TIME IS MONEY

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London is the fintech capital of the world and has led technology innovation for the global markets for decades. In 2022 alone, fintech firms raised $9.7B of investment [1], more than any city globally. Time is historically associated with London and since the markets first started trading, early access to information and minimising the time (latency) to receive this information has always been a driver to success. Time really is money.

Over the past few decades, there's been a transition from open outcry to electronic trading in the markets, and specifically, high-frequency trading, where electronic systems conduct hundreds of thousands of trades every second. This form of high volume, high-rate trading, requires traders to operate very fast computing systems co-located in the same data centre halls as the stock exchange to rapidly respond to changes in the market.

Accessing market information early is key to successful trading strategies. To minimise the time taken between accessing market information and performing a transaction, market participants have driven the development of low-latency infrastructure to reduce the delay in transferring data. This race to zero latency is sought after [2] as the quest for alpha (highest returns above the benchmark), incurs significant investment to maintain market advantage.

Underpinning the markets is time, an invisible utility, synchronising the digital infrastructure, supporting trading algorithm development through accurate timestamps, enabling vast amounts of data to be transferred intra and inter markets between participants at high data rates, providing the measurement basis by which low latency infrastructure is managed and operated, and supporting the regulators to ensure market clarity, detect potential market anomalies and fraudulent activity, and conduct robust forensics in the event of a market crash.

BACKGROUND

The May 2010 flash crash, when the US equity market dropped by 600 points in 5 minutes, eliminated approximately US$800B of value, and then regained almost all the losses within 30 minutes, severely eroded market confidence. In response, Sir John Beddington commissioned a report [3], which recommended the implementation of high-accuracy traceable timestamps for high frequency trading and highlighted the role of standards.

Regulators face challenges assessing potential market abuse and fraud due to data from multiple exchanges having offsets in time, or grey areas where multiple events had the same timestamp. Accurate timestamps are key to market clarity, understanding the order of events and forensics. Timing underpins the digital infrastructure the sector depends on, for operational use, but also for high precision synchronisation of local trading infrastructures to leverage small differences in the price of instruments.

Most access time from Global Navigation Satellite Systems (GNSS) such as the US' Global Positioning System (GPS). Although primarily known for the positioning and navigation capabilities, it is not widely known that they are used across our digital infrastructure for time. The signals these satellite constellations broadcast are primarily timing signals.

However, significant challenges are faced including disruption and denial of the weak signals from space, lack of roof access for antennas, multipath errors in built up environments, sparsity of skillsets to implement and operate systems, lack of calibration and monitoring inconsistencies, resulting in discrepancies in time between market participants and venues, negative latencies, reversed orders of execution, and infrastructure failures due to loss of sync. The varying implementations across trading architectures, can result in discrepancies across market participants and venues, resulting in a similar problem the UK faced with the Victorian railways, no one had the same time, except now, not at the minute level, but at the tens of microseconds.

Having a common time is critical to stable digital infrastructures (synchronisation), exchange of information, reporting and to determine causality. The global reference time scale, Coordinated Universal Time (UTC), is the basis of civilian time across the world. The concept of traceability for time, requires an unbroken chain of comparisons, from the point of generation of the timestamp or synchronisation of a clock, back through the network and systems, to the global reference. UTC is calculated based on data submissions from around 500 atomic clocks from 80 national timing laboratories across the world, the real-time realisation of UTC being the time scales at the laboratories themselves. In the UK, the National Physical Laboratory (NPL), as the UK's National Metrology Institute, manages the national time scale, UTC(NPL), and disseminates it to the UK.

"NPL's support was instrumental in the development of the Regulatory Technical Standards on clock synchronisation (RTS 25), which were essential to ensure a consistent approach to recording precisely when market transactions happen. We were able to leverage NPL's technical expertise and their practical experience in implementing high-precision business clocks for use in the financial industry.

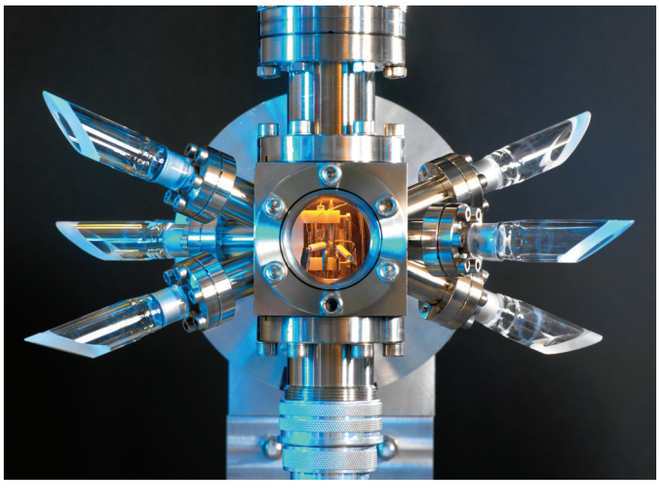
Makoto Seta, Trading Conduct and Settlement Policy, Financial Conduct Authority (FCA)

THE DEVELOPING REGULATORY LANDSCAPE

Working closely with the UK's Financial Conduct Authority (FCA) and the European Securities and Markets Authority, NPL helped develop a new Regulatory Technical Standard for timestamp traceability for reportable events across the European financial sector, ensuring market achievability, and delivering benefits to market clarity and forensics. The standard is structured to allow ease of iteration to more stringent requirements as the markets develop.

The Markets in Financial Instruments Directive II (MiFID II) went live on 3rd January 2018, and for the first time, timestamp accuracy, traceable to UTC, was mandated for trading in Europe[4]. The most stringent requirement in the new regulatory technical standard, RTS25, requires high frequency trading reportable events to be accurate to 100µs (100 microseconds, 100 millionths of a second), traceable to UTC.

NPL engaged with international finance regulators to raise awareness of the importance of UTC traceability and the development in the UK. Further discussion with the international regulatory bodies through IOSCO, has resulted in a formal recommendation that global markets use UTC as the reference for all timestamps across markets[5].



The next generation of atomic clocks at NPL, using laser cooled trapped ions or atoms, should achieve accuracies around 100 times better – equivalent to gaining or losing no more than one second in the age of the universe

A NEW DIGITAL TIMING SERVICE

NPL developed a new time service, NPL*Time*®, delivering high precision, traceable time to the trading system, monitored at the user, within 1µs (1 microsecond) of the global time scale UTC. This is the first time, globally, a reference standard has been delivered digitally to the point of need, monitored at the end user for accuracy and provided with service levels for accuracy to UTC, availability and certification for traceability.

THE FUTURE OF TIME

New applications such as distributed ledger technologies[6], enhanced solutions for algorithm optimisation and playback, cross market and cross venue data aggregation and tick warehousing, new infrastructures such as trading platforms, low latency networks (trans-oceanic and terrestrial) based on microwave links and hollow core fibre networks, all have increasing demands on time and timing for instrumentation, metrology and timestamp traceability. Data rates and

volumes are increasing, and the underpinning timing capabilities need to cope with performance demand. The current Ukraine crisis has highlighted the vulnerability and threat to weak satellite signals, with the potential for disruption and long-term outages affecting business continuity, market confidence and public trust.

Regular failures in financial sector IT infrastructures have driven regulatory bodies to place strong emphasis on operational resilience, extended to third party services such as cloud services. The European Union's Digital Operational Resilience Act (DORA)[7] (coming into effect in late 2024) and the UK regulatory bodies' rules[8] on operational resilience (coming into effect by March 2025), are starting to address operational resilience standards to ensure stable market operation.

Through NPL's National Timing Centre programme we're developing a national timing infrastructure to provide a resilient alternative to GNSS. London as the historical datum for time, and the fintech capital of the world, has certainly been ahead of its time with technology, now extending UK leadership through resilient and traceable time, providing a new layer of trust for the future.

The race to zero and the quest for alpha continues…

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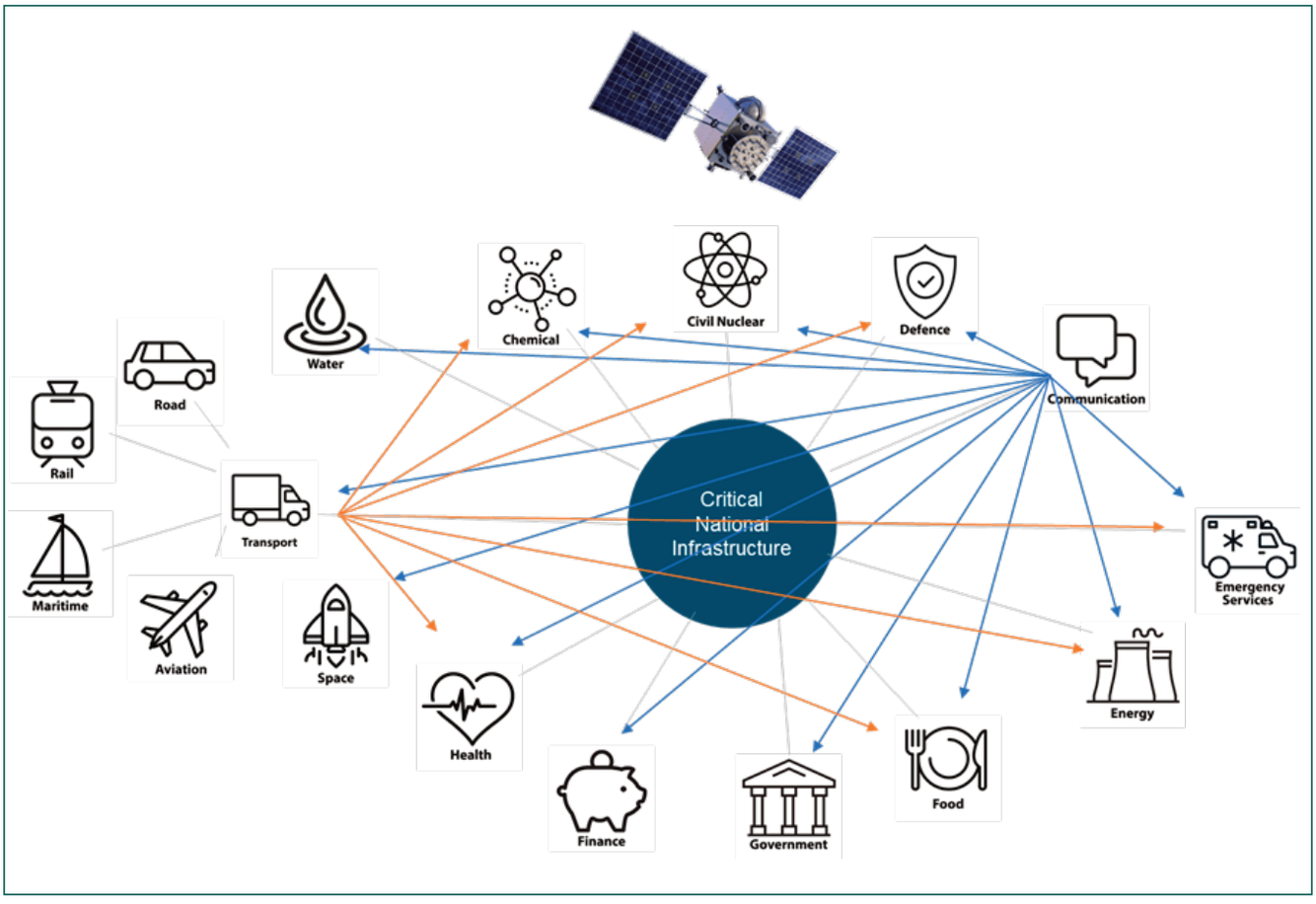

Critical national infrastructure describes the resources, systems, processes, and facilities that keep society and the economy functioning, from generating electricity and transmitting it around the country, to producing and transporting food in agricultural supply chains. The communications networks and transport systems that underpin so many other sectors are heavily reliant on GNSS.