Technical Annex: Innovation in Time Resilience, Dissemination and Application

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This annex outlines the NPL facilities and capabilities offered as part of the Innovate UK competition: Innovation in Time Resilience, Dissemination and Application. At the end of this document are the forms which applicants must submit if they wish to request NPL consultancy or access to timing signals and facilities during their project.

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Note: Forms in section 4 are required for access to consultancy and/or signal and facility access.

Table of Abbreviations

The following abbreviations are used in this document:

3GPP	3rd Generation Partnership Project
5GIC	5G Innovation Centre, University of Surrey
5GNR	5G New Radio
ADEV	Allan deviation
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPSDO	GPS-disciplined oscillator
IEEE	Institute of Electrical and Electronics Engineers
LTE	Long-term evolution
NOC	Network Operations Centre
NPL	National Physical Laboratory
PPS	Pulse per second
PTP	Precision Time Protocol
R&D	Research & development
SDR	Software-defined radio
T&F	Time & Frequency
TDD	Time Division Duplex
UAV	Unmanned aerial vehicle
UTC(NPL)	Physical realisation of Coordinated Universal Time maintained by NPL
WR-PTP	White Rabbit Precision Time Protocol

1. Introduction

This annex outlines the NPL facilities and capabilities offered as part of the Innovate UK competition: Innovation in Time Resilience, Dissemination and Application. The offer for successful competition applicants includes facilities and expertise for device characterisation, provision of highly accurate and traceable time and frequency reference signals, and up to 12 hours of free NPL consultancy support.

The overall aim of the support is to enable innovation, create links with industry, and stimulate the time and frequency (T&F) ecosystem in the UK.

Access to facilities, T&F signals and support will be free of charge, unless otherwise indicated.

If you require access to consultancy or test facilities, you must:

1. *Complete and submit the forms at the end of this NPL technical annex by e-mail to support@iuk.ukri.org at least 10 working days before the submission deadline. This is to ensure NPL can accommodate your request and provide feedback if necessary.*
2. *Upload the finalised NPL technical annex forms as part of your application.*

The forms which applicants must submit to request access to the facilities and capabilities as part of their application, are located at the end of this document.

Test & evaluation facilities and capabilities are expected to be of interest to those testing their own T&F products and services, or for validation of third-party supplied T&F products and services.

Representative examples of typical characterisation activities, time and frequency reference signal provision and consultancy envisaged under this competition could include:

Typical / representative scope	**Notes**
Synchronisation of devices to UTC(NPL)	• packet based IEEE 1588 Precision Time Protocol (PTP) or White Rabbit (WR-PTP) • signals delivered via optical fibre
Bespoke device / component performance characterisation against UTC(NPL)*	• access to laboratory facilities • time (1 PPS) and frequency (10 MHz, 100 MHz) signals delivered via coaxial cable or optical fibre, depending on location • characterisation conducted by the applicant, by NPL, or a combination of both
Technical advice / consultancy	• up to 12 hours (per project) of free consultancy and support from NPL's T&F experts • can be provided remotely or on-site (as appropriate) • covering a wide spectrum of T&F expertise

***** This could include a diverse range of T&F devices and components such as oscillators, clocks, filters and custom hardware.

The access will come from four sites in the South East of England and one site in Scotland. Each site has different types of signals and support facilities available. This will allow a variety of different projects with individual requirements to access facilities which can support their innovation.

The sites are in two broad categories:

Innovation nodes

The innovation nodes are sites that combine signal access with laboratory space and where traceable signals are available for R&D, testing and validation of applications. Three innovation nodes are being set up in partnership between NPL and respective host organisations and are available to successful applicants during their project:

1. The University of Surrey 5G/6G Innovation Centre provides access to a shared lab and is particularly suitable for telecommunications and network timing projects.
2. Cranfield University provides access to a shared lab and is particularly suitable for autonomy and transport related projects (to be available by March 2023).
3. The University of Strathclyde provides access to a dedicated lab and is particularly suitable for developments related to photonics, smart grids and fintech (to be available by March 2023).

Data centres

Two data centres in London and Reading allow signal connections via a cross-connect in a real-world delivery environment.

Summary of the facilities and capabilities per location:

Location	Summary of test & Evaluation capabilities
5GIC (Guildford / University of Surrey)	• laboratory / R&D environment (supervised access) • access to 1 PPS, 10 MHz and WR-PTP signals • access to a range of basic test & measurement hardware • access to 5GIC testbed • technical support (T&F and 5GIC)
Cranfield University (Milton Keynes)	• laboratory / R&D environment (supervised access) • access to 1 PPS, 10 MHz and 100 MHz signals • access to a range of basic test & measurement hardware • technical support (T&F)
University of Strathclyde (Glasgow)	• laboratory / R&D environment (supervised access) • access to 1 PPS and 10 MHz signals • access to a range of basic test & measurement hardware • technical support (T&F)
Telehouse (London)	• commercial, operational data-centre environment (no access to on-site laboratory or R&D facilities) • access to PTP signal via cross-connect / meet-me room if applicant has presence in Telehouse or via a Service Provider with Telehouse presence
Daisy (Reading)	• commercial, operational data-centre environment (no access to on-site laboratory or R&D facilities) • access to PTP signal via cross-connect / meet-me room if applicant has presence in Daisy or via a Service Provider with Daisy presence

Summary by location					
T&F signal or service	**5GIC**	**Telehouse**	**Daisy**	**Cranfield**	**Strathclyde**
1 PPS and 10 MHz signals traceable to UTC(NPL)	✓			✓	✓
100 MHz signals traceable to UTC(NPL)				✓	
PTP		✓*	✓*	✓	
White Rabbit (WR-PTP)	✓				
Supervised laboratory access	✓			✓	✓
5GIC Testbed	✓				

*Point of presence at data centre required. Cross-connect required. Will involve additional cost for the applicant.

2. Access Locations

2.1 Innovation Nodes

2.1.1 5GIC (Guildford)

If required, projects can access high-quality T&F signals at the University of Surrey as well as the 5G testbed at the 5G Innovation Centre (5GIC). This facility is already in place and will be available from October 2022 for use in either feasibility or demonstrator projects.

Supervised laboratory access can be arranged to install equipment and connect to high-quality time & frequency signals simulating the operation of a time distribution node.

1 PPS, 10 MHz

Users can connect to 1 PPS and 10 MHz signals from the UK's National Time Scale UTC(NPL). Traceability to UTC(NPL) is provisioned through a White Rabbit fibre link from NPL Teddington. 1 PPS and 10 MHz outputs are available to users over coaxial cable.

1 PPS signal specification	**Surrey 5GIC**
Amplitude	3 V
Rise time	5 ns
Pulse duration	20 ms

Table 1: Expected 1 PPS signal specification (based on experimental data).

10 MHz signal specification	**Surrey 5GIC**
ADEV at: 10 s 100 s 1000 s	 2.6e-12 2.4e-13 2.0e-14

Table 2: Expected 10 MHz signal specification (based on experimental data).

White Rabbit PTP

A White Rabbit PTP feed, offering sub-nanosecond stability, is also available to endpoint devices via an optical fibre link. Traceability to UTC(NPL) is provisioned through a White Rabbit fibre link to NPL Teddington.

5GIC testbed

The University of Surrey's 5G Innovation Centre houses a live testbed which allows testing of technologies in a realistic situation. Both industry and academic teams can have access to this testbed, which includes:

- 5G core, 3GPP Release 15 and Release 16
- Edge computing radio access at 60 GHz
- 700 MHz SDR
- 2.6 & 3.5 TDD (LTE and 5GNR respectively)
- 26 GHz beam former (in the laboratory)
- UAV popup network
- Connected Vehicles

The 5GIC testbed covers 4 km^2 around the University of Surrey campus and consists of three macro cells and 56 small cells, with a combination of LTE and 5GNR. A cluster 5GIC exchange hub can provide brokerage between testbeds to enable dedicated end-to-end sliceable services and

virtualised context-aware core network interconnection between network services. The testbed is managed by Network Operation Centres (NOCs).

Applicants wishing to make use of the 5GIC testbed must discuss their requirements with the 5GIC before submitting their proposal.

2.1.2 Cranfield University

If required, projects can access high-quality T&F signals at Cranfield University. This facility is being established in partnership between NPL and Cranfield, and will consist of an area housing the time source within an existing laboratory. Capital equipment purchases and a fibre lease are currently being planned and are scheduled to take place during 2022. The laboratory will be set up and accessible by March 2023. Any prospective bidders are asked to contact NPL for the most up to date information regarding timescales.

Supervised laboratory access will be arranged to install equipment and enable connection to high-quality time & frequency signals simulating the operation of a time distribution node.

1 PPS, 10 MHz, 100 MHz

Users can connect to 1 PPS and 10 MHz signals from the UK's National Time Scale UTC(NPL). Traceability to UTC(NPL) is planned to be provisioned through a PTP fibre link from NPL Teddington. 1 PPS, 10 MHz and 100 MHz outputs are available to users over coaxial cable.

1 PPS signal specification	**Cranfield University**
Amplitude	≥2.5 V
Pulse duration	20 µs

Table 3: Expected 1 PPS signal specification (based on manufacturer's equipment specification).

10 MHz signal specification	**Cranfield University**
ADEV at: 1 s	<2.0e-12

Table 4: Expected 10 MHz signal specification (based on manufacturer's equipment specification).

100 MHz signal specification	**Cranfield University**
ADEV at: 1 s	5.0e-13

Table 5: Expected 100 MHz signal specification (based on manufacturer's equipment specification).

2.1.3 University of Strathclyde

If required, projects can access high-quality T&F signals at University of Strathclyde. This facility is being established in partnership between NPL and Strathclyde, and will consist of a 50 m^2 dedicated laboratory space. Building works are required to prepare this laboratory, which are scheduled to take place during 2022. The laboratory will be available by March 2023. Any prospective bidders are asked to contact NPL for the most up to date information regarding timescales.

Supervised laboratory access will be arranged to install equipment and enable connection to high-quality time & frequency signals simulating the operation of a time distribution node.

1 PPS, 10 MHz

Users can connect to 1 PPS and 10 MHz signals from the UK's National Time Scale UTC(NPL). Traceability to UTC(NPL) is provisioned through a calibrated common view GNSS link from NPL Teddington. 1 PPS and 10 MHz outputs are available to users over coaxial cable.

1 PPS signal specification	**University of Strathclyde**
Amplitude	≥2.4 V
Rise time	5 ns
Pulse duration	20 µs

Table 6: Expected 1 PPS signal specification (based on manufacturer's equipment specification).

10 MHz signal specification	**University of Strathclyde**
ADEV at: 10 s 100 s 1000 s	 8.5e-12 2.7e-12 8.5e-13

Table 7: Expected 10 MHz signal specification (based on manufacturer's equipment specification).

2.2 Data Centres

2.2.1 Telehouse (London)

A PTP signal is available at Telehouse data centre, with traceability to UTC(NPL) provided via a fibre link from NPL Teddington.

Telehouse is a commercial data centre, and as such does not provide R&D laboratory facilities. Access to the PTP signal can be provided from NPL's rack via a cross-connect (or meet-me room connection) to other racks within this facility. The PTP signal can be disseminated externally via existing fibre service providers if the applicant does not have direct access to Telehouse. NPL will be able to provide further support and guidance, and if required can help to configure timeserver devices.

2.2.2 Daisy (Reading)

A PTP signal is available at Daisy data centre, with traceability to UTC(NPL) provided via a fibre link from NPL Teddington.

Daisy is a commercial data centre, and as such does not provide R&D laboratory facilities. Access to the PTP signal can be provided from NPL's rack via a cross-connect (or meet-me room connection) to other racks within this facility. The PTP signal can be disseminated externally via existing fibre service providers if the applicant does not have direct access to Daisy. NPL will be able to provide further support and guidance, and if required can help to configure timeserver devices.

3. Technical consultancy

Up to 12 hours of free technical consultancy from NPL's T&F experts is also available to successful applicants. This consultancy can be delivered remotely or at the relevant facility. It must be directly relevant to the project scope.

4. Request forms: for access to facilities and expertise

This section contains the relevant forms to be completed by the applicant and submitted as an appendix to the application if access is required to any of the facilities, or if characterisation of equipment or consultancy is required.

If you require access to consultancy or test facilities, you must:

1. *Complete and submit the forms at the end of this NPL technical annex by e-mail to support@iuk.ukri.org at least 10 working days before the submission deadline. This is to ensure NPL can accommodate your request and provide feedback if necessary.*
2. *Upload the finalised NPL technical annex forms as part of your application.*

For an editable Word version of the forms, please click here.

Request Form	***Complete this form if….***
Signal and facility access	*You want to access to signals or any of the test & evaluation facilities / capabilities described in this document*
Consultancy	*You would like to receive up to 12 hours of project support from NPL*

NPL will review your test & evaluation requirements and reserve the right to request further information, or to suggest alternative ways of achieving an equivalent result.

If NPL cannot service an applicant's requirement, we will advise fully and promptly.

Funded projects will be expected to formalise arrangements with the relevant providers of facilities and capabilities on confirmation of their funding. This is likely to involve an access agreement, and confirmation of adherence to site access procedures.

4.1 Request for signal and facility access

This form (link to editable Word version) must be completed and submitted as detailed above if the applicant wishes to request access to signals or test and evaluation facilities during their project. This form is intended to capture high level information in order for NPL to try and accommodate the request. We may need to ask for additional information after the initial engagement. Desired dates entered below are subject to confirmation.

Request for signal and facility access	
Name and company of lead applicant	
Project summary (2-3 sentences)	
Preferred location (please refer to the summary table of T&E availability when making selection)	☐5GIC (Guildford) ☐Cranfield (Milton Keynes) ☐Strathclyde (Glasgow) ☐Telehouse (London)* ☐Daisy (Reading) * *Existing point of presence required
Short description of signal and/or facility access being requested	
Desired duration of access	
Desired start date of access	
Desired end date of access	
Any other information which will help us understand your needs	

4.2 Request for technical consultancy

This form (link to editable Word version) must be completed if the applicant would like to receive up to 12 hours NPL consultancy offered in support of the competition.

Request for Consultancy Support	
Name and company of lead applicant	
Project summary (2-3 sentences)	
Description of consultancy requested	
Specific areas of expertise requested	
Description of desired output (*e.g.* report, meeting summary)	
Timeline for consultancy	
Any other information or requests which will help us understand your needs	

Appendix: Supporting links

NPL	http://www.npl.co.uk/
National Timing Centre programme	https://www.npl.co.uk/ntc
5GIC (Guildford)	https://www.surrey.ac.uk/institute-communication-systems/5g-innovation-centre
Telehouse (London)	https://www.telehouse.net/data-centre-services/uk/london/telehouse-north
Daisy (Reading)	https://daisycomms.co.uk
Cranfield University (Milton Keynes)	https://www.cranfield.ac.uk/
University of Strathclyde (Glasgow)	https://www.strath.ac.uk/