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Algorithmic Trading

EU Regulatory Framework and Compliance Validation Playbook

March 2026

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Executive Summary

- **Algorithmic trading** has become a central component of modern financial markets, enhancing **automation, execution efficiency**, and advanced **risk-management capabilities**. Its use, however, requires robust organisational **structures** and **rigorous** process controls, given the speed and complexity of interactions with **market** microstructure.
- The **European regulatory framework**, comprising **MiFID II, MiFIR, the ESMA's RTS and MAR**, sets stringent requirements for **governance, transparency, system resilience**, and the prevention of abusive behaviours, including those generated by automated systems. Recent **ESMA guidance** further reinforces this framework by raising expectations on **testing, documentation,** and **accountability**.
- In an increasingly complex operational landscape, the adoption of algorithmic systems therefore demands an integrated approach that aligns **technological innovation** with strong **control environments** and full **compliance** with European regulatory standards.

At a Glance

Keywords: Market risk, Algorithmic Trading, Technology

Algorithmic Trading

Overview of Trading Algorithms

Main Trading Strategies

Main Trading Methodologies

High-Frequency Trading (HFT)

Algorithmic Trading 1/6

Overview of Trading Algorithms

A **trading algorithm** is a set of mathematical and computational **rules designed** to make automated buy or sell decisions in **financial markets**. These algorithms analyze **large volumes** of data in very **short timeframes** and are implemented to **reduce** human discretion, **increase** operational speed, and improve the consistency of **trading strategies, distinguishing** them from **order routing** systems that merely handle the **transmission of orders** across venues.

Key Features of a Trading Algorithm

- Automation of trading decisions
- Ability to process real-time data
- Reduced exposure to trader emotion
- Repeatability of strategies
- Optimization driven by quantitative metrics
- Possibility of backtesting and statistical validation

Advantages of Using Trading Algorithms

- Elimination of emotional bias
- Ability to execute complex strategies consistently
- Higher speed compared to manual trading
- Possibility to test strategies on historical data
- Operational scalability

Main Trading Strategies

- Execution Optimization Algorithms
- Market Making Algorithms
- Arbitrage/Relative Value Algorithms
- Directional Algorithms

Limitations and Risks

- Model governance & auditability requirements
- Dependency on technological infrastructure
- Risk of unexpected behavior in extreme market conditions
- Potential amplification of market dynamics

Algorithmic Trading 2/6

Main Trading Strategies 1/2

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Execution Optimization Algorithms

Strategy Goal:
An execution algorithm aims to execute large orders by optimally slicing and routing them over time to minimize total execution cost (market impact and slippage) relative to a chosen benchmark.

Key Mechanism:

- **Input**: a parent order plus constraints (time horizon, price limits, max participation rate, allowed venues);
- **Core mechanism**: the algorithm slices the parent order into child orders and continuously decides how much, when, how (limit vs market/aggressiveness), and where (routing) to trade;
- **Adaptive logic & controls**: parameters are updated using real-time signals such as liquidity (spread, depth), intraday volume, and volatility, and bounded by execution constraints (price limits, participation caps, throttling).

Examples:

- TWAP (Time-Weighted Average Price);
- VWAP (Volume-Weighted Average Price);
- POV/Participation (Percent of Volume).

Market Making Algorithms

Strategy Goal:
A market making algorithm aims to provide liquidity by continuously quoting bid and ask prices, capturing the bid–ask spread while controlling inventory risk and adverse selection.

Key Mechanism:

- **Input**: market data (spread, depth, volatility), order-flow signals, and risk limits (inventory bounds, max quote size, max message rate);
- **Core mechanism**: the algorithm posts and updates two-sided limit orders, dynamically setting quote prices and sizes based on market conditions and the current inventory;
- **Risk controls**: inventory is actively managed via skewed quotes (widening/tightening one side), order size adjustments, and hedging; activity is throttled under stress (volatility spikes, low liquidity, venue controls).

Examples:

- Two-sided quoting with inventory skew;
- Optimal market making models (Avellaneda–Stoikov);
- Options market making with delta-hedging.

Trading strategies describe the **trading objective** (what the algorithm aims to achieve) and the resulting market behaviour, independently of the modelling technique used to implement them.

Algorithmic Trading 3/6

Main Trading Strategies 2/2

Arbitrage/Relative Value Algorithms

Strategy Goal:
A relative value algorithm aims to profit from temporary mispricings between related instruments by taking offsetting long/short positions, targeting spread convergence while keeping directional market exposure limited.

Key Mechanism:

- **Input**: prices of two or more related instruments (e.g., cash vs futures, ETF vs basket, pairs), transaction costs, and risk limits (max exposure, stop-loss, leverage);
- **Core mechanism**: the algorithm estimates a "fair" relationship (spread/ratio) and triggers trades when deviations exceed thresholds; positions are sized to maintain (approx.) market neutrality;
- **Stability monitoring**: monitors spread stability and regime shifts (correlation/cointegration breakdown), controls "leg risk" (one side fills, the other doesn't), and enforces exit rules (time stop, mean-reversion stop, risk limits).

Examples:

- Pairs trading/statistical arbitrage;
- ETF–futures (or ETF–basket) arbitrage;
- Cash–futures basis/calendar spread strategies.

Directional Algorithms

Strategy Goal:
A directional (opportunistic) algorithm aims to profit from anticipated price moves by taking net long or short exposure based on signals such as momentum, mean reversion, or event-driven information, while tightly controlling drawdowns and execution costs.

Key Mechanism:

- **Input**: price/volume and volatility features, event signals (e.g., earnings releases, macro news), and risk constraints (position limits, stop-loss, leverage);
- **Core mechanism**: the algorithm generates a directional signal, converts it into orders via sizing rules (risk targeting, volatility scaling), and adapts aggressiveness/routing to market conditions;
- **Risk management**: continuous monitoring of exposures and drawdown; regime-shift controls and time-based exits; throttling or shutdown under stress to prevent runaway trading.

Examples:

- Time-series momentum;
- Cross-sectional momentum;
- Short-term reversal.

Trading strategies describe the **trading objective** (what the algorithm aims to achieve) and the resulting market behaviour, independently of the modelling technique used to implement them.

Algorithmic Trading 4/6

Main Methodologies 1/2

Methodologies describe how trading decisions are generated (rules, statistical inference, machine learning, or optimization), and can be applied across different trading objectives.

Rule-based Methods

Description:
Rule-based algorithmic trading uses predefined logical conditions to execute operations in a fully automated manner. Every trade is the direct result of a set of fixed criteria checked in real time, such as price levels, technical indicators, or quantitative patterns. This methodology ensures high repeatability and transparency. Rule-based strategies are widely used in initial automation stages because they are easy to backtest, simple to validate, and effectively eliminate human discretion.

Key Points:

- Fully transparent and non-adaptive rules;
- Easy to verify through backtesting;
- High operational stability;
- Risk of obsolescence in highly dynamic markets.

Typical Strategy Fit:

- Execution optimisation (simple schedules), Market making (basic quoting rules), Directional (indicator signals).

Statistical/Econometric Methods

Description:
Statistical/econometric models use inference to estimate market relationships and risk from data (e.g., regression, time-series and volatility models, cointegration). They quantify uncertainty and enable risk-aware decisions but require calibration and ongoing monitoring for parameter drift and regime changes.

Key Points:

- Explicit treatment of noise, variance, and confidence bands;
- Supports spread/ratio estimation and risk-aware sizing;
- Requires stationarity checks and monitoring of model breakdown.

Typical Stretegy Fit:

- Arbitrage/Relative value (pairs/cointegration), Directional (forecasting), Execution (impact/vol models).

Algorithmic Trading 5/6

Main Methodologies 2/2

Methodologies describe how trading decisions are generated (rules, statistical inference, machine learning, or optimization), and can be applied across different trading objectives.

Machine Learning Methods

Description:
Machine learning-based algorithms learn complex, nonlinear patterns from historical data. Unlike rule-based systems, these models generalize from data and produce probabilistic forecasts of direction, volatility, or expected return. They can incorporate hundreds of variables: technical indicators, macroeconomic inputs, on-chain metrics, sentiment analysis, or order-book signals. They require rich and clean datasets, well-designed feature engineering pipelines, and techniques such as cross-validation or regularization to prevent overfitting.

Key Points:

- Ability to model nonlinear relationships;
- Require large datasets and high computational power;
- Susceptible to overfitting;
- Support continuous model updates (online learning).

Typical Strategy Fit:

- Directional (signal generation), Market making (state/toxicity prediction), Surveillance-adjacent anomaly detection.

Optimization & Control Methods

Description:
Optimization & control methods compute the "best action" by maximizing an objective (e.g., return, spread capture, or execution quality) subject to constraints such as risk limits, inventory bounds, and liquidity/market-impact costs. They formalize the trade-off between performance and risk and can be implemented via convex optimization, dynamic programming, or stochastic control (and, in some settings, reinforcement learning).

Key Points:

- Natural framework for cost vs risk trade-offs and hard limits;
- Produces consistent decisions aligned with risk constraints;
- Requires robust calibration of objective terms (impact, risk aversion, costs).

Typical Stretegy Fit:

- Execution optimisation (optimal execution / TCA), Market making (optimal quoting / inventory control), Portfolio construction (allocation/rebalancing).

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Algorithmic Trading 6/6

High-Frequency Trading (HFT)

High-Frequency Trading (HFT) is an **operating style** of algorithmic trading characterized by **ultra-low latency**, high order **message** rates, and very short **holding** periods. It typically exploits short-lived **microstructure** signals (e.g., spread dynamics, order-book imbalance) and **relies** on highly **optimized** infrastructure to react very fast.

Market Data

Ultra-low-latency **market data** is ingested and processed within **microseconds** to identify exploitable **signals** and **trigger** responses faster than competing **market** participants.

HFT Algorithm

HFT algorithms **analyze** real-time **data** using **statistical** and **predictive** models to detect **micro-patterns** and **imbalances**, enabling ultra-fast **sub-millisecond** decisions.

Trade Order

The algorithm generates **optimized** orders as soon as it **detects** an **opportunity**, aiming to outperform the **market** by **exploiting** microsecond-level **advantages**

Execution

Orders are transmitted through **ultra-low-latency** connections with **automated** pre-trade controls, enabling the capture of **opportunities lasting** only microseconds.

Direct Electronic Access (DEA)

Direct Electronic Access (DEA) is a market **access** model where a **client** submits orders directly to a trading venue using **a broker's trading infrastructure** (sponsored access), while the broker remains **responsible** for ensuring the required **controls** and **supervision** (the regulatory framework is detailed in the following section). It enables **fast and automated** access **to markets** but requires robust **pre-trade risk** checks, monitoring, and clear **governance** across the **client–broker–venue** chain. With **DEA**, orders are sent directly to the **market** through the **broker's infrastructure**, without any manual review or **validation** by the broker's personnel.

02

EU Regulatory Framework

Overview

MiFID, ESMA Guidelines and RTS

ESMA - RTS 6 vs RTS 7: Pillars of MiFID II Algorithmic Trading

Pre- and Post-Trade Regulatory Controls

Regulatory Treatment across Trading Models

Markets in Financial Instruments Regulation (MiFIR)

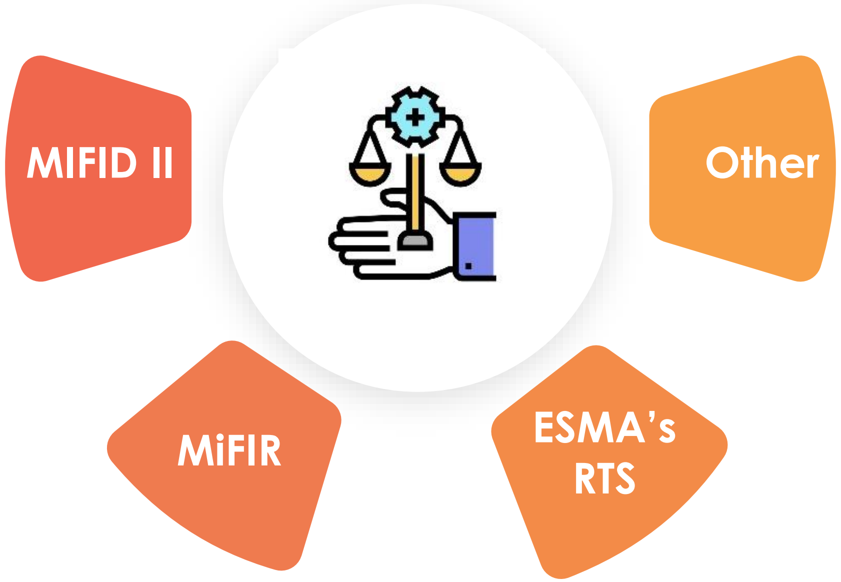
Market Abuse Regulation (MAR)

ESMA Supervisory Briefing – The Latest EU Supervisory Guidance on Algorithmic Trading

EU Regulatory Framework 1/8

Overview

The **EU framework** for **algorithmic trading** is built on **multiple**, interconnected regulatory **layers**: **MiFID II** defines core organisational and risk-control requirements, **MiFIR** sets transparency and reporting obligations, and **ESMA's RTS** translate these into detailed technical rules, subsequently adopted by the European Commission as **Delegated Regulations.** Complementary legislation further supports **market integrity** and **operational resilience.**



MiFID II sets out clear **organisational**, **governance**, and **risk-control requirements** for firms using algorithmic trading, including **robust pre-** and **post-trade controls**, real-time monitoring, and strict change-management and testing procedures. It also introduces specific **obligations for high-frequency trading (HFT)**, such as clock synchronisation, detailed record-keeping, and, where applicable, **market-making duties**, to ensure that **algorithmic strategies** operate safely and support orderly markets.

MiFIR **imposes** broad **pre-** and **post-trade transparency** and **transaction-reporting obligations** on **trading venues** and **investment firms**, covering equities, bonds, derivatives and other instruments, thereby ensuring that **algorithmic trades** are publicly visible and traceable, and subject to **consolidated** real-time market data and **regulatory** oversight.

In addition to **MiFID II** and MiFIR, algorithmic trading is also shaped by MAR, which targets **market abuse** and manipulation; by **ESMA's reports** and guidance on **algorithmic trading**, which **provide supervisory** expectations and recommendations for consistent oversight; and by DORA, which introduces **high-level** ICT resilience and **cybersecurity** requirements to safeguard critical trading systems.

ESMA's Regulatory Technical Standards (notably Commission **Delegated Regulation** (EU) 2017/589 – RTS 6 and (EU) 2017/584 – RTS 7) set legally binding requirements for the **governance** and **control** of algorithmic trading. They define organisational **arrangements**, testing, and risk controls, ensuring algorithms are **properly tested**, monitored, and supported by resilient infrastructures to promote orderly and robust markets.

EU Regulatory Framework 2/8

MiFID, ESMA Guidelines and RTS

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Requirements for Algorithmic Trading

MiFID II establishes a comprehensive **regulatory framework** for **algorithmic trading**, acknowledging its **potential impact** on market integrity and financial stability. **Article 17 MiFID II** requires **firms** engaging in algorithmic trading to maintain **resilient** trading systems with adequate capacity, thresholds, and controls that **prevent erroneous** orders or disorderly **market conditions**. Systems must not facilitate **behaviours** contrary to the Market **Abuse Regulation** and must be **supported** by robust **business contin**uity and **ICT** recovery plans, aligned with **Regulation (EU) 2022/2554** on digital operational resilience **(DORA).** Firms must notify their **competent authority** and provide detailed **information on strategies**, parameters, testing, and risk controls upon request.

Regulatory Technical Standards

The **RTS** issued by **ESMA** establish uniform **standards** for operational capacity, risk controls, business continuity, and **algorithm management**, thereby addressing the **risks associated** with the widespread use of **automated trading** systems. Their overarching **objective** is to **harmonise** supervisory practices across the **European Union**, reducing **regulatory** divergences among **Member States** and strengthening the protection and integrity of **financial markets**. The main **RTS** of reference are as follows:

- **RTS 6** pursuant to **Article 17** of **MiFID II**) which sets out the **technical** and **organisational requirements** that **investment firms** must implement when deploying algorithmic trading systems and HFT;
- **RTS 7** pursuant to **Article 48** of **MiFID II**, which defines the **organisational requirements** applicable to **trading venues** (RM, MTF, OTF) that enable algorithmic and high frequency trading;
- **RTS 9**, issued pursuant to **Article 48** of **MiFID II**, defines the **methodology** and **parameters** for calculating the Order to Trade Ratio (**OTR**), establishing uniform criteria to limit the ratio of unexecuted orders to transactions in order to prevent **abnormal trading conditions** and ensure the orderly functioning of markets.

ESMA Guidelines: Supervision, Testing and Governance

ESMA Guidelines refine **MiFID II** by specifying how **firms** must implement **algorithmic-trading** controls. They require rigorous **system testing**, continuous **monitoring**, fallback procedures, and fully documented **business-continuity frameworks**. Firms must maintain **comprehensive** algorithm **documentation** (parameters, risk limits, logic, and oversight controls) to **support** supervisory review. The **guidelines** also reinforce governance expectations, mandating **board-level** involvement and strict **separation** between trading, risk management, and internal audit.

EU Regulatory Framework 3/8

ESMA RTS 6 vs RTS 7: Pillars of MiFID II Algorithmic Trading

The integrated **analysis** of ESMA **RTS 6** and **RTS 7** (adopted by the European Commission as **Delegated Regulations (EU) 2017/589** and **(EU) 2017/584**) shows that the European **framework** governing **algorithmic trading** and **high-frequency trading** (HFT) is structured along **two** complementary dimensions: on the one hand, the **strengthening of accountability** and **organizational safeguards** within **investment firms**, and on the other, the capacity of **market infrastructures** to ensure robustness and operational resilience.

RTS 6 investment firm

RTS 6 adopts a firm **centric** approach, **imposing** stringent governance, **risk control** and **operational supervision** requirements on **investment firms** engaging in **algorithmic trading**. These firms must implement a **robust** algorithm management **framework**, which includes **pre trade** controls on price, volume and value, real time monitoring with **alert** generation, kill switch **functionalities**, and **automated surveillance** systems designed to detect potentially abusive or **market distorting** behaviors. Moreover, **RTS 6** mandates a **rigorous testing regime**, with segregated **environments** for algorithm testing and **periodic stress tests** on operational capacity, connectivity, and adverse market conditions, as well as a set of **business continuity** measures proportionate to the firm's complexity.

RTS 7 trading venue

RTS 7, on the other hand, adopts a **venue** centric perspective, focusing on the ability of **trading venues** to ensure a stable and orderly **market environment** even in the **presence** of high volumes of **automated** traffic. Venues are required to **guarantee** systems with a **capacity** at least twice the **highest messaging** peak recorded over the past five years, together with real time monitoring of **technical performance** and order flows, with mandatory alert activation within five seconds. Moreover, they must **implement** volatility **management mechanisms**, infrastructure level **pre trade** controls, and a robust **due diligence framework** for their members, **particularly** when they provide **direct electronic** access or sponsored **access** to the **market**, with the aim of preventing disorderly **trading** conditions and **ensuring** the responsible use of **automated** access channels.

Taken together, RTS 6 and RTS 7 establish an integrated regulatory framework operating on two complementary levels: the former strengthens the quality, safety and accountability of firms that develop and deploy trading algorithms, while the latter ensures the robustness of the market infrastructures that execute them. This distinction between micro-prudential requirements at firm level and macro-operational requirements at venue level creates a coherent architecture aimed at safeguarding systemic stability and market integrity. The complementarity between the two RTS is essential to mitigate the risks inherent in algorithmic and high-frequency trading, ensuring a balanced evolution of technological innovation and market resilience.

EU Regulatory Framework 4/8

Pre- and Post-Trade Regulatory Controls

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The structure of **pre-** and **post-trade controls** within the realm of **algorithmic trading** emerges as a crucial **component** of the governance of European **financial** markets. The **MiFID II** Directive and the associated **ESMA Regulatory Technical Standards** (RTS), in particular **RTS 6** and **RTS 7**, establish stringent organizational **requirements** for firms employing **trading algorithms**, with the aim of **mitigating** the risks **associated** with high-speed automation and structural **complexity**.

Pre-Trade Controls

Pre-trade controls function to **prevent** erroneous or high-risk orders from **entering** the **market**. In 2024, **ESMA** initiated a **Common Supervisory Action** to **assess** their **effective** implementation, with **specific attention** to **calibration**, governance, and the integration of internal risk limits. The **main controls** include the following:

- **Price controls (price collars)**: these mechanisms compare the order price against static or dynamic price bands and automatically block orders that fall outside the permitted range;
- **Value and size controls**: they restrict the maximum order size or the overall exposure permitted to an algorithm, thereby preventing excessive aggressiveness or large-scale input errors;
- **Message throttling**: these mechanisms regulate the frequency of API messages and order submissions, in accordance with RTS 7, to prevent market flooding and preserve operational stability;
- **Credit and risk limits**: these thresholds interact directly with pre-trade controls, serving as an essential preventive barrier against excessive exposure.

Post-Trade Controls

Post-trade controls operate after **execution** to detect **anomalie**s, **risky patterns**, or algorithmic behaviors that are **sub-optimal** or potentially **manipulative**.

- **Order-to-Trade Ratio (OTR):** A key indicator used to assess order-flow quality and prevent abusive practices (e.g., layering, spoofing). BrokerTec explicitly incorporates OTR-based controls within its system;
- **Fill ratios and operational anomalies:** These metrics help identify inefficient algorithms or those generating unnecessary order volumes, thereby supporting overall market resilience;
- **Market abuse surveillance:** MiFID II mandates post-trade surveillance to detect manipulation, disruptions, or suspicious patterns—an obligation strengthened by ESMA and national regulators.

Additional **post-trade** processes **include performance** and **slippage analysis**, incident reporting, **audit-trail** and **reconciliation** procedures, ex-post **stress testing**, continuous **parameter** optimisation, and the **integration** of findings into **governance** to enhance **risk controls** and pre-trade mechanisms

EU Regulatory Framework 5/8

Regulatory Treatment across Trading Models

Algorithmic trading requirements under **MiFID II** (Article 17) and RTS 6 apply consistently across **different trading models**; however, **additional obligations** arise depending on whether trading is performed on **proprietary portfolios**, on **behalf of clients**, or through **DEA arrangements**.

- **Proprietary trading:** the firm trades financial instruments using its own capital;
- **Client trading (managed portfolios):** the firm executes transactions on behalf of clients using its own algorithms;
- **Client trading via broker:** the client accesses the market through the firm, which retains control over the execution process;
- **Client trading via DEA:** the client submits orders directly to the market using the technological infrastructure provided by the firm.

Dimension	Proprietary Trading	Client Trading (Managed Portfolios)	Client Trading via Broker	Client Trading via DEA	Regulatory Reference
Algorithmic trading applicability	Applies	Applies	Applies (if execution is algorithmic)	Applies	MiFID II Art. 17(1)
Responsibility for trading activity	Firm	Firm	Firm (execution responsibility)	Firm remains fully responsible	MiFID II Art. 17(5)
Governance & controls	Full internal governance	Full internal governance	Execution governance	Extended to client access	RTS 6 (EU) 2017/589
Pre-trade controls	Internal controls	Internal controls	Applied at execution layer	Enhanced on client flow	RTS 6 – Art. 15
Testing & validation	Required	Required	Required (execution algos)	Required also for DEA onboarding and changes	RTS 6 – Art. 5–7
Monitoring & kill switch	Internal monitoring	Internal monitoring	Execution monitoring	Real-time monitoring + intervention capability	MiFID II Art. 17(5) + RTS 6
Best execution	Not applicable	Applicable	Applicable	Applicable	MiFID II Art. 27
Client protection & transparency	Not applicable	Applicable	Applicable	Applicable	MiFID II Art. 24
Conflicts of interest	Limited	Relevant	Relevant	Relevant	MiFID II Art. 23
Due diligence on users	Not required	Not required	Limited	Mandatory on client and systems	MiFID II Art. 17(5)

While the core **algorithmic** trading requirements (MiFID II Article 17 and RTS 6) remain **unchanged**, additional **obligations** under **MiFID II** (Articles 23, 24 and 27) apply in client trading, and **regulatory** complexity increases significantly in **DEA** scenarios, where firms must ensure full **control** and oversight over **third-party** algorithmic activity.

EU Regulatory Framework 7/8

Markets in Financial Instruments Regulation (MiFIR)

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MiFIR, in coordination with **MiFID II**, frames **algorithmic trading** by mandating **transparency** and **reporting** on orders and **transactions**. **Pre** and **post** trade transparency and **market structure** rules shape **algorithm** design and **HFT** operations across **trading venues**. Transaction reporting **obligations** and **standardized** order fields make algorithmic behaviors traceable, enabling surveillance and auditability. **Market** safeguard **mechanisms** (e.g., circuit breakers) and access rules integrate with the **technical controls** and **testing** specified in the **ESMA RTS**.

Operational Pillars

The **MiFIR** framework operates along **three fundamental** conceptual **axes**:
1) **the transparency axis**, which establishes harmonised pre- and post-trade disclosure requirements and mandates the unambiguous identification of automated decision-making processes through flagging mechanisms (Algo ID);
2) **the systemic-stability axis**, expressed through obligations related to operational thresholds, flow-control tools (including Order-to-Trade Ratios, throttling, and rate-limiting), automated kill-switch mechanisms, and comprehensive testing requirements;
3) **the fair-access axis**, which seeks to counteract informational and infrastructural asymmetries arising from the differential use of low-latency technologies, co-location services, and predatory algorithmic strategies.

Requirements for Algorithmic Trading

Algorithmic transactions must be **transaction-reported** with the identifiers (IDs) of the **natural** persons and the **algorithms** responsible for the investment decision and its execution; **firms** must retain a **complete audit** trail of orders and executions for five years.
Pre and post trade transparency **requires** the publication, on a near real time basis wherever **technically feasible**, of prices, sizes, and order book depth across **equity** and **non equity** instruments, **directly** shaping the **design of market making** and **execution algorithms**.
Under the double volume cap (**DVC**), use of the "**reference price**" and "**negotiated trade**" waivers is limited to **4%** per venue and **8%** EU wide, **calculated** on the rolling 12 month **trading volume**; breaching either **threshold triggers** an automatic six month **suspension** of the relevant waiver for the instrument

Algorithmic Risk Oversight

Acting in coordination with the **technical-organisational** requirements laid down in **Article 17 of MiFID II**, MiFIR establishes a multilayered and comprehensive **regulatory framework** designed to mitigate the **systemic risks** arising from **high-speed algorithmic** interaction, messaging congestion, and the **self-reinforcing** dynamics inherent in **latency-driven** trading strategies. This **framework** constitutes a **genuine architecture** of '**regulatory engineering**', imposing rigorous **obligations** concerning system resilience, infrastructural redundancy, **the integrity** and **stability of information flows**, and **the traceability of algorithmic** activity, while concurrently enhancing the **mechanisms** of continuous supervisory oversight.

EU Regulatory Framework 7/8

Market Abuse Regulation (MAR)

Regulation (EU) No. 596/2014 (**Market Abuse Regulation**) applies fully to **algorithmic trading**. AR prohibits any form of **market manipulation**, including automated **behaviours** that artificially distort the **price**, demand, or supply of **financial instruments**, or that disseminate misleading signals about their formation.

Regulation EU n. 596/2014 (MAR)

MAR applies fully to **trades** executed through **algorithms**: every order or **transaction** generated by **automated systems** falls within the **scope** of the prohibitions on **insider** dealing and **market** manipulation. In particular, **Article 12** explicitly deems **algorithmic** activities **manipulative** when they transmit **false** or misleading signals regarding **price**, demand, or supply, or when they **set prices** at artificial levels—including high frequency strategies. **MAR** also **prohibits** the **submission** of orders that **overload**, **destabilise**, or **obstruct** the functioning of the **trading system**, such as **large scale** cancellations, rapid fire **order entry**, and **manipulative** order book practices. The prohibition also extends to **algorithmic techniques** such as spoofing, layering, **artificial volatility** generation, and **strategies** that exploit **informational** advantages to **distort market** dynamics. Finally, MAR requires trading venues to maintain **surveillance systems** capable of detecting abusive behaviours generated by algorithms (Article 16).

Requirements for Algorithmic Trading

Under **MAR**, several **practices** are particularly **relevant** in the context of **algorithmic trading**, including:

- **Algorithmic** layering and **spoofing**, namely the **large-scale** submission of **orders** that are not intended to be **executed,** with the purpose of distorting **market perception**;
- **Volatility manipulation**, achieved through **strategies** designed to generate **abrupt** and **artificial price** movements;
- The use of **algorithms** to disseminate **false** or misleading **signals** regarding **liquidity** levels or **perceived** demand- and **supply-side** pressure.

National competent authorities and **ESMA** have reported a growing number of cases referred to **prosecutors** concerning market abuse conducted through **algorithms**, including within energy **markets classified** as **financial instruments**

Compliance Requirements

MAR imposes specific **obligations** on **market** participants that **deploy algorithms**: They must **monitor** and **record** all automated **activity** to identify potentially **abusive behaviours**. They must implement **controls** and **surveillance systems** capable of **detecting** anomalies **generated** by their algorithms. They **remain** fully accountable for the **effects** of their **algorithms**, even when relying on **third-party technological solutions**. This framework integrates with **MiFID II/RTS 6** and **RTS 7**: while **MiFID** governs the technical **resilience of algorithms**, MAR addresses their **behavioural** impact on the market, preventing **manipulation** and **safeguarding** the integrity of price formation. **European authorities** have confirmed that **recent** episodes of heightened **volatility** underscore the need for robust **MAR** oversight of automated strategies and **high-frequency trading algorithms**.

EU Regulatory Framework 8/8

ESMA Supervisory Briefing – The Latest EU Supervisory Guidance on Algorithmic Trading

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In February 2026, **ESMA** published the ***Supervisory Briefing on Algorithmic Trading*** *in the EU*, a non-binding supervisory convergence tool **designed** to align NCA **practices** and **support investment firms** in assessing their own compliance, including practical **templates** and **checklists**. The **main takeaways** are summarised below.

Perimeter clarity & definitions: reinforces a broad interpretation of algorithmic trading (in scope whenever an algorithm determines any order parameter beyond mere routing/post-trade) and clarifies key concepts such as algorithm and algorithmic trading strategy

Governance expectations: clarifies what "robust governance" looks like in practice by requiring (i) compliance staff understanding and continuous contact with technical owners, (ii) an annual RTS6 self-assessment documented article-by-article with a clear compliance rationale, and (iii) auditable change governance (timestamp/approval/recording of material changes) across the full algorithm lifecycle;

Testing expectations: reinforces a structured testing framework covering conformance testing, stress/scenario testing and regression testing against predefined pass/fail criteria, with results retained as audit evidence; it further clarifies that material changes (including changes to decision logic or trading behaviour, key risk controls (e.g., pre-trade checks/limits), external dependencies or data inputs, and (re)training of ML components) should trigger re-testing and updated documentation;

Pre-Trade Controls (PTCs): operationalises expectations on PTCs by focusing not only on their presence but on calibration and governance—controls must be appropriately parameterised per instrument/venue and consistently applied across algorithm flows (including DEA where relevant); the briefing stresses real-time enforcement, escalation/kill-switch capabilities, and evidence of effectiveness (monitoring metrics, exceptions and periodic testing) to prevent erroneous orders and disorderly trading;

Outsourcing & third-party solutions: firms retain full regulatory responsibility and must ensure effective oversight, access to relevant logs/evidence, and the ability to monitor, suspend or terminate outsourced algorithms without undue reliance on the provider;

Direct Electronic Access (DEA): reaffirms that the DEA provider remains accountable for controls and monitoring and for ensuring clients' compliance with MiFID II and venue rules, even when the client is itself authorised;

AI considerations: notes that algorithmic trading is not currently classified as "high-risk" under the AI Act, but governance, documentation, and (where applicable) transparency obligations must still be addressed for AI components;

03

Compliance Validation Playbook

Inventory and Scoping of Trading Algorithms

Controls Matrix

Control Testing, Scenario Validation & Evidence Collection

Governance, Remediation & Continuous Compliance

Example of Scenario-Based Control Validation

Compliance Validation Playbook 1/5

Inventory and Scoping of Trading Algorithms

Just in Time

This section introduces a **Regulatory Compliance Playbook** that translates **regulatory requirements** into a **structured, repeatable assessment process**. The **definition of the scope** of the algorithms under analysis is carried out through a **structured mapping** of their entire lifecycle and the different types of logic implemented. **The objective** is to establish a **centralised, comprehensive**, and **continuously updated catalogue** of the algorithms in use.

Objectives of the Inventory Phase

- **Identify** and **classify** all **active algorithms**, covering both trading strategies (e.g., execution **optimisation**, market making) and operating modes (e.g. HFT, DEA if applicable);
- **Map supporting components** such as routing logic, pricing/valuation engines, **hedging** modules, and optimisation layers that influence order **generation** and execution;
- **Distinguish ownership** and **sourcing**, separating in-house **developed algorithms** from third-party/vendor solutions (**including outsourced or hosted services**).

Mandatory Information Set for Algorithm Profiling

For each algorithm, collect and maintain the following minimum dataset:

- **Identity & purpose:** name, internal ID, owner, strategy and asset class, in-scope rationale);
- **Lifecycle & governance:** status (dev/test/prod), approvals, change management, recertification cadence;
- **Architecture & dependencies**: tech stack, key modules, integrations (OMS/EMS, risk gateway, market data, venues), resiliency/failover;
- **Decision logic & parameters**: high-level logic, key triggers, limits, activation/deactivation and override conditions;
- **Risk, performance & capacity**: main risk drivers, criticality tier, latency/throughput, message-rate/operational limits;
- **Existing controls:** pre-trade, in-trade, post-trade controls;
- **Essential documentation:** functional/technical specifications, test evidence, change logs.

Deliverables of the Phase

Upon completion of the algorithm inventory, the phase produces a set of structured outputs that serve as the informational foundation for compliance assessments:

- **Centralised catalogue in tabular format**: a complete and structured representation of all identified algorithms, organised according to a standardised tabular model;
- **System Interdependencies Map:** the diagram highlights the critical points of the architecture (single points of failure), the functional dependencies, and the input/output flows, thereby supporting assessments of system resilience, capacity, IT risks, and the adequacy of technical controls;
- **Algorithmic Risk and Criticality Mapping:** a structured representation that classifies each algorithm based on its inherent risk (market, execution, operational, and IT), its level of technical complexity, and its potential impact on the market and on clients;
- **Data lineage & time sync note:** data/parameter flows and timestamping for traceability and replay.

Compliance Validation Playbook 2/5

Controls Matrix

Once the **algorithm catalogue** has been defined, the next step is to build a **control matrix** that maps regulatory requirements (**MiFID II/MiFIR, ESMA RTS and guidance**) to the controls and evidence implemented by the firm. The **objective** is to **identify compliance gaps**, **assess** their **severity** and **impact**, and **prioritise remediation actions**.

Matrix Structure

The control matrix **provides** a **structured means** of **assessing compliance** by reporting, for each regulatory requirement, the expected control, the control currently implemented, the control owner, **the supporting evidence**, and the testing approach/results. It highlights any gaps, assigning risk-based severity and priority. The matrix also identifies **the necessary corrective actions**, including responsibilities and ownership, and defines an operational priority that guides the **remediation activities** with a possible scoring gap (e.g. **High:** missing/ineffective control - **Medium:** partially implemented control- **Low:** control in place but better documentation needed).

Controls

The following control categories represent the main control areas reviewed in the matrix to identify design/implementation/evidence gaps:

- **Pre-trade risk controls**: price collars, fat-finger limits, max order size/notional, message-rate throttles, credit/position checks;
- **Testing & validation:** conformance, regression and stress testing, scenario-based validation, documented pass/fail criteria;
- **Governance & lifecycle controls**: approvals, segregation of duties, role-based responsibilities, change management and periodic recertification;
- **Monitoring & surveillance**: real-time alerting, logging, audit trail, parameter dashboards, anomaly detection / performance monitoring;
- **Incident management & escalation**: kill-switch procedures, escalation runbooks, post-incident documentation and corrective actions;
- **Regulatory communications:** notification/ update processes with competent authorities.

Analysis Deliverables

The **Analysis produces** a set of structured outputs that support the **definition** and **implementation** of corrective actions, as well as the **strengthening** of the overall control **framework**. They are also designed to support external **supervisory/audit readiness**. The key outputs include:

- **Gap Assessment Report**, detailing and classifying gaps against regulatory requirements;
- **Remediation Action Plan**, outlining remediation activities, responsibilities, and timelines;
- **Residual Risk Heatmap**, assessing remaining risks in terms of likelihood and impact;
- **Remediation Roadmap (prioritized)**, sequencing initiatives based on priority and operational dependencies;
- **Control Enhancement Recommendations**, aimed at enhancing controls, processes, and governance over algorithmic trading;
- **Inspection-ready Evidence Pack**: documented controls, test results, and traceability artefacts supporting supervisory reviews.

Compliance Validation Playbook 3/5

Control Testing, Scenario Validation & Evidence Collection

Just in Time

This phase **validates** the **effectiveness of** the **controls** identified in the matrix through **structured test scenarios** and collects the evidence required to support **compliance assessments**, **remediation decisions**, and **supervisory readiness**.

Testing Approach & Scenario Design

- **Define test scope** based on control criticality and algorithm risk tier;
- **Design test cases** to assess both design effectiveness and operating effectiveness of controls;
- **Use a scenario library** covering:

1. **market stress** (volatility spikes, liquidity drops);
2. **venue/connectivity events** (disconnects, throttling, auction transitions);
3. **algorithm malfunctions** (runaway loops, parameter/configuration errors);
4. **data issues** (stale prices, feed degradation, missing data).

- **Define expected control responses** (reject, throttle, alert, pause, kill switch, escalation).

Test Execution & Evidence Collection

- Execute tests in a **controlled environment** (simulation/ conformance/replay) with documented preconditions;
- **Record** pass/fail **criteria**, **deviations**, and severity of exceptions;
- **Collect** and preserve **evidence**, including:
  - logs and alerts;
  - configuration snapshots / parameter settings;
  - test run IDs and timestamps;
  - screenshots / dashboards (where relevant);
  - approvals, escalation records, incident notes;
- **Ensure traceability** and **replay-ability** of results (data lineage, time synchronization, run trace);

Phase Deliverables

- **Scenario Library Catalogue** (test scenarios, expected responses, pass/fail criteria);
- **Control Testing Report** (results by control category, gaps and exceptions);
- **Inspection-Ready Evidence Pack** (logs, test outputs, approvals, traceability artefacts);
- **Exceptions Register & Retesting Plan** (failed tests, remediation actions, validation follow-up);
- **Control Coverage Assessment** (tested vs untested controls / scenario coverage gaps).

Compliance Validation Playbook 4/5

Governance, Remediation & Continuous Compliance

This **phase translates** assessment and testing outcomes into a **risk-based remediation plan** and embeds them into a **governance model** for ongoing compliance, periodic **recertification**, and continuous **control** improvement.

Governance & Lifecycle Operating Model

- **Define the end-to-end lifecycle** for algorithm changes: design → testing → validation → approval → production → monitoring → recertification;
- Establish **roles and responsibilities** (RACI) across Front Office, Risk, Compliance, and IT;
- **Implement change governance** with approval gates, version control, and documentation updates;
- **Define review triggers** (material model/parameter changes, incidents, venue/rule changes, periodic reviews).

Risk-Based Remediation Prioritisation

- **Prioritise gaps** based on:
  - regulatory criticality;
  - impact on market/clients;
  - algorithm criticality tier;
  - operational dependencies / implementation effort;
- **Group actions into remediation buckets:**
  - Quick wins (documentation, ownership, evidence gaps);
  - Control enhancements (limits, alerts, monitoring);
  - Structural changes (architecture, testing environment, governance redesign);
- **Define owners**, timelines, and dependencies for each action.

Phase Deliverables & Continuous Compliance Outputs

- **Prioritised Remediation Roadmap** (actions, owners, timelines, dependencies);
- **Residual Risk Heatmap** (pre-/post-remediation view);
- **Governance & RACI Model** (approval and escalation responsibilities);
- **Periodic Review & Recertification Calendar** (testing, reviews, documentation refresh)
- **Management Steering Pack** (status, risks, escalation points, decision requests)

Compliance Validation Playbook 5/5

Example of Scenario-Based Control Validation

Just in Time

This is an **example** of a **scenario-based** validation use case: **venue-level volatility** controls **(EU volatility interruptions vs U.S. LULD halts**) are used as external **market events** to test algorithm behaviour, **internal controls**, and **operational readiness**.

Volatility Interruption

European **trading venues** apply the **Volatility Interruption mechanism**. This system relies on two complementary corridors: a **dynamic** price corridor, **updated** after each **trade** based on the last **transaction price**, and a **static price** corridor, anchored to the most recent auction price. When an incoming order would **result** in an **execution** outside either **corridor**, the **venue** suspends continuous **trading** and initiates a **volatility** auction, generally lasting 120 seconds plus a randomization **window**. The purpose of this auction is to slow down price **formation**, consolidate available **liquidity**, and establish a new **equilibrium price** through an **order-driven** mechanism.

Limit Up–Limit Down

In the United States, the **Limit Up–Limit Down** (LULD) mechanism constitutes the central **regulatory** tool for mitigating excessive **price** movements. Introduced in 2013, **LULD** establishes price bands **computed** as **fixed** percentage **deviations** from a reference price, **typically** defined as the **arithmetic** mean of **transactions** executed over the **preceding five-minute** window. When the **best** bid or **offer** reaches or **breaches** the upper or **lower** band, the **instrument** enters a **Limit State.** If this condition persists for 15 seconds, a five-minute trading halt is initiated. Consequently, **LULD** acts as a hard **interruption mechanism**, prohibiting **executions** outside a predetermined **price range** to preserve orderly market **functioning**.

When **venue-level volatility controls** are triggered, **trading algorithms** must handle specific market-state changes to avoid disorderly behaviour and to ensure controls remain effective. Playbook application (example):

- **EU Volatility Interruption** (auction-based): validate auction transition handling (order cancellation/persistence rules), quoting/routing pause and re-entry logic after the auction, and controls preventing erroneous executions during the auction phase;
- **U.S. LULD** (time-based halt): validate halt detection and order management during the halt (cancellation/queuing), restart procedures at re-open (throttling, staged re-entry), and controls preventing trading outside the allowed price bands.

The **playbook** maps each venue event to **expected algorithm responses**, control **test cases**, and evidence to **collect** (logs, alerts, configuration snapshots) for **audit** and **supervisory readiness**.

04

Conclusions & Takeaways

Final Remarks

Final Remarks

Just in Time

The adoption of **algorithmic trading** requires **continuous alignment** between technological innovation, operational **robustness**, and full **adherence** to the European regulatory framework.

The regulatory architecture (MiFID II, MiFIR, ESMA RTS, MAR) establishes **strict requirements** regarding governance, risk controls, **testing**, and **system resilience**, safeguarding market integrity and orderly trading conditions.

The **Compliance Validation Playbook** enables a **structured management** of the **algorithm** lifecycle through inventory mapping, control matrix assessment, **scenario-based** testing, and **traceable** evidence **collection**.

Scenario-based validation using real market events, such as e.g. volatility interruptions, strengthens the ability to assess **algorithm behaviour**, its robustness, and the effectiveness of **internal controls**.

A **clear governance** structure, **comprehensive documentation**, and periodic **reviews** are essential to **ensure** operational continuity, effective **risk management**, and sustained regulatory compliance.

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