

# STSM REPORT

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## 1. Background and motivation:

I am currently working with the modelling group at the University of Strathclyde, Scotland, on mathematical modelling of drug-eluting stents. Stents have become one of the most popular treatments for coronary heart disease. Over the past fifteen years, stents have evolved from bare metal structures to drug-eluting stents (DESs). These stents are coated with anti-proliferative drugs that are released into the arterial wall. The drug prevents the artery from re-narrowing as a result of uncontrolled smooth muscle cell (SMC) proliferation. However DESs are associated with increased risk of thrombosis (blood clotting) which, when it occurs, is often deadly. Current research is focussed on the development of stents which accelerate the healing process to minimise thrombosis risk. To optimize stent design, a multidisciplinary collaboration between mathematicians, engineers, experimentalists, clinicians and industry is required.

Therefore I would like to visit Prof Abdul Barakat's cardiovascular and cellular engineering lab at Ecole Polytechnique, France (<http://chair-axa-ccc.polytechnique.fr/>) to collaborate with experts in experimental investigation. Prof Barakat is an expert in cardiovascular fluid mechanics, cardiovascular devices and vascular cell engineering. We will develop project concepts with regards to modelling interactions of drugs released from stents with cellular surfaces, how flow modulates interactions and experiments of drug release from stents in artificial artery systems, and modelling the formation of thrombosis. I would also visit the Instent company in Paris (<http://www.instent.eu/>) to discuss potential collaborations.

I also plan to attend the 117th European Study Group with Industry at the University of Avignon, which is the first study group in France, to interact and develop a network with academic researchers and companies in Europe, especially in France.

## 2. Work plan and main results:

**23<sup>rd</sup> – 27<sup>th</sup> May 2016:** I attended the 117<sup>th</sup> European Study Group with Industry (ESGI 117) at the University of Avignon, France. The purpose of this meeting is to strengthen the links between academic community and industries by using mathematical optimization tools to tackle industrial problems. During the study group, I worked with researchers from France, Belgium and Australia on a problem from EDF "*Energy management in a decentralized setting*" and contributed to the report "*Power flow optimization in the presence of microgrids*". We are planning to prepare a paper for publishing in the Mathematics-in-Industry Case Studies journal. I also gave feedback to help the organisers organise a more effective study group after their first ESGI in France.

**30<sup>th</sup> May – 10<sup>th</sup> June 2016:** I visited Prof Abdul Barakat and his group at the cardiovascular and cellular engineering lab at Ecole Polytechnique, France. We are developing a model of platelet deposition and the formation of thrombosis in the configuration of a drug-eluting stent apposition in coronary arteries. The model is formulated using a series of convection-diffusion-reaction equations to describe the mechanisms leading to the formation and growth of thrombus. The effect of shear gradient on platelet aggregation and thrombus growth is also considered.

I discussed with Dr Elizabeth Antoine on how flow modulates endothelial wound healing and effects of drug release after stent deployment in artificial artery systems from her experimental results. We will set up experiments of drug release from polymer-free stents in her artificial artery systems. The stents will be provided by my collaborators at the University of Strathclyde. The experimental data will be compared with my modelling results. I also discussed with Johanne Mensah (a PhD Student) on developing models of stent design optimization and learned how to use the software COMSOL Multiphysics to build and solve computational models for stent problems, especially to build stent geometries.

I also met and discussed with Dr Franz Bozsak, CEO of Instent company (<http://www.instent.eu/>) on potential collaboration. Instent has joined the ECMI Special Interest Group in ‘*Advancing the design of medical stents*’ that I organised and will be an industrial partner when we submit proposals for the Horizon 2020 European program, especially the Innovation Training Network (ITN) from Marie Skłodowska-Curie actions.

### **3. Expected outcomes:**

I have been a co-author of a technical report “Power flow optimization in the presence of microgrids” for the problem from EDF at the ESGI 117. We are expecting to publish a paper on this problem in the Mathematics-in-Industry Case Studies journal.

I am working with Prof Barakat to prepare a paper on modelling the formation of thrombosis to publish in a peer-reviewed journal. We will prepare a proposal to apply for the Ulysses Research Programme that supports research collaborations between Irish and French researchers. Instent Company will be an industrial partner when we submit proposals for Industry Fellowship Programme from Science Foundation Ireland or Innovation Training Network (ITN) from Marie Skłodowska-Curie actions.

### **4. Benefits of the STSM funding:**

The STSM grant has had a considerable effect on my research career. I have developed a new international and interdisciplinary network from academia and industry, enhanced communication and presentation skills via my interaction with researchers during my trip in France, and acquired new knowledge on modelling and computational simulation of stent related problems and also on optimization problems in the energy industry. My collaboration with Prof Abdul Barakat’s group and Instent company will lead to research publications and funding proposals (possible sources include Ulysses Research Programme from the Irish Research Council and the Campus France, Industry Fellowship Programme from Science Foundation Ireland, Innovation Training Network (ITN) from Marie Skłodowska-Curie actions, etc.). The novelty of this work will further enhance my reputation in the field of modelling in biology and biomedical engineering.



(Working on the EDF problem at the ESGI 117 at the University of Avignon, France)