BE1601 - Development of an Implantable Passive Control System for Right Ventricular Assist Devices

**Background:** The high afterload sensitivity of rotary right ventricular assist devices (RVADs) can lead to harmful left ventricular suction events, where the ventricle collapses about the left VAD inflow cannula. Active control systems are limited as they rely on potentially inaccurate sensors or unreliable inferred data. A passive RVAD control system has been developed at the ICETLAB which uses a compliant, banded outflow cannula.

**Aim:** The aim of this project is to develop an implantable passive control system for VADs and validate the system using a mock circulation loop (MCL).

**Tasks:** Specific tasks include:

- Conduct preliminary MCL tests to determine key design criteria.
- Use mechanical engineering techniques to design and manufacture the passive control system.
- Validate the design using a mock circulation loop.

**Significance:** This project will progress the design of a novel passive control system for VADs, resulting in improved life expectancy and quality of life for heart failure patients around the world.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1602 – Hydraulic Development of the OpenHeart Prototype

**Background:** Ventricular assist devices are not implanted in low- or medium-income countries due to high device costs. The ICETLAB is working with our international collaborators to make a low cost device (The OpenHeart) aimed at providing mechanical circulatory support in low- and medium-income countries.

**Aim:** The aim of this project is to design, manufacture and test the hydraulic system for the OpenHeart and prepare it for in-vivo testing.

**Tasks:** Specific tasks include:
- Design the OpenHeart housing and impeller using centrifugal pump design theories.
- Model the design in SolidWorks.
- Rapid prototype the design using 3D printing.
- Test and evaluate the system using an in-vitro test rig.
- Prepare a final prototype for in-vivo evaluation.

**Significance:** This project will result in an extensively evaluated OpenHeart prototype ready for in-vivo testing.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1603 – Evaluation of Human Response Times to Changes in Patient State

**Background:** Rotary blood pumps (RBPs) have a limited ability to automatically respond to changes in patient state. This inability can lead to ventricular suction. In order to prevent suction events, a physiological control system for RBPs is required. A physiological controller should mimic the response of the native heart, but data on the native heart’s response time to changes in patient state is not available.

**Aim:** The aim of this project is to investigate the response of the native heart during changes in patient state, especially head-up tilt experiments.

**Tasks:** Specific tasks include:

- Improve experimental set up for head-up tilt experiments
- Conduct human experiments in accordance with ethics approval
- Data analysis and comparison with in-vitro simulations

**Significance:** This project will provide a better understanding of the native heart’s response to changes in patient states and will help progress the development of physiological control systems.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1604 - Evaluation of a Quick-Connect System to Reduce Artificial Heart Implantation Time and Complexity

Background: Implantation procedures for artificial hearts and ventricular assist devices (VADs) can be technically challenging, time consuming and costly. The connection mechanism between the sutured grafts / cannulas and the device requires optimization to provide a rapid, simple and reliable procedure.

Aim: The aim of this project is to evaluate a prototype quick-connect system to rapidly attach a VAD to the graft / cannula which has been surgically fixed to the patient.

Tasks: Specific tasks include:

- Complete extensive in-vitro evaluation of the system including connection strength and leak testing under high fluid pressure.
- Complete design modifications of the device if required.
- Validation of the system through in-vivo trials.

Significance: This project will result in a novel device for rapid attachment of VADs to accelerate implantation procedures with fewer operative and postoperative complications for heart failure patients.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com

Quick-connect systems could be used to revolutionise cardiac surgery.
**BE1605 – Optimising bilayered scaffolds for tissue integration of a suture-less inflow cannula**

**Background:** A novel suture-less inflow cannula has been developed to decrease surgery time in order to eliminate the need for cardiopulmonary bypass, which is associated with postoperative complications. Tissue integration of the suture-less inflow cannula creates a safety barrier in case of potential tissue necrosis at the site of attachment and can reduce incidences of thrombus formation.

**Aim:** Determine optimal melt electrospun bilayered scaffold parameters for efficient cell attachment and growth.

**Tasks:** Specific tasks include:

- Understand how different melt electrospinning parameters affect scaffold characteristics
- Optimise porosity, geometry, scaffold thickness, fibre diameter using melt electrospinning
- Compare various bilayered scaffold characteristics using *in vitro* assays

**Significance:** This project will result in an optimised bilayered scaffold allowing efficient tissue integration of a suture-less inflow cannula.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1606 – Improved in-vitro testing of a suture-less inflow cannula using a bioreactor

Background: Current scaffold evaluation techniques are predominantly conducted on tissue culture plates under static conditions. However this is not representative of the physiological environment that the scaffold would experience in vivo. There is a need to create a better model to assess the efficacy of scaffolds in the left ventricle.

Aim: Design a bioreactor to mimic different physiological flows, in particular, flows on a cannula at the left ventricular apex.

Tasks: Specific tasks include:
- Determine the flow characteristics required
- Design and manufacture a bioreactor
- Verify flows in the bioreactor
- Analyse the data to determine design improvements

Significance: This project will result in a highly beneficial tool in the assessment of scaffolds in the left ventricle and for other tissue engineering applications.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com

Example of a cell culture bioreactor
BE1607 – Optimisation of a Novel Drug Delivery System

**Background:** Time to adrenaline delivery after cardiac arrest is crucial for patient resuscitation and prevention of brain death. A novel adrenaline delivery system is under development which can reduce adrenaline delivery time through a simple design and by being placed in shopping centres, sports facilities, homes etc.

**Aim:** The aim of this project is to optimise the flow dynamics in the delivery device to disperse the adrenaline particles.

**Tasks:** Specific tasks include:

- Work with experts in computational fluid dynamics (CFD) to numerically optimise device flow dynamics.
- Use the CFD results to produce prototype adrenaline delivery devices.
- Validate the CFD results using particle image velocimetry.

**Significance:** This project will result in a novel device for rapid delivery of adrenaline to improve outcomes after cardiac arrest.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1608 – Preserving Right Heart Function During LVAD support

**Background:** Survival rates of heart failure patients supported by LVADs are influenced by the pumping capacity of the native right heart. Previous studies have indicated that a failing right heart is a result of interactive effects between the left ventricle and right ventricle. This condition is difficult to detect, and is often caused by the unloading of the LV volume by the LVAD.

**Aim:** This study aims to explore the interactive mechanisms that affect the right heart’s pump after LVAD is implanted, in order to find features that can monitored for diagnosis and management.

**Tasks:** Specific tasks include:

- Investigating left ventricular wall and septal motion on right ventricular function during LVAD support.
- Identifying markers that indicate right heart dysfunction using echocardiography.
- Verifying hypotheses in-vitro and in-vivo

**Significance:** Optimal unloading of the LV to preserve/improve right heart function will improve the survival of patients with heart failure supported by LVAD alone.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

The effect of LV contraction/septum motion on RV function (left), and measurement of ventricular wall motion with LVAD support (right).
BE1609 – Development of a Septal Position Model with a Rotary Blood Pump

**Background:** Changes to the structural geometry of the heart are often observed with rotary blood pumps (RBPs). RBP over- or under-loading may cause significant shifts to the septal position, which may lead to right ventricular failure. Therefore it would be desirable to have a test platform to relate the changes of septal position due to RBP loading and unloading.

**Aim:** To develop a test platform relating septal position to a range of RBP operating conditions

**Tasks:** Specific tasks include:

- Investigate current literature relating to septal position with RBPs
- Develop a numerical model of the relation of septal position and RBP
- Validate model in a mock circulatory loop

**Significance:** This project will provide a platform to aid in the development of optimal over- and under loading of RBPs.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
**BE1610 – Evaluation of Rotary Blood Pumps Hydraulic Performance Using Particle Image Velocimetry**

**Background:** Ventricular assist devices (VAD) are used to support the failing heart. The hydraulic design of the device holds the key to its performance. Particle Image Velocity (PIV) is an optical method to obtain instantaneous velocity measurements and related properties in fluids. The hydraulic performance of the rotary blood pumps (RBP) can be evaluated by tracing the fluid path, shear stress, etc in the device.

**Aim:** The aim of this project is to develop a PIV test rig to visualize and evaluate the hydraulic design of the RBP.

**Tasks:** Specific tasks include:

- Design and build a PIV test rig using SolidWorks.
- Evaluate the RBP design using PIV.

**Significance:** This project will contribute to the improvement of RBP hydraulic design and performance by optimizing the design to reduce thrombus formation and haemolysis caused by static points or high shear stress.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
**BE1611 – Comparison of Blood Damage with Different Pulsing Rotary Blood Pumps**

**Background:** Continuous-flow rotary ventricular assist devices (VADs) may benefit from simulating the pulsing flow created by the native heart. However, this may create higher shear forces and subsequent blood damage.

**Aim:** The aim of this project is to compare the blood damage in pulsatile flow modes with different rotary VADs.

**Tasks:** Specific tasks include:
- Investigate VAD parameters to produce the required haemodynamics in pulsatile flow modes in different rotary blood pumps
- Compare the blood damage between different rotary blood pumps in pulsatile flow modes.

**Significance:** This project will allow researchers to compare pulsatile performance of different rotary blood pumps.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

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Red blood cell damage during pulsatile operation of VADs will be investigated in this study.
BE1612 – Hematologic Interaction with Banding Versus Reduced Speed When Using a LVAD for Right Ventricular Support

**Background:** Implantable left ventricular assist devices (LVADs) are modified for their use as right-VADs (RVADs), by either reducing pump speed or by applying a restriction across the pump outflow cannula, to support right ventricular function. Since LVADS are only optimised to perform under higher pressures, similar to left ventricles, problems such as degradation of blood, causing blood thrombosis, reduced end-organ function and stroke occur as a result of blood re-circulation, stagnation and high shear forces.

**Aim:** To investigate the effect of outflow banding and reduced pump speeds on the loss of integrity and functionality of blood and blood components.

**Tasks:** Specific tasks include:

- Complete and submit ethics applications for research using human blood
- Develop an ex-vivo model using a mock circulation loop and LVAD
- Evaluate the effect of out-flow banding and reduced pump speeds on red blood cell functionality, and platelet and coagulation cascade induced-thrombus formation.

**Significance:** This project will enhance the understanding of blood interactions on mechanical circulatory support and allow for the future development of safer therapies for patients suffering from right-heart failure.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

Implanted RVAD and LVAD
**BE1613 – Evaluation of Ventricular Flow Dynamics with Rotary Blood Pumps Using Particle Image Velocimetry**

**Background:** Ventricular assist devices are used to support the failing heart and are connected to the ventricular apex through specially designed cannula. The flow dynamics within the ventricle are influenced by the shape, orientation and protrusion length of the inflow cannula, and incorrect placement or design may result in thrombus formation and subsequent stroke.

**Aim:** The aim of this project is to develop an anatomically correct model of the left ventricle and assess various inflow cannula designs to reduce the potential for thrombus formation using engineering techniques.

**Tasks:** Specific tasks include:

- Modify a 3D model of the left ventricle to create a 3D printed mould.
- Mould the left ventricle and attach to a mock circulation loop.
- Use particle image velocimetry techniques (PIV) to assess ventricular flow dynamics with various inflow cannula designs.

**Significance:** This project will contribute to the design of an inflow cannula to reduce thrombus formation and bleeding with ventricular assist devices.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

MRI data of the left ventricle will be used to construct the model for flow evaluation.
Background: Ventricular assist devices are used to support the failing heart and are connected to the ventricular apex through specially designed cannula. The flow dynamics within the ventricle are influenced by the shape, orientation and protrusion length of the inflow cannula, and incorrect placement or design may result in thrombus formation and subsequent stroke.

Aim: The aim of this project is to develop a computational fluid dynamics (CFD) model of a left ventricle and assess various inflow cannula designs to reduce the potential for thrombus formation.

Tasks: Specific tasks include:

- Import extracted 3D data of a failed heart into ANSYS.
- Incorporate various inflow cannula designs in the ventricular model.
- Validate the model using PIV data.
- Assess the flow dynamics with various inflow cannula designs, orientations and protrusion lengths.

Significance: This project will contribute to the design of an inflow cannula to reduce thrombus formation and bleeding with ventricular assist devices.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com
**BE1615 – CFD modelling of a mitral valve to create physiological intraventricular flows**

**Background:** In order to understand how flows change in the left ventricle (LV) after implantation of ventricular assist devices (VADs), accurate physiological flow models are required to be constructed for assessment of these devices. Critically, increased understanding on the flow from the left atrium to the LV, through the mitral valve (MV) is an important consideration for these models.

**Aim:** To determine the optimal mitral valve model that recreates physiological flows in an anatomically correct LV.

**Tasks:** Specific tasks include:

- Create a list of potential MV models
- Implement each MV into the LV in steady state simulations
- Assess and compare flow pattern with literature
- Refine MV models

**Significance:** This project will create a fundamental LV CFD model that can be used to assess various inflow cannula designs to minimise blood recirculation and stagnant regions.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

![Intraventricular flow during diastole (Seo et al, 2014)](image.png)
**BE1616 – Particle Image Velocimetry Evaluation of Mechanical Heart Valves**

**Background:** Various evaluation techniques are required for the continued development of mechanical heart valves. Particle image velocimetry (PIV) can be used to track the flow through a heart valve and identify any regions of stagnation which may promote harmful thrombus formation.

**Aim:** Use PIV and a mechanical representation of the heart and circulatory system for evaluation of mechanical heart valves.

**Tasks:** Specific tasks include:

- Design and construct a mock ventricle, aorta and circulation made of clear materials.
- Validate the haemodynamics produced by the clear mock circulation against patient data.
- Use the clear mock circulation for preliminary PIV evaluation of heart valves.

**Significance:** This project will contribute to the development of new mechanical heart valves which may lead to improved therapy for many patients worldwide.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

The mock circulation will be used for flow dynamics evaluation of mechanical heart valves.
BE1617 – Development of Rotary Blood Pump Flow Estimator for Left, Right and Bi-ventricular Support

**Background:** Rotary blood pump (RBP) flow is an essential parameter to determine if sufficient blood is delivered to the end-organs. Commercial estimations of RBP flow have been developed which are suitable for the critical care setting. However, as patient health improves and they are exposed to a wider range of conditions, the pump flow estimators are prone to greater inaccuracies.

**Aim:** The aim of this project is to develop a pump flow estimator for a wide range of cardiovascular conditions.

**Tasks:** Specific tasks include:

- Evaluate a RBP in a range of cardiovascular conditions in-vitro for left, right and bi-ventricular support
- Develop a RBP flow estimator and evaluate against a directly measured flow and commercial estimator.
- Validate the developed flow estimator in-vivo

**Significance:** An improved RBP flow estimator has the potential to have greater performance and accuracy in a wider range of cardiovascular conditions. The significance of this will improve monitoring of patient condition.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
**BE1618 - Development of an Implantable Passive Control System for Ventricular Assist Devices**

**Background:** The lack of preload sensitivity of rotary ventricular assist devices (VADs) can lead to harmful suction events, where the ventricle collapses about the inflow cannula. Active control systems rely on potentially inaccurate sensors or unreliable inferred data. A passive VAD control system has been developed at the ICETLAB which uses a compliant inflow cannula to automatically adjust device flow based on pressures within the heart.

**Aim:** The aim of this project is to develop an implantable passive control system for VADs and validate the system using a mock circulation loop (MCL).

**Tasks:** Specific tasks include:

- Optimise existing compliant inflow cannula to minimise haemolysis and design for implantation.
- Use mechanical engineering techniques to design and manufacture prototypes.
- Validate the design using a mock circulation loop.

**Significance:** This project will progress the design of a novel passive control system for VADs, resulting in improved life expectancy and quality of life for heart failure patients around the world.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1619 – Development of a Non-Invasive Implantation Tool for Right Ventricular Assist Devices

**Background:** Right ventricular assist devices (RVADs) are used to support patients who have failing right ventricles. Traditional implantation techniques have involved opening the chest or inserting a cannula through the femoral artery – both of which render the patient bed-bound.

**Aim:** The aim of this project is to develop a novel, non-invasive implantation tool for right ventricular assist devices to allow patients to become mobile shortly after surgery.

**Tasks:** Specific tasks include:

- Use MRI / CT scans of patients with right heart failure to determine optimal device geometry.
- Design and construct prototypes of the implantation device and evaluation in-vitro.
- Complete in-vivo evaluation of the device.

**Significance:** This project will result in a novel, non-invasive RVAD implantation technique and improve the life expectancy and quality of life for patients with right ventricular failure.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

The Impeller LVAD is an example of a non-invasive implantation of a ventricular assist device.
BE1620 – An MRI Compatible Mock Circulation Loop

**Background:** Mock circulation loops (MCLs) are mechanical representations of the heart and circulatory system. They can be used for extensive evaluation of cardiovascular devices, such as artificial hearts or heart valves. Use of MRI technology to evaluate device performance and flow dynamics has opened a new field of research in cardiovascular device development.

**Aim:** The aim of this project is to develop an MRI compatible mock circulation loop for evaluation of cardiovascular devices.

**Tasks:** Specific tasks include:

- Use MRI data to create anatomically correct MCL components, such as a ventricle and aorta.
- Develop a fully functional, MRI compatible MCL.
- Validate the MCL against data from patients.
- Use the MCL to evaluate new heart valve implantation techniques in an MRI machine.

**Significance:** Development of an MRI compatible MCL will provide an ideal platform for cardiovascular device evaluation and allow for immediate assessment of a new heart valve implantation technique.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1621 - Improvement of a Mock Circulation Loop for Testing Cardiovascular Devices

**Background:** Mock circulation loops (MCLs) are mechanical representations of the heart and circulatory system, and are used to evaluate artificial hearts, ventricular assist devices and other cardiovascular devices.

**Aim:** The aim of this project is to design, construct and implement new regional blood flow paths within the mock circulation loop located at the ICETLAB.

**Tasks:** Specific tasks include:
- Construct regional blood flow paths such as coronary artery and cerebral circulation.
- Implement these regional blood flow paths within the existing mock circulation loop.
- Validate the pressure and flow patterns produced by the new flow paths against patient data and the literature.

**Significance:** This project will result in a vastly improved mock circulation loop which can be used to test a wide range of cardiovascular devices, such as artificial hearts, prior to animal and human trials.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

More components of the cardiovascular system need to be represented in a MCL.
**BE1622 – Automatic Control of a Mock Circulation Loop for Testing Cardiovascular Devices**

**Background:** Mock circulation loops (MCLs) are mechanical representations of the heart and circulatory system, and are used to evaluate artificial hearts, ventricular assist devices and other cardiovascular devices.

**Aim:** The aim of this project is to improve the Frank-Starling response of the MCL to automatically change between a healthy response and various heart failure (HF) conditions.

**Tasks:** Specific tasks include:
- Implement healthy starling response and various HF conditions (e.g. mild, moderate and severe HF)
- Implement control algorithm to automatically tune the various conditions in the MCL

**Significance:** This project will result in a vastly improved mock circulation loop which can be used to test a wide range of cardiovascular devices, such as artificial hearts, prior to animal and human trials.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1623 – Simple Mock Circulation Loop for Cardiovascular Device Evaluation

**Background:** A mock circulation loop is a mechanical representation of the human circulatory system. Mock circulation loops use complex validated models to simulate human cardiovascular pressure and flow dynamics. Mock circulation loops allow engineers to quickly and cheaply evaluate prototype technologies in the lab by simulating various heart failure conditions.

**Aim:** The aim of this project is to produce a simplified mock circulation loop for cardiovascular device evaluation.

**Tasks:** Specific tasks include:
- Review mock circulation loop design
- Design and assemble electronics and circulatory loop
- Design control environment using LabView IDE
- Evaluation of designed MCL using known models and controllers.

**Significance:** This project will provide the ICETLAB with a simplified mock circulation loop for cardiovascular device evaluation.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1624 – Evaluation of Rotary Blood Pump Control Strategies for Myocardial Regeneration

**Background:** Clinical experience has shown that heart failure patients may sometimes recover from mechanical unloading of the heart. Patients may benefit from rotary blood pump (RBP) control strategies that promote myocardial regeneration.

**Aim:** This project aims to develop a physiological control strategy that can support patients to recover ventricular function.

**Tasks:** Specific tasks include:

- Identify patients who have the potential to regenerate myocardial function through data mining techniques
- Evaluate physiological control strategies that enhance regeneration
- Validate in-vitro with potential to progress to in-vivo

**Significance:** This project will provide a better understanding of patients that may recover from heart failure through RBP control.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1625 – Evaluation of Speed Modulation Waveforms on the Cerebral and Coronary Circuit

**Background:** Rotary blood pump (RBP) speed modulation methods have been developed for particular applications, such as enhancing coronary flow. The effects of the particular modulation methods on other circuits however remain relatively unknown. Specifically, cerebral flow needs to be maintained physiologically to prevent neurological damage.

**Aim:** To develop a RBP speed modulation profile, to optimize flow for both the cerebral and coronary circuit.

**Tasks:** Specific tasks include:

- Investigate a variety of speed profile parameters suitable for rotary blood pumps
- Investigate in a numerical model the speed profile parameters in a range of cardiovascular conditions
- Evaluate cerebral and coronary flow and optimize the speed profile

**Significance:** This project will identify key parameters for speed modulation profiles to deliver adequate cerebral and coronary flows.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1626 – Development of a ‘Sensor-less’ Control System that Replicates the Native Heart

Background: Patients may benefit from physiological control systems that balance the cardiovascular circulatory system. Control systems require feedback to make informed decisions and adjust accordingly. Implantable sensors however, have limitations as they are invasive and are prone to blood clots and measurement drift.

Aim: The aim of this project is develop a physiological control system using intrinsic rotary blood pump (RBP) signals that replicates the native heart response

Tasks: Specific tasks include:

- Develop methods to estimate cardiovascular conditions from RBP signals
- Implement estimation methods in a physiological control system
- Validate the ‘sensor-less’ control system in-vitro

Significance: This project will provide a better understanding of the native heart’s response to changes in patient states and will help progress the development of physiological control systems for RBP’s, thus improving quality of life for heart failure patients around the world.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com
**BE1627 – Evaluation of a Stroke Work Controller**

**Background:** Rotary blood pump (RBP) patients may benefit from control systems that adapt to patient demand, which may therefore prevent secondary complications such as heart collapse and congestion in the lungs. Currently, a controller that replicates the native heart’s response has been developed in a numerical model. The next steps are to evaluate the system in-vitro and in-vivo.

**Aim:** To evaluate a stroke work controller based on the native cardiac response

**Tasks:** specific tasks include:
- Implementing the stroke work controller in-vitro
- Evaluating the controller in a range of patient conditions
- Validate the controller in-vivo

**Significance:** The stroke work controller has the potential to prevent the heart from collapsing and congestion in the lungs by adequately adapting the RBP. This has the significant to dramatically improve the quality of life for RBP patients.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

**Ventricular function curve of work done by the LV and left-rotary blood pump**
BE1628 – Development of Stroke Work and Preload Estimation with Centrifugal and Axial Pumps

Background: Monitoring cardiac function of ventricular assist device (VAD) patients is significant to determine patient condition and for VAD control purposes. Current implantable sensors however are prone to blood clots and drift in measurements. Instead, estimation techniques using easily obtainable VAD parameters may be a suitable alternative until implantable sensors are made more reliable.

Aim: The aim of this project is to develop estimators for stroke work and preload from easily obtainable VAD signals.

Tasks: Specific tasks include:
- Investigate in-vitro the relationship between VAD signals against stroke work and preload at a constant speed
- Repeat previous task with a speed modulated VAD
- Validate relationship in-vivo

Significance: This project will provide a better understanding between the relationship between VADs and cardiac function. The significance of this has the potential to improve patient monitoring systems and for VAD control applications.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com

Features of blood pump signals for estimator development
**BE1629 - Flow loop for isolated veins**

**Background:** The dilation of veins under the influence of wall shear stress is well documented, but the mechanisms of this are as yet unknown. This project will bring physiologists and engineers together to research the mechanisms of vein dilation.

**Aim:** Projects will develop a flow loop which can pass blood through isolated veins allowing us to see the dilation of the vein and to measure the biochemistry in the vein sections.

**Tasks:** Specific tasks include:

- Designing a flow loop with specific connectors which allow attachment to vein sections without blood loss and sampling of blood.
- Setting up a NI Virtual instrument to control the loop + make measurements of flow rate and other electrical signals derived from biochemical processes.
- Verify that the loop can accurately duplicate the pulsatile flow of the human circulatory system.
- Help to write a journal paper on the flow loop and measurements.

**Significance:** This project will inform a research project on wall shear stress-mediated vein dilation as part of a research project aimed at increasing access to haemodialysis for patients with kidney failure.

**Contact:** Prof Geoff Tansley: g.tansley@griffith.edu.au or Dr Shaun Gregory: shaun.gregory1@gmail.com
BE1630 – Development of an Integrated Ventricular Assist Device Driveline to Reduce Infection Rates

Background: Infection at the driveline exit site is one of the most significant complications following ventricular assist device (VAD) implantation and is associated with increased mortality and hospital costs. Researchers at The Prince Charles Hospital hypothesise that improved integration of the driveline at the exit site will reduce infection rates.

Aim: The aim of this project is to promote VAD driveline integration using a seeded, electro-spun mesh.

Tasks: Specific tasks include:
- Create scaffolds for the VAD driveline.
- Cell culturing on the scaffold.
- Analysis of results and potential in-vivo evaluation.

Significance: This project will result in improved driveline integration for patients on VAD support, thus reducing postoperative complications and improving the life span and quality of life for heart failure patients.

Contact: Dr Shaun Gregory: shaun.gregory1@gmail.com

Traditional surgical implantation techniques for VADs can be technically challenging.
ME1601 – Computational Fluid Dynamics Analysis of Rotary Blood Pump Performance

**Background:** Computational Fluid Dynamics (CFD) is a promising design tool for the development of biomedical devices. It delivers detailed insight into the complex patterns of fluid flow which aids hydraulic design of the rotary blood pump.

**Aim:** The aim of this project is to analyse the hydraulic performance of the rotary blood pump using CFD.

**Tasks:** Specific tasks include:
- Reconstruct the rotary blood pump using SolidWorks
- Simulate the hydraulic performance of the pump using CFD
- Compare experimental results with CFD predictions

**Significance:** This project will evaluate the hydraulic performance of the pump and contribute to the improvement of rotary blood pump hydraulic design and performance. The project will result in a pump design with higher efficiency, better performance and lower power consumption.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
ME1602 – Intra-abdominal Pressure Measurement System

**Background:** Following surgery it is commonplace to measure the intra-abdominal pressure of the patient. Typically this is carried out using a catheter which is passed into the bladder and which is uncomfortable for the patient and unpleasant for the nursing staff.

**Aim:** The aim of this project is to design and test a device which can measure the intra-abdominal pressure and remove the need for bladder catheterization.

**Tasks:** Specific tasks include:

- Review current catheterization techniques.
- Design and construct a pressure measuring system.
- Test the pressure measuring system in-vitro (and maybe in-vivo) and compare its performance with current methods.

**Significance:** Such an intra-abdominal pressure measurement system would reduce the need for invasive interventions and could lead to much more frequent and accurate measurements.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com or Prof Geoff Tansley: g.tansley@griffith.edu.au
ME1603 – In-silico (and In-vitro) fluid mechanics of Coronary Arteries

**Background:** Blockages and narrowing in coronary arteries can lead to angina and heart attacks. We have a database of models of human arteries with clinical flow data.

**Aim:** The aim of this project is to 3D model these arteries and predict flow and shear stress through them and compare this to the clinical situation.

**Tasks:** Specific tasks include:

- Develop 3D models from Dicom images
- Apply CFD modelling to extract fluid dynamical data
- Compare CFD models with clinical data
- (maybe also make physical models of the arteries and use PIV to validate the CFD data).

**Significance:** Such models will assist surgeons in deciding whether a stenosis is critical and whether to operate on an individual or not.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com or Prof Geoff Tansley: g.tansley@griffith.edu.au
ME1604 - Haemolysis modelling in a backward-facing step

**Background:** Shear stresses are known to destroy red blood cells (a process known as haemolysis). As yet there is no good CFD model for haemolysis but the FDA has proposed generation of such a model which can be benchmarked for accuracy across many labs. This model comprises a backward-facing step which was a benchmark many years ago for turbulence modelling.

**Aim:** Create a computational (CFD) model of a backward facing step informed by open literature. In parallel, create a physical blood flow loop of the same configuration and predict haemolysis from shear stress fields compared with physical measurements of haemolysis.

**Tasks:** Specific tasks include:

- Review current models of backward-facing steps in literature
- Develop a CFD model of the backward-facing step
- Develop a physical model of the backward facing step and measure haemolysis in it.

**Significance:** This project will feed into an international effort to develop a reliable CDF predictor of haemolysis

**Contact:** Prof Geoff Tansley: g.tansley@griffith.edu.au or Dr Ben Simpson: b.simpson@griffith.edu.au
ME1605 - Haemolysis modelling in pipes of varying roughness

**Background:** Shear stresses are known to destroy red blood cells (a process known as haemolysis). As yet there is no good CFD model for haemolysis – a process which is known to be very strongly influenced by shear stresses at the pipe walls (rather than bulk flow). This project will model flow in pipes of varying roughness to examine the significance of roughness on shear stress and haemolysis and CFD wall modelling on its prediction.

**Aim:** Create a computational (CFD) model of pipes of varying diameters and wall roughness, and in parallel, create a physical blood flow loop of the same configuration and predict haemolysis from shear stress fields compared with physical measurements of haemolysis.

**Tasks:** Specific tasks include:

- Review current models of CFD haemolysis predictions in literature
- Develop a CFD model of pipes of varying diameter and wall roughness
- Develop a physical model of pipes of varying diameter and wall roughness and measure haemolysis.

**Significance:** This project will feed into an international effort to develop a reliable CDF predictor of haemolysis.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com or Prof Geoff Tansley: g.tansley@griffith.edu.au
ME106 - Cell exclusion and Haemolysis in a Spiral Groove Bearing

**Background:** Anecdotal evidence shows that red blood cells avoid flowing through very tight gaps (e.g. in spiral groove bearings) in rotary blood pumps and that this behaviour saves the red blood cells from damage. We have been able to show photographically this behaviour but not to confirm protection of the red cells.

**Aim:** To replicate a spiral groove bearing in the lab and to gather photographic evidence of cell exclusion and protection against cell damage (haemolysis).

**Tasks:** Specific tasks include:

- Set up a bench-top milling machine + add new control software
- Design and make equipment for spiral groove experiments
- Set up a laser-based system to gain photographic evidence of cell exclusion
- Carry out blood flow experiments to show a reduction in haemolysis where cell exclusion processes are at work.

**Significance:** Bearing design in blood pumps is a significant problem and we hope through this project to draw up design code for commercial blood pump designers.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com or Prof Geoff Tansley: g.tansley@griffith.edu.au
ME1067 – Moulding and Prototyping of a Cannula for Fibre Optic Transducers

**Background:** A cannula is a tube that connects the heart to the ventricular assist device. For this project a cannula is required for embedding newly emerging fibre optic transducers. Manufacturing of a silicone cannula is done using 3D printed moulds that are designed and prototyped using SolidWorks.

**Aim:** The aim of this project is to optimise the design of the cannula and help improve prototyping techniques for manufacturing silicone cannulae from 3D printed moulds.

**Tasks:** Specific tasks include:

- Refinement of cannula designs using SolidWorks
- Printing and finishing of 3D models
- Moulding of cannulae using 3D printed moulds
- Optimisation sensor-cannula bonding

**Significance:** This project will produce the optimal cannula design for the embedding of fibre optic sensors. The project will refine techniques for prototyping silicone cannulae from 3D printed moulds.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
EE1601 - Fibre-Optic Pressure sensor

**Background:** Measuring pressures within the body is fraught with difficulties – particularly as most pressure sensing elements drift and cannot be recalibrated. This poses a particular problem in using pressure to control implanted rotary ventricular assist devices which are liable to collapse the patient’s ventricle and cause injury or death.

**Aim:** Continue the development of a fibre-optic pressure sensor to the point where it can be implanted in an animal.

**Tasks:** Specific tasks include:

- Design work of an outer shell for conduit-mounted fibre optical pressure sensors
- Calibration and characterization of the sensor
- Further development of the National Instruments Virtual Instrument which drives the sensor.

**Significance:** Ultimately new control strategies will be developed which can use fibre-optic based pressure sensors which will enable more aggressive and safer therapies for heart-failure patients

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com or Prof Geoff Tansley: g.tansley@griffith.edu.au
EE1602 – Development of a XYZ Traverse System for Particle Image Velocimetry

**Background:** Particle Image Velocity (PIV) is an optical method to obtain instantaneous velocity measurements and related properties in fluids and can be used for evaluation of cardiovascular devices. To observe the flow dynamics on various planes, a traverse system is required for accurate and repeatable movement of a high powered laser.

**Aim:** The aim of this project is to develop a system which can accurately and repeatedly shift a PIV laser along X, Y and Z directions.

**Tasks:** Specific tasks include:
- Investigate systems which allow 3-axis movement.
- Design and construct a platform which allows 3-axis movement of a high powered laser.
- Verify the accuracy and repeatability of the system.

**Significance:** This project will contribute to and enhance other projects using PIV to investigate flow dynamics in cardiovascular devices in the ICETLAB.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
EE1603 – GUI Development of a Cardiovascular Numerical Model

**Background:** Numerical studies have benefits that include; direct haemodynamic measurements, repeatability and cost efficiency. Currently the back-end of a numerical model is available; however, a front-end graphical user interface (GUI) has not yet been developed. This project will develop the front-end GUI to aid VAD control development and teaching purposes.

**Aim:** Develop a graphical user interface of a current cardiovascular and rotary blood pump numerical model

**Tasks:** Specific tasks include:
- Develop GUI of cardiovascular numerical model in Matlab environment
- Develop GUI of rotary blood pump (RBP) model in Matlab environment
- Integrate cardiovascular and RBP model

**Significance:** The significance of a GUI of the cardiovascular and RBP model will benefit researchers for robust numerical studies and will be implemented as a teaching tool.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com
ID1601 – Improving Ventricular Assist Device Usability Through Qualitative Assessment of all Users

**Background:** With the rising acceptance of ventricular assist devices (VADs) for use in destination therapy, the patient, caregiver, cardiologist, surgeon and nurses will have interactions with the device and support system. Current systems have been shown to be unintuitive and require improvements to optimise patient outcomes.

**Aim:** The aim of this project is to qualitatively assess the experiences of all users associated with the VAD ‘lifecycle’ and provide recommendations for future designs.

**Tasks:** Specific tasks include:
- Complete and submit ethics applications for research
- Develop a questionnaire for all VAD users
- Interview patients, caregivers, doctors and nurses
- Analyse the data to determine design improvements
- Work with industry to design new VAD components

**Significance:** This project will provide a set of recommendations for improved VAD support. This will assist all users associated with the VAD lifecycle and improve patient quality of life.

**Contact:** Dr Shaun Gregory: shaun.gregory1@gmail.com

VAD system design must overlap with current issues faced by the many users of these devices.