FINANCIAL INFORMATION FORUM

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Via Electronic Delivery

February 20, 2014

Marcia E. Asquith
Office of the Corporate Secretary
FINRA
1735 K St. NW
Washington, DC 20006-1506

Re: Regulatory Notice 14-47 - Proposal to Tighten Business Clock Synchronization Requirements

Dear Ms. Asquith,

The Financial Information Forum (FIF)[1] would like to take this opportunity to comment on Regulatory Notice 14-47 - Proposal to Tighten Business Clock Synchronization Requirements (the "proposal"). We appreciate the extension of the comment period which has allowed FIF to conduct a clock synchronization survey as part of our analysis of the proposal. In addition to the comments below, the Preliminary FIF Clock Synchronization Survey Report (the "FIF survey") is attached to this comment letter.

The FINRA proposal discusses tightening business clock synchronization requirements to 50 milliseconds and also asks for the burden associated with a 100 or 200 millisecond offset. The FIF survey revealed that 39% of respondents are above the proposed clock offset of 50 milliseconds including 29% at the current mandated clock offset of 1 second for all systems. The average cost of moving to 50 milliseconds is roughly half a million dollars per firm. Survey respondents identified the following implementation activities that would be required in support of a 50 millisecond offset:

- Rollout colocation server implementation to all other servers in scope
- Replace Windows Event Log with separate log/archive infrastructure
- Dedicate new hardware, software, OS and personnel
- Address challenges with desktop PCs meeting stricter tolerance limit
- Software changes to switch from NTP Stratum 2 to GPS source and potentially PTP
- Process changes to escalate to support teams/business and remediation work on drift
- Replacement of 25% of infrastructure and reengineering effort

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[1] FIF (www.fif.com) was formed in 1996 to provide a centralized source of information on the implementation issues that impact the financial technology industry across the order lifecycle. Our participants include trading and back office service bureaus, broker-dealers, market data vendors and exchanges. Through topic-oriented working groups, FIF participants focus on critical issues and productive solutions to technology developments, regulatory initiatives, and other industry changes.

- To achieve consistent 50ms precision, dedicated stratum-2 servers required
- Larger storage requirements due to log of increased synch events
- Networking enhancements
- Windows servers would require NTP replacement of a workaround to Win32Time issues
- Development/deployment of alternative alert and event logging platform
- Mainframe change to PPS derived local stratum-1 source
- Possible refactor of certain applications based on change in timestamp precision
- Need to tune current NTP infrastructure to achieve
- Implement CDMA or GPS time sources and NTP via internal time sources
- Dependent on service bureau for clock synch

One concern raised in the study was the lack of participation by small firms. Given that the 20% of the firms responding to the FIF survey did not have in-house clock synchronization expertise, we would expect lack of clock synchronization expertise to be an issue for small firms as well. FINRA should offer an exemption for small firms or re-iterate existing OATS guidance which relieves firms of clock synchronization requirements if all relevant times are recorded by a clearing firm or other third party.[2]

Given that the CAT NMS Plan submitted in September 2014 already includes a clock offset requirement of 50 milliseconds, FIF does not believe a separate FINRA proposal is required. We acknowledge FINRA's concerns with the timing of CAT; however, it is our understanding that the SRO consortium, which includes FINRA, is actively working on an amendment to the CAT NMS Plan that should be filed within 1Q2015. It is also worth noting that clock synchronization requirements go into effect four months after the approval of the CAT NMS Plan and are not dependent on the selection of the CAT Processor.

As part of the FIF clock synch survey, respondents were asked about the potential for reduced burden if FINRA were to require a tolerance of 100 or 200 milliseconds in advance of tighter tolerances imposed as part of the CAT NMS Plan. Survey respondents questioned the benefits of an interim tolerance citing that any changes to the current clock offset would require modifications to systems and processes.

It is also worth noting that CAT clock synch tolerances are still under discussion, the CAT-mandated clock tolerances included in the amendment to the CAT NMS Plan will have a significant impact on how clock synch requirements will be implemented at firms. As indicated in the FIF survey, the implementation effort required by firms will vary depending on the scope and granularity of clock offset tolerances. Additionally, any mandated reduction in clock offset will need to address compliance with new requirements. FIF recommends a pattern and practices approach to compliance that minimizes the need for generating and archiving clock synchronization logs. Changes made in support of interim FINRA

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[2] OATS Clock Synchronization FAQ S15 states: If the times required under OATS Rules are all recorded by your clearing firm or another third party, you are not required to synchronize your business clocks. However, if there are any cases when you must record the time yourself, such as when the computer system malfunctions and you must record the order on a paper ticket, you must maintain a synchronized clock for recording the times required under OATS Rules.

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tolerances may not be sufficient to meet CAT tolerances. Firms would like to avoid multiple clock offset projects if at all possible. Additionally, we question the value of tighter clock offsets when the mandated timestamp granularity remains at the second level. Mandated millisecond timestamps are another change already required by Rule 613 and the CAT NMS Plan.

Another concern of FIF members is the scope of the FINRA proposal. In evaluating scope within the FIF survey, the recommendation is to focus tighter clock offsets on server-side trading systems only. The proposal states "that these requirements apply to the recording of the date and time of any event that must be recorded under FINRA By-Laws or rules, not just OATS requirements." FIF requests that any future rule-making associated with this proposal itemize all records to which the tighter clock offsets would apply. Activities for which the sequencing of events is still possible at the 1 second tolerance may not require tighter clock offset tolerances.

In closing, we encourage FINRA to work through the CAT NMS Plan process to achieve their clock synchronization objectives and avoid redundant, and potentially conflicting, rule-making.

Regards,

Manisha Kimmel
Managing Director
Financial Information Forum

Enclosure

cc: Richard G. Ketchum, Chairman and Chief Executive Officer
        Stephanie Dumont, Senior Vice President and Director of Capital Markets Policy
        Shelly Bohlin, Vice President, Market Analysis and Audit Trail Group, Market Regulation
        Lisa Horrigan, Associate General Counsel, Office of General Counsel (OGC)

        Stephen Luparello, Director, Division of Trading and Markets, Securities and Exchange Commission
        Gary Goldsholle, Deputy Director, Division of Trading and Markets, Securities and Exchange Commission
        David S. Shillman, Associate Director, Division of Trading and Markets, Securities and Exchange Commission

FIF Clock Offset Survey Preliminary Report

Updated: February 17, 2015

Contact: Manisha Kimmel, Managing Director, FIF, kimmel@fif.com

Executive Summary

Key Conclusions

- 39% of firms manage clock offsets that are not at the proposed 50 ms
- Even firms with clock offsets at 50 ms or lower have significant investment to meet compliance requirements
- Low clock offsets require GPS and PTP (used today in specialized applications only)
- Very costly to apply low clock offset broadly across a firm's infrastructure
- Compliance methodology key driver of cost

Key Recommendations

- Establish clock offset tolerance at 50 ms.
- Allow firms sufficient implementation time to meet new tolerances, e.g., requirement set in first quarter for implementation in fourth quarter (i.e., 9 month lead time)
- Rule should mandate reasonably designed policies and procedures to prevent a pattern or practice of clock offsets outside of mandated tolerances
- Only require logging of exceptions with archived data requirements of 3 years
- Limit mandated clock offset tolerances to electronic CAT reportable events such that manual events are excluded as well as off-production hours

Agenda

- Purpose of Clock Offset Survey
- Survey Respondent Profile
- Survey Responses
    - Current Clock Offset Environment
    - Achieving Lower Cost Offsets
- Opportunities To Reduce Cost Of Compliance
- Recommendation

Purpose of Clock Offset Survey

- The SEC/SROs and FINRA are considering new regulation to reduce clock offset tolerances when recording events for CAT or in the interim, FINRA-related submissions.

- To better understand the cost and implementation concerns of these proposals, FIF conducted a Clock Offset Survey.

- The survey was distributed to the FIF CAT Working Group and other industry participants.

- Cost feedback was requested on four target clock offset tolerances – 100 microseconds, 1 millisecond, 5 milliseconds and 50 milliseconds.

- Follow-up interviews where conducted with 8 firms to better understand cost of compliance and suggestions to better frame regulation

- Management of clock offsets was discussed with cloud providers

Survey Respondent Profile

- **By Firm Type**
  - Broker Dealers – 23 (82%)
  - Service bureaus – 5 (18%)
- **By Business Model - Introducing/Clearing**
  - Clearing Only - 10 (35.7%)
  - Clearing/Introducing – 7 (25%)
  - Introducing Only – 1 (3.6%)
  - None of the above (e.g., Institutional BD, Self-Clearing or Service Bureau) – 10 (35.7%)
- **By Business Model - Retail/Institutional**
  - Retail Only – 4 (14%)
  - Retail & Institutional – 11 (39%)
  - Institutional Only – 4 (14%)
  - None of the above (i.e., principal traders, market makers, service bureaus) – 9 (32%)
- **Additional Categories**
  - Twelve firms identified themselves as registered market makers including two that were not self-clearing
  - Ten firms identified themselves as principal traders

Note: Responses were not consistent across firm type. 6 firms indicated they did not have in-house clock synch expertise.

# Survey Respondent Profile – OATS Records Perspective

ROE/month	# Respondents	% of Respondents in Tier	Respondents as % of All Firms in OATS ROE Tier
100,000,000 or more	11	39%	27%
3,000,000 to 99,999,999	7	25%	15%
100,000 to 2,999,999	7	25%	9%
10,000 to 99,999	0	0%	0%
1 to 9,999	1	4%	0.2%
non-FINRA member B/D	2	7%	N/A

Note:
- The firm with the smallest number of ROEs was unable to provide cost estimates relating to target clock offsets
- No data from smaller firms in lower Tiers (representing over 400 firms). An effort is underway to solicit small firm input.
- Firms in OATS ROE Tier based on FINRA provided data from August 2014 for OATS Reporting Firms only

Current Offset Achieved

Distribution of Current Clock Offsets

29 % 21%

|_____ 39%_____| |_____18%_____|
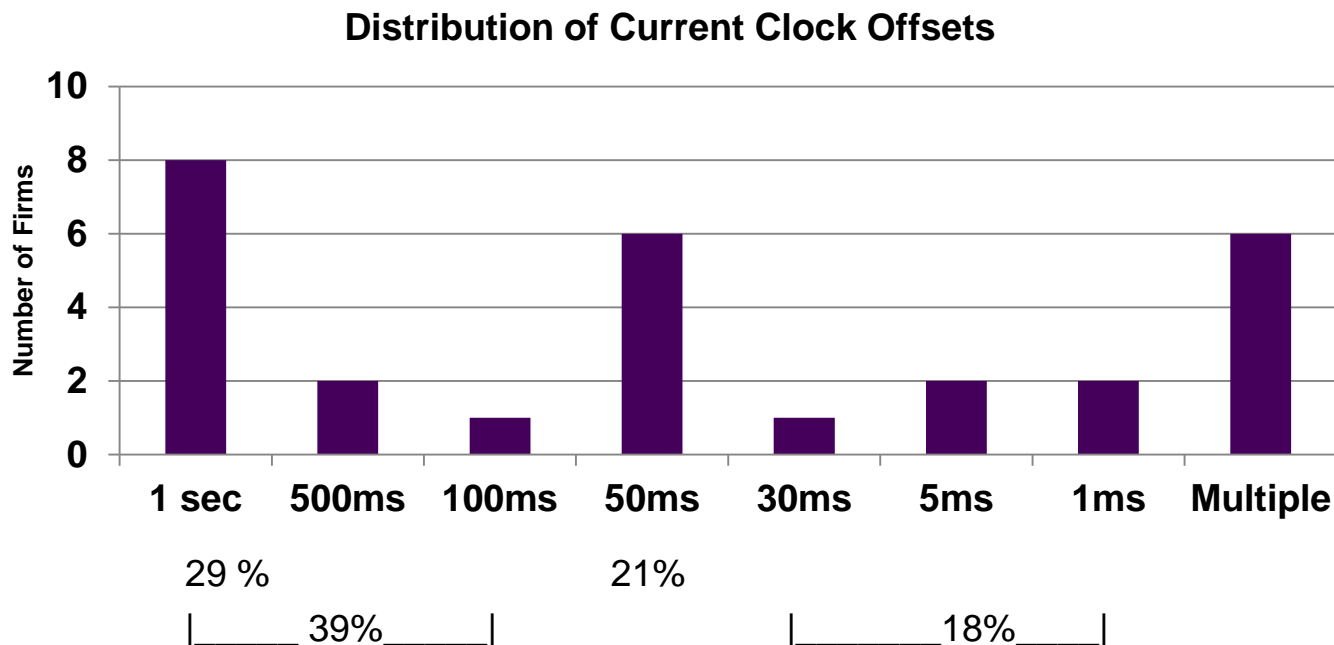
Notes:

- 39% of respondents are above the currently proposed clock offset of 50 milliseconds including 29% at the current mandated clock offset of 1 second for all systems
- 21% are currently at the current CAT NMS proposed clock offset of 50 ms for all systems
- 18% are below the 50 millisecond offset as shown in the table below for all systems
- 22% of firms have multiple clock offsets and indicated the following: 1 sec, 100 ms, 50 ms (2 firms); 100 ms, 100 µs; 50 ms to less than 1 ms; 50 ms, 100 µs; 5 ms, 5 µs
- 69% of firms (11 out of 16) achieving 50ms or better (in all or part of their installation) are Tier 1 and 2 firms
- Even where firms were at the target clock offset, many firms cited additional costs associated with compliance including logging and achieving greater degrees of reliability

Current Clock Technologies Used

Distribution of Clock Technologies
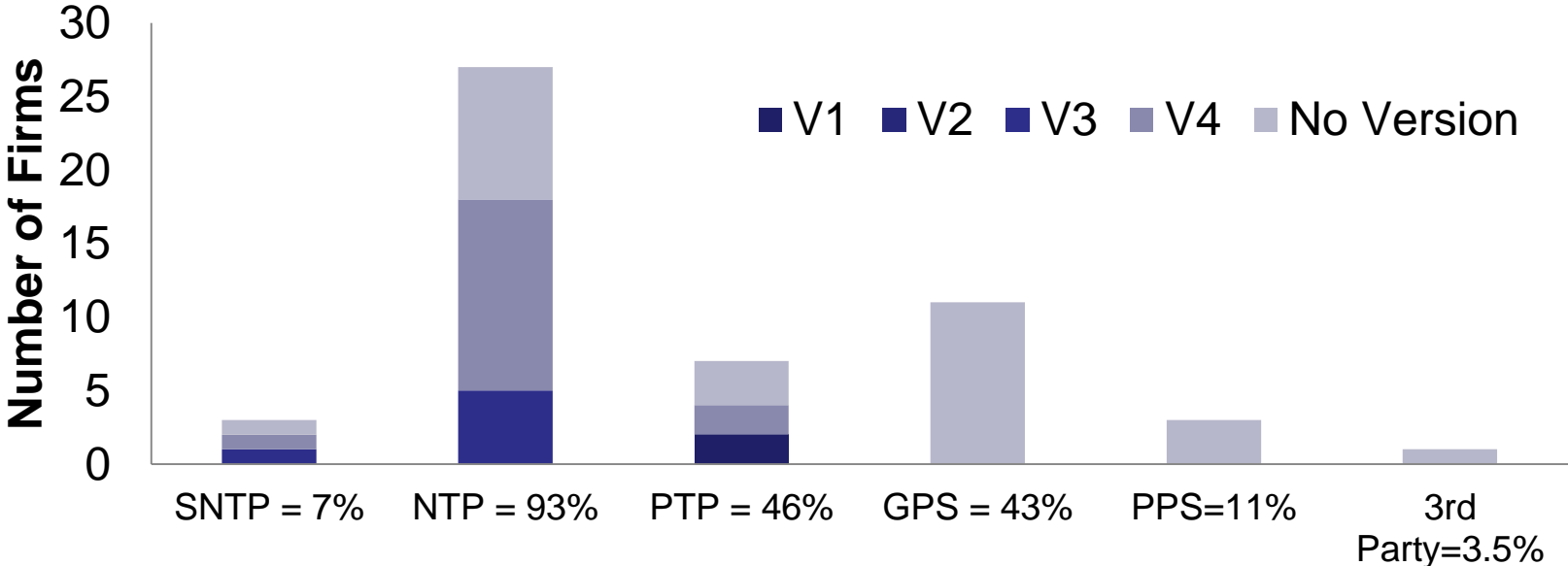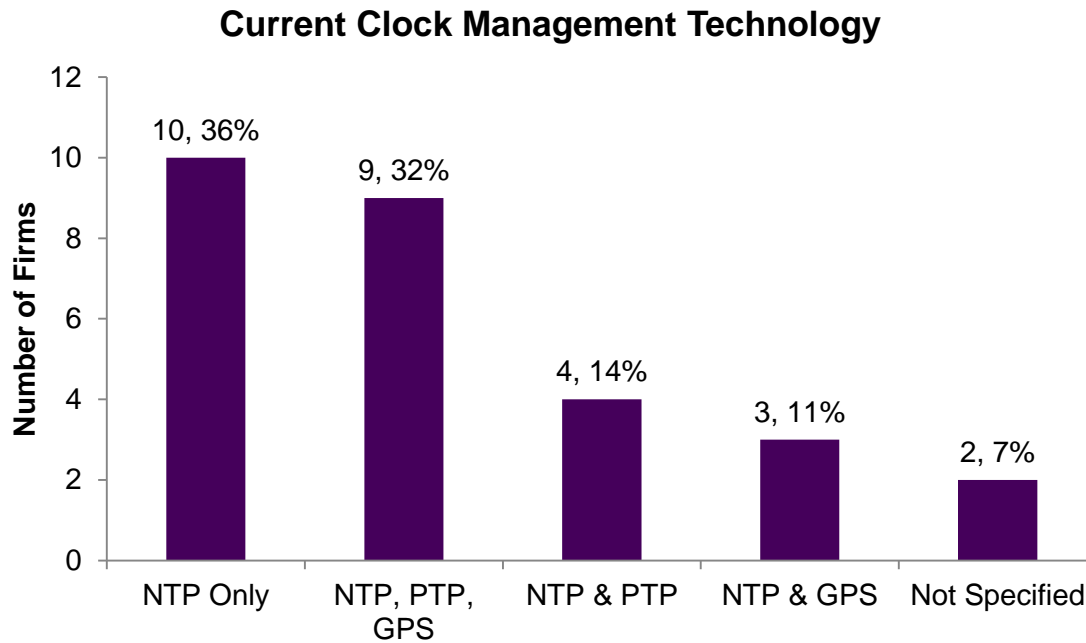

Clock Synchronization Technologies
Percentage Installed Today with Versions in Use

Note:

- PTP and GPS (or similar) technologies would be required to achieve the lowest proposed clock offsets included in the survey yet less than half of the respondent firms use this technology today
- 100% of PPS usage is by Tier 1 firms and 100% usage of PTP and GPS is by Tier 1 and 2 firms

Current Clock Technologies Used – Alternate Perspective

Current Clock Management Technology

Note:

- All firms that answered the question (26 of 28) use NTP today. This is significant because PTP and GPS (or similar) technologies would be required to achieve the lowest proposed clock offsets included in the survey.

01/28/14

Current Clock Management Costs

Annual Cost for Current Clock Management
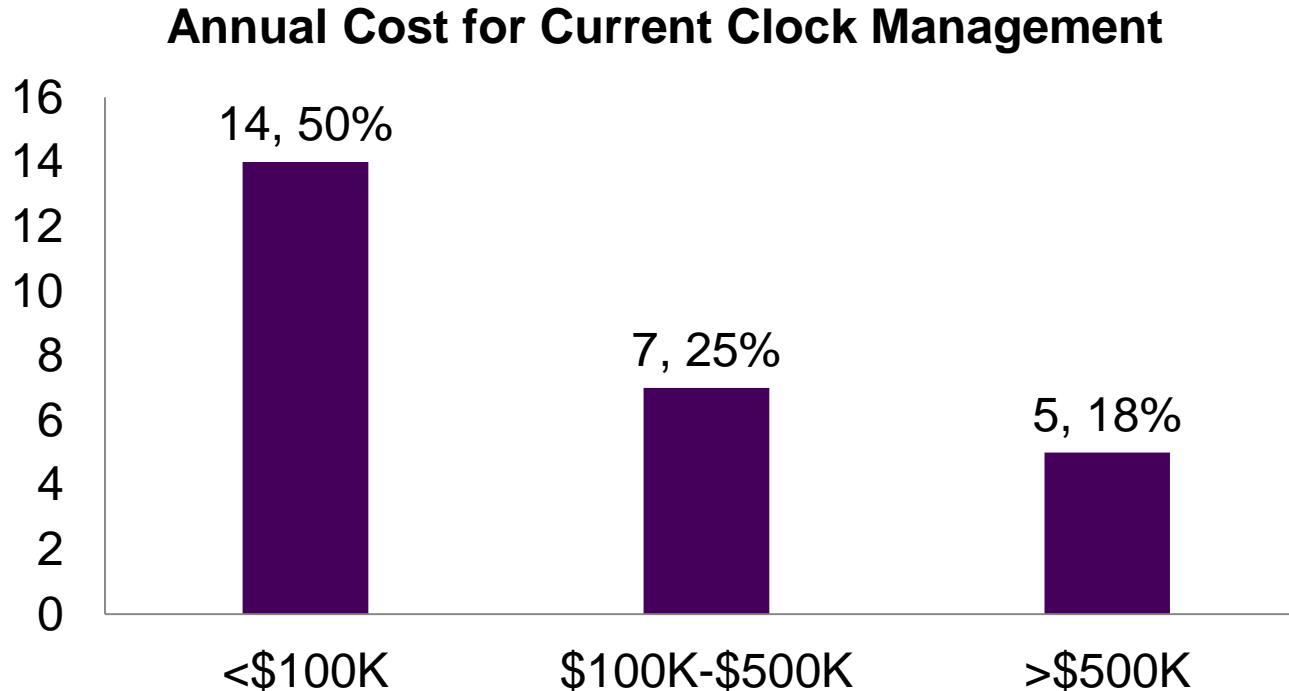
Note:
- Half of the firms spend less than $100K on clock management today
- Two firm (7%) did not respond to the question
- 80% of firms with current costs over $500K are in Tier 1; 20% in Tier 5
- 64% of firms with current costs less than $100K in Tier 1 and 2

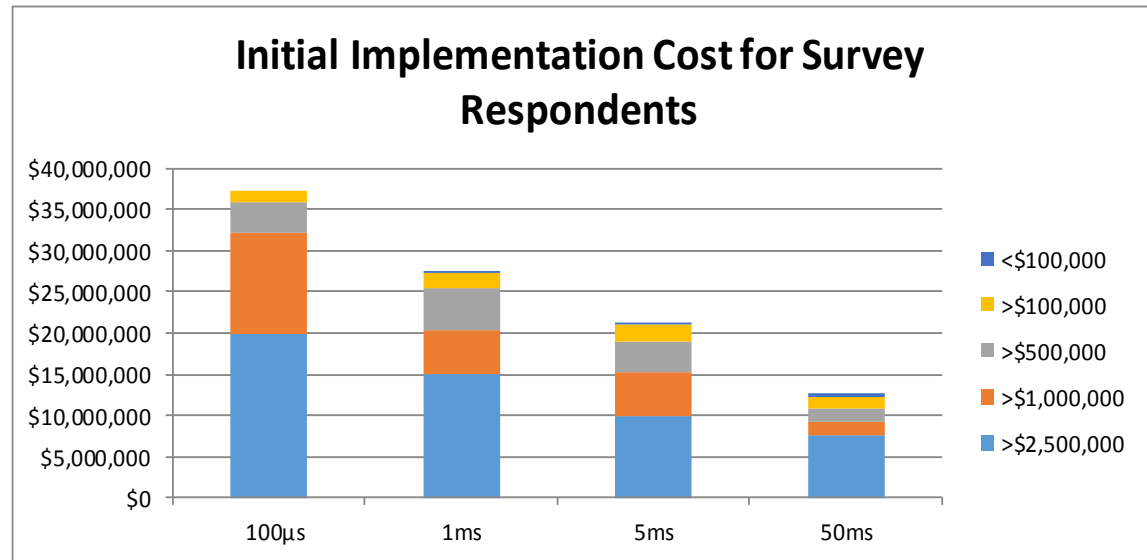# Initial Implementation Costs for Proposed Clock Offsets

Range in Survey	Amount Used
Less than $100K	50,000
Between $100K and less than $500K	300,000
Between $500K and less than $1M	750,000
Between $1M and less than $2.5M	1,750,000
$2.5M and over	2,500,000

Initial Implementation Cost for Survey Respondents

Legend: ■ <$100,000 ■ >$100,000 ■ >$500,000 ■ >$1,000,000 ■ >$2,500,000

Clock Offset	100μs	1ms	5ms	50ms
Average Cost	$ 1,550,000	$ 1,141,667	$ 887,500	$ 554,348
Total Cost for Respondents	$ 37,200,000	$ 27,400,000	$ 21,300,000	$ 12,750,000
% Cost Increase over 50 ms	192%	115%	67%	

Note:

Although some firms already have a monitor/log/archive infrastructure in place, many firms would require significant infrastructure and process investment at any clock offset tolerance.

Implementation Effort for 50 ms Clock Offset: Representative Comments

- Rollout Colocation server implementation to all other servers in scope
- Replace Windows Event Log with separate log/archive infrastructure
- Dedicate new hardware, software, OS and personnel
- Challenge – desktop PCs meeting stricter tolerance limit
- Software changes to switch from NTP Stratum 2 to GPS source and potentially PTP
- Process changes to escalate to support teams/business and remediation work on drift
- Replacement of 25% of infrastructure and reengineering effort
- To achieve consistent 50ms precision, dedicated stratum-2 servers required
- Larger storage requirements due to log of increased synch events
- Networking enhancements
- Windows servers would require NTP replacement of a workaround to Win32Time issues
- Development/deployment of alternative alert and event logging platform
- Mainframe change to PPS derived local stratum-1 source
- Possible refactor of certain applications based on change in timestamp precision
- Potential to tune current NTP infrastructure to achieve
- Currently implementing CDMA or GPS time sources and NTP via internal time sources
- None – our service bureau provides support

Implementation Effort for 5 ms Clock Offset: Representative Comments

- Install GPS clocks in all locations
- Create custom time distribution network to connect all hosts to
- Migrate from NTP to PTP
- New enterprise level NTP client or PTP via current management network
- 3rd party time keeping software to get tolerance down that low
- Conversion of servers to PTP requires upgrades of oscillators, new physical cabling, GPS antenna arrays and lightning rods for each impacted datacenter
- Hardware configuration tuning for NTP/PTP with OS of current generation Linux
- Applications running on older generation HW or OS will need to be upgraded
- Enhancement of monitoring/logging tools
- MS Windows 7 desktop does not appear to be widely used at these tolerances – significant effort to ensure compliance
- Unpredictable load at user workstation (video, trading app, office tools) may impact clock synchronization, requiring change to trader workspace or dedicated equipment or move to thin clients
- Replacement of 25% of legacy/older infrastructure and reengineering effort
- Clock synch instability (few minutes to hour) after server reboot
- Network level reengineering may be required to reduce jitter

Implementation Effort for 1 ms Clock Offset: Representative Comments

- GPS required time sources in every relevant data center
- New network segment physically cabled to each server for dedicated PTP access
- PTP software solution implemented for Windows and Unix servers, each with their own degree of complexity
- Do not have microsecond precision in DB (currently 3 millisecond tolerance); significant software changes and testing
- Requires replacement of stock NTP client with custom solution and possible dedicated switched LAN access to stratum-1 servers
- 1ms precision on virtual machines may not be possible and thus require reengineering or dedicated deployments
- Mainframes would require PPS access to local stratum-1 source
- If 1 ms offset to be achieved 99.9% of time, requires installing additional backup GPS devices per colocation as PTP over WAN will never achieve this
- 3rd party vendor would need to determine support
- Additional time synch hardware and OS changes

Implementation Effort for 100 µs Clock Offset: Representative Comments

- May require PTP plus configuration changes and additional functionality to network
- Specialized NIC cards for hardware assisted time synch
- OS updates, new hardware and network design required
- Restructuring current server layout in data centers to minimize GPS sourced PPS timing along with PPS enabled time cards/server
- Outside vendors and expertise would need to be contracted
- Monitoring of systems clock drift would increase significantly
- Extremely expensive and may not be possible
- Requires significant reengineering, production certification efforts and global hardware upgrades to support pervasive PTP and PPS access to local reference time
- If a Windows based solution even exists, it would require significant engineering effort.
- Migrate to PTP with hardware / NIC time stamping
- Network infrastructure must be PTP aware and may need dedicated PTP network
- All applications must be upgraded to recent generation hardware and OS to ensure clock quality and use of PTP software
- If 100µs achieved 99.9% of time, requires physically dedicated time infrastructure, multiple GPS applications/center, reliable PCIe oscillators in many hosts
- Possible rebuild of entire trading environment; stable ambient & CPU temperature control critical

Annual Costs for Proposed Clock Offsets

Range for Projected Cost	Amount Used	
Less than $100K	$	50,000
Between $100K and less than $500K	$	300,000
Between $500K and less than $1M	$	750,000
Between $1M and less than $2.5M	$	1,750,000
$2.5M and over	$	2,500,000

Range for Current Cost	Amount Used	
Less than $100K	$	50,000
Between $100K and less than $500K	$	300,000
Over $500K		$500,000

Projected Annual Cost

Legend:
- <$100,00
- >$100,00
- >$500,00
- >$1,000,
- >$2,500,
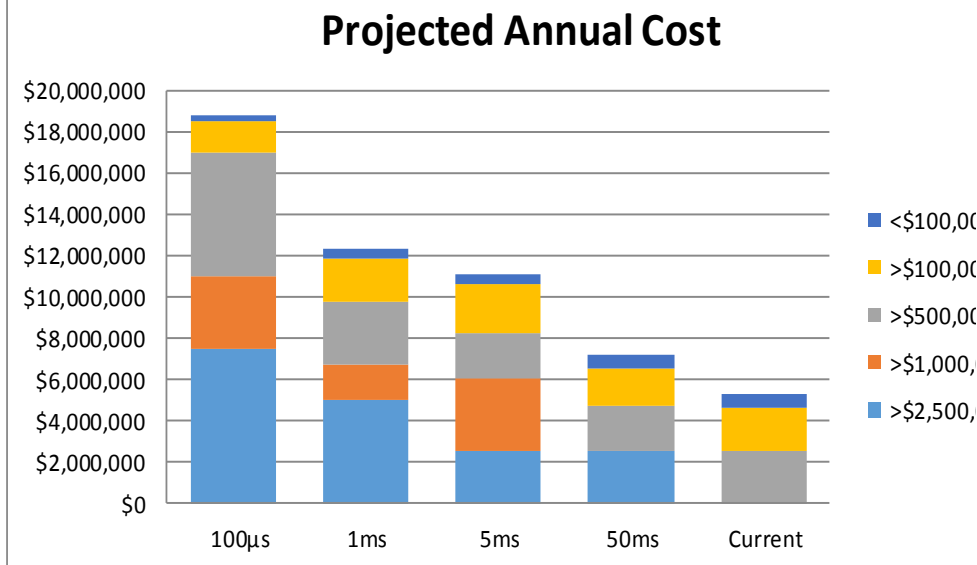
Clock Offset	100µs	1ms	5ms	50ms	Current
Average Annual Cost	$783,333	$ 534,783	$ 482,609	$ 313,043	$ 203,846
Total Annual Cost for Respondents	$18,800,000	$ 12,300,000	$ 11,100,000	$ 7,200,000	$ 5,503,846
% Cost Increase Over Current	242%	123%	102%	31%	

Note:

The on-going costs to monitor/manage clock system increases significantly at 5 ms and again at 100µs.

Opportunities to reduce cost of compliance

The survey responses included a number of recommendations to reduce the cost of compliance for achieving a new clock offset:

- Maintain clock offset tolerance of 50 ms
- Reduce log/archive requirement
- If required, limit clock offsets < 50 ms to server-side trading systems only
- Delay Implementation Date
- Reduce ongoing compliance burden

Each of these suggestions are describe in more detail on the following slides.

Recommendation
Clock Offset Tolerance of 50ms

Opportunity:

Maintain current CAT Rule 613 clock offset tolerance of 50 ms

Recommendation:

Establish a clock offset tolerance of 50 ms

Sample of Survey Responses:

- To achieve a 50ms clock offset tolerance these 28 respondents must invest almost $13M of initial development costs to achieve 50 ms
- The current annual costs of $5.5M for this set of respondents increases by 31% to maintain a 50ms clock offset
- The Initial cost to establish a lower clock offset escalates by 67%, 115% and 192% as the clock offset moves to 5ms, 1ms and 100μs
- The Annual cost to maintain a lower clock offset escalates by 102%, 123% and 242% as the clock offset moves to 5ms, 1ms and 100μs
- Survey respondents are very concerned with the technology challenges and risks of applying low tolerances across their enterprises
- Survey respondents do not include small firma that may be more impacted by clock offset changes.

Recommendation: Reduce Logging/Archive Requirements

Cost Associated with Logging Requirement	Number of Firms	Percent of Total
High	10	36%
Medium	4	14%
Low	13	46%
Not Specified	1	4%
Total	28	100%

Recommendation:
- Only log exceptions and clock synchronization setting changes, not every synchronization event
- Reduce archive requirement to under 5 years
- Consolidated log format should not be required (was not assumed in survey)

Representative Comments from respondents on log/archive requirements:
- Requires implementing new log/archive system (current system logs 86K events/day across 400 machines which would grow to 35M events/day)
- Currently log synch events, highly compressed, requiring 1 gig data storage each day for 1 second offset. The proposed clock offsets would increase data storage requirements at least 10 fold.

Recommendation: Limit Lower Clock Offsets to Server-side Trading Systems

Survey asked what savings could be expected if clock offsets <50ms were only required for server-side trading systems. Server-side trading systems were defined as those systems focused on execution that are managed by back-end servers as opposed to desktop applications.

	100µs		1ms		5ms	
	# firms	% firms	# firms	% firms	# firms	% firms
50% or greater cost savings	8	28.5%	4	14%	2	7%
<50% cost savings	6	21%	6	21%	6	21%
No cost savings	7	25%	9	32%	9	32%
No response or don't know	5	18%	7	25%	9	32%
N/A	2	7%	2	7%	2	7%

Note:

- 28% noted cost savings at a 5 ms offset with savings cited by 50% of respondents at a 100µs offset
- Based on follow-up interviews:
  - All firms agreed that clock offset tolerances close to 1 ms or lower should only be required for trading systems/matching engines/ATS
  - One reason cited for no cost savings was that clock offset is set and managed globally at their firms

Recommendation: Delay Implementation

- The survey asked what cost savings might be realized if the implementation date for a lower clock offset was end of 2016 or 2017.

- Many respondents (12 firms, 43%) did not believe that a delay would reduce costs. In follow-up interviews with 5 firms, they said that they answered this question purely from a cost perspective,. They said that much of their costs were hardware/software – and they couldn't predict any significant cost changes over the two year period.

- Eleven respondents (39% of firms) did not respond or indicated that cost savings are not known at this time

- Respondents did cite the need for sufficient implementation time especially for the lower clock offset tolerances. One firm indicated that to achieve any reduced clock offset by the end of 2015, the offset requirement would need to be set in 1Q2015.

- While additional time may not reduce costs, it may ease implementation as firms manage this effort in conjunction with other compliance initiatives. .

Recommendation: Reduce Ongoing Compliance Burden

Issue:

- Firms indicated concern regarding the level of reliability and expectations to demonstrate and achieve compliance that would be required to ensure clock offset at prescribed tolerances.

Recommendation:

- Compliance with any new clock offset should be based on reasonably designed policies and procedures to prevent a pattern and practice of clock offsets outside of mandated tolerances

Representative comments:

- "100ms 100% of the time is below the tipping point under any realistic scenario – for 100ms an entirely physically separated time infrastructure with full redundancy is required [to achieve 100% reliability"

- Must the log/archive solution be managed for 100% reliability?

- Server reboot occurs due to failure during trading hours, application of maintenance after hours, periodic reboots on weekends. It causes clock instability until the server stabilizes (few minutes to an hour), causing a flurry of clock variances. These type of incidents should not constitute a "regulatory requirement for unusual action".

- Clock protocols automatically adjust the clocks based on settings, etc. These low offsets cannot require manual intervention except when anomalies are noted.

Review of FIF Recommendation

- Establish clock offset tolerance at 50 ms.

- Allow firms sufficient implementation time to meet new tolerances, e.g., requirement set in first quarter for implementation in fourth quarter (i.e., 9 month lead time)

- Rule should mandate reasonably designed policies and procedures to prevent a pattern or practice of clock offsets outside of mandated tolerances

- Only require logging of exceptions with archived data requirements of 3 years

- Limit mandated clock offset tolerances to electronic CAT reportable events such that manual events are excluded as well as off-production hours

Appendix A. Tipping Points for Implementation Costs Associated with Proposed Clock Offsets & Additional Tipping Points Beyond 100 Microseconds

#	Firm ID	<100µs	100µs	1ms	5ms	50 ms
1	23	<100µs	H++	H++	H	H
2	7	50µs	H++	H+	H+	H
3	6		H	H	H	H, H for anything less than 100 ms
4	14	<100µs	H	H	M/H	M/H
5	19		H	H	H	L
6	22		H	H	No add'l cost	No add'l cost
7	11		H+	M/H	M/H	M
8	17		H	M/H, H for anything less than 1 ms	M/H	M
9	8	<50µs	M/H	M/H	L/M	N/A
10	1	20-50µs	M/H	M	M	L/M
11	5		M/H	M	L/M	L
12	13	<50µs	M/H	M	L/M	N/A
13	16	10µs	M/H	M	M	L/M
14	18		M/H	M	M	L
15	26		M/H	M, M/H for anything less than 1 ms	M	L
16	20	<100µs	M	L	L	L
17	12	TBD	M	L/M	L/M	L
18	25	<100µs	M	L/M, M for anything less than 1 ms and 100 µs	L/M	L/M
19	27		M	M	M	L
20	9	< 100 µs	M	L/M	L	L
21	4	<100µs	L/M	L	L	L
22	15	<50µs	L/M	L/M	L/M	L
23	21		L/M (Tipping point for Linux OS)	L/M (Tipping point for Windows OS)	L	L
24	2		L/M, costs due to logging	L/M, costs due to logging	L/M, costs due to logging	L/M, costs due to logging
25	10		TBD	TBD	TBD, current	
26	24		TBD	TBD	TBD	TBD
27	28		TBD	TBD	TBD	TBD
28	3		TBD	TBD, current		

Legend:
- L = Less than $100K
- L/M = Between $100K and less than $500K
- M = Between $500K and less than $1M
- M/H = Between $1M and less than $2.5M
- H = $2.5M and over
- H+ = Respondent indicated cost impact as significant within the $2.5M and over range
- H++ = Respondent indicated cost impact as extremely significant within the $2.5M and over range

Appendix B. Current Clock Offset Environment and Costs (Sorted by Firm Size based on ROE Tiers and then Current On-going Cost)

Firm #	Firm ID	Tier	Business Model	Current Offset	Clock Skills	Current Protocol(s)	Current On-going Cost
1	1	1	Inst, Retail, MM, PrinTr	50ms, <1ms. <1ms	yes	SNTP, NTP, GPS, PPS	>$500K
2	7	1	Clr, Inst, Retail, MM	100ms, 100µs	yes	SNTP, NTP, PTP	>$500K
3	14	1	Clr, Inst, Retail, MM	1sec	yes	NTP, PTP, GPS, PPS	>$500K
4	23	1	Clr, Inst, MM, PrinTr	500ms	yes	NTP, PTP, GPS	>$500K
5	8	1	Inst, Retail, MM	50ms	yes	NTP, PTP	$100K-$500K
6	15	1	Clr, Inst, Retail	50ms, 100µs	yes	NTP, PTP, GPS, PPS	$100K-$500K
7	16	1	Clr, Inst, Retail, MM, PrinTr	50ms	yes	NTP, PTP	<$100K
8	17	1	Clr, Inst, Retail, MM, PrinTr	1sec	yes	NTP, PTP, GPS	<$100K
9	21	1	Intr, Inst, MM, PrinTr	50ms	yes	NTP, PTP, GPS	<$100K
10	26	1	Clr, Intr, Inst	50ms	yes	NTP, PTP, GPS	<$100K
11	28	1	Clr, Intr, Inst, Retail,MM, PrinTr	1 sec	no	NTP	<$100K
12	13	2	MM	50ms		NTP, PTP	$100K-$500K
13	22	2	Inst, PrinTr	<5ms, <5 µs	yes	NTP, PTP, GPS	$100K-$500K
14	4	2	SB	5ms	yes	NTP, GPS	<$100K
15	9	2	Clr	1sec	yes	NTP	<$100K
16	11	2	SB	1sec	yes	NTP, PTP, GPS, 3rd Party	<$100K
17	24	2	Clr, Retail	1sec	no	NTP	<$100K
18	3	2	SB	1ms	no	NTP	No answer
19	12	3	Clr, Intr, Inst, Retail	50ms	yes	NTP	$100K-$500K
20	19	3	Clr, Intr, Retail	1sec, 100ms, 50ms	no	NTP	$100K-$500K
21	5	3	Clr, Intro, Inst, Retail	500ms	no		<$100K
22	20	3	Clr, Intr, Inst, Retail, MM, PrinTr	1sec	yes	NTP	<$100K
23	25	3	SB	100ms	yes	NTP	<$100K
24	27	3	Clr, Retail	1sec, 100ms, 50ms	yes	NTP	<$100K
25	6	3	Clr, Intro, Retail, PrinTr	1sec		NTP	No answer
26	10	5	SB	5ms, 1ms	yes		>$500K
27	18	N/A	Clr, PrinTr	30ms	yes	NTP, PTP, GPS	$100K-$500K
28	2	N/A	MM	1 sec, 100ms, 50ms, <50ms	no	NTP, GPS	<$100K

Business Model Legend:
- Clr – Clearing Firm
- Inst – Institutional
- Intr – Introducing Firm
- MM – Registered Market Maker
- PrinTr – Principal Trading
- Retail – Retail
- SB – Service Bureau