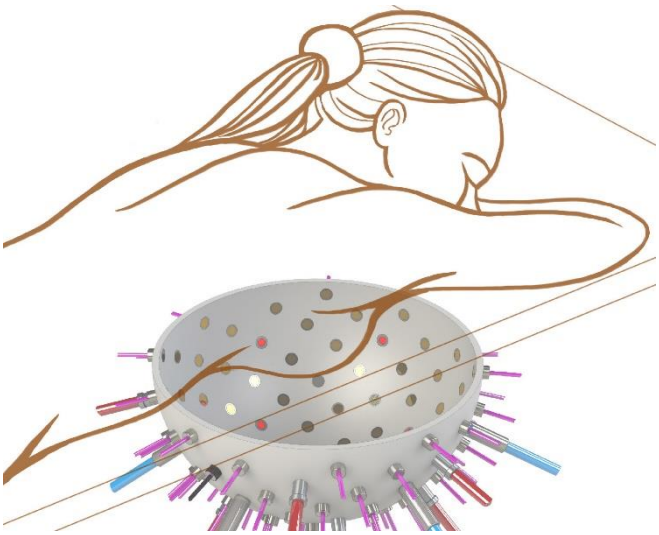
PAMMOTH

Photoacoustic/Ultrasound Mammoscopy for evaluating screening-detected lesions in the breast



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PAMMOTH publishable summary

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Content

PAMMOTH – publishable summary

PAMMOTH is a collaborative research project, receiving a 5.1 Mio € grant from the European Commission and the Swiss Government in the H2020 research and innovation program. Within four years, experts from seven countries will develop a novel system that uses light and sound to provide a more accurate diagnosis of breast cancer.

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The 'PAMMOTH' project on 'Photoacoustic Ultrasound Mammoscopy for evaluating screening detected abnormalities in the breast-, hopes to lead the research into photoacoustic, real-time 3D imaging of suspicious lesions. Project coordinator Srirang Manohar, University of Twente, explains: 'We are creating an imaging device that we hope will reduce all of the stages involved in spotting breast cancer into one convenient appointment in order to reduce time, uncertainty and the number of unnecessary biopsies. We intend to make breast cancer diagnosis a one-stop-shop, while you wait.'"

Summary of the context and overall objectives of the project

With Europe's aging population, its high incidence of breast cancer, its tightening health-care budget, [Rechel *et al* 2013, Ferlay *et al* 2013, Karanikolos *et al* 2013, Morgan & Astolfi 2015] and drawbacks in conventional breast imaging modalities, [Nass, S.J. *et al* 2001] **there is a need for a technique that can provide high specificity, contrast and image resolution, all at a sufficiently low cost** that it can be made universally available. Photoacoustic (also called optoacoustic) imaging, [Wang & Hu 2012, Beard 2011, Ntziachristos & Razansky 2010.] in which the contrast is dependent on light absorption and which therefore offers spectroscopic (molecular) specificity, has the potential to be that technique. [Heijblom et al 2015a] However, while the literature of the last 15 years has witnessed technological advances in photoacoustic breast imaging, these have been incremental and conservative steps, fragmented across various groups and companies. The end result is that many possibilities and opportunities have not been exploited or explored, and even after a decade and half following the first application of photoacoustic imaging in the breast, [Oraevsky et al 2001] we still describe the method tantalizingly as having potential and promise.

PAMMOTH brings together applied physicists, technology developers, mathematicians, algorithm developers, ultrasound detection experts, laser specialists, epidemiologists and radiologists to work on a new generation system for imaging the breast using both photoacoustics and ultrasound. Academia, Industry and the Clinic from 6 different countries in Europe are represented strongly in PAMMOTH.

The PAMMOTH consortium's objective is to **develop, validate and begin exploitation of a dedicated breast imaging device for a significant impact in breast cancer diagnosis.** The proposed device combines **non-invasive 3D photoacoustic imaging and ultrasound imaging.** The device will provide **near real-time, full-breast, multimodal images** to the radiologist. From the ultrasound mode, the radiologist will visualize **anatomical features and extent of tumors**, and from multiwavelength photoacoustics, she will see tumor vascularity.

Quantitative spectroscopic photoacoustic images will be extracted off-line, providing the radiologist information relating to **tumor physiology and function such as angiogenesis and hypoxia.**

The choice of the relevant biological targets, and of the functionalities and technical principles applied in the PAMMOTH imager, will provide relevant information to the radiologist to **make accurate diagnosis with high specificity.**

The consortium aims to make the imaging device such *for all populations of women, with short time intervals between positive screening and diagnosis, having high through-put, possessing no carcinogenic potential and causing no pain and discomfort to patients.*

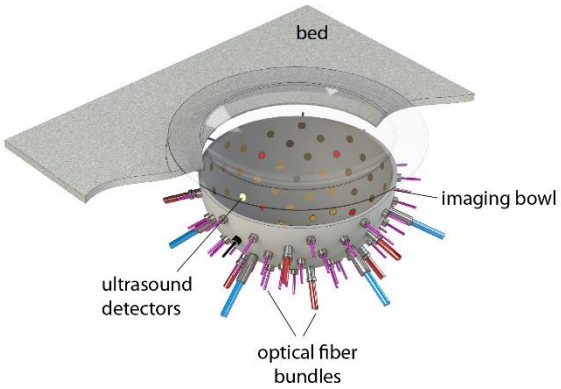
Work performed from the beginning of the project to the end of the period

At the 18th month in the project we have together realized the following:

- Developed a comprehensive set of functional requirements for the PAMMOTH imager to give the instrument the potential for impact in the clinic. This device should be able to perform hybrid photoacoustic-ultrasound imaging of the breast.
- Production of the imaging bowl within which the breast will be immersed for imaging is underway. The bowl will carry inserts which accommodate multiple ultrasound transducers, multiple optical fiber bundles and plurality of ultrasound transmitters. (See Figure)
- Cups of various sizes have been prototyped by vacuum forming to hold the breast in the imaging bowl.
- A new compact high-energy nanosecond laser was designed and developed for photoacoustic excitation. This pumps a second-harmonic generator.
- The design and prototyping of the final version of the ultrasound detector has been completed and multiple detectors have been developed and tested for essential parameters.
- A multi-channel Data-Acquisition System (DAS) has been designed and prototypes have been tested. The production of the final version is underway.
- A novel algorithm for this specific task has been developed to reconstruct intermediate images on the fly as projections are being acquired.
- The framework for the acoustic inversion to perform image reconstruction (using SOS data) has been developed based on an iterative approach.
- The ultrasound simulation codes required for the acoustic inversion above has been optimized for systems with multiple GPUs reaching almost 10 fold speed-up compared to conventional servers.
- The framework for quantitative photoacoustic reconstruction has been decided. Prototype component codes required to develop this algorithm have been prepared.
- The framework for automatic planning and execution of the off-line image reconstructions (quantitative photoacoustics) has been designed and is being implemented.
- Excellent communication and cooperation between consortium partners, has seen a detailed design for the integrated system and the planning for the delivery, testing and integration of the sub-systems has been made.
- A laboratory test system has been developed as test imager for ultrasound imaging.

- We have developed novel 3D phantoms. These have been tuned with acoustic and optical properties matching well with the breast and its abnormalities.
- The ground is being prepared for the clinical study which is to start in month 39.

Data was collected from Cancer registry databases originating from roughly thirty thousands of patients with suspicion for breast cancer to analyse the imaging procedures undergone by these patients. This is hoped to provide insights that may guide the application of the new imager, but in any case presents the complexities at this point in time in the application of imaging procedures to arrive at diagnosis.



PAMMOTH concept

Progress beyond the state of the art and expected potential impact

(including the socio-economic impact and the wider societal implications of the project so far)

- The capabilities of the PAMMOTH imager being built make it unique in the combination of quantitative photoacoustics and ultrasound imaging. The aimed at specifications are also well beyond the state of the art.
- The laser developed and being tested produces pulse energies at the fundamental and second-harmonic which are highest in similar compact systems as far as we are aware.
- The values obtained from testing of the ultrasound detectors are better than required specifications which themselves are superior to the state of the art detectors.
- A multi-channel Data-Acquisition System (DAS) shows low noise and also has higher level; of complexity compared to devices available. The analog front ends in the PAMMOTH DAQ are also capable of driving ultrasound generation by electrical actuation of transducers.
- The ultrasound simulation codes required for the acoustic inversion optimized for systems with multiple GPUs reaching almost 10 fold speed-up compared to conventional servers.
- The 3D phantoms developed are among the first which may be described as semi-anthropomorphic.
- The data collected from around thirty thousand patients with suspicion for breast cancer in the diagnostics trajectory is the first of its kind for analysis about imaging. This is expected to provide insights into imaging in the current practice of breast cancer diagnosis in the Netherlands and may show areas where these can be optimized.

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Public website

More information on PAMMOTH is available via www.pammoth-2020.eu. The public PAMMOTH website addresses the wider public, presents PAMMOTH's research and technical objectives, explains partners' complementary expertise – also as videos - and will be dynamic and continuously be updated. Training and further information material will be provided after project midterm.

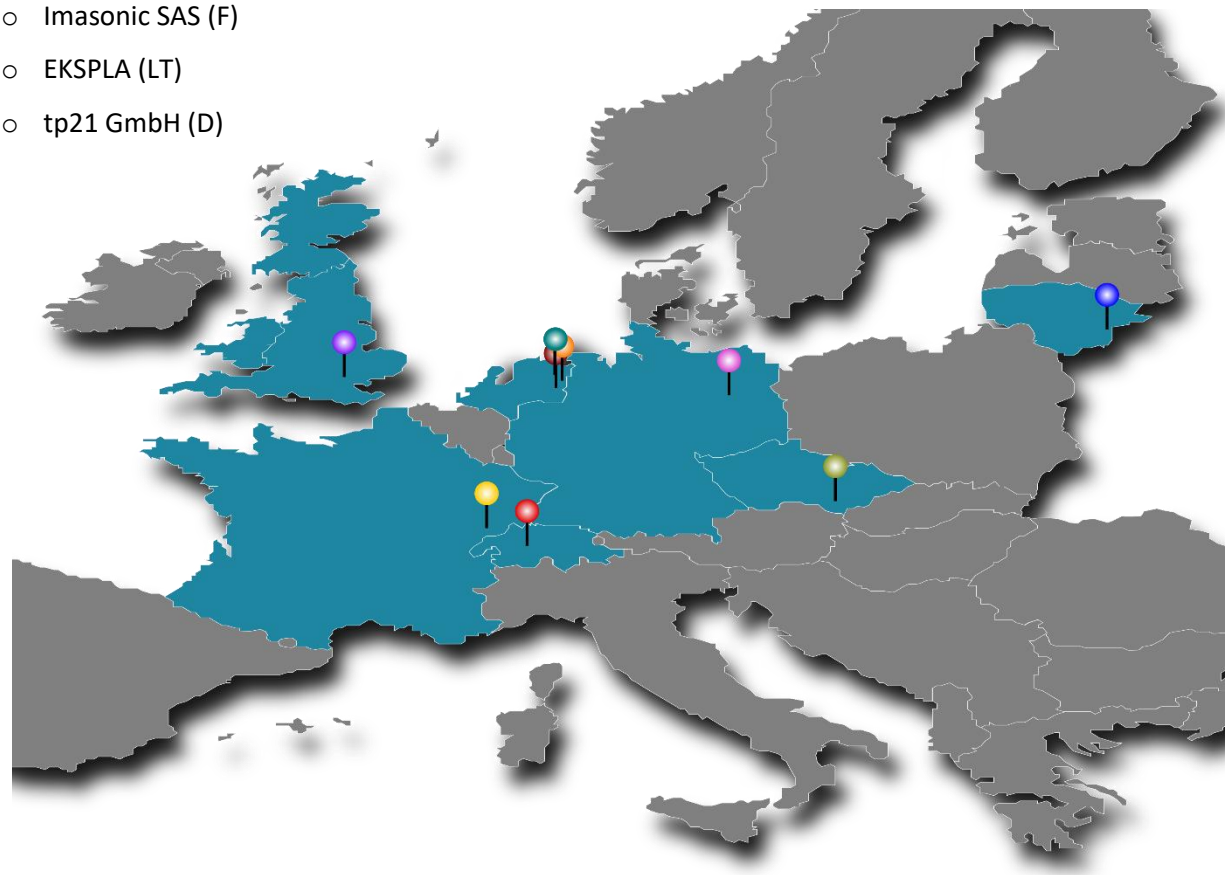
PAMMOTH - consortium

Coordinator

- University of Twente (NL)

Partners

- PA Imaging R&D B.V. (NL)
- Stichting Medisch Spectrum Twente (NL)
- University College London (UK)
- University of Bern (CH)
- Brno University of Technology (CZ)
- Imasonic SAS (F)
- EKSPLA (LT)
- tp21 GmbH (D)



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PHOTONICS PUBLIC PRIVATE PARTNERSHIP

PAMMOTH is part of the European Technology Platform Photonics[21], founded in 2005, representing the industry as well as research organisations in the field of photonics in Europe.