EMERGE
Emerging Printed Electronics Research Infrastructure

D5.9
2nd Interim report on design and architecture of devices and systems, FLAPEP connected

WP5 Access to design, modelling and simulation

The EMERGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 101008701

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Author(s)	Livia Silva (UNOVA), Hans Kleemann (TUD), Eirini Koutsouroubi (HMU), Jakub Krzeminski (WUT), Yusuf Mulla (RISE), Olivier Ronsin (FZJ), Jerzy Szałapak (WUT)
Responsible person for the deliverable	Olivier Ronsin, o.ronsin@fz-juelich.de
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List of abbreviations

AI – Artificial Intelligence
CAD – Computer-Aided Design
CFD – Computational Fluid Dynamics
CT/CTA – Computer Tomography / Computer Tomography Angiography
DRL – Deep Reinforcement Learning
FLAPEP – Flexible Large Area Printed Electronics and Photonics
FZJ – Forschungszentrum Jülich / Helmholtz Institute Erlangen-Nürnberg
HMU – Hellenic Mediterranean University
JOR – Joanneum Research
PDA – Patent Ductus Arteriosus
RISE – Research Institute of Sweden
RTO – Research and Technology Organization
SLA – Stereolithography
SME – Small & Medium Enterprise
TA – Transnational access activity
TUD – Technische Universitaet Dresden
UNOVA – Instituto de Desenvolvimento de Novas Tecnologias (UNINOVA)
WP – Work package
WUT – Warsaw University of Technology

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1. Executive Summary

This document gives an overview of the incoming projects that required design and architecture of devices and systems activities (TA1.1) offered by the EMERGE consortium between June 20th, 2023 and June 20th, 2024.

As a conclusion, seven projects formally requesting design and architecture of devices and systems activities (TA1.1) have been submitted in the last year of the EMERGE project, by only four groups, some of them submitting several projects. This is in remarkable progress as compared to the first period (see deliverable D5.8) thanks to active advertising. All projects are joint modelling/experimental projects because they deal with CAD-design of devices which are then fabricated in the same project. For the design part of these projects, offer from the EMERGE partners WUT and RISE partners have been requested. All incoming projects target at low-maturity 'proof of concept' devices.

Three projects are accepted but not fully implemented yet. Three projects involving TA1.1 activity have already been implemented with a very positive feedback. The scientific support of the EMERGE partner is judged crucial, which shows that EMERGE has an important added value beyond providing access to experimetal or modelling tools and methods. In addition, discussions of EMERGE partners with the project owner prior to project submission are judged crucial for proper project definition.

The main concern regarding TA1 activities still remains the low number of incoming projects.

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2. Introduction

This document aims at giving an overview of the incoming projects that required design and architecture of devices and systems activities (TA1.1) offered by the EMERGE consortium in the last year of the EMERGE project (30/06/2023-30/06/2024). This is an interim report on the project status to date (30/06/2024).

3. Overview of EMERGE projects requesting TA1.1 activity

The table below summarizes the general information on the incoming projects. To date, there have been seven project proposals requesting design and architecture of devices and systems activities (TA1.1) during the 3rd-9th EMERGE calls.

There have been multiple submissions or follow-up projects of the same users:

- Three of these projects have been submitted by the same users (projects 4749, 6431, 6432), projects 6431 and 6432 as follow-up of project 4749.
- Another pair of project have been submitted by the same user, the second one (project 6497) being a follow-up of a successfully implemented project (4010). Both projects involved CAD activities.
- Another pair of project have been submitted by the same user, the second one (project 6399) being a follow-up of a successfully implemented project (3663).

Regarding the status:

- Four projects have been implemented (3rd and 5th call)
- Two projects have been accepted but not implemented yet (5th and 7th calls)
- The project 6432 (5th call) has been rejected because it was actually a duplication of project 6431.

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Call	ID	Title	Previous proposals	Author	Nationality	Type of institute	Country/ Home institute	TA(s)	Pretended Institution	Status	Comment relative to TA1
3	**4010**	Thin and flexible electrodes for capacitance measurement		**Kyoko Jansson**	Sweden	SME	Sweden/ Innovation Partners (Europe) AB	**TA3.1. Device Preparation** TA2.2. Chemical & physical techniques TA1.1. Device design and architectures	**WUT**	Completed	Design of the screen-printed electrodes prior to device fabrication @ WUT
4	**4749**	Patient-specific numerical modelling in palliative solutions for infants with ductal-dependent pulmonary blood flow		**Selma Mulla** 2nd user: Wael Basha	Albania Syria	University	Turkey/ Istanbul Medipol University	**TA1.2. Modelling & simulation** TA3.2. Functional 2D & 3D printing	**WUT** **RISE**	Completed	CAD for 3D modelling of heart vessels + CFD on this geometry @WUT,RISE
5	**6399**	Point-of-care (PoC) Nanoplasmonic biosensor chip integrated microfluidic device for pathogen detection	**3663**	**Nagarajan Subramaniyam**	Finland	SME	Finalnd/ Xfold Imaging Oy	**TA1. Theory: Modelling, simulation, and design of materials, devices and systems** TA3. Prototype fabrication TA4. Characterization of prototypes and	**JOR** **RISE**	Completed	Nothing implemented regarding TA1
5	**6431**	Patient-Specific Numerical Modeling in Palliative Solutions for Infants with Dependent Pulmonary Blood flow.	**4749**	**Wael Shamsi Basha** 2nd user: Selma Mulla	Syria	University	Turkey / Istanbul Medipol University	**TA1. Theory: Modelling, simulation, and design of materials, devices and systems** TA2. Material synthesis and ink formulation	**FZJ** **RISE**	Completed	CAD for 3D modelling of heart vessels + CFD on this geometry @WUT,RISE
5	**6432**	Patient-specific numerical modelling in palliative solutions for infants with ductal-dependent pulmonary blood flow	**4749**	**Selma Mulla**	Albania	University	Turkey / Istanbul Medipol University	**TA1. Theory: Modelling, simulation, and design of materials, devices and systems** TA3. Prototype fabrication	**WUT** **RISE**	Rejected	CAD for 3D modelling of heart vessels + CFD on this geometry @WUT,RISE
6	**6468**	Realization of dielectric micro-capacitors by 3D-printing using polymeric filaments loaded with metal or ceramic particles.		**Athanasios Tiliakosl** 2nd user: Robert Rabuga	Greece (EU)	RTO	Greece (EU)	**TA3. Prototype fabrication** TA1. Theory: Modelling, simulation, and design of materials, devices and systems	**TUD** **WUT**	Accepted	Design of 3D-printed nicrocapacitor devices using Autodesk @WUT
7	**6497**	Bio-compatible wet-state organic material for a sensitive sensor	**4010**	**Kyoko Jansson** 2nd user: Goran	Sweden (EU)	SME	Sweden	**TA3. Prototype fabrication** TA1. Theory: Modelling, simulation, and design of materials, devices and systems	**WUT**	Accepted	Design of the screen-printed electrodes prior to device fabrication @ WUT

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4. Analysis of incoming proposals

4.1. Overall information

We cannot see any trend regarding the institution, gender, experience of the project owners. Three of the groups applying for EMERGE are from EU countries whereas the last group is from Turkey.

All projects are joint experimental / design projects. As a consequence, five of the seven projects require offer from two EMERGE partners. For the design part of these projects, only WUT and RISE partners have been requested.

The degree of maturity of almost all projects (six out of seven) has been evaluated by the project owners as “Proof of concept”.

4.2. Focus on publicity

Contrary to TA1.2 activities (see deliverable D5.6) and to the general trends for EMERGE, it is remarkable that half of the applicant learnt about EMERGE through the social media. This shows the positive consequences of the dissemination activities of the EMERGE partners regarding “Design and fabrication of device” topics.

In addition, the multiple submission of projects by the same users (follow-up projects notably) proves positive regarding the attractivity of the EMERGE approach.

4.3. Focus on the requested TA1 activity

For all projects, the TA1.1 “Design and architectures” activity was associated with experimental activities, with a CAD-design of devices to be fabricated in the same project. Thereby, the following design methods have been requested:

- CAD of electrodes and of the corresponding screen-printing screens offered by WUT (projects 4010 and 6497),
- 3D CAD modelling of heart vessels and capillary using Ansys-Fluent (RISE) for subsequent 3D printing as well as CFD simulation of blood flow (projects 4749, 6431, 6432)

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- Design of 3D-printed microcapacitor devices using Autodesk, offered by WUT (project 6468).

Note that for project 6399, the initially requested CAD design activity has been implemented at the project owner's lab and not within the EMERGE offer.

5. Overview of completed projects

In this section, we provide a quick description of the results obtained for the completed project involving TA1.1 activity, as described by the project owners. Note that the completed project 6399 is not considered here since no TA1.1 activity was actually involved.

5.1. Summary of objectives and results, potential use after project

5.1.1. Project "Thin and flexible electrodes for capacitance measurement" (4010)

- Objectives: the primary objective is to print and test dedicated bladder monitor electrodes using printed electronic. The initial design with multiple layers of the device printed on flexible substrates will be developped. A set of 50 electrodes will be fabricated, their thickness measured and their electrical behaviour characterized.
- Results: The design of the electrodes and of the screen printing process have been successfully implemented. However, the fabrication could not be fully implemented due to material shortage, and the electrode's characterization could not be performed due to lack of time. However, The project has already identified limitations in the current.performance of these electrodes
- Potential use after the project: significant contribution to the advancement of the industry in the field of pressure sensors, with substantial commercial value. However, the likelihood owner's patent applications or publishing is very slim.

5.1.2. Project "Patient-specific numerical modelling in palliative solutions for infants with ductal-dependent pulmonary blood flow" (4749)

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- Objectives: The objectives are to gather comprehensive computer tomography image data of infants aged 0-1 years with ductal-dependent circulation and create accurate, patient-specific 3D arterial models. These models have to be 3D printed using resin stereolithography (SLA) printers to provide detailed visualizations for improved pre-operative planning. The project aims at inspiring further research and development in medical imaging and surgical planning, and establish a foundation for future collaborations and publications.
- Results: throughout this project, several significant milestones were achieved. We successfully gathered comprehensive computer tomography angiography (CT/CTA) image data of infants aged 0-1 years with ductal-dependent circulation and created accurate, patient-specific 3D arterial models. 3D models were reconstructed from CT/CTA patient specific data for further simulations. Notably, we 3D printed a model of a patient with a patent ductus arteriosus (PDA) case using resin SLA printers. Brief literature study for Deep reinforcement learning (DRL) for shape optimization in fluid dynamics for shape optimization in fluid dynamics was carried out and a few options were selected for future project on AI guided surgery planning.
- Potential use after the project: It is planned to apply for another call to expand the project with more data, and to make a journal article out of this study.

5.1.3. Project “Patient-Specific Numerical Modeling in Palliative Solutions for Infants with Dependent Pulmonary Blood flow.” (6431)

- Objectives: this research proposal focuses on studying neonates with ductal-dependent pulmonary circulation and developing patient-specific treatment strategies through mathematical modelling and simulation. Specifically, the study aims at simulating palliative interventions such as PDA stents or modified Blalock-Taussig shunts to address the challenges inherent in managing these infants. By retrospectively analyzing CT/CTA image data and creating patient-specific arterial models, the research aims to simulate 3D pulsatile hemodynamics and assess critical parameters for meticulous preoperative planning. Furthermore, the investigation will prioritize validation against post-operative outcomes and compare virtual reconstructions with actual repair results.

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- Results: throughout this project timeline, significant milestones have been achieved. Notably, patient models were effectively meshed using Ansys Fluent, employing transient simulation techniques. Furthermore, the establishment of boundary conditions, including inlet and outlet parameters, tailored to pediatric patients' specific density, viscosity, and velocity, was successfully completed. Detailed observations of velocity streamlines, wall shear stress, and pressure were attained utilizing Ansys Fluent. However, further consultations with clinicians are necessary to ascertain the most optimized solution for each patient
- Potential use after the project: this study will not be commercialized and will be published in scientific journal when study is completed, but the outputs of this study could be used as inputs for a new project, resulting in a product (a medical device with software) that could target the European and global market.

5.2. Realized vs. expected

For project 4010, the objectives could not be fully reached due to lack of time,but the theoretical activities have been realized. A follow-up EMERGE project proposal will be submitted by the project owner to carry on working on this topic.

For project 4794, almost all objectives could be reached (90%), although some technical problems have been encountered in the generation of the 3D models, due to imprecision of the CT scans and the difficulty of precise SLA printing.

For project 6431, the objectives could be met only to about 60%. There were some scientific issues with the assumption on vessel wall rigidity for CFD modelling. Mereover, not all the cases could be simulated due to lack of time. Overall, the complexity of the project might have been underestimated.

Note that for both projects 4794 and 6431, the activity has been realized remotely, even though a visit of the project owners was planned. This was due to personal issues fo the project owner, and visa obtention problems, respectively.

5.3. User feedbacks

Regarding project 4010, the feedback on how the project itself was carried out is excellent and the project owner claim that he will recommend access to EMERGE infrastructures to

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a colleague. The support, expertise and advice of the EMERGE partner WUT has been very valuable and very much appreciated by the project owner from the proposal writing to the implementation. Most importantly, the user highlights that things would be more efficient if the EMERGE partner and the applicant would have jointly written the proposal right from the beginning.

Regarding projects 4749 and 6431, the feedback is also excellent and points out the quality and the relevance of the EMERGE partner's support. The access to not only cutting edge infrastructure, but also to the support from top-level researchers, and the way it fosters collaboration, has been highlighted as a central strength of the EMERGE project.

Regarding the general EMERGE workflow for project submission, operation and finalization, and the EMERGE tools (website…), the feedback is marked almost systematically as "excellent" or "satisfactory".

6. Conclusion

As a conclusion, seven projects formally requesting design and architecture of devices and systems activities (TA1.1) have been submitted in the last year of the EMERGE project, by only four groups, some of them submitting several projects. This is still a very low number, but in remarkable progress as compared to the first period (see deliverable D5.8) thanks to active advertising. All projects are joint modelling/experimental projects because they deal with CAD-design of devices which are then fabricated in the same project. All incoming projects handle low maturity, research-oriented topics and target at 'proof of concept' devices.

Four projects have been implemented, only three of them finally involving TA1.1 activity. Overall, the feedback on the completed scientific projects is very positive. The scientific support of the EMERGE partner is judged crucial, which shows that EMERGE has an important added value beyond providing access to experimetal or modelling tools and methods, namely the scientific expertise. In addition, discussions of EMERGE partners with the project owner prior to project submission are judged crucial for proper project definition.

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