**Part 1: Scientific sheet**

| Thesis proposal title | Quasi real-time simulation of a capsule in flow using Reduced-Order Models  
Simulation en quasi temps réel d'une capsule sous écoulement grâce à des Modèles d'Ordre Réduit |
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<tbody>
<tr>
<td>PhD grant</td>
<td>MultiphysMicroCaps, financed by ERC</td>
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| Research laboratory   | Laboratory: Biomechanics & Bioengineering Laboratory (UMR CNRS-UTC 7338), UTC Compiègne  
reseauch team: Biological Fluid Structure Interactions  
web site: http://www.utc.fr/~salsacan/ |
| Thesis supervisor(s)  | Dr Anne-Virginie Salsac, CR CNRS (HDR), BMBI, UTC  
Dr Florian de Vuyst, Prof, LMAC Laboratory, UTC |
| Scientific domain(s)  | Science and technology  
Biomedical and health science engineering  
*EURAXESS fields*: Biomedical Engineering, Mechanical Engineering, Simulation Engineering, 3D Modelling, Modelling Tools, Computational Mathematics |
| Research work         | Micro-capsules, which are fluid droplets enclosed in a thin elastic membrane, are current in nature (red blood cells, phospholipidic vesicles) and in various industrial applications (biotechnology, pharmacology, cosmetics, food industry). They are used to protect and transport active principles, by isolating them from the external suspending fluid. One application with high potential is the use of microcapsules for active substance targeting, but scientific challenges remain to be met, such as finding the optimal compromise between payload and membrane thickness, characterizing the membrane resistance and controlling the moment of rupture. Once injected in an external flow, the particles are indeed subjected to dynamical loading conditions, which result from the complex 3D capsule-flow interactions. To model them numerically, one needs to account for the non-linear large deformations and wrinkling of the capsule membrane and potential damage, which results in large systems of equations and thus in long computational times.  
The objective of the thesis project is to explore the use of reduced order modeling approaches to enable fast-time simulations. Innovative sophisticated numerical models will be conceived to simulate the deformability and damage of microcapsules under hydrodynamic stresses.  
We will use the fast-simulation tools to identify the mechanical properties from experimental results of capsule deformation. The properties will be determined by fitting the deformed capsule shape predicted by the reduced order models to the experimental one using diffuse approximation techniques.  
The reduced order models will thus help design deformable liquid-core capsules of micrometric size for health-related applications to protect and deliver active substances. It will enable optimize their properties for specific industrial and biomedical applications, and predict membrane damage to control the delivery. |
| Key words             | Microcapsules, reduced order models, fluid-structure interaction, active substance targeting |
| Requirements          | **Skills:**  
- Strong scientific background in fluid-solid mechanics and/or scientific computing  
- Notions of biomechanics and bioengineering will be a plus  
- Good English skills  
- Excellent interpersonal and communication (written and verbal) skills **Personal Qualities:**  
- Ability to work collaboratively as part of a team in an interdisciplinary context  
- Flexibility, motivation, pro-activity, commitment to high quality  
- Commitment to continuous educational and professional development  
- Commitment to UTC’s and CNRS’ policy of Equal Opportunity, ability to work harmoniously with colleagues and students of all cultures and backgrounds **Qualification:**  
MS degree or equivalent qualification. |
| Starting time         | September 2018 |
| Location              | BMBI Laboratory, UTC |
# Part 2: Job description

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<th>Duration</th>
<th>36 months</th>
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<th>Additional missions available</th>
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### Research laboratory
The project will take place within the ‘Biological Fluid-Structure Interactions’ Group, directed by A.V. Salsac, which is one of the 3 research teams of the UTC Biomechanics & Bioengineering Laboratory (http://www.utc.fr/bmbl/). The group is specialized in the fields of biofluids and hemodynamics at both the microscopic and macroscopic scales. It focuses on the study of the fluid-structure interactions that occur between fluid flows and various flexible structures (vessel wall, capsule and cell membrane, biomedical devices, etc.).

The strength of the group is the long expertise in numerical modeling of artificial capsules with the boundary integral method. The group has the unique characteristic of combing numerical and experimental expertise, which enables to translate theoretical results into practical applications. They have developed microfluidic techniques to produce and characterize microcapsules, as well as study their deformation when they flow in micro-tubes and networks.

http://www.utc.fr/~salsacan/

The project will be conducted in collaboration with LMAC and Roberval Laboratories from UTC. Florian de Vuyst, who will co-supervise the PhD, is an expert in numerical modeling in Fluid Mechanics and engineering, with special focus on models and methods in 2-phase flows as well as model-order reduction. He is specialized in the development of numerical tools to model complex multiphysics problem in mechanical engineering, correlate experiments and numerical simulation and optimize large-scale problems using reduce-order approaches.

https://fdevuyst.jimdo.com/

### Material resources
All of the tools and equipment needed for the project are available in the ‘Biological Fluid Structure Interactions’ team of BMBI and the LMAC Laboratory:

For the numerical simulations:
- Fluid-structure simulation codes based on the coupling between the Boundary Integral Method to solve for the fluid flow and the Finite Element Method for the capsule wall deformation
- Workstations, High Performance Computing facilities

### Human resources
The BMBI laboratory is composed of about:
- 40 permanent staff members (27 academic staff, 13 technical and administrative staff)
- 31 PhD students
- 8 Postdocs
- 7 associated researchers
- 15 Master students

### Financial resources
MultiphysMicroCaps, financed by ERC

### Working conditions
What is expected from the candidate is to have a sense of autonomy and to be capable to work in group. His/her mission will be to conduct the research project, present his/her results during the research meetings (meetings with the advisors, lab meetings, etc) and to the rest of the scientific community via publications in international journals and conferences.

### Research project
MultiphysMicroCaps, financed by ERC

### National collaborations
- Roberval, GEC, TIMR Laboratories, UTC
- Solid Mechanics Laboratory, Ecole Polytechnique
- INRIA Paris Institute
- Reims Molecular Chemistry Institute, URCA

### International collaborations
- Applied Mechanics and Bioengineering, Zaragoza (Spain)
- School of Engineering and Materials Science, Queen Mary University of London (UK)

### International cosupervision

### Contact
To apply please send a complete CV, a letter of motivation, 2 letters of recommendation or the contact details of 2 referring persons, as well as the result transcripts for all the courses followed at university to:

Dr Anne-Virginie Salsac (+33 (0)3 44 23 73 38, a.salsac@utc.fr)
BMBI Laboratory (UMR CNRS-UTC 7338), UTC CS60319 60203 COMPIEGNE cedex, France

Prof Florian de Vuyst (+33 (0)3 44 23 43 61, florian.de-vuyst@utc.fr)
LMAC Laboratory, UTC CS60319 60203 COMPIEGNE cedex, France

Please note that only candidates who have been shortlisted will be contacted

Please contact first the thesis supervisor before applying online on https://webapplis.utc.fr/admissions/doctorants/accueil.jsf