

MiFID II and Best Execution: The Challenges Ahead

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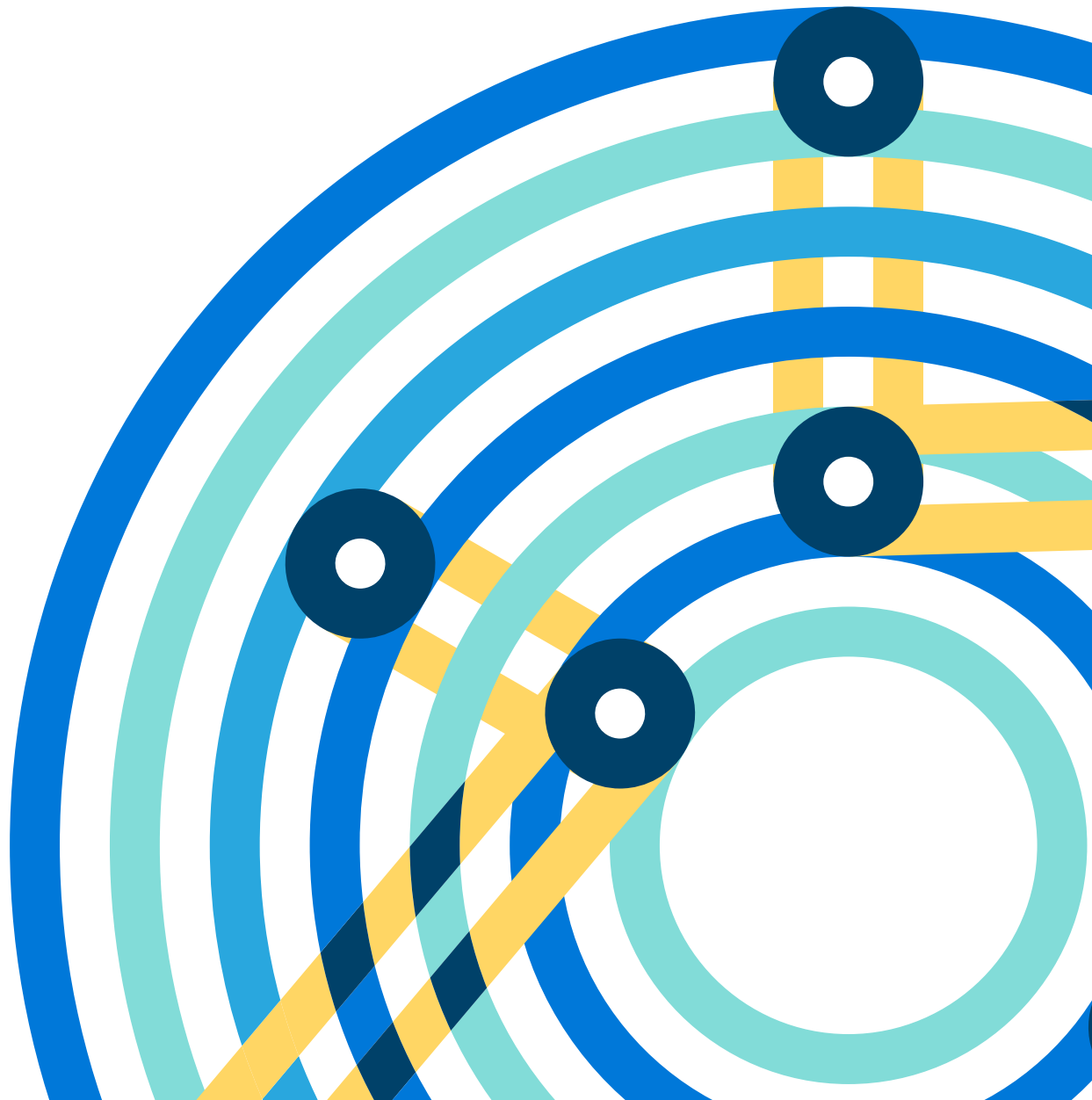


Table of Contents

Best Execution Challenges:	3
RTS-27: Best Execution Requirements for Trading-Related Venues	4
I. Disclosures of All Order Execution Charges (RTS-27: 11)	4
II. Public Website Access for All Provided Data (RTS-27: 15)	4
III. Execution Venue Trade Summary Reporting Requirements (RTS-27: 3)	4
RTS-28: Best Execution Requirements for Investment Firms	5
The Role of the Modern Data Platform	7
Why TickSmith	8
Providing out-of-the-box data management for capital markets with TickVault	8
TickVault: Hadoop-based big data management platform for capital markets	8
TickSmith	9
What can TickVault tackle	10
TickVault's RTS-27 Solution	10
TickVault's RTS-28 Solution	13
Why Cloudera:	14
Making Hadoop Fast, Easy, and Secure	14
Fast for Business	14
Easy to Manage	14
Secure without Compromise	15
The Largest Hadoop Ecosystem	15
References:	15
About TickSmith	16
About Cloudera	16

The financial crisis of 2008 demonstrated several critical shortcomings of the existing regulatory environment. This triggered a global wave of regulatory changes designed to impose more stringent controls covering a wide range of market, compliance, and operational changes. In particular, regulatory changes have improved data collection, data quality, data coverage, risk measurement, and risk reporting. Coincident with these institution-specific enhancements, significant changes have been imposed in areas such as market surveillance, market transparency, and investor protections.

The Markets in Financial Instruments Directive II (MiFID II), which comes into force on January 3, 2018, is one of the cornerstones of EU financial services law, setting out which investment services and activities should be licensed across the EU and the organizational and conduct standards that those providing such services should comply with. MiFID II and the related Markets in Financial Instruments Regulation (MiFIR) empower ESMA (the European Securities and Markets Authority) to develop numerous draft Regulatory Technical Standards (RTS) and draft Implementing Technical Standards (ITS).

The European Commission identified four overriding objectives for MiFID II and its related regulation, MiFIR:

1. To strengthen investor protection
2. To reduce the risks of a disorderly market
3. To reduce systemic risks
4. To increase the efficiency of financial markets and reduce unnecessary costs for market participants

MiFID II and MiFIR impose a wide range of changes that will have a large impact on the EU's financial markets, especially with respect to how institutions collect and manage their data, how critical business functions are managed, and new regulatory reporting obligations on market participants. These changes will require firms to modernize their data and analytics platforms to enable a more streamlined, agile, and cost-effective IT environment.

Specifically, new requirements imposed by MiFID II include:

- Transparency for a broader range of asset classes
- The obligation to trade derivatives on-exchange
- Restrictions on algorithmic and high-frequency trading
- New supervisory tools for commodity derivatives
- Strengthened protection for retail investors through limits on the use of commissions
- New conditions for the provision of independent investment advice
- Stricter organization of product design and distribution
- New product intervention powers
- The disclosure of costs and charges to investors
- New rules on best execution, suitability, trade reporting, and transaction reporting

Best Execution Challenges:

Among the major impacts of the MiFID II regulation will be new requirements on best execution standards. Designed to protect investor interests, these changes are broad and require both buy-side and sell-side firms to document, monitor, and demonstrate best execution based on quantitative and qualitative metrics—such as price, cost, speed, likelihood of execution, settlement, size, and nature of the trade. All firms are impacted and will be required to:

1. Explain their execution policies in sufficient detail to allow clients to easily understand how orders will be executed
2. Disclose the top five execution venues used
3. Disclose on at least an annual basis the quality of execution
4. Prohibit the use of payments for order flow
5. Upgrade the obligation to achieve the best result from taking “all reasonable steps” to a more stringent requirement of taking “all sufficient steps”

The specifics of these general requirements are outlined within two Regulatory Technical Standards. RTS-27 covers specific requirements applicable to the general category of Trading Venues, while RTS-28 covers requirements applicable to Investment Firms.

RTS-27: Best Execution Requirements for Trading-Related Venues

The institutional categories covered under RTS-27's Best Execution requirements consist of all trading venues, systematic internalisers, market makers, or other liquidity providers.

These institutions have a range of monitoring and reporting requirements as outlined in the following deliverables:

I. Disclosures of All Order Execution Charges (RTS-27: 11)

"It is essential for the public to have full transparency on all costs charged when executing an order through a given venue. In determining the total costs relevant to execution, it is necessary to specify all the relevant costs in the execution of a client order related to the use of a specific venue and for which the client pays directly or indirectly."

II. Public Website Access for All Provided Data (RTS-27: 15)

A key requirement to transparency is to have this information made available to the broader public. Specifically, "it is important that execution venues collect data throughout the normal hours of their operation. Reporting should therefore be made without charge in a machine-readable electronic format via an Internet website to enable the public to download, search, sort, and analyse all the provided data."

III. Execution Venue Trade Summary Reporting Requirements (RTS-27: 3)

There are several types of reporting requirements: Disclosures covering General Venue Information, Pricing Information, Cost Information, and specifics about the Likelihood of Execution.

General Information Disclosures

- a. Name and venue identifier of the execution venue;
- b. Country of location of the competent authority;
- c. Name of the market segment and market segment identifier;
- d. Date of the trading day;
- e. Nature, number, and average duration of any outage, within the venue's normal trading period, that interrupted trading across all instruments available to trade at the venue on that date;
- f. Nature, number, and average duration of any scheduled auctions within the venue's normal trading period on that date;
- g. Number of failed transactions on that date;
- h. Value of failed transactions expressed as a percentage of the total value of transactions that were executed on that date.

Daily Pricing Disclosures

- a. Simple average and volume-weighted average transaction price, if more than one transaction occurred;
- b. Highest executed price, if more than two transactions occurred;
- c. Lowest executed price, if more than two transactions occurred.

Daily Cost Disclosures

- a. Components of costs applied by the execution venue, before any rebates or discounts are applied by the execution venue;
 - Execution fees;
 - Fees for the submission, modification, or cancellation of orders or quotes withdrawals;
 - Fees related to market data access and use of terminals;
 - Any clearing and settlement fees and any other fees paid to third parties involved in the execution of the order.
- b. Rebates, discounts, or other payments offered to users of the execution venue, including information on how those rebates, discounts, or other payments differ according to the user or financial instrument involved and the amounts by which they differ;
- c. Any nonmonetary benefits offered to users of the execution venue, including information on how those nonmonetary benefits differ according to the user or financial instrument involved and the value by which they differ;
- d. Any taxes or levies invoiced to, or incurred by, the execution venue on behalf of the members or user of the venue;

- e. Link to the website of the venue or to another source where further information on costs is available;
- f. Total value of all rebates, discounts, nonmonetary benefits or other payments as set out under (b) and (c), expressed as a percentage of the total traded value during the reporting period;
- g. Total value of all costs as set out in point (a), excluding the total value of rebates and discounts, nonmonetary benefits or other payments as set out in points (b) and (c) of paragraph 1, expressed as a percentage of the total traded value during the reporting period.

Daily “Likelihood of Execution” Disclosures

- a. Number of orders or requests for quotes that were received;
- b. Number and value of transactions that were executed, if more than one;
- c. Number of orders or requests for quotes received that were cancelled or withdrawn, excluding passive orders with instructions to expire or to be cancelled at the end of the day;
- d. Number of orders or requests for quotes received that were modified on that date;
- e. Median transaction size on that date if more than one transaction occurred;
- f. Median size of all orders or requests for quote on that date if more than one order or request for quote was received;
- g. Number of designated market makers.

Continuous Trading Venue Disclosures

- a. Average effective spread;
- b. Average volume at best bid and offer;
- c. Average spread at best bid and offer;
- d. Number of cancellations at best bid and offer;
- e. Number of modifications at best bid and offer;
- f. Average book depth for three price increments;
- g. Mean and median time elapsed between an aggressive order or quote acceptance being received by the execution venue and the subsequent total or partial execution;
- h. Average speed of execution for unmodified passive orders at best bid and offer;
- i. Number of Fill or Kill orders that failed;
- j. Number of Immediate or Cancel orders that got zero fill;
- k. Number and value of transactions that were executed on the trading venue that are Large in Scale pursuant to Article 4 or Article 9 of Regulation (EU) No 600/2014;
- l. Number and value of transactions that were executed on the trading venue pursuant to Article 4 or Article 9 of Regulation (EU) No 600/2014, except for orders that are held in an order management facility of the trading venue pending disclosure and not included under point (k);
- m. Number and average duration of trading interruptions as the result of any volatility auction or circuit breaker which occurred within the venue’s normal trading period;
- n. Nature, number, and average duration of any trading suspension that occurred as a result of a decision by the venue within the venue’s normal trading period, outside of any that were reported under Article (1)(e).

RTS-28: Best Execution Requirements for Investment Firms

Investment firms must also provide annual reports for public disclosure of their top five execution venues of client orders based upon volume and order count for each class of financial instrument. This creates several data and technology challenges:

- Extensive benchmark data across all relevant markets must be sourced, stored, and accessible
- Where benchmark data is not available, firms will need to devise proxy methodologies to compute the required best execution metrics
- Many firms will need to modify and enhance their data feeds and coded “best execution” logic in their trade capture systems and market data sources
- Agile big data solutions will be required to process, store, and analyse the vast amounts of benchmark and proxy data required for “best execution”

Under RTS-28, data will need to be captured at each transaction/order level, such as the percentage of passive/aggressive/directed orders, which will need to be stored for future recall, if necessary. The data must then be mapped and attached to every order for reporting purposes. To maintain the data's accuracy and reliability, consistent management and control will also be required. This controlled data can then be fed into various post-trade feeds for allocations, confirmations, affirmations, and surveillance or global order and risk monitoring.

Retail Clients Top 5 Execution Venue Disclosure

Investment firms shall publish the following information for each class of financial instruments the top five execution venues in terms of trading volumes for all executed orders for retail clients:

- a. Class of financial instruments;
- b. Venue name and identifier;
- c. Volume of client orders executed on that execution venue expressed as a percentage of total executed volume;
- d. Number of client orders executed on that execution venue expressed as a percentage of total executed orders;
- e. Percentage of the executed orders referred to in point (d) that were passive and aggressive orders;
- f. Percentage of orders referred to in point (d) that were directed orders;
- g. Notification of whether it has executed an average of less than one trade per business day in the previous year in that class of financial instruments.

Professional Clients Top 5 Execution Venue Disclosure

- a. Class of financial instruments;
- b. Venue name and identifier;
- c. Volume of client orders executed on that execution venue expressed as a percentage of total executed volume;
- d. Number of client orders executed on that execution venue expressed as a percentage of total executed orders;
- e. Percentage of the executed orders referred to in point (d) that were passive and aggressive orders;
- f. Percentage of orders referred to in point (d) that were directed orders;
- g. Notification of whether it has executed an average of less than one trade per business day in the previous year in that class of financial instruments.

Quality of Execution Disclosure

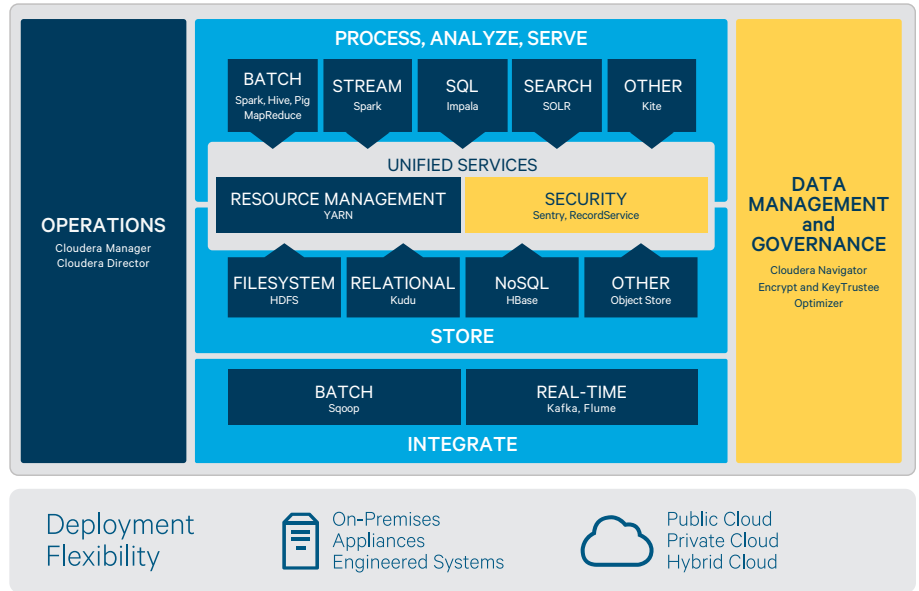
An investment firm shall publish for each class of financial instruments, a summary of the analysis and conclusions it draws from its detailed monitoring of the quality of execution obtained on the execution venues where it executed all client orders in the previous year. This information shall include:

- a. An explanation of the relative importance the firm gave to the execution factors of price, costs, speed, likelihood of execution, or any other consideration, including qualitative factors when making assessments of the quality of execution;
- b. A description of any close links, conflicts of interests, and common ownerships with respect to any execution venues used to execute orders;
- c. A description of any specific arrangements with any execution venues regarding payments made or received, discounts, rebates or nonmonetary benefits received;
- d. An explanation of the factors that led to a change in the list of execution venues listed in the firm's execution policy, if such a change occurred;
- e. An explanation of how order execution differs according to client categorisation, where the firm treats such category of client differently and where it may affect the order execution arrangements;
- f. An explanation of when other criteria were given precedence over immediate price and cost when executing retail client orders and how these other criteria were instrumental in delivering the best possible result in terms of the total consideration to the client;
- g. An explanation of how the investment firm has used any data or tools relating to the quality of execution, including any data published under 27(10)(a) of Directive 2014/65/EU.
- h. An explanation of how the investment firm has used, if applicable, output of a consolidated tape provider established under Article 65 of Directive 2014/65/EU, which will allow for the development of enhanced measures of execution quality or any other algorithms used to optimise and assess execution performances.

The Role of the Modern Data Platform

While a holistic view of risk and regulatory compliance is achievable when all of the critical data sources, algorithms, and monitoring tools reside on a single platform, the reality for most institutions is far from this goal. A more practical phased approach would entail building out a streamlined regulatory and reporting platform based on the Modern Data Platform powered by Apache Hadoop.

The Modern Data Platform provides a nondisruptive, highly efficient, agile, and scalable environment to support all current and future Risk, Regulatory Compliance, and Reporting requirements. This environment supports the full Risk and Regulatory Compliance workflow from real-time data ingestion, through data processing, analysis, aggregation, and reporting.



The Modern Data Platform: (Apache Hadoop)

- One place for unlimited data
- Unified data access

Cloudera makes it:

- Fast for business
- Easy to manage
- Secure without compromise

The Modern Data Platform, as provided by Cloudera Enterprise, provides the full complement of capabilities including the following core benefits:

<p>Handle Real-time Data Ingest from Diverse Sources</p>	<ul style="list-style-type: none"> • Able to support streaming and batch data ingest from various data sources covering client, pre-trade, trade, post-trade, market and other data sources.
<p>Scale Easily & Cost Effectively</p>	<ul style="list-style-type: none"> • Cloudera Enterprise is the most cost effective and scalable platform to build a streamlined regulatory compliance platform that can be on premise or in the cloud.
<p>Machine Learning Capabilities</p>	<ul style="list-style-type: none"> • Embedded machine learning algorithms enable data scientists to utilize the regulatory data to gain additional insights into a range of applications: AML, Fraud, MAD/MAR, customer journey analytics...
<p>Fundamentally Secure</p>	<ul style="list-style-type: none"> • Cloudera Enterprise provides the highest level of security and governance capabilities to ensure that confidential KYC-related data is fully secure and protected.
<p>Diverse Analytical Options</p>	<ul style="list-style-type: none"> • Cloudera provides the largest Hadoop ecosystem to ensure the widest range of tools & partners to support changes in future regulatory and business requirements.

Cloudera Enterprise provides a path forward to building a modern data architecture while enabling institutions to leverage their existing IT infrastructure. Banks can aggregate, store, and analyse any volume, age, and type of data required for meeting MiFID II and other regulatory requirements.

Cloudera Enterprise makes Hadoop fast, easy, and secure. We provide and support the only Hadoop platform to achieve the highest level of compliance with our comprehensive security and governance capabilities.

Why TickSmith

Providing out-of-the-box data management for capital markets with TickVault

TickSmith, with its TickVault platform, is a leader in big data applications for capital markets and financial services. TickVault is used for data centralisation and distribution, market surveillance, strategy discovery, and analytics.

TickSmith received the 2015 Innovator Award for Best New Hadoop-Based Platform for Management of Brokerage Data by the FIA, the world's leading trade organization for the futures, options, and cleared swaps markets.

TickVault: Hadoop-based big data management platform for capital markets

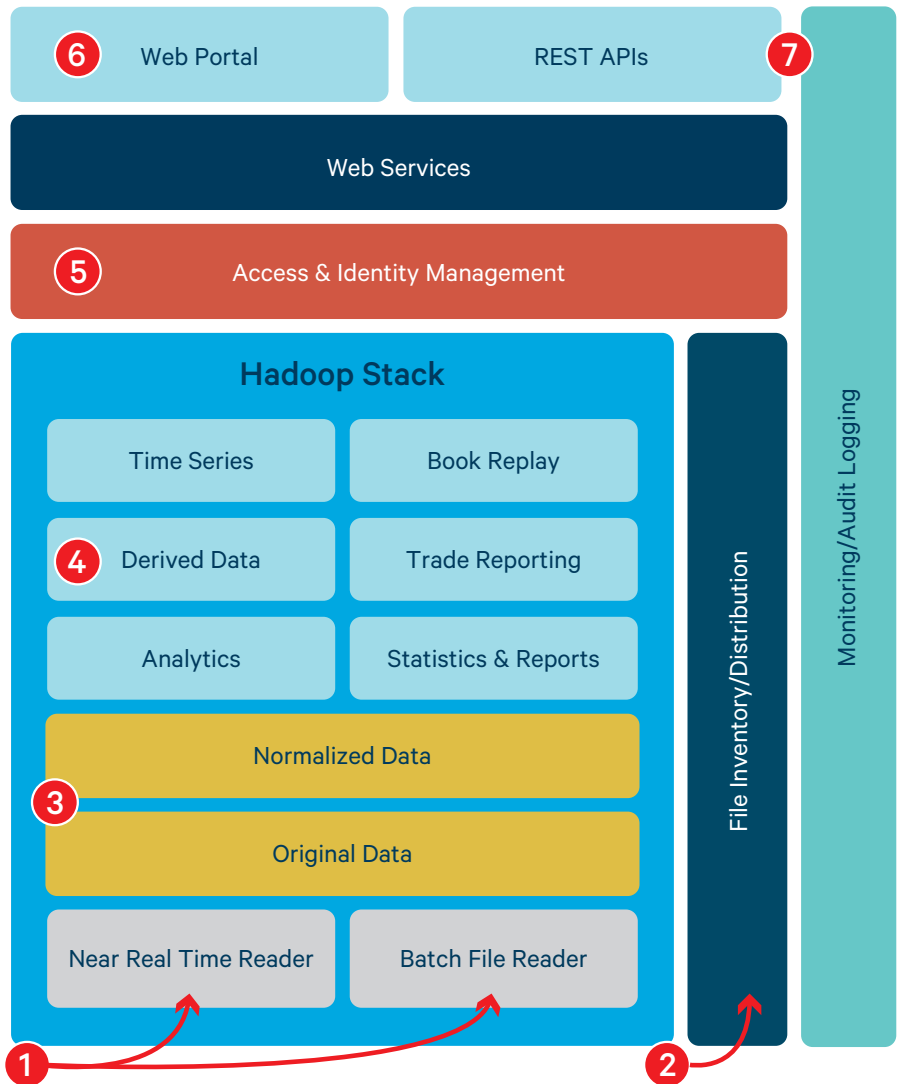
TickVault is a complete software application built on a modular architecture.

- **Accumulate, centralise, normalise**—Centralise terabytes and petabytes of data received from quote feeds, trading systems, event feeds, timestamps, and more. Normalise and combine data from various sources. Rebuild point-in-time market depth. Convert to time series and reports. Improve back-testing, risk management, compliance, and reporting.
- **Analyse and report**—Automate the creation of reports from data on TickVault.
- **Visualise and distribute**—Business users have access to various visualisation tools to view detailed data, charts, reports, and more.
- **Interact**—Rest APIs provide developers and applications controlled access to data and analytics in TickVault. Ideal for back-testing, quantitative research, RISK data management, compliance, machine learning, financial econometrics, and algorithmic models.
- **Flexible deployment**—A comprehensive modular software platform that leverages Hadoop and is scalable to petabytes of data. TickVault can be deployed:
 - In-house, on your hardware and Hadoop cluster
 - In the cloud
- **High capacity**—Capacity is driven by the infrastructure size and can support terabytes to multi-petabytes.
- **Cloudera Certified**—TickVault is a Cloudera-certified technology that supports CDH 4.7, 5.2, 5.3, 5.4, 5.7, 5.8.

TickSmith

1. Load all your exchange, trade, and other data from exchange feeds, network appliances (Corvil, Solace, Exegy, etc.), aggregators, OMS, order routers, FIX engines, trade venues.
2. Connect directly to your data files on local and cloud storage.
3. Retain the original data. Normalise through time and across sources.
4. Create combined and derived data sets. Turn data into time series. Run analytics, create reports and statistics. Structure data for market reconstruction.
5. Entitle and control data and features access to users and systems. Interface with your billing system.
6. Provide data via web interfaces and Rest APIs.
7. Monitor and manage all tasks and processes.

The amount of execution data that must be retained, processed, and organised for reporting requirements can be tremendous for large trading venues and investment firms. To facilitate ease with MiFID II best execution compliance, a report generation process can be partly automated by the TickVault platform.



What can TickVault tackle

Running on fault-tolerant HDFS technology, TickVault is able to store, normalise, and run calculations on terabytes to multi-petabytes of financial market data. This platform is ideal for processing and analysing the large magnitudes of sensitive data required for MiFID II compliance.

TickVault can automatically generate RTS 27/28 reports, provide a public portal for data queries, and produce timestamp validation methods, all with future-proof implementation.

- **RTS 27/28 Best Execution Reports** – By loading a trading venue’s book by order data or an investment firm’s private execution data, TickVault can automate the generation of reports that would otherwise take intensive human capital to produce with conventional database management systems.
- **Public Portal** – TickVault provides a public portal to query, download, and run calculations on both raw as well as normalised data. Generated reports can be displayed for the public or made exportable for regulators. All this data is also available through a REST API.
- **File Inventory centralization** – MiFID II also describes data storage requirements for trading venues and investment firms. TickVault is able to implement a file inventory module that can categorize and store massive amounts of financial market data with granular access entitlements for compliance or internal documentation purposes.

Depending on the needs of the client, these files can include transparency requirement data (RTS 1 and 2), order submission records for algorithmic trading firms (RTS 6), transaction reports to regulators (RTS 22), and financial instrument data for trading venues (RTS 23 and 24).

- **Timestamp Validation** – Exchange latency factors have become increasingly relevant in modern times with the prominence of electronic trading. As a result, MiFID II has detailed timestamp accuracy requirements to a millisecond granularity for reports and microsecond granularity for high-frequency algorithmic trading activities as outlined in RTS 25. TickVault’s technology provides timestamped accuracy on a nanosecond granularity.

Having all data from all systems that add timestamps in one location, together with powerful analytical capabilities, means that a firm can compare and confirm when timestamps are out of sync.

In addition, centralised trading and market data in TickVault can be leveraged to provide added back-testing, quantitative research, compliance, and risk assessment capabilities.

TickVault’s RTS-27 Solution

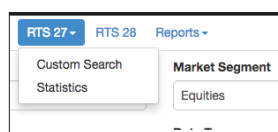
TickVault is able to take book by order data from trading venues and automatically generate relevant best execution tables for MiFID II RTS 27 data retention and publication requirements.

Reports are organised by TickVault’s internal custom search and statistics engine. These generated reports are exportable for publication. TickVault also provides alerts on specific unfilled table fields that may require ad hoc descriptions to be inputted¹.

TickVault is able to automatically generate Tables 1, 2, 3, 4, 6, 7, 8, and 9 given the following trading venue data:

- Financial instrument directory
- System event information (halts, suspensions, outages, failed transactions)
- Book by order for all price levels including number of market makers and specific types of orders
- All timestamped execution information of every financial instrument

The generation of Table 5 requires both continuous TickSmith support on arranging venue fee, rebate, and discount information as well as a venue operator’s manual ad hoc input of descriptions.



¹ Table 1 may need system failure descriptions, Table 2 may need manual financial instrument descriptions, Table 5 needs rebate/fees/cost descriptions, and Table 8 may need descriptions on the nature of trading suspensions

Custom Search

The Custom Search page displays top of book or rollups (derived at one second/minute time intervals) data for each queried financial instrument which can be exported as a CSV file. The export button can also produce automatically generated RTS-27 tables.

If the “Financial Instrument” field is left blank, the export button generates files for all financial instruments within the indicated market segment and date range.

Custom Search page

Top of Book interface and charting available from trading venue data

Comprehensive Book by Order interface available from trading venue data

Statistics

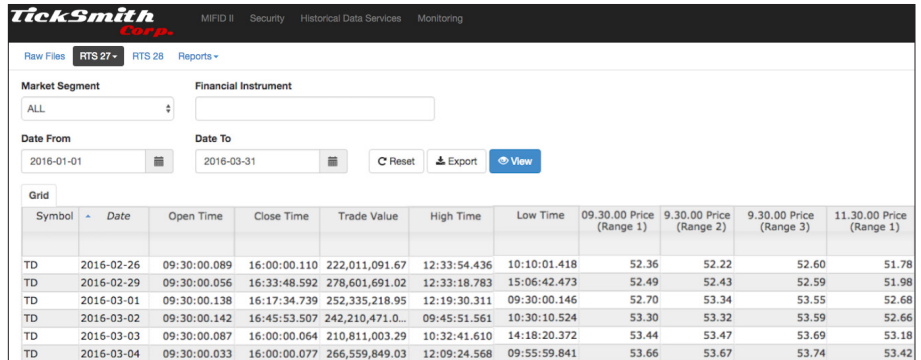
The Statistics page displays calculated information for each queried financial instrument, including but not limited to:

- Daily VWAPs
- OHLC
- Trading Value
- Number of Passive/Aggressive Orders

- Mean time elapsed between order acceptance and execution
- Number of suspensions
- Average Spread at Best Bid and Offer

The Statistics page is tailored to provide statistics to populate RTS-27 tables, and fields are customizable by admin accounts. All statistics information can be exported as a CSV file. The export button can also produce automatically generated RTS 27 tables.

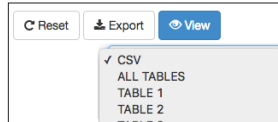
If the “Financial Instrument” field is left blank, the export button generates files for all financial instruments within the indicated market segment and date range.



Statistics page:

Exporting Reports

The export button will produce CSV files of the queried financial instrument for the specified date range, and will export HITS and Rollup data if the user exports from the Custom Search page, or Statistics data if the user exports from the Statistics page.



In order for a user to export a report on a specific date, all financial instrument data must first be processed for that day. An admin account can set automatic processing tasks upon receiving a file or manually reprocess failed jobs from the Monitoring page.

Note that when a user decides to export a specific table or “ALL TABLES” for RTS 27 reporting requirements, it does not matter which page the user exports from, the data produced will be the same.

TickVault-generated machine-readable Table 6 for an example trading venue and financial instrument:

Table 6 – likelihood of execution information to be published as referred to in Article 6

Number of orders or request for quotes received	739,869
Number of transactions executed	25,731
Total value of transactions executed	231,452,051.12
Number of orders or request for quotes received cancelled or withdrawn	198,262
Number of orders or request for quotes received modified	82,103
Median transaction size	1000
Median size of all orders or requests for quote	900
Number of designated market makers	31

TickVault-generated machine-readable Table 7 for an example trading venue and financial instrument:

Table 7 - likelihood of execution information to be published as referred to in Article 7(1)

Time	Best Bid Price	Best Offer Price	Bid Size	Offer Size	Book depth within 3 price increments
9.30.00	52.36	52.36	31300	34500	56/72
11.30.00	52.41	52.42	800	7600	35/100
13.30.00	52.46	52.47	8200	800	110/72
15.30.00	52.31	52.32	2500	3500	79/90

TickVault's RTS-28 Solution

Whenever a client investment firm executes an order, TickVault will log all relevant best execution information for that order and organise it appropriately for reporting requirements. While Tables 1, 2, and 3 can be automatically generated, RTS-28 reporting requirements also require a significant amount of manual inputs and descriptions. The trade analysis report requires the investment firm's participation with adding "Notes" to any irregular executions.

The screenshot shows the TickSmith interface for RTS-28 reporting. It includes filters for Venue (ALL), Instrument Class (Equities (Bands 5 & 6)), and Client (Retail). Date filters are set from 2016-02-26 to 2016-02-29. A data grid displays trade records with columns for Symbol, Date, Timestamp, ts_ns, Type, Initiator Side, Last Price, Volume, Execution Venue, Instrument Class, and Notes.

Symbol	Date	Timestamp	ts_ns	Type	Initiator Side	Last Price	Volume	Execution Venue	Instrument Class	Notes
UNAA	2016-02-26	08:00:00.079390210	1456473600079390210	E	S	39.715	200	BCXE	Equities (Bands 5 & 6)	...
UNAA	2016-02-26	08:00:00.087283073	1456473600087283073	E	B	39.715	700	BCXE	Equities (Bands 5 & 6)	...
UNAA	2016-02-26	08:00:00.151029675	1456473600151029675	E	S	39.72	100	BCXE	Equities (Bands 5 & 6)	...

Private Data Portal

Due to the sensitive nature of retaining private data, TickVault contains an Access and Identity Management module which manages user authentication and authorization.

This allows for management user registration and entitlements through an administration user interface tool. The module provides granular levels of access control over data. The investment firm's execution statistics can be exported into a CSV file or onto a completed report ready to publish.

The screenshot shows the export options menu with the following items:

- ✓ CSV file
- RTS 28 Report (Professional)
- RTS 28 Report (Retail)
- RTS 28 Report (SFT Trades)

TickVault-generated machine-readable Table 2 for an example investment firm and class of instrument:

Class of Instrument	Equities (Bands 5 & 6)				
Notification if <1 average trade per business day in the previous year	N				
Top five execution venues ranked in terms of trading volumes (descending order)	Proportion of volume traded as a percentage of total in that class	Proportion of orders executed as percentage of total in that class	Percentage of passive orders	Percentage of aggressive orders	Percentage of directed orders
LONDON STOCK EXCHANGE XLON	41%	37%	45%	41%	0.2%
BATS EUROPE BCXE	17%	21%	41%	46%	0%
NASDAQ COPENHAGEN A/S XCSE	11.2%	13%	44%	45%	0%
EURONEXT - EURONEXT PARIS XPAR	6.6%	7.8%	37%	49%	3.1%
BOERSE BERLIN XBER	3.1%	5.4%	41%	39%	0%

Each execution can be queried on TickVault by administrators and authorized users. Authorized users are able to append “notes” to each execution detailing information on any conflict of interests, common ownerships, arrangements made for rebates, and any other considerations that were made over price/cost when executing client orders.

RTS-28 also defines a trade analysis report that must be produced and made public. Executions with notes attached can be filtered, conglomerated, and viewed for manually creating the annual trade analysis report for RTS-28. The notes should supplement trade analysis report creation by providing information on any conflict of interests, common ownerships, arrangements made for rebates, and any other considerations that were made over price/cost when executing client orders.

Why Cloudera: Making Hadoop Fast, Easy, and Secure

Apache Hadoop is a new type of data platform: one place to store unlimited data and access that data with multiple frameworks, all within the same platform. However, all too often, enterprises struggle to turn this new technology into real business value.

Cloudera Enterprise changes that. Powered by the world’s most popular Hadoop distribution, only Cloudera Enterprise makes Hadoop fast, easy, and secure so you can focus on results, not the technology.

Fast for Business

Only Cloudera Enterprise enables more insights for more users, all within a single platform. With the most powerful open source tools and the only active data optimisation designed for Hadoop, you can move from big data to results faster. Key features include:

- **In-Memory Data Processing:** The most experience with Apache Spark
 - Fast Analytic SQL: The lowest latency and best concurrency for BI with Apache Impala
 - Native Search: Complete user accessibility built into the platform with Apache Solr
 - Updatable Analytic Storage: The only Hadoop storage for fast analytics on fast-changing data with Apache Kudu (beta)
- **Active Data Optimization:** Cloudera Navigator Optimizer (limited beta) helps tune data and workloads for peak performance with Hadoop

Easy to Manage

Hadoop is a complex, evolving ecosystem of open source projects. Only Cloudera Enterprise makes it simple so you can run at scale, across a variety of environments, all while meeting SLAs. Key features include:

- **Powerful Cluster Operations:** Cloudera Manager is the Hadoop administration tool trusted by the professionals
- **Hybrid Cloud Operations:** Only Cloudera Director provides dynamic cluster management across all the major cloud environments
- **Expert Support:** Dedicated help and predictive care, just a click away
- **Open Source Leadership:** Constant open source development and curation, with the most rigorous testing, for trusted innovation

Software and OEM	alteryx, ARROYO, CASK, Cognilytics, Datameer, H2O.ai, informatica Information Builders, Microsoft, MicroStrategy, ORACLE, Paxata, pentaho, platforma Qlik, rapidminer, racana, SAP, sas, SECURONIX, SKYTREE Spotfire, StreamSets, syncsort, tableau, talend, teksmith, TRIFACTA, VCOMDATA	System Integration
Data Systems	IBM, Hewlett Packard Enterprise, ORACLE, SAP Partner, TERADATA, cloudera	
Platform & Cloud	amazon, CenturyLink, CISCO, DELL, EMC, FUJITSU, Hewlett Packard Enterprise, lenovo, Microsoft, NetApp, ORACLE, redhat, S-Systems, TERADATA, vmware	

Secure without Compromise

The potential of big data is huge, but not at the expense of security. Cloudera Enterprise is the only Hadoop platform to achieve compliance with its comprehensive security and governance. Key features include:

- Enterprise Encryption and Key Management: Protect everything with Navigator Encrypt and Navigator Key Trustee
- Uniform Access Policy Enforcement: Uniformly manage and enforce role-based access controls across the entire platform with Apache Sentry and RecordService
- Automated Data Management: The only full-stack audit, lineage, discovery, and lifecycle management for Hadoop with Cloudera Navigator
- Secure Operations: The only separation of duties to protect production environments and built-in log and query redaction to protect sensitive information

The Largest Hadoop Ecosystem

Cloudera partners more broadly and deeply across the Hadoop ecosystem than any other vendor. With more than 2,500 partners across the entire stack, customers can choose wherever and however they want to deploy their big data platform. With integrations to existing technologies, we are able to provide our customers with compatibility with your existing tools and skills.

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About TickSmith

TickSmith, with its TickVault platform based on Hadoop technology, is a leader in big data applications for the brokerage ecosystem and financial services. TickVault is used for data centralization and distribution, market surveillance, strategy discovery, and analytics. It is ideal for trading and risk groups, regulators, exchanges, and data vendors who need to accumulate, transform, analyse, and disseminate larger scales of financial data from multiple sources. Learn more at www.ticksmith.com.

About Cloudera

Cloudera delivers the modern data management and analytics platform built on Apache Hadoop and the latest open source technologies. The world's leading organizations trust Cloudera to help solve their most challenging business problems with Cloudera Enterprise, the fastest, easiest, and most secure data platform available for the modern world. Our customers efficiently capture, store, process, and analyse amounts of data, empowering them to use advanced analytics to drive business decisions quickly, flexibly and at lower cost than has been possible before. To ensure our customers are successful, we offer comprehensive support, training, and professional services. Learn more at www.cloudera.com.

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