# Cambridge NERC Earth Systems Science DTP
# 2016-17 Project Pro Forma

1. **Project Title:**

A Dune Roundabout: Underwater Bedforms in a 1D Annulus

2. **Lead Supervisor (name, institution, email address):**

Dr. Nathalie Vriend, University of Cambridge, nv253@cam.ac.uk

3. **Co-Supervisor(s) (name, institution, email address):**

Dr. Sean Lovett, Schlumberger, slovett@slb.com

4. **Course to which applicants should apply (e.g. British Antarctic Survey (BAS), Department of Earth Sciences, Division of Biological Anthropology):**

Department of Applied Mathematics and Theoretical Physics (DAMTP)

5. **Which of the NERC DTP thematic areas does your project best fit:**
   - **Climate Theme**
   - **Solid Earth Theme**
   - **Biology Theme**

Solid Earth Theme

6. **Importance of the area of research concerned (limit 150 words):**

Mobile sediment transport influences flooding thresholds, coastal boundaries and shipping lines with major environmental and economic consequences. After the 2011 Japan earthquake, tsunamis dramatically changed the seafloor in Japan's coastal areas, forming new underwater dunes and influencing the marine ecosystem. Mouths of major rivers or tidal currents through narrow orifices---such as the Golden Gate Bridge strait---can create underwater sand waves as well and change drastically over short times. Oilfield applications of bedform dynamics include the cross-flow past subsea pipelines or tiebacks, and particle bed flow in pipes or annuli.

Although their prominence in our natural world is known, there are many open questions related to the mathematical modelling and physical description of these bedforms of different size and shape. What happens if these bedforms encounter obstacles (e.g. pipes) on a seabed? This project aims to thoroughly investigate the structure and migration of underwater bedforms.

7. **Project summary—the first sentence should convey the essence and importance of the project. (up to 100 words):**

What is the effect of external forcing (river inflows, tidal cycles and storms) or obstacles on the morphology, structure and migration speed of underwater bedforms? In this project the student investigates the formation and migration of underwater one-dimensional bedforms in a novel experimental set-up at DAMTP and, potentially, in a meso-scale industrial flow loop at Schlumberger Gould Research in Cambridge. Due to the continuous interaction with the water and air phase, the

bedforms evolve their shape, height and wavelength depending on external influences. Experiments and modelling aim to determine the physical behaviour of evolving annular bedforms.

8. **What the student will actually do? (limit 150 words)**

The student will use a novel thin annular Taylor-Couette geometry on a turn-table to create a 1D aqueous periodic system. First, the long-term behaviour of bedform evolution is investigated with different initial conditions. Next, the forcing on the system will be varied, with a continuously increasing velocity, step-size increases or out-of-phase alternating velocities (mimicking tidal flow). Thirdly, an array of objects of different orientation, size and submersion will be inserted in the channel to study aspects of coastal/beach erosion and design optimisation. Is it possible to design a structure that stabilises a seabed or guarantees its cleaning?

The mathematical component of this work includes the construction of a model for initiation and selection of waveforms in a 1D circular and periodic geometry. Furthermore, a mathematical analysis of the long-term, steady behaviour should include both a stability analysis for the initiation phase and mass and momentum conservation arguments for the interaction between neighbouring bedforms.

9. **Training to be provided (limit 60 words):**

The student will be embedded in the granular group (currently 4 PhD-students, 1 postdoc) in the GK Batchelor Laboratory at the University of Cambridge, which is at the forefront of fluid-dynamical research, will engage in regular project meetings with the co-PI at Schlumberger and potentially spend short periods at Schlumberger Gould Research in Cambridge while conducting numerical or experimental work.

10. **If there are requirements as to the educational background of candidates that would be suitable for the project, please specify below:**

A quantitative mathematical, engineering or (geo)science background will be essential to perform the theoretical component of this project. The experimental skills will be taught on the job.

11. **References: Maximum three and should be in the following style**
***White, R.S. & McKenzie, D. 1989. Volcanism at rifts. Scientific American, vol. 260, pp.62-71., DOI (if known)***

Barnard, P. L., Hanes, D.M., Rubin D.M. & Kvitek R.G., 2006. Giant sand waves at the mouth of San Francisco Bay. Eos Transactions of the American Geophysical Union, vol. 87, pp.285,289.

Ashley, G.M., 1990. Classification of large-scale subaqueous bedforms: a new look at an old problem. J Sed Petr, vol 60, pp.160-172.

Betat, A., Kruelle, C.A., Frette, V., Rehberg, I. 2002. Long-time behaviour of sand ripples induced by water shear flow, Eur Phys J E Soft Matter, vol 8, pp.465-476.

12. **Potential CASE partners associated with the research:**

Schlumberger Gould Research, Cambridge (confirmed)