



**FP7-ICT-2007-2**

**Nano-Actuators and Nano-sensOrs for Medical  
Applications**

**NANOMA**

**Coordinator:** Antoine FERREIRA

Université d'Orléans

antoine.ferreira@ensi-bourges.fr

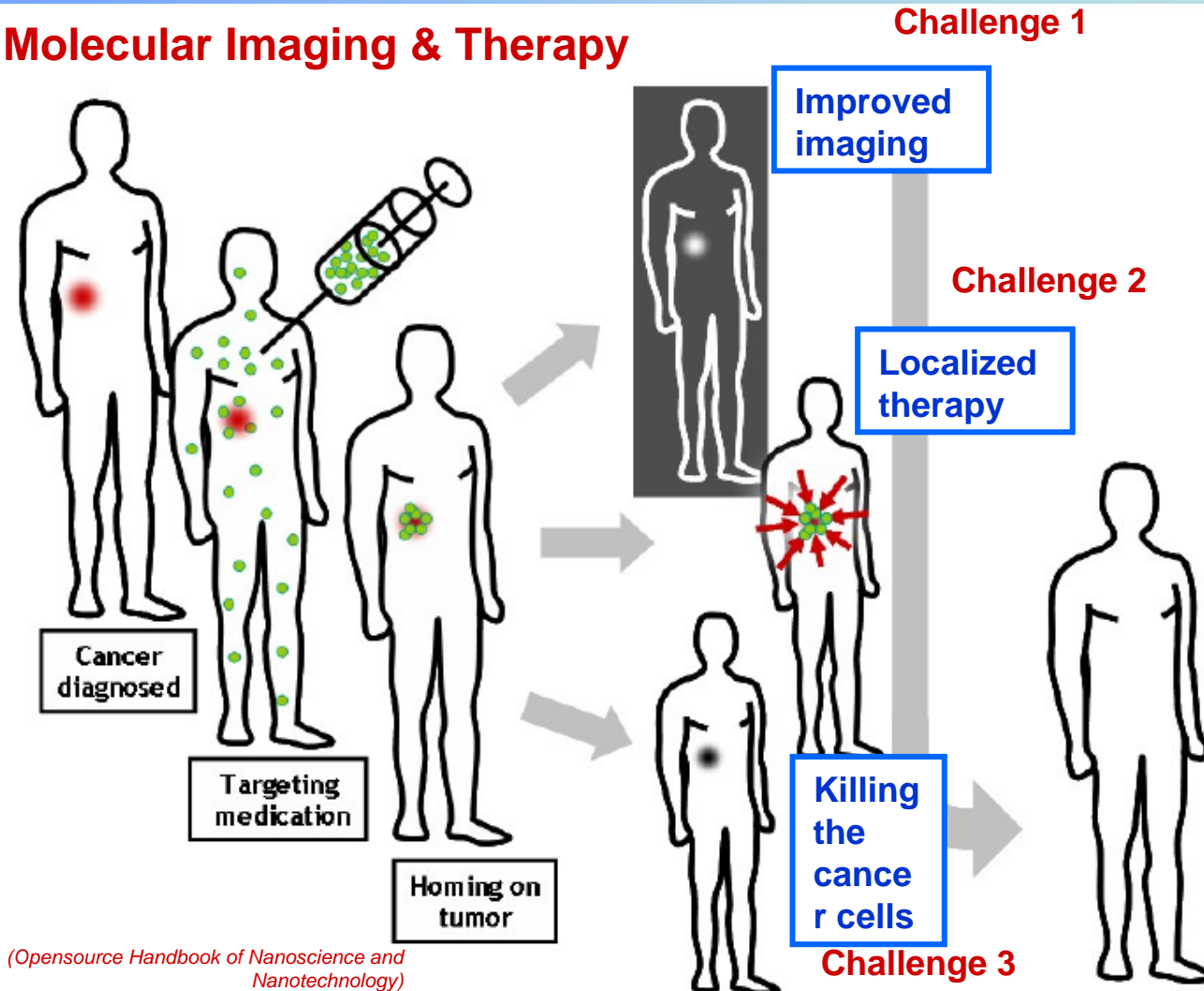




- **Partner 1**    **University of Orléans (Coord.)**    **(UORL) - France**
- **Partner 2**    **Zenon S.A.**    **(Zenon) - Greece**
- **Partner 3**    **ETH Zurich**    **(ETHZ) - Switzerland**
- **Partner 4**    **Universität Oldenburg**    **(Amir) - Germany**
- **Partner 5**    **Biomedical Research Foundation (BRF)** - **Greece**
- **Partner 6**    **University of Cyprus**    **(UCY) - Cyprus**
- **Partner 7**    **FemtoTools**    **(FemtoTools) - Switzerland**
- **Partner 8**    **Hospital Oldenburg**    **(HOId) - Germany**



## Molecular Imaging & Therapy



## Concept and Motivation:

NANOMA aims at developing drug delivery microrobotic systems (composed of nanoActuators and nanoSensors) for the propulsion and navigation of ferromagnetic microcapsules in the cardiovascular system through the induction on magnetic gradients.

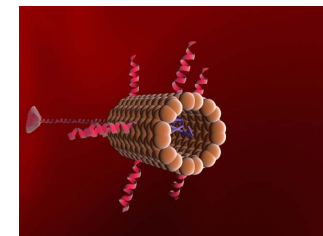
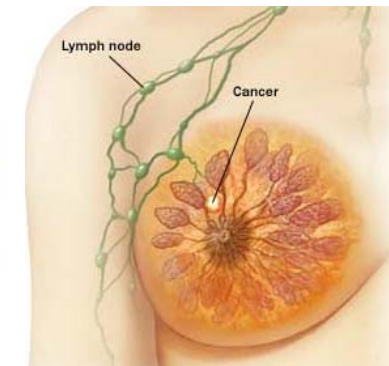
**New approach for diagnosing and treating breast cancer :**

1. **Enhanced diagnostics using MRI,**
2. ***In-Vivo* propulsion and navigation,**
3. **Targeted drug delivery using functionalized nanovectors.**

Magnetic microcapsule steering using MRI system



Early cancer stage I

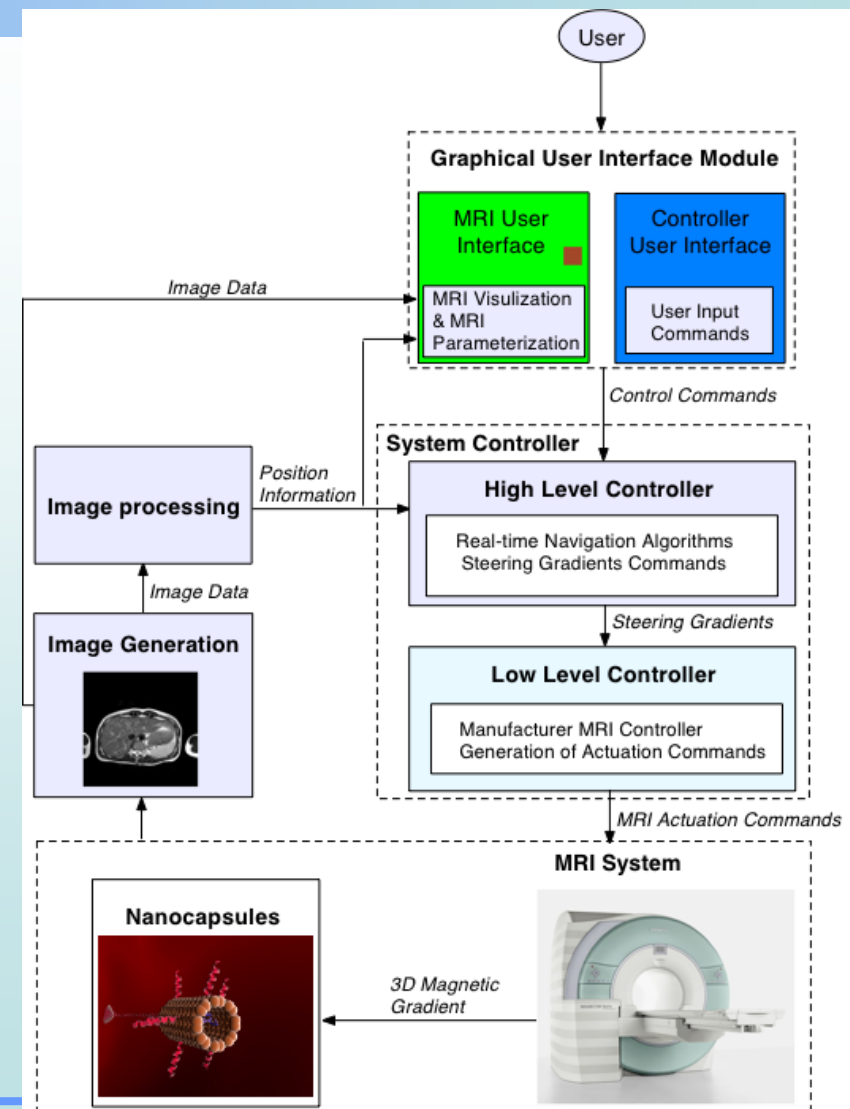


Microcapsule-based drug delivery

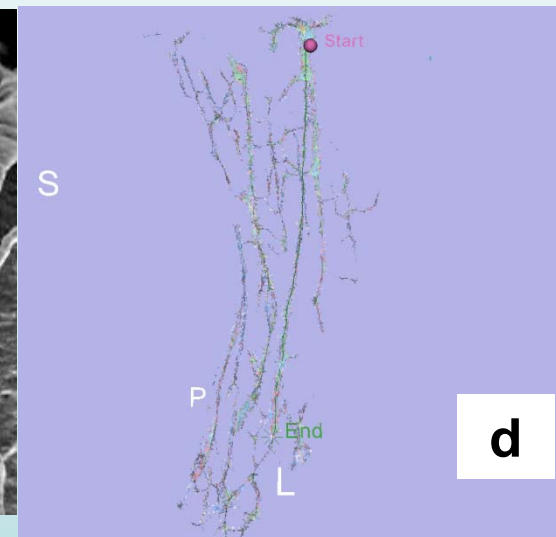
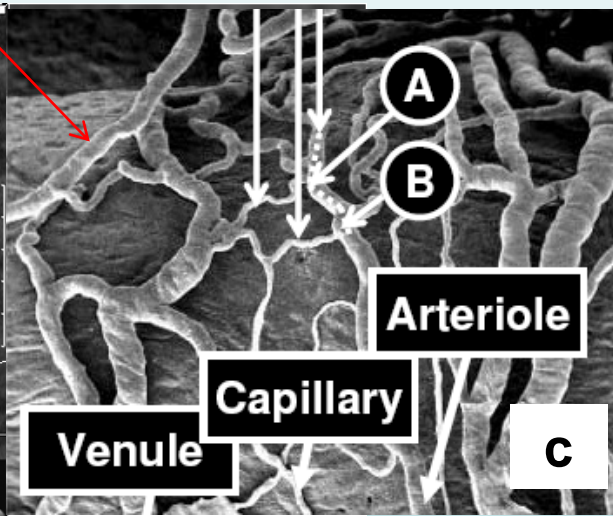
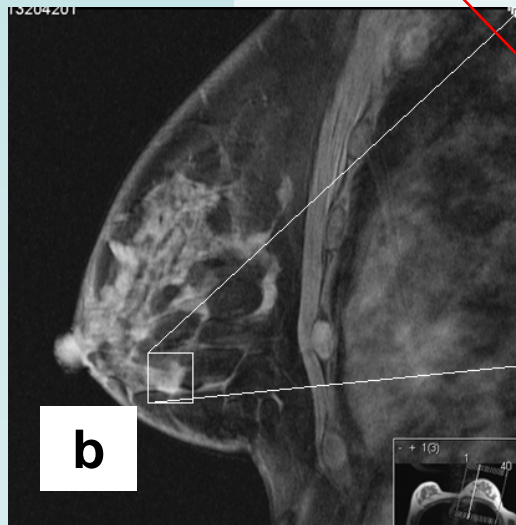
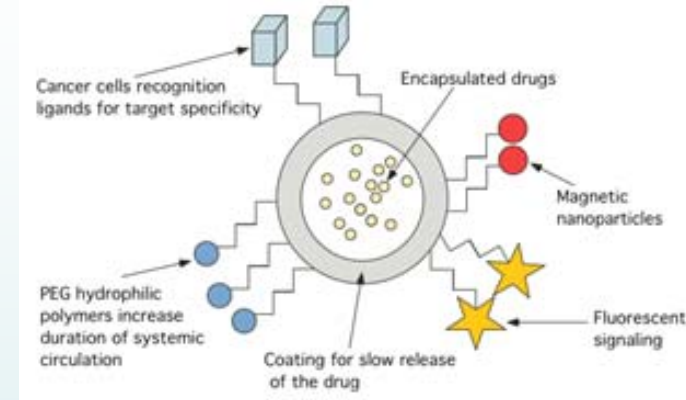
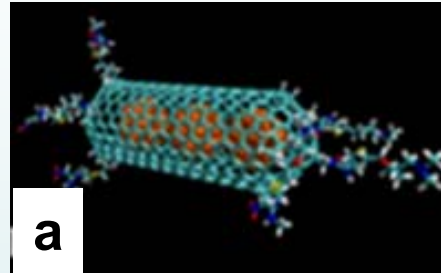
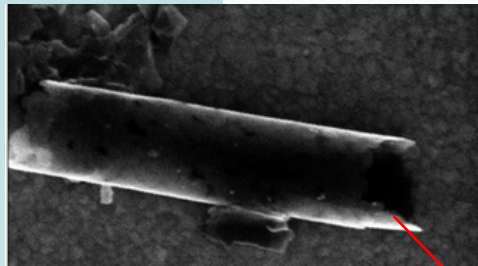
## Scientific and Technological Objectives:

- **Design and modeling of nanorobotic capsules:** Energy approach based on multi-scaled and multi-physics modeling and interactive computational tools.
- **Functionalization-based targeting of biocarriers :** Biodistribution-driven mechanisms using surface functionalization processes at the nanocapsule surface (*f*-CNT and *f*-NP).
- **MRI navigable biocarriers in blood vessels :** The integration of ferromagnetic particles allows potential MR-tracking and automatic delivery of biocarriers through induced forces generated by magnetic gradients from an upgraded MRI system.
- **In-vivo MR-tracking drug delivery in mouse cancer models:** Efficiency of drug release at specific site (breast cancer cell and/or tumor) will be tested (proof-of-concept): Cell lines and In-vivo,

- Can implement the three essential components for real-time controlled navigation of untethered devices in the human vasculature:
  - **Propulsion**
    - Using the three imaging orthogonal coils of the MRI system and implementing additional software
  - **Tracking**
    - Using the conventional hardware and software of the MRI system
  - **Control**
    - By implementing control algorithms on the computer system of the MRI platform based on tracking information



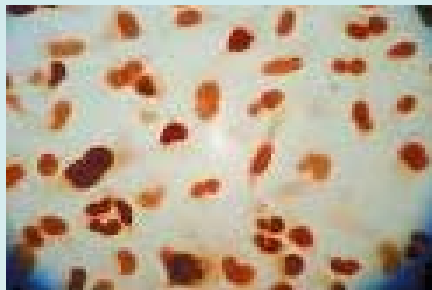
## Magnetic and Biologically functionalized CNT



MRI diagnostics of breast cancer

Magnetic steering navigation ?

Path planning of nanocapsules



## PHASE 1: Human-sized Phantom

- Recognition and Tracking of an Object
- Propulsion along a preplanned path
- No flow, no overly complicated structure

## PHASE 2: Animal

- Injection
- Tracking
- Propulsion/Control

## PHASE 3: Cell Culture

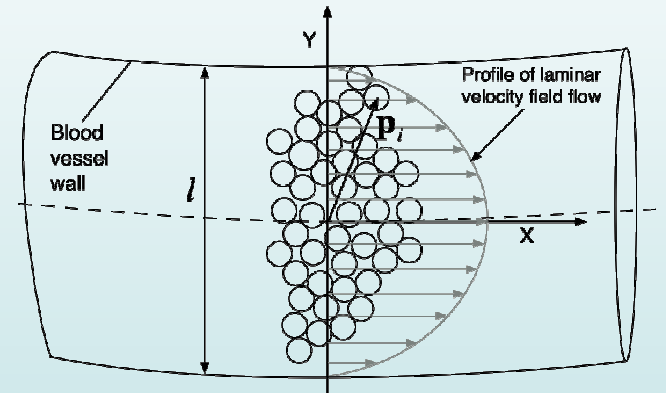
The efficacy and cytotoxicity studies will be performed initially in cells in culture.

# Limitations

NANOMA: Nano-Actuators and Nano-Sensors for Medical Applications

## Outlook on technical limitations:

- Investigation of self-assembly and break-up process
- Investigation of agglomeration size dependence on external parameters:
  - Magnetic field
  - Temperature
- Experimental validation on
  - 3-D microfluidic systems
  - Power source for break-up process
- 



# Cluster Collaborations

NANOMA: Nano-Actuators and Nano-Sensors for Medical Applications

## Technological Needs :

- Microfabrication of 3D microfluidic channels with different sizes, shapes and fluids,
- Development of integrated power coils with high magnetic gradients and constant field,
- Expertise en Magnetic Resonance Imagery system.

## Cluster Collaboration :

- Scientific collaboration, expertise exchange and participation to Nanomedecine clusters



# Contacts

NANOMA: Nano-Actuators and Nano-Sensors for Medical Applications



**Co-ordinator :**

Prof. Antoine FERREIRA  
University of Orléans  
Institut PRISME

Email: antoine.ferreira@ensi-bourges.fr

***<http://nanoma.zenon.gr/>***

