DISSEMINATION, COMMUNICATION AND EXPLOITATION PLAN

Grant Agreement number	22HLT01
Project short name	QUMPHY
Project full title	Uncertainty quantification for machine learning models applied to photoplethysmography signals
Dissemination, Communication and Exploitation Plan	☐ 1st (Interim 1) ☐ 2nd (Interim 2 - only if requested) ☒ 3rd (Periodic 2)

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1 Dissemination, communication, and exploitation requirements

Statement	Put an X in the box to confirm	Or, list any exceptions to this
All participants have adhered to the requirements of the project's GA and CA with respect to IPR management and protection (GA Article 16 and its Annex 5) for this reporting period	☒	
All participants have adhered to the requirements of the project's GA and CA with respect to the guidelines for dissemination and communication (GA Article 17 and its Annex 5) for this reporting period	☒	
All participants have adhered to the requirements of the project's GA and CA with respect to open access (GA Article 17 and its Annex 5) for this reporting period	☒	
All participants have adhered to the requirements of the project's GA and CA with respect to the use of the European flag, the granting authority's special logo and acknowledgements (GA Articles 17.2, 18, 29.2 and their Annex 5 (if applicable)) for this reporting period	☒	

2 Dissemination and communication (Task [X.1]) (do not complete this section at period 2 reporting)

2.1 Stakeholder analysis

Target groups (including key stakeholders)	Their needs / the benefits that the project can provide	Key messages for communication and dissemination
…..		

2.2 Activity action plans

Activity number and due date	Activity summary (e.g. “website”, “publications”)	Plan to ensure the successful completion of each activity for the remainder of the project
AX.X.X MX		
AX.X.X MX		
…..		

3 Key exploitable results (KER)

Please complete one table for each KER.

Key exploitable result (KER)		**No. 1**
Title		Good practice guide developed ML/DL models, UQ methods and benchmark datasets.
Related activity (or task/WP)		A2.2.1, A2.2.7
Lead participant (organisation short name), contact name (bold) and other contributing participants (organisation short name)		**NPL**, PTB, CMI, IMBiH, IPQ, LNE, KCL, FC, Uni-Oldenburg, KTU, UCAM, SectorHealth, THM, FVB, UGent, SURREY
Background / overview	Problem / need being addressed	Currently there exist no guides or standards on how to quantify performance and uncertainties of machine learning application in PPG signals.
	Briefly describe the KER e.g. new technology / solution, product, evidence, service, teaching course, improvement / modification to specific background etc.	The consortium created a good practice guide describing the developed machine learning models, uncertainty quantification methods and benchmark datasets. The good practice guide includes the evaluation of accuracy and uncertainty of the machine learning models with respect to the uncertainty quantification methods for the different developed benchmark problems.
	Briefly describe the expected outcome	Implementing the good practice guidelines into the development of machine learning solutions by digital healthcare companies will result in better quality and a more accurate machine learning in PPG applications. Clinicians and other end users benefit from the good practice guide by a clear understanding of how accuracy and uncertainty of a machine learning solution were obtained.
	Briefly describe the expected impact	Better understanding of machine learning and uncertainty quantification in application including PPG signals to enhance reliability in software outputs allows faster certification of digital healthcare products and medical devices including machine learning approaches.

Key exploitable result (KER)		No. 1
Innovative potential	How is the KER going beyond the state-of-the-art (what will it enable that was not possible before)?	Currently there exist no guides or standards on how to quantify performance and uncertainties of machine learning application in PPG signals. The good practice guide provides a first baseline towards comparative accuracy and uncertainty determination in healthcare applications.
	Is the KER disruptive (will it displace established processes / products / services)? Give brief details.	No
Target group(s)	Who will use the KER?	NMIs/DIs, academia, industry, standardisation bodies, other projects
	Contacts available: Y/N	Yes
Competition and Unique Selling Proposition (USP)	Are there competitive solutions already available?	No
	What is the competitive advantage of the KER in relation to existing solutions (USP)?	n/a

Key exploitable result (KER)		No. 1
Stakeholders / collaborators involved in the KER (i.e. from outside of the consortium)	Will a stakeholder / collaborator (from outside of the consortium) contribute background or new results to the exploitable result?	No
	Details of contribution	n/a
Exploitation Pathway	How will you access the market? e.g. direct industrial use, technology transfer, patent / license agreement, publication, open source (e.g. for software), sale, spin-off, spin-out, joint venture etc.	The good practice guide is openly available for use in science and industry. The document is available through the project website and as an ArXiv preprint.
	Describe dissemination activities	The good practice guide is available as a download on the project website and on ArXiv. It is advertised through presentations and the final project newsletter.
	Describe exploitation activities	Presentation on scientific conferences. Advertisement through the project website and institutional websites of the consortium. E-mail notification to the stakeholder committee. Publication of the good practice guide on arxiv: https://arxiv.org/abs/2607.19999
	Are there barriers / obstacles for end users to take up your KER? If so, how might you overcome these?	No

Key exploitable result (KER)		No. 1
	Describe how your result can feed back to policy making and how it contributes to EU priorities	The described methods can be used as a foundation towards standardisation of machine learning in metrology.
IPR (If applicable)	Which background / existing / prior IP (e.g. patents etc.) will be part of the KER?	n/a
	Which member of the consortium owns this background?	n/a
	Which member(s) of the consortium will (co-)own the KER and how will this be achieved (e.g. shares, ownership agreement)?	n/a
Progress	Please describe progress that has been made in this reporting period (refer to dissemination and exploitation activities from earlier)	Publishing of the good practice guide on the website and on ArXiv. Advertisement through a stakeholder workshop, newsletter and presentations at conferences.
	Which end users have expressed interest in the results?	n/a

Key exploitable result (KER)	No. 2

Title		Software repository containing machine learning models and uncertainty quantification methods
Related activity (or task/WP)		A2.2.5, A2.2.6
Lead participant (organisation short name), contact name (bold) and other contributing participants (organisation short name)		**PTB**, NPL, CMI, IMBiH, IPQ, LNE, KCL, FC, Uni-Oldenburg, KTU, UCAM, SectorHealth, THM, FVB, UGent, SURREY
Background/ overview	Problem /need being addressed	A tested and validated implementation of the models, methods and results described in the good practice guide for easy access by the target end users is required.
	Briefly describe the KER e.g. new technology /solution, product, evidence, service, teaching course, improvement /modification to specific background etc.	Code basis for uncertainty quantification applied to PPG signals and examples on how uncertainties should be computed accompany the methods described in the good practice guide (see KER No. 1).
	Briefly describe the expected outcome	A software repository containing all the models and methods described in the good practice guide (see KER No. 1) alongside scripts which reproduce the comparison performance results included in the good practice guide.
	Briefly describe the expected impact	Easy access to the developed models and methods by the end users.
Innovative potential	How is the KER going beyond the state-of-the-art (what will it enable that was not possible before)?	The results described in the good practice guide can easily be reproduced and the provided scripts explain how the software repository can be utilised and adapted the end user's application.

	Is the KER disruptive (will it displace established processes /products /services)? Give brief details.	No
Target group(s)	Who will use the KER?	NMIs/DIs, academia, industry
	Contacts available: Y/N	Yes
Competition and Unique Selling Proposition (USP)	Are there competitive solutions already available?	No
	What is the competitive advantage of the KER in relation to existing solutions (USP)?	n/a
Stakeholders / collaborators involved in the KER (i.e. from outside of the consortium)	Will a stakeholder / collaborator (from outside of the consortium) contribute background or new results to the exploitable result?	No
	Details of contribution	n/a
Exploitation Pathway	How will you access the market? e.g. direct industrial use, technology transfer, patent / license agreement, publication, sale, spin-off, spin-out, joint venture etc.	The software repository is open access and available to the public (https://gitlab.com/qumphy/qumphy-software).
	Describe dissemination activities	The software repository is openly available for everyone as a git repository. A documentation of the code is hosted on an online website. Advertisement has been done through the project newsletter, multiple stakeholder workshops and conference contributions.

	Describe exploitation activities	Presentation on scientific conferences. Advertisement through the project website and institutional websites of the consortium. E-mail notification to the stakeholder committee.
	Are there barriers/obstacles for end users to take up your KER? If so, how might you overcome these?	No
	How your result can feed back to policy making and how it contributes to EU priorities	n/a
IPR (If applicable)	Which background /existing /prior (e.g. patents etc.) will be part of the KER?	n/a
	Which member of the consortium owns this background?	n/a
	Which member(s) of the consortium will (co-)own the KER and how (e.g. shares, ownership agreement)?	n/a
Progress	Please describe progress that has been made in this reporting period (refer to dissemination and exploitation activities from earlier)	During this reporting period, the core software package has been fully developed and finalized within the public project repository (https://gitlab.com/qumphy/qumphy-software). Alongside the repository, comprehensive, automatically generated documentation has been fully populated and is openly available online (https://qumphy-software.readthedocs.io). The repository has been structured into a comprehensive framework containing guidelines to support the adoption of the project's benchmarking problems by the medical device, digital, and health communities. It establishes a clear framework for the independent review of machine learning models to assist developers and researchers in securing regulatory approvals. To ensure complete transparency and scientific reproducibility, the consortium has also deployed multiple accompanying software repositories hosted under the project's official GitLab group. These individual repositories contain the exact source code, model

		configurations, and environments necessary to perfectly recreate the benchmarking experiments and results detailed across the other project deliverables.
	Which end users have expressed interest in the results?	n/a

Key exploitable result (KER)		**No. 3**
Title		Benchmark problems with datasets and meta data descriptions
Related activity (or task/WP)		A2.1.4, A2.1.5
Lead participant (organisation short name), contact name (bold) and other contributing participants (organisation short name)		**THM**, PTB, CMI, IMBiH, IPQ, LNE, KCL, KTU, FC, NPL, UCAM, UGent, Uni-Oldenburg, SURREY, SectorHealth, FVB
Background/ overview	Problem /need being addressed	Currently there exist no benchmark problems in PPG applications to evaluate and compare machine learning solutions against.
	Briefly describe the KER e.g. new technology /solution, product, evidence, service, teaching course, improvement /modification to specific background etc.	The consortium created 6 benchmark problems comprising a collection of PPG signals for a set of clinically relevant measurement problems. The accompanying datasets are in an open format and are ready for use by developers of machine learning models for analysing PPG signals and by medical device manufacturers. The benchmark problems include guidance documentation and examples, to support the continued use of the datasets by the community of end-users beyond the end of the project.
	Briefly describe the expected outcome	The benchmark problems are described in the good practice guide (see KER No. 1). The accompanying datasets are publicly available and include meta data describing their application and usage.

	Briefly describe the expected impact	End users will use the datasets to benchmark their machine learning applications against the results described in the good practice guide.
Innovative potential	How is the KER going beyond the state-of-the-art (what will it enable that was not possible before)?	Currently there exists no common benchmark problems involving PPG signals to test machine learning applications against.
	Is the KER disruptive (will it displace established processes /products /services)? Give brief details.	No
Target group(s)	Who will use the KER?	NMIs/DIs, academia, industry, other projects
	Contacts available: Y/N	Yes
Competition and Unique Selling Proposition (USP)	Are there competitive solutions already available?	No
	What is the competitive advantage of the KER in relation to existing solutions (USP)?	n/a
Stakeholders / collaborators involved in the KER (i.e. from outside of the consortium)	Will a stakeholder / collaborator (from outside of the consortium) contribute background or new results to the exploitable result?	Yes
	Details of contribution	Stakeholders as well as clinicians and digital healthcare companies will consult on the choice of the benchmark problems to assur their practical relevance.

Exploitation Pathway	How will you access the market? e.g. direct industrial use, technology transfer, patent / license agreement, publication, sale, spin-off, spin-out, joint venture etc.	Publication of a report/preprint describing the benchmark problems. Direct use by other scientists and industry.
	Describe dissemination activities	Publication of a report/preprint describing the benchmark problems. Description of the benchmark problems in the good practice guide (see KER No. 1). Upload datasets and accompanying description and meta data to a trusted open access repository (Zenodo) if possible. If third-party datasets are not open access, provide instructions to gain access to the data and provide scripts for processing the data once access has been granted.
	Describe exploitation activities	Presentation on scientific conferences. Advertisement through the project website and institutional websites of the consortium. E-mail notification to the stakeholder committee.
	Are there barriers/obstacles for end users to take up your KER? If so, how might you overcome these?	No
	How your result can feed back to policy making and how it contributes to EU priorities	n/a
IPR (If applicable)	Which background /existing /prior (e.g. patents etc.) will be part of the KER?	n/a
	Which member of the consortium owns this background?	n/a

	Which member(s) of the consortium will (co-)own the KER and how (e.g. shares, ownership agreement)?	n/a
Progress	Please describe progress that has been made in this reporting period (refer to dissemination and exploitation activities from earlier)	Potential benchmark problems have been identified, and open-source data sources have been gathered. The datasets are currently under preparation. Six key clinical reference problems were successfully identified, encompassing continuous blood pressure estimation, atrial fibrillation detection, hypertension classification, vascular age determination, sleep apnea detection, and respiratory rate estimation. To support these benchmarks, at least six diverse datasets, including PulseDB/VitalDB, AuroraBP, DeepBeat, TriggersAF, OSASUD, MESA, MIMIC-III-Ext-PPG, and MIMIC Perform Large datasets, have been curated and made accessible through open-access platforms or specific request protocols. Furthermore, code for preprocessing, segmenting, and stratifying these datasets into reproducible cross-validation sets has been made available. A comprehensive benchmarking study, "Machine-learning for Photoplethysmography Analysis: Benchmarking Feature, Image, and Signal-Based Approaches" (arXiv:2502.19949, 2025), has been released, providing a core dissemination channel and a reproducible framework to foster clinical trust and support future regulatory approvals within the digital health community. Scripts for processing the data are availabe at https://gitlab.com/qumphy/d4-code.
	Which end users have expressed interest in the results?	n/a

Key exploitable result (KER)	**No. 4**
Title	Framework for independent evaluation of ML models
Related activity (or task/WP)	A2.3.1, A2.3.2, A2.3.3
Lead participant (organisation short name), contact name (bold) and other contributing participants (organisation short name)	**Uni-Oldenburg**, THM, PTB, CMI, IMBiH, IPQ, LNE, KCL, KTU, FC, NPL, UCAM, UGent, SURREY, SectorHealth, FVB

Background/ overview	Problem /need being addressed	Provide an interface for end users to test their own machine learning applications against established results.
	Briefly describe the KER e.g. new technology /solution, product, evidence, service, teaching course, improvement /modification to specific background etc.	The consortium will draft a proposal for a general-purpose interface, comprising a data format and protocol for communicating with machine learning software, to support the implementation of the framework for independently reviewing machine learning models.
	Briefly describe the expected outcome	Software providing an easy-to-use interface for end users to test their machine learning applications.
	Briefly describe the expected impact	End users can evaluate their own machine learning applications independently and compare against established results given e.g. by the developed good practice guide (see KER No. 1).
Innovative potential	How is the KER going beyond the state-of-the-art (what will it enable that was not possible before)?	No common evaluation framework to access the models and methods developed in this project exists so far.
	Is the KER disruptive (will it displace established processes /products /services)? Give brief details.	No
Target group(s)	Who will use the KER?	NMIs/DIs, academia, industry, other projects
	Contacts available: Y/N	Yes

Competition and Unique Selling Proposition (USP)	Are there competitive solutions already available?	No
	What is the competitive advantage of the KER in relation to existing solutions (USP)?	n/a
Stakeholders / collaborators involved in the KER (i.e. from outside of the consortium)	Will a stakeholder / collaborator (from outside of the consortium) contribute background or new results to the exploitable result?	No
	Details of contribution	n/a
Exploitation Pathway	How will you access the market? e.g. direct industrial use, technology transfer, patent / license agreement, publication, sale, spin-off, spin-out, joint venture etc.	Direct use by other scientists and industry.
	Describe dissemination activities	The framework will be openly accessible through a git repository (see KER No. 2). A description of the framework will be included the online documentation of the software repository.
	Describe exploitation activities	Presentation on scientific conferences. Advertisement through the project website and institutional websites of the consortium. E-mail notification to the stakeholder committee.
	Are there barriers/obstacles for end users to take up your KER? If so, how might you overcome these?	No

	How your result can feed back to policy making and how it contributes to EU priorities	n/a
IPR (If applicable)	Which background /existing /prior (e.g. patents etc.) will be part of the KER?	n/a
	Which member of the consortium owns this background?	n/a
	Which member(s) of the consortium will (co-)own the KER and how (e.g. shares, ownership agreement)?	n/a
Progress	Please describe progress that has been made in this reporting period (refer to dissemination and exploitation activities from earlier)	The consortium completed the comprehensive evaluation framework for machine learning models applied to PPG signals. Deliverable D3 documents the systematic application of this framework across all benchmark datasets, covering regression tasks (blood pressure, vascular age, respiratory rate) and classification tasks (hypertension level, sleep apnea detection, skin tone classification). The analysis compared models based on raw signals, PPG features, and SPAR image representations, evaluating performance alongside model-agnostic and model-specific uncertainty quantification methods. It further examined demographic subgroup performance, biological sex classification, out-of-distribution robustness, data dependence, and aleatoric/epistemic uncertainty disentanglement. Deliverable D6 provides the guidelines for independent adoption of this framework. The accompanying QUMPHY software repository implements all components as reusable Python code, including a common evaluation metrics module with standardized binary and regression metrics, and an uncertainty quantification module providing expected calibration error, cumulative calibration error, entropy, and other UQ metrics for model assessment. To facilitate adoption by non-expert users, the repository also ships a cross-platform graphical user interface (GUI) that wraps the training pipeline. The GUI allows users to select or create a Python environment, pick and edit YAML configuration files, and launch training runs with real-time output streaming, all without writing command-line instructions.
	Which end users have expressed interest in the results?	n/a