How Do Proprietary Trading Firms Control the Risks of High Speed Trading?

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For the past several years, various regulatory agencies and industry groups have focused attention on pre and post trade risk controls[1] for high frequency trading, particularly, for firms that access the markets directly. Trading firms that access the markets directly do not use their broker-dealer/futures commission merchants' (FCM) trading systems. Rather, they send orders directly to the exchange matching engine via their own proprietary trading platform or via a vendor-provided trading platform the broker-dealer/FCM approves. Such arrangements are referred to as sponsored access in the equities and options markets and as direct market access in futures markets.[2] Trading firms that access markets directly may have pre trade risk controls on their trading platform and/or may rely on pre trade risk controls at the exchange level.

Broadly speaking, regulatory and industry attention on high frequency trading has produced recommendations and best practices related to how pre and post trade risk controls at one or more levels of the trade life cycle – from trade execution to trade settlement - may be improved. Staff from the Federal Reserve Bank of Chicago's Financial Markets Group (FMG) used these recommendations[3] as a baseline to elicit information on the controls that are currently in place at each level of the trade life cycle to manage the risks of high speed trading. We define high speed trading as high frequency, automated, and algorithmic trading, since firms engaging in these styles of trading can potentially send thousands of orders to an exchange within a second(s). It is also important to note that it is difficult to quantify the precise number of orders that would designate a firm as being engaged in high speed trading. As an obvious example, an algorithmic trader could execute 100 trades over the course of a day, which would not be considered high speed trading.

Over thirty interviews were conducted with primarily U.S. domiciled technology vendors,[4] proprietary trading firms, broker dealers and futures commission merchants, exchanges,[5] and clearing houses. Non-U.S. entities interviewed include one exchange, one clearing house and one foreign broker-dealer. This article summarizes what was learned during conversations with nine proprietary trading firms located in three cities. The interviews focused on risk controls and other topics of interest or concern to these firms. Other articles will summarize interviews with brokers and futures commission merchants and clearing houses.

Firm Profiles
Proprietary trading firms typically trade using their own capital and do not have customers. Each firm interviewed trades on public exchanges, but some also trade on alternative trading systems such as ECNs and dark pools. Three of the nine firms also have a presence on the exchange trading floor(s). Some firms self clear most of their trades and use other clearing members[6] to clear particular products. Other firms clear all their trades via one or more clearing member. The majority of firms trade multiple asset classes like equities, futures, options, foreign exchange, fixed income, and over the counter (OTC) in one or more of the following regions: North America, South America, Europe, Asia, and/or Australia. Two firms only trade U.S. equities. Some firms have multiple offices within the U.S. and/or globally.

Trading Platforms

Each firm interviewed accesses the markets directly with trading platforms and software that are built in-house (proprietary) and executes trades via black and grey boxes. Black box trading strategies are 100 percent automated, pre-programmed, and traders cannot interact or modify the algorithms. Grey box trading strategies are also 100 percent automated, but traders are able to modify the configurations for algorithms at their own discretion. In addition to building proprietary trading platforms and software, some firms also purchase trading platforms and software as a backup solution for contingency scenarios and as a way to manually exit positions via point and click trading.

Strategy Development

Ideas for new trading strategies are generated by traders(s)/trading groups who work with developers and IT staff to translate these ideas into source code.[7] Source code is first compiled and then transformed into executable programs with graphical user interfaces (GUI) that traders can interact with.

Depending on the trading firm, the life cycle for the development, testing, and deployment of a new trading strategy ranges from minutes to months to one year. At a few firms, new trading strategies are quickly implemented by tweaking code from existing strategies and placing the new code into production in a matter of minutes. Most firms have formalized development processes that define the involvement of the trading and risk management staff. A typical life cycle for a new trading strategy includes the following step by step process:

Step 1: Develop a new trading strategy

Step 2: Back-test the strategy in a simulated trading environment that is either provided by a trading venue or built in house

Step 3: Analyze the results of the back-testing process
- If the results are not economically viable, modify the strategy and return to Step 2 or terminate the project
- If the results are economically viable, set a few risk limits and trade in the production environment with small quantities

Step 4: Analyze the results of the small quantity trades
- If the results are not economically viable, modify the strategy and return to Step 2
- If the results are economically viable, go to Step 5

Step 5: Set risk limits in the strategy and/or hard code limits in the source code

Step 6: Finalize the trading strategy and trade in the production environment with larger quantities

Some firms take additional precautions when developing new trading strategies. One has a compliance team that requires traders to demonstrate their knowledge of the markets and the risks associated with the new trading strategy. At another firm, the source code goes through a higher degree of quality assurance before it is placed into production.

Access Controls/Change Management

At each firm interviewed, one or more of the following staff can develop, edit, and access the source code: trader, trading group, programmers, IT group, and/or the quality assurance group. Most firms have traders that also program. Firms typically, have a formal approval process where executable programs can be moved from the test environment to the production environment by one or more of the following staff: trader, trading group, system administrator, CIO, risk management, and/or the release manager.

Once the executable programs are placed in production environment and run, traders/trading group(s) are allowed to modify certain parameters of these programs using the GUI. Firms typically maintain logs that indicate when changes have been made to source code, risk parameters and login credentials and authentications. All firms review these logs when a problem is detected. One firm requires its development managers to periodically review these logs.

Risk Management

Some firms have a hierarchical risk management structure where trading and risk staffs report to a single risk manager. Others have a horizontal reporting structure where every trading desk has a risk manager, but there is no enterprise wide risk manager. Some firms with multiple offices manage risk from a central location.

To help manage and control their exposures, firms either build or buy risk platforms, which check all trades leaving the trading platform before routing them to the trading venue. The majority of firms interviewed have developed their own proprietary risk platforms but a few firms also use vendor provided risk platforms as an independent verification of their proprietary risk platforms.

Firms' risk platforms use various models such as VAR[8], SPAN[9], or some proprietary algorithm to estimate profit and loss (P&L) and their amount of exposure. Some firms do not use VAR or SPAN because they do not hold positions overnight. Models are fed by data sets from various sources. These may include data compiled by the firm, purchased from a vendor, and provided and/or purchased from trading venues. Because these data sets can be corrupt for various reasons, firms may cross check the values using multiple sources to identify outliers and incorrect or stale price feeds. It is interesting to note that not all trading firms' risk platforms are able to calculate enterprise wide portfolio risk.

Depending on the organizational structure of the firm, the business requirements for the risk model(s) supporting the risk platform are defined by the head of risk, risk managers at the trading desk, or by the firm's management. Each firms' risk platform operates in near real time (microseconds to seconds) for electronic trades. However, open outcry trades may be confirmed and manually entered into the risk system at the end of the day.

Trading limits are set on the risk platform at one or more of the following levels: trading desk, account (trader), group, product/symbol, strategy, trading venue, and/or overall firm level. Depending on the organizational structure of the firm, limits may be set by the risk manager for the firm or by risk managers at each trading desk. One firm mentioned that traders that make the most money get higher risk limits. At most firms, the CEO and/or management committee review risk limits daily, but some firms conduct more formal reviews on a monthly or quarterly basis.

When risk limits are breached, the trading platform responds in one or more of the following ways: sending traders audible, text message and/or e-mail alerts, stopping trades entirely, liquidating trades, and/or requiring traders to take opposite positions. At some firms, alerts are also sent to risk management staff.

Pre Trade Risk Controls

Well designed trading platforms include pre trade risk limits that if enabled may do one or more of the following: alert a firm when an order(s) is approaching a pre set limit, stop order entry entirely once a limit is breached, and/or require traders to take opposite positions when a limit is hit. Sometimes, algorithms deployed by high speed trading firms that access the markets directly may go awry due to corrupt data, programming errors, hardware failures, network issues, or any number of other unforeseen circumstances. Depending on the pre-trade risk checks[10] performed by the trading platform, out-of-control algorithms and/or erroneous orders may be detected and stopped before they would otherwise be transmitted to the exchange matching engine(s).

If they are not, exchanges may become the last line of defense and may stop orders by:

- Setting pre trade limits at the exchange level for all market participants and/or
- Providing functionality to clearing members and/or market makers that allows them to determine limits for their orders (including proprietary and customer orders) as well as to set limits on orders of clients that access the markets directly. However, the use of this functionality by clearing members may be optional.

Proprietary trading firms can set limits on their trading platforms below those established by their clearing member. Staff that set these limits may include one or more of the following: CEO, COO, trading manager, and/or risk team.

Each proprietary trading firm interviewed has pre trade risk controls on the trading platform that are applied at one or more of the following levels: strategy, account and/or gateway. However, no firm evenly applies each risk check to every trading strategy. Most firms apply fewer pre trade risk checks to some strategies to reduce latency (delays). Following are the pre trade limits used by the firms interviewed:

- Each proprietary trading firm has limits that set a maximum size order that can be placed in the market and intraday position limits which set maximum positions a firm can take at any time within the day.
    - At one firm, position limits are also dependent on the percentage of average daily volume in an asset class and on portfolio risk.
- All but one firm sets credit limits for every trading account, which restricts the dollar value each trader/account can trade.
    - For firms that do set credit limits for every account, the way they are established varies by firm and are based on one or more of the following parameters: product, open positions, dollar value, and/or working orders.
        - One firm only sets credit limits for new traders. These limits are dynamic throughout the day and are dependent on the P&L of each new trader's account(s).
- About half the firms interviewed have limits that check orders against a specific price range before sending them to the exchange. Any orders entered outside this range are stopped. These limits are symmetrical and work when the market is going down as well as up.
- Every firm but one halts trading based on some type of P&L limit like P&L per order and/or P&L per trading strategy.
- Most firms have limits on the number of orders that can be sent to a trading venue during a specified period of time (per second, millisecond, minute). These limits may be set for two purposes:
    - To comply with trading venues' bandwidth policies and/or
    - To identify if one of their own algorithms has gone awry and to automate an appropriate response.
- One firm uses a volume detecting mechanism that identifies rapid numbers of order submissions and cancellations in the market to avoid trading against such orders.[11]

Post Trade Risk Controls

Trading venues typically provide post trade information (e.g. drop copies) to clearing members and to high speed trading firms that access the markets directly. However, the frequency with which these reports are generated and their content varies. Some trading venues provide information that includes executed trades and working orders while others only provide information on executed trades. Clearing members may receive this information sorted by

trading account(s) or may receive a consolidated view of the trading activities for all its non-clearing firms. Some trading venues provide post trade information in near real time and some provide it at the end of the day. Clearing houses also generate end of day reports for clearing members, who may pass this information on to their non clearing customers.

Post trade information is received by the trading desk at each firm. For firms with hierarchical reporting structures, risk managers and/or risk teams may also receive this information.   In addition, back and middle offices receive these reports at most firms.

Trading firms may also keep track of their trading activity recorded in their internal databases and reconcile this information with the post trade information received from trading venues. Doing so identifies any outlier information requiring a follow up phone call with the clearing member and/or trading venue to resolve discrepancies.

Some firms have additional checks to identify orders that are placed or filled too rapidly, which may be an indication that something is wrong like an erroneous trade(s) or out-of-control algorithm. When rapid fills are detected, the trading platform may automatically shut down or delay trades for a few seconds. Staff then calls the clearing member and/or trading venue to verify any trades that may have occurred prior to the shut down or to report a clearly erroneous trade.

Error Trades/Out-of-Control Algorithms

When asked how frequently error trades occur each month on average, two firms indicated that error trades that are ultimately busted by an exchange occur very infrequently. One respondent felt that the incidents that occurred during the flash crash were regulatory in nature and arose because the infrastructure in the equities market has devolved and liquidity has gone to un-lit markets (internalizers, dark pools, etc.). When discussing the flash crash, staff at this firm said that traders needed to quantify risk and if they cannot calculate it, they will liquidate positions until they can.

Another respondent said that the flash crash was less about algorithms and market infrastructure than about volatility and financial news. Staff at this firm also characterized stop orders, which were also used on April 14, 2000 and during the 1987 stock market crash, as weapons of mass destruction that should be banned. Staff said they stopped trading during the flash crash because there was information asymmetry.   Once they checked the news and saw there were no new developments, they turned their systems back on.

FMG staff also inquired whether proprietary trading firms had ever experienced an out of control algorithm. Six of the nine firms interviewed had such occurrences or got caught up in other firms' out of control algorithms. Firms described the following incidents:

- After receiving many fills in a short duration of time, one firm realized it was caught in another firm's out of control algorithm. To prevent such an occurrence in the future, the trading firm instituted 5-10 second delays that slow down trading when orders are filled too quickly.
- Another firm had two incidents of out of control algorithm. To address the first incident, the firm added fat finger and credit checks to its pre trade risk controls. The second out of control algorithm was caused by a software bug that was introduced when fixing the error code that caused the first incident.
- A trader at one firm was sending sell orders to a trading venue. However, the algorithm for the trading strategy was not logging order confirmations, which resulted in the trading platform continuing to send more sell orders. The risk platform detected the problem within seconds and shut down trading. In response to the problem, the firm modified the algorithm for this trading strategy to track the number of orders sent per second.
- The pricing algorithm for a strategy at another firm was incorrect. To resolve the problem, the firm fixed the pricing algorithm and formalized its change management process for deployment of new algorithms.
- Errors in one firms' automated system impacted market prices, but the firm declined to provide specific details related to what went wrong.
- One firm had hard coded limits in the algorithm that did not bind and applied additional checks to correct the problem.

Kill Button

Each firm interviewed has a kill button that can be used in exigent circumstances to stop trading activity. Depending on the trading firm, the kill button stops trades at one or more of the following levels: trader/trading desk, strategy, product, firm, and/or individual trading venue. Personnel authorized to use the kill button include one or more of the following: trader, risk management staff, and/or COO. Most kill buttons are manual, but some firms may have automated kill functionalities that are pre-programmed to be activated in certain circumstances. Depending on the trading firm, one or more of the following order types are deleted when kill button is activated: all outstanding orders, GTD orders, and/or GTC orders.[12]

Cancel on Disconnect

Sometimes, trading firms may experience connectivity problems that create uncertainties as to which of their orders are left working in the market and which orders were filled. There are two types of connections that can be lost:

(1) Trading firms monitor whether there is a connection (heartbeat) between their server and their client application.

(2) Exchanges monitor whether the connection between their server and trading firms' servers are lost due to network disruptions, an ungraceful disconnect (termination of a session by the trading firm without an authenticated signoff), or the trading venue's systems going down.

If connectivity between the trading firms' server and their client application is lost (scenario 1) it does not necessarily mean that connectivity between the trading firms' server and the exchange server has also been lost (scenario 2) and vice versa.

During the interviews, trading firms indicated that not all trading venues monitor whether the connectivity in Scenario 2 is lost. Trading venues that do monitor this connection offer cancel on disconnect functionalities, which cancel open orders in the order book. However, the policies regarding which open orders are deleted vary by trading venue. For example, some trading venues delete all working orders including GTCs and GTDs and others only delete all working GTD orders.

Each trading firm interviewed subscribes to cancel on disconnect functionality at the trading venues that offer this service. Nevertheless, some trading firms indicated that there should be a consistent definition of cancel on disconnect across trading venues. For example, if a connection is lost for 30 seconds, then the cancel on disconnect should be activated. Some firms also felt that:

- Trading venues should report which orders are left working in the market and which orders were filled when cancel on disconnect is activated,
- Cancel on disconnect functionality should be offered by all trading venues, and
- All trading firms should be required to subscribe to the service.

Key Challenges in Monitoring Risk

When proprietary trading firms were asked if there was data, system notifications or other information they were not receiving or not receiving on time to build the risk management tools they would like, they raised a variety of suggestions and concerns, including:

- Obtaining information on OTC data is a huge problem.
- Modeling stress test scenarios to replicate events like May 6, 2010 is a challenge.
- Automating risk checks on a sub second basis is needed to maintain an edge in the market.
- Providing drop copies to clearing members and trading firms that access the markets directly needs to be done in as near real time as possible. Some Asian exchanges do not send drop copies to clearing members in a timely manner. As a result, these clearing members can only provide their non-clearing customers with trade confirmations on T+1.

- Prescribing vendor solutions for managing the risks of sponsored access is not a role regulators should take on. Rather, regulators should provide trading firms with the framework for a risk model and let trading firms build their own risk models based on this framework.
- Relying on existing industry best practice documents for risk management is desirable. Regulatory guidance on risk management is not needed because trading firms have a better understanding of risks than regulators.

Best Practices in Risk Management

Proprietary trading firms interviewed provided a number of examples that may serve as best practices for other trading firms. One firm considers operational risk as its greatest threat. Therefore, it maintains a strict separation of duties for risk management as follows:

- Risk management staff is not involved in trading,
- Trading staff has no access to risk controls,
- Heads of each trading desk must review risk limits daily,
- Accounting staff has no access to trading or risk management,
- Treasury staff has no access to accounting,
- The CEO gets reports from each department daily

In addition, the head of trading at each trading desk must sign a contract stipulating that he/she is responsible for trades executed by that trading desk and will be held personally, financially, responsible for any violation of risk limits. Previously, this firm charged the head of trading at one trading desk 100 percent of a loss that occurred due to a violation in risk limits. Conversely, if profits are made from a trade that violates risk limits, the head of the trading desk is not allowed to share in the proceeds.

Some proprietary trading firms said that risk is constantly changing. To manage emerging issues, they hold periodic meetings with cross-functional teams (risk managers, traders, developers, legal staff, etc). Two firms hold weekly meetings and one firm holds risk meetings daily.

In terms of potential best practices for access control, one firm restricts the responsibility for turning on programs to traders/trading groups, which prevents uninformed and unauthorized staff from activating programs. To enhance risk management, this firm also allows various employees including risk staff to turn programs off. Another firm restricts traders from accessing the source code.

One interviewee recommended that as a best practice firms should reconcile their trading activity reports from three sources: trading venues, clearing members and internal databases. Such an exercise would identify any discrepancies between the data. Moreover this firm said that trading venues should introduce risk management checks such as reconciliation scenarios during

performance testing.[13] For example, if a trading firm sends 11 messages to a trading venue, the trading venues should inject discordant data, such as acknowledging 13 messages, as a test challenge. Such scenarios would enable firms to better handle unusual circumstances that may arise in production mode.

Clearing Member Audits

FMG staff surmised that clearing members would periodically audit the risk controls of their proprietary trading firms that access the markets directly since clearing members are financially responsible for all trades they clear. When discussing such audits and their frequency, most proprietary trading firms said risk controls are reviewed and credit limits are set when a new clearing relationship is established. Depending on the clearing member, the frequency of subsequent follow up audits varies. Some clearing members conduct follow-on audits once a year. Others require screenshot images (annually or periodically) that demonstrate how the firm's internal risk parameters functioned when orders were executed. Two proprietary trading firms reported that periodic audits are not common and that their clearing members primarily focused on a credit review at the time they opened an account.

How do proprietary trading firms envision high speed trading evolving over the next few years?

When asked how they saw high speed trading evolving over the next few years, proprietary trading firms expressed a variety of opinions. Some said that regulations could change the future course of high speed trading. Two firms thought high speed trading would decline in the upcoming years. One of these predicted high speed trading firms would decrease by 50 percent over the next five years resulting in 5-6 dominant firms and three exchange groups worldwide. The remaining firms felt high speed trading would increase in the future; although, some thought an arms race to invest in better and newer technologies may make it difficult for startup firms to compete in the marketplace. Other firms thought comparative advantages in the future will be related to ideas and financial engineering rather than speed. A few interviewees were also concerned that high speed trading would become faster and more dangerous and that some high speed trading firms are not adequately controlling their risks.

Has the market reached a saturation point for marginal returns for high speed trading?

Proprietary trading firms also expressed conflicting viewpoints when they were asked if the market has reached a saturation point for marginal returns for high speed trading. Some felt the markets are not saturated and correlations can be made for any number of futures, options, and equities products. One firm pointed out that an oversaturated market and competition among firms to provide liquidity is desirable. Other firms felt barriers to entry are very high and

marginal returns are thin for certain trading strategies and asset classes. However, one firm said the problem was not with oversaturated markets, but with low barriers to entry and with increased risks posed by firms that access the markets directly.

What keeps proprietary trading firms awake at night?

Proprietary trading firms expressed the following opinions when asked what keeps them awake at night:

- Off exchange trading is eroding public markets and transparency is needed.
- Standard formats for drop copies are needed.
- Some trading venues aggregate data in drop copy rather than providing granular information by product, trading account, etc.
- The speed at which drop copy is received from trading venues varies from milliseconds to minutes to hours, depending on the venue.
- Some firms that access the markets directly do not have adequate risk controls.
- Liquidity drying up, even temporarily, is of great concern.
- Transaction taxes may create negative feedback loops that may send liquidity offshore.
- Market and stop orders should be banned.
- Exchanges should be prevented from busting trades.
- There are negative connotations to high frequency trading in the news and people blame it for the flash crash. Politicians are blaming market disturbances on high frequency trading.
- Large consolidators are paying some online retail brokers for their order flow.
- Sometimes, staff at trading venues that have seen the order flow of various trading firms leaves their positions to work for proprietary trading firms. By having familiarity with other firms order flows, former trading venue staff may be able to guess at the trading strategies those firms employ and develop competing trading strategies. This shortens the shelf life of algorithms used by these firms and also makes trading more difficult. Trading venue staff should be required to sign a non compete clause, which restricts them from taking a position with a trading firm for some specified amount of time.

What would proprietary trading firms do if they had the power and ability to change anything for the betterment of the markets?

When asked what they would do if they had the power and ability to change anything for the betterment of the markets, proprietary trading firms had the following viewpoints:

- Normalizing the time in which trading venues deliver drop copies to clearing members and in which clearing members deliver drop copies to sponsored access clients would be beneficial.

- Requiring trading venues to uniformly apply pre-trade risk checks for all market participants would consistently apply latency to and level the playing field for all trading firms.
- Every trading venue should have limits on maximum positions, quantity per order, and credit. In addition, there should be a limit on number of messages that can be sent to the trading venue within a specified period of time. These limits should be established per product/customer. Each trading venue should also have a price banding mechanism in place. Trading should be automatically stopped when these limits are hit.
- All trading, including OTC, should occur on public exchanges.
- Economically equivalent products should be fungible and centrally cleared.
- Trading venues should not allow hidden order types.
- If regulators required high speed traders to become market makers they should provide privileges along with these obligations.
- Various trading venues' pricing models (rebates, volume based pricing, etc.) are creating a deterioration of the markets. If firms trade on rebates, they should give up their direct access and trade through their broker-dealer/FCM.

What are proprietary trading firms' regulatory concerns?

Six of the nine firms interviewed trade equities. All but one of these firms discussed various aspects of Regulation NMS.[14] One firm said there had been thoughtful regulatory changes in the equities markets in recent years and Regulation NMS was a successful innovation. The other four firms expressed a variety of concerns. One of these firms said Regulation NMS was a big mistake and fragmented the equities markets. The second firm said Regulation NMS was too complex and ambitious, took a decade to roll out, and was drafted by regulators who did not appreciate how small changes may impact the markets. Unintended consequences arose because regulators were ill informed about how the quotation system at each trading venue has different latencies. This idea was best expressed by a third firm, which gave the following graphic example,

> "Suppose you go to the market A to buy a banana. The banana guy says the regulation needs you to go to a Mom & Pop shop across town because the bananas are cheaper there. By the time you reach the Mom & Pop shop, the price of bananas has gone up and now you have to go back to market A to buy them. You end up going back and forth and do not end up with the best price ever."

This firm also likened routing trades to the trading venue with the best execution price to playing "whack a mole" and said this contributed to the flash crash.

The fourth firm said fragmentation is a huge drain on resources and getting rid of national best bid and offer (NBBO) would enable the fastest trading venues to dominate. Proprietary trading firms also expressed the following regulatory concerns:

- Regulators that do not understand the business and one-size-fits-all regulations do not work.
- Regulators should make rules simple so that anyone can understand them.
- Regulators are doing a bad job identifying the policies, practices, and procedures that are anticompetitive by allowing a single clearing organization to offer "one pot" cross margining of fixed income securities to the exclusion of all others that clear economically equivalent products. Allowing other clearing organizations to offer "one pot" cross margining on identical terms would level the playing field and foster competition in a manner that would enhance liquidity.
- Regulators should maintain a consistent focus on the markets. They tend to take their eye off the ball.
- Frictions arise between different regulatory agencies' approach to regulation.
- Some firms are acting irresponsibly with regard to their risk management. Regulatory oversight would be helpful.
- Regulators are looking at problems and not solutions.
- There are more trading venues than are needed for a healthy market, which has created market data and technology challenges for trading firms but benefitted retail investors through better prices. Thoughtful policy design that is not politically reactive is helpful.

Conclusion

FMG staff interviewed nine proprietary trading firms that access the markets directly. The majority of these firms trade multiple asset classes globally. Some firms have a hierarchical risk management structure where staff report to a single risk manager. Other firms have a horizontal risk management structure where there is no enterprise wide risk manager. Regardless of the risk management structure employed, not all trading firms risk platforms can calculate enterprise wide portfolio risk. In addition, no firm evenly applies every risk check to each trading strategy. Most firms apply fewer pre trade risk checks to some strategies to reduce latency.

A majority of the firms interviewed experienced out of control algorithms on one or more occasions, which may have been detected by the firms and/or the trading venue. A review of the circumstances that led to these out of control algorithms revealed that there is no clear pattern related to their cause. One firm's out of control algorithm resulted in a significant impact on market prices over a short time frame.

Based on the interview findings, proprietary trading firms, clearing members, trading venues, and regulators may want to consider the following:

Trading Firms
- Quality assurance of the code and development process
- Strict access controls to source codes and trading systems
- Strict separation of duties for trading, risk management and middle/back office team.

- Assigning financial responsibility for the violation of risk limits
- Periodic risk meetings with a cross functional team
- Reconcilement of trading activity using information from three sources: trading venues, clearing members, and proprietary trading firms' internal databases
- Subscribing to cancel on disconnect at trading venues where it is offered
- Developing a volume detecting mechanism that identifies rapid numbers of order submissions and cancellations, which may be useful in identifying out of control algorithms

Clearing Members
- Conduct periodic, comprehensive audits of customers that access the markets directly
- Assess each of these firm's risk management practices, including: access controls, change management and pre, and post trade risk controls

Trading Venues
- Standardize formats for drop copy
- Standardize delivery time frames for drop copies to as near real time as possible
- Include information on working orders in drop copies so clearing members and proprietary trading firms can better manage their financial exposures
- Establish maximum quantity per order limits, message limits, price limits, and mandatory credit limits at the exchange level
- If functionality is offered to clearing members to input pre trade risk checks for customers that access the markets directly, conduct periodic audits of the reasonableness of the limits set and their usage
- Offer cancel on disconnect functionality
- Standardize the definition of cancel on disconnect
- Have written policies regarding how orders are treated when cancel on disconnect is activated
- Periodically require audits of clearing members and trading firms that access the markets directly
  - Include access controls in these audits to identify who can turn on/off an algorithm
  - Review change management processes related to who can modify/delete algorithms
- During performance testing of trading firms' programs, introduce reconciliation scenarios to familiarize firms with handling unusual circumstances

Regulators
- Maintain a consistent focus on the markets
- Concentrate on solutions rather than problems

- Provide guidelines on how trading firms should manage their risk. These guidelines may include a list of pre-trade risk checks that every trading strategy should be subject to.
- Make rules simple so that anyone can understand them
- Design thoughtful policies that are not politically reactive
- Identify what policies, practices, and procedures are anticompetitive
- Harmonize regulations

FMG staff notes that despite the best efforts of market participants and regulators, unusual circumstances may occur and may not be preventable. Trading firms pointed out that during such times of uncertainty, they will always liquidate positions until they can quantify their risk.

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[1] Risk controls include the processes, procedures and systems a firm needs to prudently manage all the risks resulting from its trading activities to ensure they are within the firms' risk appetite.

[2] As of July 2011, the SEC implemented Rule 15c3-5, which among other things requires broker dealers providing sponsored access to maintain a system of risk controls and supervisory procedures reasonably designed to limit the financial exposure of the broker dealer that could arise as a result of market access. In addition, the CFTC issued a notice of proposed rulemaking, "clearing member risk management," Vol. 76, *Federal Register* No. 147, p. 45724 to bolster risk management at the clearing member level on 8/1/11.

[3] See: FIA Asia (2007), "Profile of exchange and fcm risk management practices for direct access customers," December 3; OICU-IOSCO (2008), "An overview of the work of the IOSCO technical committee," July; OICU-IOSCO (2007), "Multi-jurisdictional information sharing for market oversight," April; FIA (2009), Letter from John Damgard to Greg Tanzer, IOSCO, May 26; FSA (2008), *Market Watch,* November, Issue no. 30, pp.10-13; FIA-FOA (2009), Clearing Risk Study; OICU-IOSCO (2009), "Policies on direct electronic access," February; FIA (2010), "Market access risk management recommendations," April; OICU-IOSCO (2010), "Principles for direct electronic access to markets," August; FIA (2010), "Recommendations for risk controls for trading firms," November; SEC (2010), "Risk management controls for brokers and dealers with market access," Release No. 34-63241; File No. S7-03-10**,** November; CFTC (2011), "Recommended practices for trading firms, clearing members and exchanges involved in direct market access," Pre-Trade Functionality Subcommittee of the CFTC Technology Advisory Committee, March.

[4] A summary of the interviews with technology providers can be found at
http://www.chicagofed.org/webpages/publications/policy_discussion_papers/2011/pdp_1.cfm

[5] A summary of the interviews with exchanges can be found at
http://www.chicagofed.org/webpages/publications/policy_discussion_papers/2011/pdp_2.cfm

[6] For a definition of clearing member, see Clark, Carol 2010, "Controlling Risk in a Lightning Speed Trading Environment, Federal Reserve Bank of Chicago *FedLetter,* March at
http://www.chicagofed.org/webpages/publications/chicago_fed_letter/2010/march_272.cfm

[7] Every computer program is written in a programming language such as C, C++, Java, etc. These programs include anywhere from a few to millions of lines of text called source code.

[8] VaR (Value at Risk) is a widely used risk measure of the risk of loss on a specific portfolio of financial assets.

[9] SPAN calculates performance bond requirements by analyzing the "what-ifs" of virtually any market scenario based on the overall portfolio risk at both clearing and customer levels.

[10] Risk checks scrutinize orders against a particular limit(s) and are carried out as part of the broader risk control process.

[11] On many trading venues, there is a heightened probability that being matched against another trading firm's algorithm that is malfunctioning would result in these trades being busted by the trading venue as clearly erroneous trades.

[12] GTD (good till date orders) are non-persistent order types that are only valid for the trading day. At the end of the trading day these orders get cancelled by the exchange. GTC (good till cancel orders) are persistent order types that do not get cancelled by the exchange at the end of the trading day. GTC orders are generally cancelled by the

trader/trading firm/clearing firm, but some exchanges set limits on how many days a GTC order can stay in the market.

[13] During performance testing, trading firms test their applications in conditions that are as close as possible to the trading venues' production environment.

[14] Regulation NMS was adopted by the Securities and Exchange Commission as a series of initiatives designed to modernize and strengthen the national market system ("NMS") for equity securities. See http://www.sec.gov/rules/final/34-51808.pdf