HORIZON 2020

Terahertz based Ultra High Bandwidth Wireless Access Networks

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Revisions

Version	Date	Author	Organisation	Details
0.0	23/01/2019	Niamh O'Mahony	DER	Proposed table of contents.
0.1	18/03/2019	Niamh O'Mahony	DER	Content with provisional requirements tables.
0.2	19/04/2019	Niamh O'Mahony and all partners	DER and all partners	Final requirements tables. All sections complete.
0.3	29/04/2019	Alan Davy	TSSG	Final Internal Review
0.4	30/04/2019	Niamh O'Mahony	DER	Final document for submission.

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Executive summary

The Revised Requirements and Scenario Specifications form the basis for the continued technology development that will be carried out by the TERAPOD project. It updates the motivating scenarios in which the technical outputs of the project will be deployed and reviews the framework for ensuring that the technology artefacts produced by the project will meet the needs of their eventual end users. The requirements and scenarios will be iteratively revised once more before the end of the project.

In this document, the four use cases which were described in D2.1 are revised, based on engagement with stakeholders and lessons learned from project efforts to date. These four use cases are:

- TERAPOD-UC-01: Commercial Feasibility of THz DC Wireless Networks
- TERAPOD-UC-02A: Static (Layer-1) THz Wireless Data Links
- TERAPOD-UC-02B: Dynamic (Multi-Layer) THz Wireless Data Link Integration
- TERAPOD-UC-03: Wireless Data Centre Auto-Configuration

These requirements are described in detail, underpinning the technology development efforts for the TERAPOD project. Each use case will continue to be refined and revised throughout the lifetime of the project, in order to ensure that the project produces technology for which deployment within a data centre environment is both technically viable and commercially feasible.

1 Introduction

1.1 Summary

This deliverable presents the Revised Requirements and Scenario Specifications for the TERAPOD project. It describes the activities undertaken to review and revise the requirements. The requirements are presented in clear and concise tables, including both functional and non-functional requirements, with alignment to TERAPOD technology components and the responsible partner(s) assigned to each. Requirements related to standardisation and to test and validation activities are also described.

1.2 Structure of this document

This document is laid out as follows:

- Section 1 provides an introduction to the deliverable, including its relationship with other TERAPOD deliverables and the partners who have contributed to the text.
- Section 2 provides an overview of the activities undertaken to revise the use cases and requirements, along with an overview of each use case and the relevant updates.
- Section 3 describes the detailed requirements for TERAPOD, structured according to functional, non-functional, standardisation and test/validation requirements.
- Finally, Section 4 provides conclusions and a summary of the next steps.

1.3 Relationships with other deliverables

The requirements presented in this document relate to the following deliverables:

- D2.1: this deliverable contains the initial use case specifications and requirements, which form the basis for those in this document.
- D2.3: this future deliverable will contain progressively more mature requirements and use case specifications than those presented in this document, following the same methodology and structure outlined in the current deliverable.

1.4 Contributors

The following partners have contributed to this deliverable:

- DER (Niamh O'Mahony, Sean Ahearne)
- TUBS (Johannes Eckhardt, Thomas Kürner)
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2 Revised Scenario Specifications and Identification of Requirements

Building on the initial requirements that were outlined in D2.1, this deliverable revises the use case scenarios and technology requirements, with the goal of ensuring that TERAPOD technologies meet the needs of their intended market. The revisions to requirements in this iteration come mainly from two sources: (1) further engagement with stakeholders regarding use cases; and (2) lessons learned from development efforts to date.

The first step in the process of revising the requirements was to engage with stakeholders to present the work to date in TERAPOD and to gather their feedback and inputs on use cases and requirements. DER met with stakeholders from the following business units across the Dell Technologies organisation:

- Modular Data Centre (North America and Europe-based teams)
- TRIGr (Advanced Technology Research and Innovation Group) Hardware Team
- Dell EMC Industry CTOs (Telco, Finance, Healthcare, Intelligent Connected Vehicles)
- Technology Strategy Enablement (Server)
- Dell Networking Engineering

Through conversation with each of the above groups, DER gathered feedback regarding the use of TERAPOD technologies in the data centre and beyond and incorporated these into the revision of requirements, which will be listed in Section 3. Full details of these engagements are the subject of confidentiality restrictions but they will be used as inputs to a Business Model Canvas, to be reported in D7.3. A summary of the main areas of feedback from all groups are outlined below.

1. Whilst the data rates targeted by TERAPOD in D2.1 will meet the needs of the data centre today, pushing the upper limits to achieve as much data throughput as possible would be attractive for future applications (upwards of 100 Gbps if possible, with 400Gbps (aggregate) mentioned by one stakeholder).
2. Security of the THz wireless links should be addressed for applications outside of conventional data centres or for multi-tenant data centres (co-location sites).
3. Initially targeting inter-rack links with wireless THz technologies is a good place to start but there is significant interest in intra-rack ultra-high bandwidth wireless links also.
4. Data centre (DC) configurations and, hence, the need for ultra-high bandwidth wireless links will vary depending on the industry vertical for which the DC is used (e.g. retail, banking, connected vehicles, healthcare, etc.)

The next step was to assess the status of the requirements previously defined in D2.1. These requirements were tabulated and organised according to the relevant TERAPOD technology components. The functionality and specifications of the technology components developed to date were compared with the relevant requirements to determine which of the requirements from D2.1 have been achieved. Where appropriate, lessons learned from developments to date were used to modify and improve the specification of requirements.

2.1 TERAPOD use case updates

2.1.1 TERAPOD-UC01

Use Case Overview	
Use Case ID	TERAPOD-UC-01
Short name for the use case scenario	Commercial Feasibility of THz DC Wireless Networks

Descriptive full name of the use case-scenario	A thorough commercial feasibility case study of the role of THz based wireless links within data centre systems.
Goal(s)	The output will be an advanced business model canvas that has been iteratively developed and validated in collaboration with the target end user and stakeholder group.

This use case will be achieved through activities in WP2 and WP7, led by TSSG and UGLA. The requirements have not changed.

2.1.2 TERAPOD-UC02A

Use Case Overview	
Use Case ID	TERAPOD-UC-02A
Short name for the use case scenario	Static (Layer-1) THz Wireless Data Links
Descriptive full name of the use case-scenario	Integration of static THz wireless data links at the physical layer of the data centre network (DCN).
Goal(s)	Seamless integration of static THz wireless links within the DCN, with data transmission performance in the THz wireless links equalling or exceeding that in the existing wired links (i.e. whether transmission occurred through a wired or wireless link should be transparent to the rest of the system).

The goals of this use case will be achieved through the integration of THz wireless links within the data centre at Dell EMC in Cork, Ireland, and will be demonstrated in D6.5. Additional requirements were defined since the publication of D2.1, regarding the specific details of the interface between the existing data centre equipment and the THz wireless hardware. Furthermore, data traffic profiles have been defined to test the links, with varying data rates, up to and including the upper limits of the data rate requirements specified in D2.1. Feedback from WP5 allowed bit error rate (BER) requirements to be more appropriately specified, taking forward error correction into account. The measurement campaign carried out by TUBS at Dell EMC's data centre in Cork, Ireland and the benchtop demonstration by UCL helped to define the relationship between link distance and other parameters (bit error rate (BER), path attenuation, signal-to-noise ratio (SNR), power delay profile, etc.).

2.1.3 TERAPOD-UC02B

Use Case Overview	
Use Case ID	TERAPOD-UC-02B
Short name for the use case scenario	Dynamic (Multi-Layer) THz Wireless Data Link Integration
Descriptive full name of the use case-scenario	On-the-fly replacement or augmentation of wired links with THz wireless data links, integrated across multiple layers of the DCN.
Goal(s)	Reduction in congestion and/or link down-time due to the seamless provisioning of flexible THz wireless links to replace and/or augment wired links, as automatically determined by software.

The goals of this use case will be achieved through the development of appropriate scenarios to be simulated, the outcomes of which will be reported in D5.5. Additional requirements were defined since the publication of D2.1, most significantly, regarding latency, which was specified on the basis of the VMware vCenter Server High Availability Performance and Best Practices[1], which defines the maximum permissible latency to use a High Availability fail-over feature in a virtualized datacentre environment.

2.1.4 TERAPOD-UC03

Use Case Overview	
Use Case ID	TERAPOD-UC-03
Short name for the use case scenario	Wireless Data Centre Auto-Configuration
Descriptive full name of the use case-scenario	Auto-configuration of wireless networking links within a data centre, allowing flexibility, scalability and rapid deployment of replacement or additional components.
Goal(s)	Full integration of THz wireless links within the DCN, with the following features: 1. Automatic device discovery and registration when a new device is added to the network or an existing device is replaced. 2. Automatic spatial configuration of wireless links, such that a given transmitter or receiver may communicate with more than one other transmitter/receiver, through reconfiguration of its beam direction, range and other appropriate parameters.

There have been on significant updates to the requirements of TERAPO-UC-03, other than those which are inherited from the previous use cases.

[1] https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/techpaper/vcha65-perf.pdf

3 TERAPOD Revised Requirements

In this section, the requirements for TERAPOD technologies are presented. These requirements have been defined based on the needs of the use cases, lessons from the initial efforts towards developing the technologies and input from interested industry stakeholders. For the sake of clarity, the requirements have been categorised as functional (what the technology must do), non-functional (how the technology must operate), standardisation (with what standards the technology must comply) and testing/validation (what additional needs must be met to allow the technologies to be tested and/or validated). Note that the test and validation requirements are only relevant for the purposes of test/validation; these do not need to be met by the devices when they are deployed.

3.1 Functional Requirements

Table 1: TERAPOD functional requirements

Id	Requirement Description	Relevant TERAPOD Component(s)	Status	Comment	Owner
REQ-F01	Power - SBD-based detectors: No power consumption by SBDs in detectors. Power supply no larger than 1.8W is required to feed the integrated amplifiers.	SBD detector	Ongoing		ACST
REQ-F02	Power - SBD-based mixer: No power consumption by SBDs in mixers. Most power is within the LNA and the LO. Typical requirements of the LNA would be 1.5-2W electrical power. The LO would be based in RTD or UTC-PD with similar power consumption to that previously indicated.	SBD mixer	Ongoing		ACST
REQ-F03	The package should be designed and materials chosen such that the mm wave beam will be emitted with minimal hinderance from: - physical barriers (minimum of 90 deg beam clearance is required) - reflections - absorption	Packaging	Designed		BAY
REQ-F04	The package will incorporate a means of fixing to a heatsink or similar	Packaging	Designed		BAY
REQ-F05	The package design will accommodate the alignment of optical fibre to the phase distribution chip and these to the UTC PD chip array in such a way that they are	Packaging	Designed	This is a 2-stage process	BAY

	fixed, and optical alignment is maintained.				
REQ-F06	The package design will allow temperature control via a feedback element.	Packaging	Ongoing	Proposed positions of the Thermo-electric cooler (TEC) were discussed and the design incorporating indirect sensing and control was eliminated as a candidate.	BAY
REQ-F07	Packets from layer 3 must have the structure of IP format.	NETWORK Layer	Achieved		DER
REQ-F08	Routing algorithm is required to maximise throughput, given the available wired and wireless links.	NETWORK Layer	Ongoing		DER
REQ-F09	Congestion and/or failures in the network can be detected. See also REQ-N09.	NETWORK Layer - network monitoring function	Ongoing		DER
REQ-F10	Dynamic load control function(s) can provision wireless THz links as required to handle high volume, high priority flow. See also REQ-N10	NETWORK Layer - load control function(s)	Ongoing		DER
REQ-F11	Routing algorithm must implement fail-over to wireless link when a wired link fails.	NETWORK Layer - routing algorithm	Achieved in simulation; Ongoing for demo		DER
REQ-F12	Network controller is capable of receiving communications from newly added and as-yet unregistered devices.	NETWORK Layer	Achieved for P2P; Onging for P2MP		DER
REQ-F13	If wireless links are not successfully established, failure must be notified to higher network layers.	NETWORK Layer - Reporting	Ongoing		DER

REQ-F14	Multiple access to a shared channel should be guaranteed by MAC protocol: a. Efficient channel access mechanism is required to support multiple nodes within a data centre to support inter and intra rack communications. b. Efficient scheduling mechanisms are required to support reliable communicaiton among the nodes. c. Antenna directionality should be considered while accessing a channel for link establishment (handshaking) and transmissions.	LINK Layer	Ongoing		TSSG
REQ-F15	Error detection field should be inserted to data link frames.	LINK Layer	Ongoing	Results in D5.3	TSSG
REQ-F16	Handshaking protocol is required: a. Efficient handshaking protocol are required to support link establishment and neighbor discover with minimum delay and message overhead. B. It should also support the directional antenna.	LINK Layer	Ongoing		TSSG
REQ-F17	Packet buffer is required.	LINK Layer	Achieved	Modelling done	TSSG
REQ-F18	Auto configuration of link is required to guarantee the required data rate and link availability.	LINK Layer	Ongoing		TSSG
REQ-F19	Link obstacle and LOS blockage can be detected and reported by monitoring the link for packet or frame loss.	LINK Layer	Ongoing	Achieved - path diversity	TSSG

REQ-F20	An efficient neighbor discovery protocol are required to detect nearby devices and maintain neighbor table. It should support the auto detection of new nodes.	LINK Layer - Neighbour Discovery Protocol	Ongoing		TSSG
REQ-F21	Node position should be inserted in control message header to be included in the neighbor table to define the positioning map of all available nodes within a data centre.	LINK Layer - Positioning Protocol	Ongoing		TSSG
REQ-F22	Method to define the indoor node coordinates is required.	LINK Layer - Positioning Protocol	Ongoing		TSSG
REQ-F23	Interface is required between data link and network layers for message exchange to optimize resources and link parameters	LINK & NETWORK Layers	Ongoing		TSSG/DER
REQ-F24	Interface is required between physical and data link layers for message exchange to optimize resources and link parameters	PHYS & LINK Layers	Ongoing	Structure decided	TUBS
REQ-F25	Power - UTC-PD: Typical 2V bias (about 2mW total electrical), a typical laser LO (200mW electrical) and Peltier cooling (<100 mW electrical at typical operation).	UTC-PD	Ongoing		UCL
REQ-F26	For the data centre demonstrator, the wireless transmitter and receiver must be transparent to DELL's optical network: the Tx THz box must take as an input the optical signal from DELL's optical transceivers and the Rx THz box must generate as output this same signal at a suitable wavelength (i.e., within the optical bandwidth of DELL's transceivers).	UTC-PD	Ongoing		UCL

REQ-F27	Modulation of the signal will be done at the laser source. The photonic phase distribution circuit does not include modulation capabilities.	UTC-PD Laser Source	Achieved		UCL
REQ-F28	UTC-PD and/or RTD must act as LO for SBD heterodyne mixer.	UTC-PD/RTD & SBD mixer	Ongoing		UCL / UGLA / ACST
REQ-F29	Electrical interface is required from TERAPOD wireless THz transceivers (E-RTD and SBD envelope detector). This involves providing connectors for data and power supply to RTDs and, more importantly, an integrated antenna (REQ-F30) mounted on a Si lens or a chip-to-waveguide interface for waveguide packaging (and use of standard horn antennas).	RTD & SBD detector	Ongoing		UGLA
REQ-F30	On-chip antenna is required for UGLA 300 GHz technology	Slot bow-tie antenna; Broadband monopole antenna; Circular slot antenna	Ongoing - not tested		UGLA
REQ-F31	Techniques to increase the antenna scanning range are required, for example phased array antenna.	Phased array antenna	Ongoing		VLC

3.2 Non-functional Requirements

Table 2: TERAPOD non-functional requirements

Id	Requirement Description	Relevant TERAPOD Component(s)	Status	Comment	Owner
REQ-N01	The design of the photonic integrated circuit must comply with the requirements for packaging.		Ongoing		BAY
REQ-N02	The position of the thermistor (the feedback element) will be close to the active component(s).	Packaging	Ongoing		BAY
REQ-N03	The preferred package connections must be of	Packaging	Designed		BAY

	a ‘standard’ configuration (pin pitch, size and finish)				
REQ-N04	The choice of and amount of fixing adhesive for (in particular) the UTC-PD chip requires zero to very thin underfil.	Packaging	Designed		BAY
REQ-N05	Latency for a point-to-point wireless connection must not exceed 10ms.	NETWORK Layer -Datacentre Services	Ongoing		DER
REQ-N06	Reduce network congestion by 10-50% (this target will be refined in later iterations of the TERAPOD requirements, considering the nature of the congestion and other factors).	NETWORK Layer -Datacentre Services	Ongoing	Dependent on scenario	DER
REQ-N07	Controller must be capable of reconfiguring and establishing new links in response to high traffic volume in less than 1000ms	NETWORK Layer - load control function(s)	Ongoing		DER
REQ-N08	Security for wireless links	N/A	Out of scope	This is a requirement from stakeholders but it will not be directly addressed by TERAPOD.	DER
REQ-N09	Congestion and/or failures detection: a. Network monitoring function will detect congestion when the following conditions occur: jitter >= 1ms; packet loss >= 0.5% b. Network monitoring function will detect congestion within 250 ms of the relevant conditions occurring. c. Network monitoring function will detect a link failure when the link has been unresponsive for 250 ms.	NETWORK Layer - network monitoring function	Ongoing		DER

REQ-N10	Dynamic load control : Controller must be capable of reconfiguring and establishing new links in response to high traffic volume in less than 1000ms	NETWORK Layer - load control function(s)	Ongoing		DER
REQ-N11	The modulation and coding format must guarantee that the maximum permitted BER for the targeted data, from an end-user's point of view, not be exceeded.	MAC/PHY Layer - Link QoS	Ongoing		DER / UCL
REQ-N12	Link modelling and network design must be based on free path loss test results and standards. Link modelling and network design must be based on realistic measurements, and existing network element arrangement (racks, inter-rack distance, rack height).	MAC/PHY Layer	Ongoing		TSSG
REQ-N13	Media Access Control (MAC) protocol for transmission via wireless THz link should be matched to the highest data rate within data centre (up to 100 Gb/s).	MAC Layer	Ongoing		TSSG
REQ-N14	MAC Layer should report to the controller when a link failure occurs	MAC/NETWORK Layer - Reporting	Out of scope	Currently the NETWORK Layer polls the MAC layer for status.	TSSG
REQ-N15	Antenna scanning range must be 90° (-45°, +45°) or greater.	All Antenna components	Ongoing		TSSG / INESC
REQ-N16	If Forward Error Correction (FEC) is used, BER must be below FEC limits (BER < $2\cdot10^{-2}$ for SD-FEC (20% over-head) or BER < $3.8\cdot10^{-3}$ for HD-FEC (7% over-head)) before FEC	MAC/PHY Layer	Ongoing		TSSG / UCL

	decoding and $1x10^{-10}$ after.				
REQ-N17	If no FEC is used, BER must be below $1x10^{-10}$.	MAC Layer	Ongoing		TSSG / UCL
REQ-N18	Transmitted power must not exceed safety limits for persons within the data centre and/or in surrounding areas.	All Tx components	Ongoing		TUBS
REQ-N19	Transmission must not interfere with other electronic equipment operating within the data centre and/or in surrounding areas.	All Tx components	Ongoing		TUBS
REQ-N20	Transmission must be possible through semi-transparent "curtains" which separate hot and cold aisles within data centre.	All Tx components	Achieved	6-7dB loss	TUBS
REQ-N21	Equivalent Isotropic Radiated Power (EIRP) must have an acceptable value so that the received power is always higher than the device sensitivity. EIRP must be chosen based on field measurements and antenna characteristics.	All Tx/Rx components	Ongoing		TUBS / INESC
REQ-N22	Antenna side lobes must be as low as possible, maintaining the necessary gain and steering range.	All Antenna components	Ongoing	Will be more strictly defined in D2.3 based on additional information from TERAPOD components.	TUBS / INESC
REQ-N23	Data rate >= 10 Gb/s for typical compute and storage traffic	UTC-PD	Benchtop - achieved; Demo ongoing		UCL
REQ-N24	Data rate >= 40 Gb/s for real time analytics platform traffic	UTC-PD	Benchtop - achieved;		UCL

			Demo ongoing		
REQ-N25	Laser source: The coupling must be optimal for all the possible wavelengths at C-Band.	UTC-PD	Ongoing	Not tested.	UCL
REQ-N26	Laser LO: laser LO must offer some degree of wavelength tuneability in order to have some control over the wireless frequency. This wavelength tuneability must also enable a wavelength offset from the signal laser of around 2.4 nm, which in the C-band corresponds to 300 GHz.	UTC-PD	Ongoing		UCL
REQ-N27	Bandwidth must be high enough that the minimum required data rate is achieved. - 40 Gbps using 16-QAM (4 bits/symbol) and 10% roll-off: 11 GHz (already demonstrated in benchtop) - 100 Gbps using 16-QAM (4 bits/symbol) and 10% roll-off: 27.5 GHz - 100 Gbps using 64-QAM (6 bits/symbol) and 10% roll-off: 18.3 GHz	UTC-PD	Benchtop - achieved; Demo ongoing		UCL / INESC
REQ-N28	Transmit power must be high enough that transmission is possible within the range of assumed environmental conditions listed previously.	All Tx components	Ongoing		U CL / UGLA
REQ-N29	Data rate >= 1 Gb/s for host management traffic	RTD	Benchtop - achieved; Demo ongoing		UGLA

REQ-N30	Achieve power consumption of 50 mW for 300 GHz RTD source.	RTD	Achieved 100 mW	100 mW current power consumption is a big improvement on the 250 mW on earlier devices. Although power consumption could be reduced further, TERAPOD's focus is on developing a packaging solution for the RTDs.	UGLA
REQ-N31	Power consumption per capacity of data centre must not increase with the deployment of THz wireless links	All HW and SW components	Ongoing	This will be demonstrated through simulation, based on assumptions & a simplified model.	UGLA / TSSG
REQ-N32	Laser source: The power delivered by the laser will be delayed between different elements of the array.	UTC-PD	Achieved	PIC is delivered	VLC
REQ-N33	Laser source: The power delivered by the laser will be divided between different elements of the array.	UTC-PD	Achieved	PIC is delivered	VLC

3.3 Standardisation Requirements

Table 3: TERAPOD standardisation requirements

Id	Requirement Description	Relevant TERAPOD Component(s)	Status	Comment	Owner
REQ-S01	A license to access the 300GHz spectrum must be acquired.	All Tx/Rx components	Achieved		TSSG
REQ-S02	The Physical Layer must comply with the requirements stated in the Std. IEEE 802.15.3dTM-2017.	PHYS Layer	Ongoing		TUBS
REQ-S03	The whole TERAPOD wireless communication system must comply with the IEEE 802.15.3dTM-2017 standard regarding operation frequency, modulation bandwidth, output power, etc.	All components	Ongoing		TUBS

REQ-S04	MAC technologies must conform to a new standard IEEE P802.1ACct, when it becomes available.	LINK Layer	Ongoing	Due to issues outside of TERAPOD's influence, the publication of this standard has been delayed.	TUBS / TSSG
REQ-S05	TERAPOD technologies must comply with any relevant regulations that may be enacted following Agenda Item 1.15 of the World Radio Conference (WRC-19), addressing the allocation of spectrum above 275 GHz in November 2019.	All components	Ongoing		TUBS
REQ-S06	TERAPOD technologies must meet the reference levels for general public exposure to time-varying electric and magnetic fields, which is given for frequencies from 2 GHz to 300 GHz as 10 W/m², as published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).	All Tx components	Ongoing		TUBS

3.4 Test and Validation Requirements

Table 4: TERAPOD test and validation requirements

Id	Requirement Description	Relevant TERAPOD Component(s)	Status	Comment	Owner
REQ-T01	Devices must be configured for free-space operation (e.g. with antennas or lenses).	All Tx/Rx components	Ongoing		UCL / UGLA / INESC
REQ-T02	Devices must be packaged and portable.	All HW components	Ongoing		BAY
REQ-T03	Standard connectors must be provided for power supplies, as needed.	All HW components	Ongoing		UCL / UGLA / INESC / ACST
REQ-T04	Standard connectors must be provided for any necessary inputs.	All HW components	Ongoing		UCL / UGLA / INESC / ACST
REQ-T05	Due to the limitations of power detectors, the minimum emitted power must be at least 10 µW, and preferably 100 µW.	All Tx components	Ongoing for packaged modules		UCL / UGLA

REQ-T06	Due to the lack of high power sources, the minimum power level detectable with acceptable SNR (>10) must be no less than 10 uW, and preferably 50 uW.	All Rx components	Ongoing		UCL / UGLA / INESC / ACST
REQ-T07	Design requirements for the environmental test chamber: • Length: Minimum: 1 m; Maximum: 10 m • Humidity range: 20% - 80% RH. • Temperature range: 18 – 27 deg C. • Air turbulence/ noise: Initial testing in the environmental chamber will use a variable speed fan to create a range of turbulence conditions; Characterisation of air turbulence within the data centre must be investigated further. • Wall reflectivity: 1 (metallic); <0.05 (anechoic); typical walls – variable; Semi-reflective wall panels will be made from materials similar to actual wall coatings in a DC, in order to replicate both reflections and scattering of the THz beams.	Environmental test chamber	Achieved		NPL
REQ-T08	The test chamber will be designed to have changeable wall linings that can be varied from wholly absorbing (anechoic) to partially reflecting/scattering (emulating indoor walls) to wholly reflecting (metallic)	Environmental test chamber	Not required	we now have seen that we don’t get reflections from the walls into the detector – which makes these wall panels entirely irrelevant	NPL

4 Conclusion/Further work

In this document, the TERAPOD use cases, and their detailed requirements have been revised. These requirements underpin the technology development efforts for the TERAPOD project and each requirement has been assigned to the partner(s) responsible for ensuring that it is achieved, and aligned to the relevant technology component. Each use case will be refined and revised in one further iteration before the end of the project, in order to ensure that the project produces technology for which deployment within a data centre environment is both technically viable and commercially feasible.