

Algorithmic Trading Compliance in Wholesale Markets

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Contents

1	Executive summary	3
2	Defining algorithmic trading	8
3	Development and testing	11
4	Risk controls	16
5	Governance and oversight	19
6	Market conduct	23
Annex 1		
	Abbreviations used in this paper	27

How to navigate this document onscreen



returns you to the contents list



takes you to helpful abbreviations



1 Executive summary

Introduction

- 1.1** Firms operating in wholesale markets increasingly use algorithms for a number of purposes across their trading activity. In particular, driven by the rise in electronic trading platforms and the increased availability of data, algorithms are now often used for making both execution and investment decisions.¹
- 1.2** Automated technology brings significant benefits to investors, including increased execution speed and reduced costs. However, it can also amplify certain risks. It is essential that key oversight functions, including compliance and risk management, keep pace with technological advancements. In the absence of appropriate systems and controls, the increased speed and complexity of financial markets can turn otherwise manageable errors into extreme events with potentially wide-spread implications. As a result, algorithmic trading continues to be an area of focus for the FCA and other regulators across the globe.
- 1.3** We continue to proactively supervise algorithmic trading activity and conduct research on algorithmic trading. This report summarises key areas of focus for algorithmic trading compliance in wholesale markets, including references to relevant legislation. It also highlights examples of good and poor practice observed during our reviews ahead of the implementation of MiFID II.
- 1.4** Good and poor practices used in this report are not exhaustive. The examples of good practice present ways, but not the only ways, in which firms might comply with applicable rules and requirements. The poor practices in this report highlight areas where firms would now need to do further work to comply with the applicable requirements.
- 1.5** While this report highlights key requirements in MiFID II, it will also be of interest to all firms that develop and/or use algorithmic trading strategies. Depending on the nature of a firm's algorithmic trading activity, certain areas of the report may be more relevant than others.

Our supervisory approach

- 1.6** We conduct work on algorithmic trading on both a firm specific and cross-firm basis, in line with our wider supervisory approach. As algorithmic trading has risen in importance, we have undertaken an increasing amount of work on this topic, covering firms such as principal traders, investment banks and investment managers.

¹ http://ec.europa.eu/finance/docs/level-2-measures/mifid-rtis-06_en.pdf "Investment decision algorithms make automated trading decisions by determining which financial instrument should be purchased or sold. Order execution algorithms optimise order-execution processes by automatic generation and submission of orders or quotes, to one or several trading venues once the investment decision has been taken. Trading algorithms that are investment decision algorithms should be differentiated from order execution algorithms having regard to their potential impact on the overall fair and orderly functioning of the market."



- 1.7** To understand how key risks across algorithmic trading are managed by regulated firms, we conducted a number of cross-firm reviews. For example, we recently completed a detailed assessment of the development and implementation procedures used by firms for algorithmic trading. We reviewed the entire development, testing and deployment lifecycle and conducted interviews with front line staff, including traders, quantitative researchers and software developers. We also met with staff in the relevant control functions such as risk and compliance, as well as senior management. We provided firms included in these reviews with detailed feedback and, where required, specific action points.
- 1.8** In general, we are encouraged that firms have taken steps to reduce risks inherent to algorithmic trading. However, further improvement is needed in a number of areas. For example, some firms lacked a suitable process to identify algorithmic trading across their business and did not have appropriate documentation in place to demonstrate suitable development and testing procedures are maintained. In these cases, firms also lacked a robust and comprehensive governance framework.
- 1.9** Additionally, firms need to do more work to identify and reduce potential conduct risks created by their algorithmic trading strategies. This includes delivering suitable market abuse training for staff involved in the development and implementation processes. Firms also need to consider the potential impact their algorithmic trading activity (including the combined impact of multiple algorithmic strategies) may have on the fair and effective operation of financial markets.
- 1.10** We will continue to assess whether firms have taken sufficient steps to reduce risks arising from algorithmic trading. These will include MIFID II investment firms and those non-MIFID investment firms, such as collective investment firms engaging in algorithmic trading, who are subject to the relevant requirements under Article 17 of MiFID II.²

Markets in Financial Instruments Directive II

- 1.11** Firms should reference a number of pieces of legislation when developing algorithmic trading practices and procedures. Most notably, MiFID II³, which was implemented on 3 January 2018, introduces a number of requirements for firms engaged in algorithmic trading.
- 1.12** In the UK, the algorithmic trading requirements were introduced through Chapter 7A of the Market Conduct Sourcebook (MAR). Further specification is provided in the Commission Delegated Regulation 2017/589 of 19 July 2016 (also known as RTS 6).
- 1.13** MIFID II requirements include:
- Ensuring effective systems and controls, in particular to ensure its trading systems are resilient, to maintain trading thresholds and limits, to prevent incorrect orders contributing to a disorderly market, and, to prevent breaches of the Market Abuse Regulation⁴ or the rules of a trading venue.

² See art 1(5) of MiFID 2 and regulations 30 and 31 of The Financial Services and Markets Act 2000 (Markets in Financial Instruments) Regulations 2017.

³ Directive 2014/65/eu of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending the Insurance Mediation Directive and AIFMD.

⁴ Regulation (EU) No 596/2014 of the European Parliament and of the Council of 16 April 2014 on market abuse (market abuse regulation) and repealing Directive 2003/6/EC of the European Parliament and of the Council and Commission Directives 2003/124/EC, 2003/125/EC and 2004/72/EC.

- The firm must have effective business continuity arrangements to deal with any trading systems' failure and ensure its systems are fully tested and properly monitored. In particular:
 - there must be a clear and formalised governance framework
 - compliance staff must have at least a general understanding of algorithmic trading and contact with individuals who have access to functionality to cancel all unexecuted orders
 - where there is IT outsourcing, the firm remains fully responsible for its regulatory obligations;
 - the firm must have sufficient appropriately trained technical, legal, monitoring, risk and compliance staff
 - the firm must employ an automated surveillance system to detect market manipulation
 - the firm must have pre-trade controls in respect of price, value, trade volumes, message volumes, trader permissions, and, market and credit risk limits
 - there must be real time monitoring of all activity under its trading code for signs of disorderly trading, and, effective post-trade controls
- Systems must be fully tested (including conformance testing with the venue) before deployment and deployed or substantially updated only on the authority of a senior management designate and only where there are predefined trading limits
- The firm must maintain defined pre-trade controls on order entry, monitor all trading activity under its trading code on a real-time basis, and continuously operate post-trade controls , including of its market and credit risk
- The firm must have emergency 'kill functionality', allowing it to cancel all unexecuted orders with immediate effect
- If the firm is a member or participant of an EU trading venue on which it engages in algorithmic trading, it must notify the venue's competent authority and the FCA
- The firm must carry out an annual self-assessment and issue a validation report covering:
 - its algorithmic systems and strategies
 - the governance and control framework
 - its business continuity arrangements
 - stress testing
 - its overall compliance with the other MiFID II requirements



1.14 There are additional requirements for firms who engage in algorithmic trading to pursue a market making strategy (see MAR 7A.3.4) and for firms who engage in high frequency algorithmic trading (particularly in relation to quote and order retention – see MAR 7A.3.8).

1.15 The UK's implementation of the requirements makes clear⁵ that the requirements above apply also to other firms not authorised as investment firms under MIFID II, in the event they carry on algorithmic trading. These are firms of the types specified in Articles 2.1(a) (e) (i) and (j) of MiFID II⁶. This is required by article 1(5) of MiFID II.

Key areas of focus

1.16 We have identified 5 key areas of focus, based on the combined findings of our reviews, and with consideration of MIFID II requirements. They cover:

- Defining algorithmic trading (Pg. 8)

Key objective: To ensure firms establish an appropriate process to identify algorithmic trading, manage 'material changes' and maintain a comprehensive inventory of algorithmic trading across the business.

- Development & testing (Pg. 11)

Key objective: To ensure firms maintain robust, consistent and well understood development and testing processes which identify potential issues across trading algorithms prior to full deployment.

- Risk controls (Pg. 16)

Key objective: To ensure firms develop suitable and robust pre and post trade controls to monitor, identify and reduce potential trading risks across algorithmic trading activity.

- Governance & oversight (Pg. 19)

Key objective: To ensure firms maintain an appropriate governance and oversight framework which demonstrates effective challenge from senior management, risk management and compliance on algorithmic trading activities.

5 Through Part 4 of The Financial Services and Markets Act 2000 (Markets in Financial Instruments) Regulations 2017 (SI 2017/701)

6 2.1 (a) insurance undertakings or undertakings carrying out the reinsurance and retrocession activities referred to in Directive 2009/138/EC when carrying out the activities referred to in that Directive;...
(e) operators with compliance obligations under Directive 2003/87/EC who, when dealing in emission allowances, do not execute client orders and who do not provide any investment services or perform any investment activities other than dealing on own account, provided that those persons do not apply a high-frequency algorithmic trading technique;...
(i) collective investment undertakings and pension funds whether coordinated at Union level or not and the depositaries and managers of such undertakings;...
(j) persons: (i) dealing on own account, including market makers, in commodity derivatives or emission allowances or derivatives thereof, excluding persons who deal on own account when executing client orders; or
(ii) providing investment services, other than dealing on own account, in commodity derivatives or emission allowances or derivatives thereof to the customers or suppliers of their main business; ...[etc.]



- Market conduct (Pg. 23)

Key objective: To ensure firms appropriately consider the potential impact of their algorithmic trading on market integrity, monitor for potential conduct issues and reduce market abuse risks.



2 Defining algorithmic trading

Key objective:

To ensure firms establish an appropriate process to identify algorithmic trading, manage 'material changes' and maintain a comprehensive inventory of algorithmic trading across the business.

- 2.1** To understand how key risks across algorithmic trading are managed, firms must first be able to demonstrate how algorithmic trading is defined and identified.
- 2.2** We have adopted the definition of algorithmic trading in Article 4(1) 39 of MIFID II, that is:

Trading in financial instruments which meets the following conditions:

(a) where a computer algorithm automatically determines individual parameters of orders such as whether to initiate the order, the timing, price or quantity of the order or how to manage the order after its submission

(b) there is limited or no human intervention

does not include any system that is only used for the purpose of routing orders to one or more trading venues or the processing of orders involving no determination of any trading parameters or for the confirmation of orders or the post-trade processing of executed transactions.

- 2.3** We can require firms to provide, within 14 days from receipt of a request, a description of the nature of its algorithmic trading strategies and firms are required to keep records for this.⁷
- 2.4** Algorithmic trading requirements encompass trading systems, algorithmic trading strategies and trading algorithms. Firms need to consider the content of this report across all of these aspects.

Identification of algorithmic trading

- 2.5** In order to comply with the requirements in MIFID II, firms need to develop processes to identify algorithmic trading across the business. Firms also need to establish processes to capture all new algorithms, trading systems and strategies on an ongoing basis, as well as any material or substantial changes to existing ones.

⁷ MAR 7A.3.7 and 7A.3.8.

- 2.6** We acknowledge this can present significant challenges, particularly for larger firms. However, we see it as a fundamental step in establishing robust governance and controls for algorithmic trading. It is important for firms to have the correct tools in place, supported by appropriate staff training, to identify all such activity.
- 2.7** The exact definition and scope of algorithmic trading can vary depending on the type of firm and strategies deployed. However, in general, we found that algorithmic trading strategies can be defined as either investment decision or execution algorithms. It is important to note that some firms combine investment decision and execution algorithms into a single algorithmic trading strategy.
- 2.8** Investment decision algorithms typically make automated trading decisions by determining which financial instruments should be purchased or sold. Execution algorithms optimise order execution processes with the automated submission of orders and quotes to one or more trading venues. Investment decision algorithms that do not initiate orders or the timing, price or quantity of an order may not fall under the definition in MIFID II but examples of good practice we observed ensured these were subject to the same systems and controls as for algorithmic trading.
- 2.9** As mentioned above, some algorithmic trading strategies consist of a number of different underlying algorithms, and firms need to consider all of these components across their algorithmic trading activity.

Good practice

Firms who conduct extensive reviews (consulting all aspects of the business) to consider at length how trading algorithms are used within the firm. These firms are able to develop appropriate definitions and ensure relevant activities across the whole business are captured.

Poor practice

Firms who apply a high level definition (without consideration of the types of activity undertaken across the business) and who conduct a basic identification exercise. This will capture trading algorithms in well-established areas of the business but often does not consider other areas where algorithms are used less frequently.

Substantial or material changes

- 2.10** Firms need an appropriate process to define and identify substantial or material changes to their algorithms (and the related trading systems or strategies) as specified in Article 5 and 11 of RTS 6. Changes are then subject to further testing and record-keeping requirements.
- 2.11** Firms had difficulty in showing what amounts to a substantial or material change to their algorithms, strategies or systems. The definition may vary, depending on the type of firm or algorithm employed but it is important that all firms have a consistent and well understood methodology to decide this.



Good practice

Firms who maintain well defined policies which establish detailed criteria for deciding what amounts to a substantial or material change and also include suitable training for all relevant staff to ensure this is consistently applied across the business.

Poor practice

Firms who conduct reviews on an ad-hoc basis and do not have a formal process to identify substantial or material changes. In these cases, firms have difficulty demonstrating how they maintain an appropriate and consistent development and testing framework.

Algorithm inventory

2.12

Firms need to establish and maintain a comprehensive inventory of algorithmic trading strategies and systems across the firm. This should include details of objectives, development procedures, testing, owners, users and risk mitigants. The inventory can provide valuable management information (MI) for senior management and ensure the firm's algorithmic trading activity, which can be very complex in nature, is suitably identified and managed.

Good practice

Firms who retain a detailed inventory across the business, with documentation which clearly sets out:

- the different types of algorithms, trading strategies and systems, including relevant operational objectives, parameters, and behavioural characteristics
- a breakdown of the various components/algorithms contained within the strategy or system
- the owner and those approved to operate the strategy or system
- policies on the completion of development, validation and testing procedures, along with appropriate sign off from senior management and other relevant control functions
- technical details of the coding protocols used during the development process and the overall system architecture
- relevant market information, including regulatory and venue requirements
- a comprehensive list of all the risk controls (including kill functionality) which apply to each strategy or system, including overall risk limits and those set within the individual components/algorithms

Poor practice

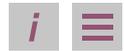
Firms who don't have clearly defined inventories in place and are only able to provide generic high-level descriptions for their algorithms, strategies and systems.

3 Development and testing

Key objective:

To ensure firms maintain robust, consistent and well understood development and testing processes which identify potential issues across trading algorithms prior to full deployment.

- 3.1** It is important to have a robust and well understood development framework in place, regardless of whether firms are developing new algorithms, systems or strategies or making changes to existing ones. This development process should be consistent with internal policies and deliver a product that not only meets the goals of the users, but is consistent with the risk appetite and behavioural expectations of the firm.
- 3.2** Provisions for the testing and deployment of trading algorithms, systems and strategies are set out in detail within Articles 5-8 of RTS 6. These require, in particular:
- 3.3** a clear methodology for testing and development, to ensure the algorithmic trading system or strategy:
- behaves only as intended
 - complies with the firm's obligations
 - complies with the rules of the relevant trading venue(s)
 - does not contribute to disorderly trading
 - works effectively in stressed market conditions
 - has effective 'kill functionality'
- a senior management delegate to authorise deployment
 - change management procedures
 - testing of conformance with trading venue systems, including material updates
 - use of testing environments separated from the production environment
 - controlled deployment of a trading algorithm, with predefined limits on the number of financial instruments traded and the trading volumes, strategy positions and the number of venues to which orders are sent



Development and testing framework

- 3.4** All firms engaged in algorithmic trading need to maintain an appropriate development and testing framework, which is consistently applied across all relevant aspects of the business. This is particularly important where firms are using innovative technology such as machine learning techniques, either within their algorithmic trading strategies or as part of the development and testing process.
- 3.5** In order to demonstrate this framework is fully embedded and constantly applied, it is important that all staff involved in the development and testing processes understand not only their own responsibilities, but are also well versed in all relevant aspects of the framework and understand the various roles and requirements within this.

Good practice

Firms who maintain a robust development and testing process supported by:

- appointing a project lead with responsibility to oversee the entire development and testing process and ensure consistency
- breaking down the development process into separate phases in which firms are able to establish independent checks and balances at each stage, particularly where subjectivity is used
- ensuring thorough due-diligence is completed at the start (and at key milestones) of the process, to ensure that any conduct risks are effectively assessed and suitable risk control thresholds are established
- encouraging a culture of open communication between different business units, while having a clear separation of roles and independent reviews. Often this was achieved by having a separate team that verifies and checks the output and quality of code
- ensuring all these tests were recorded in the development plan and included in the information provided to the appropriate decision makers for formal approval and sign-off

Poor practice

Firms who don't consistently apply their development and testing process across all aspects of their business. For example, different trading desks and/or business lines use different methodologies.

Approval and sign off

- 3.6** Before a new algorithm, strategy or system is deployed into the production environment (including any material or substantial changes), firms need to complete a comprehensive review and approval process. All stakeholders should sign off that their assigned tasks are completed, verified and documented.

3.7 The approval and sign off process should ensure there:

- is appropriate challenge by objective, competent and informed parties who can identify the types of algorithmic trading strategies, expected behavioural characteristics and assumptions and suggest appropriate change
- are independent incentives which separates the process of validation from the development process, encourages impartial validation and empowers model validators with the appropriate level of influence
- is a corporate culture which encourages collaboration but is also subject to appropriate challenge
- is evidence that the firm's risk appetite is being consistently adhered to its authorisation for deployment, including substantial updates, of an algorithm, trading system or strategy by appropriate decision makers

Good practice

Firms who have checkpoints throughout the development and testing process (for example, after initial due-diligence was completed, at several stages during testing and prior to full deployment) with a full review at the end of each stage. This includes:

- an independent committee to check all the relevant documentation, ensure all testing procedures have been completed satisfactorily and verify that the algorithm is consistent with the original specifications
- active representatives on the committee from Risk, Compliance, Legal, Business, Technology, Finance and Operations
- a dedicated software development team to provide independent verification before moving to the next stage

Poor practice

Firms who use a simplistic final sign off process, which involves a small number of individuals and no independent representation. As such, the process does not give the decision maker sufficient documented evidence and independent verification to confirm that the required checks have been completed.

Deployment procedure

3.8 Once the development and testing process is completed, documented and verified, firms need to establish a suitable procedure to ensure any new or updated algorithms are deployed into live environments in an appropriate and controlled manner. Well defined and understood deployment procedures are critical to reduce the risks of errors in algorithmic trading, such as those faced by Knight Capital Group in 2012.

**Good practice**

Firms with detailed staging and scheduling plans. These plans establish how controlled deployment into the production environment will be carried out. Phased deployment allows the firms to efficiently manage risks by keeping as many parts of the algorithmic trading strategy or system constant from day-to-day.

Good practice

Firms with established procedures to identify issues during the deployment process. In these cases, firms are able to determine and record whether any material or significant changes are required and, if so, ensure the proposal is rolled back to the development and testing process.

Poor practice

Firms who are unable to demonstrate co-ordination between the relevant front line and support/control functions to review and confirm preparedness ahead of the deployment process.

Poor practice

Firms who are unable to provide effective MI to senior management on areas such as conformance testing, operational arrangements, pre-trade risk parameters, training and surveillance procedures prior to deployment.

Documentation and audit trail

3.9

Firms need to ensure they have adequate documentation and a comprehensive audit trail throughout the development and testing process. This information is fundamental to ensuring sound governance and oversight frameworks are in place. However, on many occasions, we saw processes and decisions which were poorly documented. In these cases, firms had difficulty in demonstrating the robustness of their approval and sign-off procedures.

Good practice

Firms who maintain comprehensive developmental evidence throughout the entire development, testing and deployment lifecycle which cover:

- theoretical construction
- behavioural characteristics and key assumptions
- detail on the types and use of input data
- numerical analysis routines, and specified mathematical calculations
- code writing language and protocols (to actualise the model)

Poor practice

Firms who retain limited documentation in relation to the development, testing and deployment process. As such, a number of key decisions are taken without an adequate audit trail and without sufficient explanation of the underlying rationale for these decisions.



4 Risk controls

Key objective:

To ensure firms develop suitable and robust pre and post trade controls to monitor, identify and reduce potential trading risks across algorithmic trading activity.

- 4.1** All firms need to maintain appropriate risk controls to protect their own interests, those of their clients (where applicable) and the wider integrity of the markets in which they operate.
- 4.2** A comprehensive suite of risk controls, set at appropriate levels and combined with effective monitoring, can significantly reduce the risks associated with algorithmic trading.
- 4.3** The MiFID II requirements for pre trade risk controls are set out in detail within Article 15 of RTS 6. This requires firms to maintain:
- market and credit risk limits
 - maximum order volumes and maximum order values
 - maximum message limits
 - repeated automated execution throttles (to pause application of the strategy until restarted by human intervention)
 - price collars
- 4.4** Firms must also maintain post-trade controls to monitor their trading activity and take appropriate action where controls are triggered. The exact requirements are set out in Article 17 of RTS 6. These require firms to:
- conduct a continuous assessment and monitoring of market and credit risk exposures (these must be capable of being calculated real-time)
 - adopt controls over maximum longs and shorts (and overall strategy positions) for derivatives, specific to the instrument
 - maintain complete, accurate and consistent trade and account information
 - maintain electronic trading logs, reconciled with relevant third parties such as trading venues, brokers, DEA providers
 - ensure traders and the risk function undertakes post-trade monitoring
- 4.5** All firms must also maintain kill functionality to disable trading activity to protect the integrity of the market. Compliance staff must also maintain contact with the individual at the firm who is able to cancel immediately any or all of the firm's unexecuted orders (the "kill functionality").

Pre-trade controls

- 4.6** All of the firms we reviewed maintained controls across the key areas in Article 15 of RTS 6. However, we saw significant differences in the level of sophistication within these controls. Examples included:

Pre-trade control	Basic controls	Enhanced controls
Market and credit limits	Overall credit/market risk limits set across all trading activity, applicable throughout the trading day	Market/credit risk limits split across the firms trading activity within a set time period (e.g. 15 min window) or exposures per symbol
Order volume/value	Volume and value limits for orders set per client/trading strategy which applied to all trading activity	Volume and value limits, set dynamically in relation to the average daily volume (ADV) and touch size for the relevant symbol
Message limits	A basic limit on the number of orders or messages across all trading activity during the trading day	Message limits broken down into smaller time periods (e.g. 15 min) and/or per symbol
Repeated automation throttles	A check on repeated orders across all activity during the trading day	A check on repeated orders and the number of rejected orders across all activity during the trading day
Price collars	Price controls which apply a basic check on limit orders vs the current market price	Price collars which differentiated between passive/aggressive orders and/or calculate the anticipated market impact of the order

- 4.7** To develop controls which are proportionate to the size and complexity of their business, firms should consider the examples of enhanced controls above as good practice.

Control setting & amendment process

- 4.8** For risk controls to operate effectively, they need to be tailored to the type of trading activity undertaken and have parameters set at the appropriate levels.

Good practice

Firms who maintain detailed controls at multiple levels. For example, by client and/or trading strategy depending on the type of business undertaken, as well as on a firm wide basis. These control settings are reviewed on a regular basis to ensure they remain appropriate.



Poor practice

Firms who apply controls broadly across multiple clients or algorithmic trading strategies. As such, controls are set without consideration of expected activity levels and therefore apply levels which are often significantly higher than normal trading activity. In these cases, it is difficult to demonstrate the effectiveness of these controls.

- 4.9** Objectives and risk tolerance are key considerations in setting appropriate risk controls. In a volatile market, for example, risk controls may need to be amended. This process should not become so burdensome that control levels are set at inappropriately high levels which are difficult to change. Firms need to ensure the risk function works closely with front-line staff to set appropriate controls.

Good practice

Firms who maintain risk controls at multiple levels, with oversight provided by an independent risk function. Certain pre-authorized front-line staff are then allowed to adjust specific controls with levels pre-agreed with the risk function.

Post-Trade Controls & Monitoring

- 4.10** Effective monitoring is critical to identify issues and take action at an early stage. It is also important this process is clearly understood by all participants in the execution chain and suitable escalation and recording procedures are in place.

Good practice

Firms who conduct extensive control monitoring with dedicated teams in place. In some cases, these teams use visual and audible alerts, including automated control thresholds where alerts are generated at pre-defined levels such as 50 and 80 percent of a control limit.

- 4.11** Regular reviews of controls, including parameter settings, amendments to controls and any limit breaches are important in establishing good governance procedures.

Good practice

Firms who have committees to conduct regular reviews of control levels with representatives from areas such as trading, client coverage, compliance, risk and, where appropriate, credit teams. These committees were presented with MI which include details as to how and why any amendments to controls have been made during the previous period, as well as information on any control breaches.

Poor practice

Firms who do not formally log incidents/breaches and fail to provide MI reports to appropriate forums. This prevents valuable MI being presented for senior management to identify potential emerging issues and risks.

5 Governance and oversight

Key objective:

To ensure firms maintain an appropriate governance and oversight framework which demonstrates effective challenge from senior management, risk management and compliance on algorithmic trading activities.

- 5.1** A strong governance framework with suitable policies and procedures, integrated with effective risk management, is fundamental in reducing the risks associated with algorithmic trading strategies.
- 5.2** MiFID II sets out general organisational requirements in Article 1 of RTS 6. Firms are required, as part of their overall governance and decision making framework, to establish and monitor trading systems and algorithms through a clear and formalised governance arrangement. This sets out:
- clear lines of accountability, including procedures to approve the development, deployment and subsequent updates of trading algorithms and to solve problems identified when monitoring trading algorithms
 - effective procedures for the communication of information within the investment firm, such that relevant issues can be escalated and instructions can be sought and implemented in an efficient and timely manner
 - a separation of tasks and responsibilities of trading desks on the one hand and supporting functions, including risk control and compliance functions on the other, to ensure that unauthorised trading activity cannot be concealed
- 5.3** Article 9 of RTS 6 sets out the requirements firms to conduct an annual self-assessment and validation of their algorithmic trading activity. This should include:
- algorithmic trading systems, trading algorithms and algorithmic trading strategies
 - governance, accountability and approval framework
 - business continuity arrangements
 - overall compliance with Article 17 of Directive 2014/65/EU, having regard to the nature, scale and complexity of the business
- 5.4** The resulting validation report should be reviewed and approved by the firm's senior management.



Governance Framework

- 5.5** A sound governance framework supports:
- a robust development, testing and deployment process
 - independent validation procedures
 - suitable risk management controls
 - appropriate monitoring and surveillance
- 5.6** It also ensures that key control functions, including senior management, compliance and risk management, are an integral part of the firm's algorithmic trading activity. However, to operate effectively, key control functions must have the requisite skills, knowledge, and expertise to provide suitable challenge to frontline functions.
- 5.7** Under the Senior Managers Regime, relevant staff must comply with the relevant conduct rules and 'Algorithmic Trading' is a certification function. This will cover staff with responsibility for approving the deployment, material amendment, and monitoring of trading algorithms.

Senior management

- 5.8** Senior management should be able to articulate the standards set for development, testing and on-going monitoring of their algorithmic trading strategies. They should also ensure these standards are appropriate and in accordance with the firm's overall risk appetite. Moreover, senior management should be able to evidence an effective governance and risk framework for algorithmic trading by receiving suitable MI and having clearly understood escalation procedures.
- 5.9** Across the firms we reviewed, senior management were often well informed and involved throughout the development and implementation processes. However, this was not always the case. In particular, we found examples within firms who did not specialise in algorithmic trading where senior management did not have sufficient knowledge of the firms' algorithmic trading activities and the governance framework around this.

Good practice

Firms where algorithmic trading is fully understood by senior management, who play a key role in providing challenge across the business. For example, where senior management are involved throughout the development and testing process and actively seek to understand the potential market conduct implications.

Poor practice

Firms where senior managers are not able to demonstrate the required knowledge to be able to provide effective challenge to front line algorithmic trading operations.

Risk management

- 5.10** Effective risk management is crucial to reduce the risks associated with algorithmic trading and should ensure this activity is consistent with the firms' risk appetite and governance framework. The firm's risk function plays a key role in identifying, assessing and reporting risks associated with algorithmic trading.
- 5.11** The risk function should be an integral part of each stage of the development and implementation process for algorithmic trading. However, the level of effective challenge varied significantly across the firms we reviewed.

Good practice

Risk functions who are well versed in the expected behaviours of the algorithmic trading strategies employed and understand the technology risks involved in the development and testing process. As such, they are able to provide input in establishing suitable risk controls and determine if this fits within the risk appetite of the firm.

Poor practice

Risk functions who are not fully involved in the development and testing process and cannot demonstrate the requisite knowledge to provide suitable challenge. This is often the case for smaller firms where the risk function is combined with other roles, making it difficult to demonstrate the independence of their risk function.

The role of compliance

- 5.12** The compliance team also has a vital role to play in ensuring algorithmic trading risks are identified and reduced. The most effective compliance functions we saw were involved at every key milestone of the algorithm development process, acting as an independent check, with a particular focus on conduct risks (such as market abuse) and requirements related to market and country specific regulations. We were also encouraged to see that some compliance functions also look to use their own technology solutions to provide effective challenge to frontline functions.
- 5.13** However, the quality of compliance input and challenge varied considerably across firms in our reviews. In the majority of smaller firms who focus on algorithmic trading, the compliance function was involved throughout the entire development, testing and deployment processes. However, compliance staff did not necessarily have the required knowledge and skills to provide suitable challenge, by asking the appropriate questions and assessing outcomes.

In larger firms with more complex businesses, compliance staff were not always fully involved with the development, testing and deployment process. Those with dedicated functions focused on electronic trading were generally better able to demonstrate adequate focus and attention on matters relating to algorithmic trading.

**Good practice**

Compliance functions who conduct a comprehensive gap analysis of their ability to supervise algorithmic trading activity and, if appropriate, establish new roles/responsibilities to focus on this activity.

Poor practice

Compliance functions who are not closely involved with front line functions on algorithmic trading activities and typically only become involved in the process as part of the final sign-off process and/or independent compliance reviews.

Poor practice

Compliance functions who are unable to demonstrate that compliance staff have sufficient technical knowledge to oversee and monitor algorithmic trading activity effectively.

6 Market conduct

Key objective:

To ensure firms appropriately consider the potential impact of their algorithmic trading on market integrity, monitor for potential conduct issues and reduce market abuse risks.

- 6.1** Algorithmic trading plays an important role across financial markets and it is vital that firms consider the market conduct implications of their trading activity and the impact it has on overall market integrity.
- 6.2** Specific monitoring and surveillance requirements are set out in Article 16 of the Market Abuse Regulation provisions, as supplemented by Commission Delegated Regulation 2016/957⁸ and further provisions relating to firms undertaking algorithmic trading are provided in Article 13 of RTS 6.
- 6.3** The general requirements set out in the Market Abuse Regulation, which apply to all investment firms, are that firms must establish and maintain effective arrangements, systems and procedures to detect and report suspicious orders and transactions.
- 6.4** Specifically, The Market Abuse Regulation requires such firms to establish systems and procedures appropriate and proportionate to the size and scale and nature of their business to monitor for market abuse and attempted market abuse, which:
- cover the full range of trading activities
 - allow for the analysis of each and every transaction executed and order placed, modified, cancelled or rejected irrespective of who is conducting the transaction, the capacity in which the firm is acting or where the transaction is taking place
 - produce alerts for further examination, including an appropriate level of human analysis
 - ensure the transmission of STOR to competent authorities without delay once reasonable suspicion is formed
 - maintain records of the analysis of alerts that could have constituted markets abuse for 5 years along with the reasons for submission or non-submission of a STOR
 - be regularly assessed, at least annually and updated where necessary

8 COMMISSION DELEGATED REGULATION (EU) 2016/957 of 9 March 2016 supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council with regard to regulatory technical standards for the appropriate arrangements, systems and procedures as well as notification templates to be used for preventing, detecting and reporting abusive practices or suspicious orders or transactions.



- 6.5** For firms undertaking algorithmic trading, the requirements also include (in Article 13 of RTS 6):
- The establishment and maintenance of an automated surveillance system monitoring orders and transactions and generating real-time alerts and reports. This shall be adaptable to regulatory obligations and changes in trading strategies
 - Cross-checking any indications of suspicious trading activity with other trading activity undertaken by the firm
 - The review of the automated systems should specifically consider the calibration of the alerts to minimise false positive and negatives
 - Ensuring complete, granular and accurate recordkeeping with appropriate reconciliations to allow for reading, replaying and analysing order and transaction data on an ex-post basis
 - Staff responsible for monitoring the investment firm's trading activities shall report to the compliance function any trading activity that may not be compliant with the investment firm's policies and procedures or with its regulatory obligations. The compliance function shall assess that information and take appropriate action
- 6.6** In addition to post-trade monitoring, firms need to be able to assess the potential impact new algorithmic trading strategies or systems may have on market integrity within the development and testing process. MiFID II sets certain requirements for firms to develop and test algorithms in Article 5 of RTS 6 of MIFID II to ensure they:
- do not behave in an unintended manner
 - comply with the investment firm's obligations under this Regulation
 - comply with the rules and systems of the trading venues accessed by the investment firm
 - do not contribute to disorderly trading conditions, continue to work effectively in stressed market conditions and, where necessary under those conditions, allow for the switching off of the algorithmic trading system or trading algorithm

Monitoring & surveillance

- 6.7** The ability to identify and reduce market abuse risks is clearly important for all firms that undertake algorithmic strategy development and SYSC 6.1.1R of the FCA handbook requires firms to have adequate policies and procedures to counter the risk that they might be used to further financial crime.
- 6.8** The sophistication of post-trade surveillance tools will vary according to a firm's size but firms need to ensure they are proportionate. During our reviews, however, we identified a number of examples which were not fit for purpose and, in particular, had not considered how their surveillance could be tailored to algorithmic trading activity.

- 6.9** In Market Watch 48⁹ we gave some observations on the calibration of surveillance systems. We noted that the most effective surveillance programs involved significant and careful calibration on both the alert parameters and alert logic based on the surveillance officers' experience of that firm's trading patterns and clients.

Good practice

Firms who consider how they can tailor their monitoring and surveillance systems to specific risks within their algorithmic trading activity and also ensure suitable market abuse training is conducted for all relevant members of staff.

Poor practice

Firms who maintain basic market abuse alerts such as insider dealing or layering and spoofing but do not consider other types of market manipulation which can be associated with algorithmic trading. For example, momentum ignition, quote stuffing and reference price gaming.

Poor practice

Firms who failed to identify where different strategies (on a combined basis) might create a false or misleading impression on the markets in which they operate.

Algorithm design

- 6.10** To comply with the requirements in Article 17(1) of MiFID II and in Article 5 of RTS 6, market conduct considerations need to be a vital part of the algorithm development process. Firms need to consider how they can integrate this into their existing processes and provide evidence to this effect as part of their approval procedures.

Good practice

Firms who include specific provisions within the approval process to consider the potential impact of algorithmic trading strategies and whether the proposal is deemed appropriate.

In these examples, considerations are not limited to whether a strategy strictly meets the definition of market abuse. They also consider whether the strategy would have a negative impact on the integrity of the market and/or if it would likely further contribute in scenarios where there is wider market disruption.

9 www.fca.org.uk/publication/newsletters/market-watch-48.pdf

**Poor practice**

Development procedures which predominantly focus on operational effectiveness and did not consider market conduct considerations. In these examples conduct risks are usually only considered on a post-trade basis, rather than as an integral part of the development process.

- 6.11** As part of our reviews, we also considered developments in machine learning and artificial intelligence. In these cases, the risks associated with market conducted may be heightened and it is particularly important for firms to consider the potential implications.
- 6.12** In considering the potential impact on market integrity, firms should also consider how they can examine market conduct considerations within their testing process.

Good practice

Firms who develop (or use third party) dynamic testing environments, that not only consider how their algorithmic trading strategies perform in a period of market disruption, but also assess whether their strategy further contributes (in combination with other trading activity) to market disruption.

Poor practice

Firms who conduct basic testing of their algorithmic trading strategies which only assess operational efficiency and focus on considerations such as their performance against certain benchmarks or the profit and loss of the strategy. In these cases, firms are unable to demonstrate the potential impact of their algorithmic trading strategies on market integrity.

- 6.13** As noted in section 5, the involvement of compliance in this process was also a key factor in the examples of good practice we observed. The majority of front office staff were primarily from quantitative backgrounds and it was key for individuals with suitable compliance knowledge to be involved to provide this input.

Annex 1

Abbreviations used in this paper

AIFMD	Alternative Investment Fund Managers Directive
DEA	Direct Electronic Access
EU	European Union
FCA	Financial Conduct Authority
MAR	Market Conduct Sourcebook
MI	Management Information
MIFID	Markets in Financial Instruments Directive
RTS	Regulatory Technical Standard
STOR	Suspicious Transaction and Order Report
SYSC	Senior Management Arrangements, Systems and Controls

