes the benefits of Solaris UNIX processing power without disrupting current or future desktop environments. Secure internet communication is provided by the Oracle Secure Global Workstation technology to ensure the integrity of the investment data. QED leverages the following security technologies:



- ✓ Cisco ISO Firewalls
- ✓ Snort IPS/IDS systems
- ✓ Cisco Application Security Appliances (5510)
- ✓ Apache Web Servers with support For HTTPS & SSL
- ✓ TCP Wrappers

## 7. Next Steps & Rollout

The next steps are to secure written confirmation to proceed and finalize the service agreement to reflect the contents of this proposal. Deployment will be based on QED's standard implementation methodology as described below.





## 8. Confirmation to Proceed

This offer is valid as of 21 August 2013 and shall remain in force and effect for a period of one hundred twenty days (120) calendar days from this date.

In witness whereof, the parties hereto, having read this Proposal presented by QED Financial Systems, Inc. in its entirety, and having affixed their signatures below, do agree hereto every particular as of the date first written below.

Kentucky Teachers' Retirement System

QED Financial Systems, Inc.

  
Signature 

  
Signature 

Philip L. Webb  
Print or Type Name

Joseph M. Potesta  
Print or Type Name

DIRECTOR - INVESTMENT ACCT  
Title

President / CEO  
Title

11/22/13  
Date

11/26/13  
Date

## **Contract Amendment**

**Date:** February 19, 2020

**Issued By:** Teachers' Retirement System of the State of Kentucky ("TRS" or "Client")

**Contractor:** QED Financial Systems, Inc.

**Service:** Q2

**Purpose:** Contract Renewal and Modification

### **RECITALS**

- A. The Contract is currently in effect through the current contract term, expiring December 31, 2019; and
- B. TRS and the Contractor (the "Parties") mutually desire to extend the current contract term; and
- C. The Parties also desire to modify the terms of renewal to allow the automatic renewal of the contract; and
- D. The Parties also desire to incorporate the terms of Contractor's third-party market data services and fees.

Therefore, for good and valuable consideration, the receipt of which are hereby acknowledged, the Parties agree as follows:

1. Contract Renewal: The parties here by agree that the Term of the Contract shall be amended and restated as follows:



Duration of Contract. The period during which services are to be performed under this Contract (the "Term") shall begin January 1, 2020 and expire five (5) years after, being December 31, 2025. Thereafter, unless either party notifies the other party of its intent to not renew the Contract at least thirty (30) days prior the expiration of the then current Term, the Contract shall automatically renew for an additional five (5) year period beginning at the end of the then expiring Term ("Renewal Term"). The Contract shall automatically renew for successive Renewal Terms until either party notifies of its intent of non-renewal in accordance with the Terms of the Contract.

2. The parties here by agree that the Contract shall be amended to add the following:

Third-Party Market Data and Fees. As a convenience to TRS, Contractor offers access to a variety of third-party data provided by agreement with Intercontinental Exchange Inc. ("ICE"). These ICE services are offered by Contractor "as is" and contingent upon ICE's continued provision of the service to QED. QED makes no claims or warranties as to the fitness or accuracy of the data provided, and Client acknowledges and agrees that QED is not responsible for Client's reliance upon any data provided. Client shall be responsible for complying with the terms of use relating to the data of third-party vendors that Client receives or accesses in connection with the Service by itself or through QED and the costs relating thereto, and QED reserves the right to terminate Client's access to such third-party

data should Client violate the terms of use. QED shall not have any liability to Client or any third party relating to, or arising out of, displaying or furnishing third-party data, including, without limitation, any delays, errors, inaccuracies or omissions of such data. These are separately charged services independent of any other pricing in the Agreement. The actual increase in the price of these separately charged services may be passed on to Client, but in no case shall Client pay more than a 7% increase per year.

3. Effective Date. This Amendment shall be effective as of the date this Amendment is fully executed.
4. Entire Agreement. Except as expressly modified by this Amendment, the Contract shall be and remain in full force and effect in accordance with its Terms and shall constitute the legal, valid, binding and enforceable obligations of the parties. This Modification and the Contract (including any prior amendments or modifications), collectively are the complete agreement of the parties and supersede any prior agreements or representations, whether oral or written, by or between the Parties.

In witness whereof, the parties have caused this Amendment to be duly executed by their authorized representatives.

Teachers' Retirement System of the State of Kentucky	QED Financial Systems, Inc.
Signature: [REDACTED]	Signature: [REDACTED]
Name: Philip L. Webb	Name: Anthony Castile
Date: February 20, 2020	Date: 21st February 2020



**AMENDMENT NO. 2**  
**(this "Amendment")**  
**to the**  
**Q2 Software License Agreement**

Reference is made to the Q2 Software License Agreement, effective as of December 2, 2003, as previously amended (the "*Agreement*"), including the Contract Amendment dated February 19, 2020 (the "*Contract Amendment*"), between QED Financial Systems, Inc. ("*QED*") and Teachers' Retirement System of the State of Kentucky ("*Client*"), which Agreement is hereby further amended as follows:

1. **Defined Terms.** Unless otherwise defined herein, all terms defined in the Agreement shall have the same meanings when used herein.
2. **Market Data.** As contemplated in Section 2 of the Contract Amendment, effective as of November 24, 2020, Client acknowledges and agrees that it may be required by ICE to sign an additional acknowledgement or agreement in order to receive its market data as part of the Services.
3. **General.**
  - (a) Except as expressly amended and supplemented by this Amendment, the Agreement remains in full force and effect.
  - (b) In the event of any conflict between the terms and conditions of this Amendment and the terms and conditions of the Agreement, the terms and conditions of this Amendment shall prevail.

**QED Financial Systems, Inc.**

By: \_\_\_\_\_

Name and

Title: Eric Bernstein, President

Date: December 1, 2020

**Teachers' Retirement System of the State of Kentucky**

By: \_\_\_\_\_

Name and

Title: Philip L. Webb, Director of Investment Acct

Date: December 1, 2020

***THIS AMENDMENT SHALL BECOME EFFECTIVE UPON SIGNATURE BY AUTHORIZED OFFICERS OF QED AND CLIENT.***

Annex I

**1. Market Pricing Services**

Category	Periodicity	Scope	Rate
North America Equity Security Prices	<input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input checked="" type="checkbox"/> Monthly	<input type="checkbox"/> Select Position Inventory <input checked="" type="checkbox"/> Publicly Traded Universe	_____ per record \$3,509.5679 per month
North America Government Bond Security Prices	<input checked="" type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	<input checked="" type="checkbox"/> Select Position Inventory <input type="checkbox"/> Publicly Traded Universe	\$0.1259 per record _____ per month
North America Municipal Bond Security Prices	<input checked="" type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	Select Position Inventory	\$0.2175 per record
North America Corporate Bond Security Prices	<input checked="" type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	<input checked="" type="checkbox"/> Select Position Inventory <input type="checkbox"/> Publicly Traded Universe	\$0.2175 per record _____ per month
North America Mortgage-Backed Security Prices	<input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input checked="" type="checkbox"/> Monthly	Select Position Inventory	\$1.1563 per record
North America Collateralized Mortgage and Asset-Backed Security Prices	<input checked="" type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	Select Position Inventory	\$5.0646 per record

Category	Periodicity	Scope	Rate
Global Equity Security Prices (excludes North America)	<input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	Select Position Inventory	_____ per record
Global Fixed Income Security Prices (excludes North America)	<input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	Select Position Inventory	_____ per record
Global Equity and Fixed Income Security Prices (excludes North America)	Monthly	Publicly Traded Universe	_____ per month
Foreign Currency Rates	<input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly	Publicly Traded Universe	_____ per month

**2. Market Information Services**

Category	Periodicity	Scope	Rate
North America Mortgage-Backed Security Payment Factors	as Updated	Select Position Inventory	\$1.1678 per record



North America Collateralized Mortgage and Asset-Backed Security Payment Factors	as Updated	Select Inventory	Position	\$2.3814 per record
Payment Factor Service Fee				\$201.2391 per month
Standard & Poor's Quality Ratings*	as Updated	Select Inventory	Position	_____ per month
Moody's Quality Ratings*	as Updated	Select Inventory	Position	_____ per month
North American Fixed Income Security Interest Rates	as Updated	Select Inventory	Position	_____ per record
Securities and Exchange Commission Section 13(f)	Annual	Publicly Universe	Traded	

\*The fees associated with the Standard & Poor's Quality Rating and the Moody's Quality Ratings are a monthly service fee in consideration of QED delivering the data. Client must have a separate direct vendor relationship/agreement with the respective source agency for the respective data.

### 3. Security Master Information Services\*

Category	Periodicity	Scope	Rate
North America Equity Security	Transaction	<input checked="" type="checkbox"/> New Position Events	\$2.42 per record
North America Fixed Income Security	Transaction	<input checked="" type="checkbox"/> New Position Events	\$6.04 per record
Global Equity Security (excludes North America)	Transaction	<input checked="" type="checkbox"/> New Position Events	\$3.62 per month
Global Fixed Income Security (excludes North America)	Transaction	<input checked="" type="checkbox"/> New Position Events	\$7.25 per month

\* Note – Security Master Information Services cannot be purchased individually. All four will be added to the plan if any are requested.

### 4. Corporate Action Services

Category	Periodicity	Scope	Rate
Global Equity and Fixed Income Security	<input checked="" type="checkbox"/> Transaction	Select Position Inventory	\$2,454.21 per month

### 5. Close of Market Evaluation Services

Category	Periodicity	Scope	Rate
U.S. Corporate and Government Bonds			
Agency Discount Notes	Daily	Select Position Inventory	_____ per record
Equipment Trusts	Daily	Select Position Inventory	_____ per record

Evaluated Corporate Bonds	Daily	Select Position Inventory	_____ per record
Fixed Rate MTN	Daily	Select Position Inventory	_____ per record
Floating Rate MTN	Daily	Select Position Inventory	_____ per record
Government Agencies	Daily	Select Position Inventory	_____ per record
US Investment Grade Listed Bond Evaluations	Daily	Select Position Inventory	_____ per record
US Listed Bonds	Daily	Select Position Inventory	_____ per record
Zero Coupon	Daily	Select Position Inventory	_____ per record
US Government Bills, Bonds, Notes	Daily	Select Position Inventory	_____ per record
Convertibles	Daily	Select Position Inventory	_____ per record
Corporate High Yields	Daily	Select Position Inventory	_____ per record
Broker Quoted Corporate	Daily	Select Position Inventory	_____ per record
<b>Canadian Corporate and Government Bonds</b>			
Canadian Bonds	Daily	Select Position Inventory	_____ per record
Canadian T-Bills	Daily	Select Position Inventory	_____ per record
<b>Certificates of Deposit</b>			
Long Term	Daily	Select Position Inventory	_____ per record
Short Term	Daily	Select Position Inventory	_____ per record
<b>Structured Finance</b>			
Collateralized Mortgage Obligation; Agency and Non-Agency	Daily	Select Position Inventory	_____ per record
Collateralized Mortgage Obligation; Agency ARMs	Daily	Select Position Inventory	_____ per record
Broker Quoted Collateralized Mortgage Obligation & Asset Backed Security	Daily	Select Position Inventory	_____ per record
Collateralized Mortgage Obligation; Non- agency Whole Loan ARMs	Daily	Select Position Inventory	_____ per record
Asset Backed Security	Daily	Select Position Inventory	_____ per



			record
Commercial Mortgage Backed	Daily	Select Position Inventory	_____ per record
<b>Mortgage Backed Security</b>			
Agency Fixed Rate	Daily	Select Position Inventory	_____ per record
SBA's	Daily	Select Position Inventory	_____ per record
GNMA Reverse MBS Evaluations	Daily	Select Position Inventory	_____ per record
ARMs	Daily	Select Position Inventory	_____ per record
GNMA Serial Notes Units	Daily	Select Position Inventory	_____ per record
<b>Money Markets</b>			
Commercial Paper	Daily	Select Position Inventory	_____ per record
Corporate Money Market	Daily	Select Position Inventory	_____ per record
Municipal Money Market	Daily	Select Position Inventory	_____ per record
<b>Municipal Fixed Income</b>			
Bonds	Daily	Select Position Inventory	_____ per record
High Yield	Daily	Select Position Inventory	_____ per record
Derivatives	Daily	Select Position Inventory	_____ per record
<b>Equity</b>			
Canadian Equities	Daily	Select Position Inventory	_____ per record