LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

intel. partner alliance

Liquid-Markets-Solutions

ÜberNIC & Precision Time in Financial Services

v2024-03-22

LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

intel partner alliance

Financial Services Key Contexts

Financial Services Profoundly Changed

intel partner alliance

1998

2008

2016

Today's Trading Is Electronic & Automated

intel partner alliance

It’s Expensive! Exchange Co-Location

intel partner alliance

US$ 3.155 Million

4x Racks	10G Co-Lo Links
US$ 410,400	US$ 759,600
Market Data	**10G External Links**
US$ 916,680	US$ 1,068,540

Annual Recurring Cost for One NY-Based Exchange Co-Lo Data Center w/External Connectivity to NY Metro and Chicago Metro

It’s Expensive! Co-Lo Trading Deployment

intel partner alliance

US$ 614 Thousand

30 1U Servers	120 ULL/HPC NICs
US$ 246,900	US$ 150,500

4 ULL Switches	4 TOR TS Devices
US$ 76,000	US$ 140,000

One-Time Build-Out Cost for One NY-Based Exchange Co-Lo Data Center w/External Connectivity to NY Metro and Chicago Metro

LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

intel. partner alliance

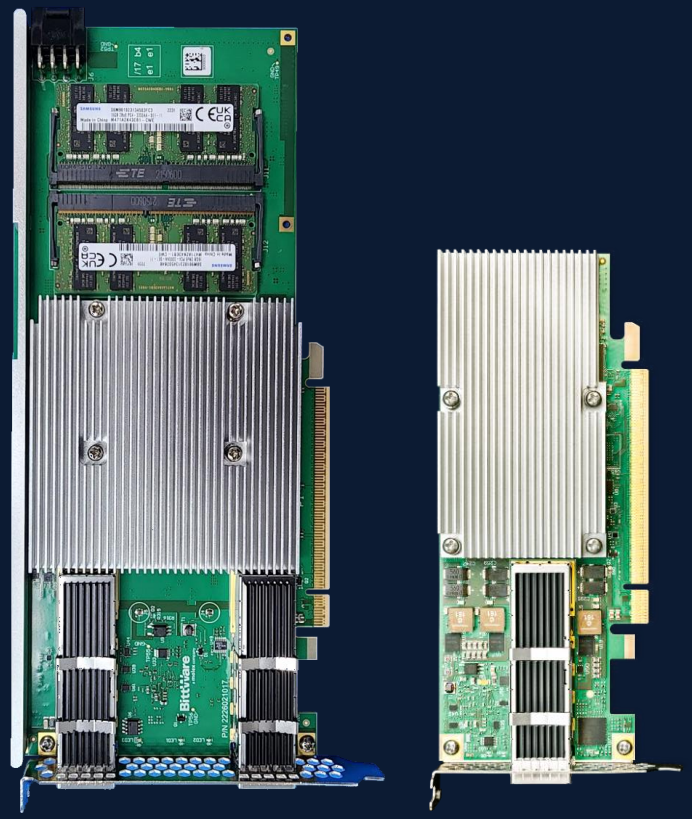
ÜberNIC Introduction

LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

ÜberNIC

FPGA Network Controller & Network Stack

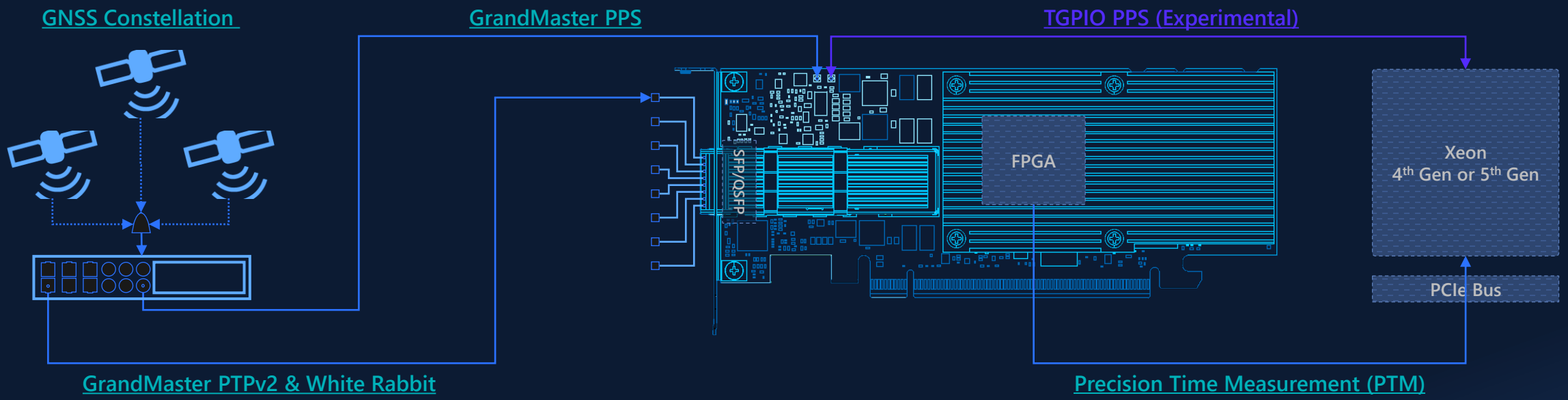
intel. partner alliance



- 100% FPGA-Based Standards-Compliant Network Stack
- Supports PCIe 3.0, 4.0, 5.0 & CXL 1.1, 2.0
- Significant Fiber Density; Max 16 FPs
- Multi-GB On-Board Memory; Max 64GB
- MAC-Level Timestamp, PCAP & Port Span
- PPS, NTP, PTPv2, PTM, TGPIO PPS, & White Rabbit
- SmartNIC Capabilities:
  - Add-On LMS Extensible Logic
  - Add-On End-User or 3rd Party Logic
- Single PCIe Slot, HH ½L or FH ¾L

ÜberNIC Precision Time Synchronization

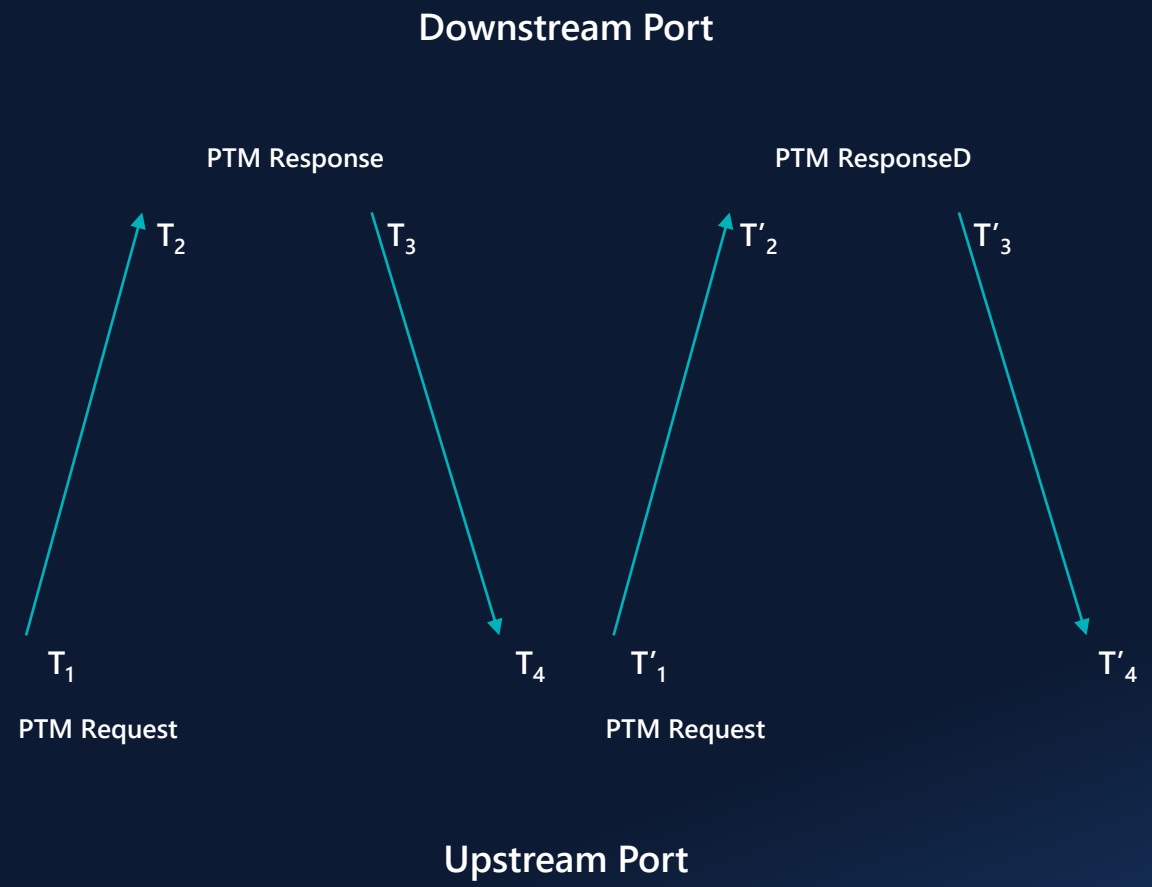
intel. partner alliance



LMS is a Member of the OCP Time Appliances Project and a Founding Member of the CERN White Rabbit Collaboration Partnership

ÜberNIC Precision Time Measurement (PTM)

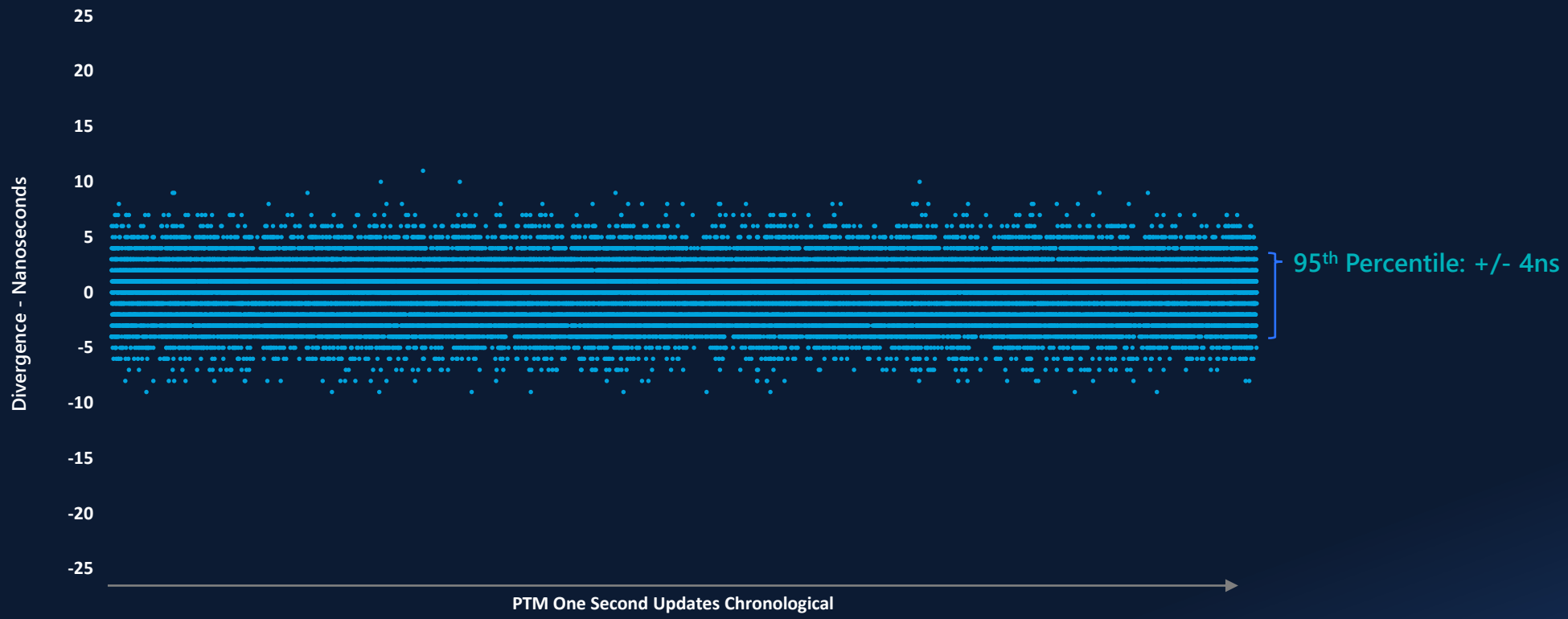
- IEEE1588 + White Rabbit Accurately Measures Time Across the Datacenter and Communicates Time Values to an Ethernet PCIe NIC
- PCIe NIC to Host Time Updates Negatively Impacted by CPU Load-Induced Degradation Whereby Software-Based PCIe NIC PTP Clock Reads Introduce Significant Error
- PCIe PTM Eliminates Clock Uncertainty via a Hardware Protocol, Substantially Reducing the Offset Between CPU Clock and PCIe Device Clock



ÜberNIC PTM Synchronization

intel partner alliance

Host/ÜberNIC Host Real-Time Clock Post-Update Time Value Divergence

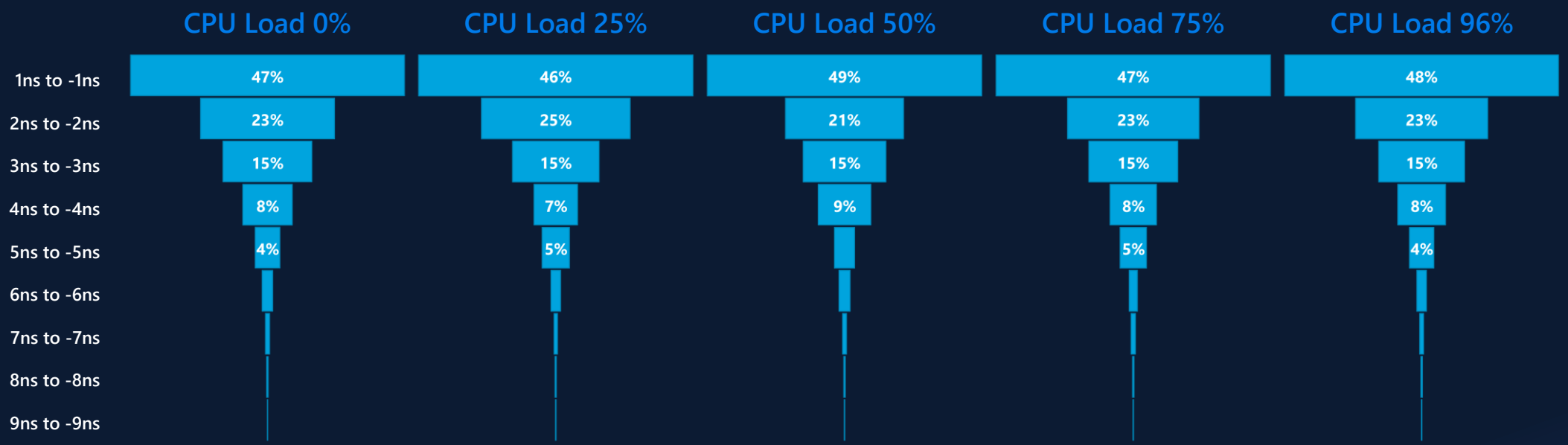


27180 One-Second Updates | | SuperMicro X13SEI-F w/Xeon 4th Gen 6442Y

ÜberNIC PTM Synchronization and CPU Load

intel. partner alliance

Host/ÜberNIC Host Real-Time Clock Post-Update Time Value Divergence



27180 One-Second Updates Per CPU Load Percentage| SuperMicro X13SEI-F w/Xeon 4th Gen 6442Y

LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

intel. partner alliance

Precision Time In Financial Services

MiFID 2 Mandates Host-Level Precision Time

intel partner alliance

- System Clocks Must be Synced to UTC via an Identifiable Source
- Clock Offset Accuracy Must be Provable
- Timestamp Divergence Limit from UTC:
  - If Exchange Access Latency > 1ms, 1.00ms
  - Else If Exchange Access Latency < 1ms, 0.10ms
  - Else If HFT, 1.00µs
- Timestamp Granularity:
  - If Exchange Access Latency > 1ms, 1.00ms
  - Else If Exchange Access Latency < 1ms, 1.00µs
  - Else If HFT, 1.00µs
- Demonstrate Location and Consistency (of Location) of Timestamp Implementation

United States SEC Rule 613 Introduces Similar Requirements

Accusation! Market Manipulation

- Regulator Accuses “Investor A” of Buying and Selling to Itself
- Regulators Globally Consider Such Activity Manipulative:
  - Creates the Appearance of a Vibrant and Active Market Attracting Other Investors
  - Market Movement Allows “Investor A” to Inappropriately Profit
- Regulator’s Evidence is Single-Second Granularity Timestamps
- Conclusion:
  - Timestamps w/Nanosecond Precision Demonstrate “Investor A” Innocent
  - Regulator Apologizes to “Investor A”
  - Regulator Implements Remediation Plan to Introduce Microsecond-Granular Timestamps

Accusation! Violation of Best Execution Rules

- Regulator Accuses “Broker C” of Inappropriately Transmitting Buy Orders to “Exchange A”
- At Time of Transmission “Exchange B” Selling Price US$ 0.10 Lower Than “Exchange A”
- “Broker C” Clients Negatively Impacted by US$ 52k Overpayment
- Regulator’s Evidence is “Exchange B” Microsecond Granularity Data Transmission Timestamps
- Conclusion:
  - Timestamps w/Nanosecond Precision Demonstrate “Broker C” Innocent
  - Data from “Exchange B” Received by “Broker C” After Orders Transmitted to “Exchange A”
  - Regulator Implements Remediation Plan to Incorporate Transmission Latency in Data Analysis

Accusation! ”Investor B” Crashes Exchange GW

intel partner alliance

- Regulator Accuses “Investor B” of Intentionally Crashing 1 of 4 “Exchange A” Gateways
- Duplicate Connections on All 4 GWs Caused by Fully Duplicated Source and Destination IP/Port
- Fully Duplicated Source and Destination IP/Port Provided to “Investor B” by “Broker A”
- Multi-Million-Message Two-Way TCP Handshake; 1 GW Server No Longer Available
- Conclusion:
  - PCAPs Showed RST From “Investor B” Followed by GW Activity for 14.1 Seconds
  - Exchange Admits Automated Actions Responsible for GW Commanded Shutdown
  - Regulator Apologizes to “Investor B”
  - Regulator Requires Multi-Component Remediation Plan from “Broker A” and “Exchange A”

Quantitative Trading Correlation Optimization

intel partner alliance

- Often, A Specific Security is Tradable on Different Venues at the Same Time
- Often, Related and Non-Related Securities Trade in Ways Correlated to Each Other
- Correlation Reflects Relation Not Necessarily Causation
- Identifying & Seizing Opportunities:
  - Granular Timestamps Empower Nuanced Analysis, Back-Testing, & Opportunity Identification
  - Comparing Index, Bond, or Single-Name Futures or ETF's to their Underlying Constituents and Identifying Those Trading at a Premium or a Discount Relative to Others or Those Trading According to, or in Defiance of, Short-Term, Mid-Term, or Long-Term Historical Relationships Represent Attractive Opportunities.

LMS
LIQUID MARKETS SOLUTIONS
The Power of the Possible™

intel partner alliance

Thank You

lets.talk@liquid-markets.com

CH: +41-79-877-6185 | US: +1-978-273-7990 | JP: +81-50-5539-9608 | UK: +44-20-8144-3329