Webinar Series Introduction and NTC Overview, Leon Lobo, NPL

Q: How can industry and academia engage on the NTC programme?

A: We are keen to ensure the NTC outcomes are relevant, so please do engage. You can register for upcoming events and status updates at www.npl.co.uk/ntc, or get in touch directly at ntc@npl.co.uk.

Q: Why is the NTC important to the UK?

A: Putting aside the rapidly evolving threat landscape affecting our current sources of time, the opportunity for the UK with the NTC will be significant – leadership in trusted time for our infrastructures, development of a supply chain, enabling industry and academia with the requisite skillsets, and a resilient capability for the future.

Q: What is the business model for NPL to work with industry in terms of dissemination of NPLTime service?

A: NPL are keen to engage with potential service providers across sectors, to deliver commercial services. These models will be developed over the programme. Please do get in touch to discuss.

Q: Would a significant reduction in the cost of White Rabbit technology resolve many timing challenges?

A: Not necessarily. WR offers enhanced sync levels (to the ns) but still requires DWDM or dark fibre. It will benefit applications that require better than PTP level sync. [Second reply from Mike Gilson] We may well find some of the WR capabilities finding their way back into the general technology used.

Q: How far has quantum technology been used for timing and secure connections?

A: The clocks used in national time scales are primarily quantum devices. In fact the first accurate atomic clock, based on the Cs atom, was developed at NPL back in 1955. Several types of devices are now commercially available, based on Cs and Rb, as well as hydrogen masers. These are also used in industry (Cs and Rb typically). Quantum Key Distribution is a rapidly evolving capability for secure connections.

Q: Do you think that time service such NPL*Time*® could enable a remote and traceable calibration service for industry such as a 10MHz-signal? Gain: this would avoid carrying around equipment for calibration

A: The NTC programme will be covering both time and frequency distribution. *In situ* calibration is an application that we are keen to address.

Q: There seems to be a future need for very good clocks, in fairly high numbers. Can the supply network support the forecast demands?

A: The National Quantum Technology Programme in the UK is certainly cognisant of this need, with industry now starting to develop low SWaP clocks to service this need.

Q: Current timing setups are quite complicated and difficult as well as bulky, when can we expect better solutions?

A: The innovation objective as part of the National Timing Centre programme will help industry develop new products and services that will start to address this challenge. In addition, the development and delivery of training courses and degree modules will support the skills shortage in this area of time, frequency and synchronisation. The first innovation call is planned for Q1 2021, and a training blueprint is being finalised now, so we should see outcomes from these in the next year or so. Please do keep engaged and for visibility as these progress.

Talk 2: History of Time and Frequency in Telecoms, Mike Gilson, BT

Q: What do you see as the key benefit to very high-performance atomic clocks in telecoms networks?

A: I think maintaining the time base at the very core of the network to minimise drift. Also, as smaller form factor devices become available allows us to look at new architectures

Q: What do you see as the killer application for timing? *(see link to download for more comments)*

A: Trying to determine a killer application is dangerous and may well result in getting it wrong. Building the timing capability and certainty that brings will i am sure result in many new and exciting applications being developed.

Q: For telecom network synchronization and the synchronization between the UE and the network, what are the different techno you (or in general 5G standards) are foreseen to be adopted?

A: In the telecom network we use SyncE+PTP to distribute down through the network.

Talk 3: Global Time Scales and Timing Dissemination, Setnam Shemar, NPL

Q: You mentioned clock comparisons are carried out between about 80 national timing labs around the world in order to produce UTC. How are the clock comparisons done?

A: GPS time transfer methods are commonly used to compare clocks between labs, but Two-way satellite time and frequency transfer is also sometimes used and this is a bit more accurate, and also resilient of GNSS disruption or failure.

Q: When creating a fibre based resilient time network, do you see the need to provide in-service monitoring and attack detection?

A: These are all really good points, and all being looked at carefully. Continual monitoring will be done of all our clocks.

Q: What about eLoran technology for timing distribution within UK? Is that also considered for timing resiliency?

A: This is a rapidly evolving discussion globally. The NTC could certainly provide the resilient source of time to eLoran infrastructure for UTC traceability.

Q: Why does the UK's national time scale need a physical 'time-point'?

A: Hardware time delays mean that you have to access the time from your time scale at a defined point in your system.

Q: How do you see UTC improving in the future?

A: Presently, the stability of UTC is of order 1 part in 10^{17} over time scales of years, in future optical clocks will contribute more and more to the generation of international atomic time and improve its stability further.
Q: Excellent presentation - what is an acceptable daily drift rate for a Cs clock contributing data to the BIPM?

A: For a commercial portable Cs clock, the drift is of order 1 ns per day.

Q: Will White Rabbit have an impact on industrial applications? Which ones?

A: The finance sector can take advantage from the sub-nanosecond timestamping available with White Rabbit, which is already in use at Deutsche Boerse, Frankfurt. Other sectors that will benefit from this high-performance timing and synchronisation technology include Energy and smart grids, Telecommunications and Space industries.

Talk 3: Testing Time for 5G, Tim Frost, Calnex

Q: What clock reference would you recommend for mobile timing? GPS, Galileo or a national UTC realization?

A: GNSS is used as the most convenient source of time, but a national UTC reference would certainly be usable. The main issue at present is getting access to it, something the NTC should help with making it more available.

Q: Why is time synchronisation a problem now for 5G when it wasn't for 4G?

A: 5G is a TDD (Time Division Duplexing) system and requires accurate timing to operate correctly. 4G was (in most deployments at least) FDD (Frequency Division Duplexing) and hence required accurate frequency but not time. Also, see presentation from Matt Baker on the additional facilities planned for 5G for time-sensitive networking, and delivering time as a service to enable new opportunities. These were not available in 4G.

Talk 4: Timing and Synchronisation in 5G, Matthew Baker, Nokia

Q: How would the NTC clock signal connect to a 5G network?

A: The NTC clock signal would be distributed by fibre to a number of points around the country, which could then be connected to the 5G network to control the timing of a number of base stations within a PTP domain.

Q: Why is 5G better than 4G for synchronisation and timing distribution?

A: Firstly, 5G is fundamentally designed to support much lower latency over the air than 4G, which makes it more naturally able to support tight timing synchronisation. Secondly, unlike 4G, the features I described to support wireless time synchronisation are designed in to the 5G standard.

Talk 5: Optical channel timing, Nir Laufer, ADVA

Q: Is this technology already released and available for use?

A: Yes, this technology is already released and available. The OTC is supported with ADVA WDM and the high accuracy boundary clocks (type D) and ePRTC (including the Caesium clocks and the PTP GM) with Oscilloquartz timing devices.
Q: What effect would fibre and the change in refractive index this enforces have on the timing accuracy if we are down in the nanoseconds?

A: Since PTP is a two-way time transfer protocol it is less affected by the delay itself (e.g. the delay caused by fibre thermic expansion) and more sensitive to asymmetry. By using single fibre for both directions, we ensure the effect on the delay on both directions will be the same and therefore no significant asymmetry is expected by thermic expansion.
Change in refractive index may lead to small variations which depends on the cable length and the fibre type. If the change is affecting both receive and transmit wavelength in similar way, this might change the delay but will not create significant asymmetry.

Q: How can redundancy be achieved with OTC (Optical Timing Channel)?

A: The OTC is using a single fibre, therefore fully redundant architecture can be achieved with two fibres – each fibre is running an independent OTC. In the ePRTC core sites, the ePRTC itself needs to support full HW redundancy of all modules to avoid single point of failure.
In the aggregation sites the BC's also need to be fully redundant, each of the BC needs to be connected to one of the two OTC's

Q: Do you have plans to implement White Rabbit or its recently standardized flavour? What's your position on White Rabbit as an equipment manufacturer?

A: The White Rabbit is very interesting technology however it was developed for a very specific applications, it requires a very dedicated and calibrated HW which makes it challenging for mass deployment at reasonable cost. When used over long distance WDM networks it typically requires calibration of the asymmetry during installation. Such calibration can be done by using GNSS references on both sides of the link, but this approach will reduce the achieved accuracy and may not be relevant when changes are made in the network.
With latest specification from ITU-T which are based on the "standard" IEEE 1588, the best clocks can achieve sub 5nsec over single link (e.g. ITU-T G.8273.2 BC type D) so it's still questionable if improving the accuracy from 5nsec to sub 1nsec is needed for most of the existing applications and if such investments can be justified commercially .

Q: What is the difference between the proposed solution and White Rabbit?

A: The OTC do not require calibration of the link asymmetry during installation (e.g. by using GNSS references on both sides). In addition, the solution is based on standard ITU-T profiles. We also provide full solution from single vendor (ePRTC at the core, OTC for delivery, High accuracy BC at aggregation sites, network management system) which guarantee interoperability and that the expected performance objectives are achieved.

Talk 6: Mitigating satellite-derived time vulnerabilities, John Pottle, Royal Institute of Navigation

Q: In the context of multi-constellation multi-frequency GNSS (i.e., approx. 120 satellites broadcasting on at least 3 different frequencies) how serious is the threat of a successful spoofing attack? would be appreciated if each member of this panel weigh in. Thank you

A: The answer depends on how the GNSS receiver works - for example receivers deriving a fix from GPS only first would tend to be more vulnerable. Even with multi-GNSS a spoof on one constellation can affect all the position information accuracy. It is true to say that adding constellations improves spoofing resilience if the receiver treats all constellations equally. Similarly, it is true to say that it's more difficult to spoof, and indeed to jam, multi-frequency GNSS systems.

Q: How much does it help to use GLONASS or Galileo alongside GPS?

A: This is a good question. Unfortunately, the answer is "it depends". The primary benefit of additional GNSS systems is that there are more satellites in view and, as such, more satellites are visible in restricted view situations (e.g. in cities). This improves continuity of a valid fix even if, say, fewer than 4 GPS satellites are visible as the receiver will bring in a satellite from other constellations. Most receivers do not take separate GPS, Galileo and GLONASS fixes, so it's not possible to compare a position from each constellation and look for out-of-range values, which would indicate a problem. Some receivers are more "intelligent" than others and will look for out-of-range "raw" measurements or power level per signal, discarding suspect signals (look up "GPS RAIM" as an example technique). So, this can help. A related, very interesting, question is accuracy. GPS is generally more accurate than GLONASS. So, adding GLONASS ranging sources currently would actually tend to degrade accuracy. Having said all this, multi-frequency and multi-GNSS receivers are generally a good thing in a system design – just don't expect that this will solve for all vulnerabilities, it's not that simple I'm afraid!

Q: What is the process to calibrate a GNSS receiver?

A: A GNSS receiver's precision comes from the navigation message information which is typically downloaded by the receiver from the signals from the satellites, although so-called "assistance data" can be received terrestrially too. Correction or integrity messages from, for example, differential reference stations of from space-based augmentation systems (EGNOS in Europe) also provide enhanced precision to the receiver. To assess the accuracy of a receiver, controlled laboratory testing is possible where "truth" signals are generated for a given scenario (e.g. location) and the reported position accuracy can be measured against the "truth". It's also important to note in this context that GNSS receivers work in a stochastic way. In practice this means that 100 fixes with identical signal conditions will result in a range of positions depending on the exact way in which the receiver correlates with the transmitted signals. In summary, though, GNSS receivers don't need regular calibration.

Q: How easy is it to set up a test for spoofing or jamming of GPS?

A: It's easy as long as you have the right equipment. Testing can be "live sky" and outdoors, but in practice this is not advisable as GPS jammer / spoofer use is not legal in most places. It is therefore advisable to test in the laboratory using simulated GPS signals along with jammer/spoofer signals. The signals can either be transmitted in a RF chamber or using a coaxial cable. Lab testing is also controlled and repeatable, adding to the merit of this approach. Test equipment can be purchased, or some specialist companies offer a test consulting service using their equipment to test customer's devices.