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HELLO TOMORROW

Faculty of Science and Engineering

POSTGRADUATE RESEARCH

Programme of Events

Department of Mechanical & Aerospace Engineering

Postgraduate Research Conference

23rd January 2026

MANCHESTER 1824
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Mechanical and Aerospace Engineering PGR Conference 2026

Friday 23 January 2026

Nancy Rothwell Building, Event Space and Blended Theatre 1 (GA.056)

Introduction

Welcome to this year's PGR Conference for the Department of Mechanical and Aerospace Engineering.

Our Postgraduate Research community includes 220 PhD and MPhil researchers, delivering the Department's agenda for research excellence, social responsibility, and teaching activities - as well as forming a vibrant and dynamic workplace.

Today's presentations highlight the range of research spanning Fluids, Solids, Manufacturing, Nuclear and Aerospace Engineering, plus a host of interdisciplinary topics reaching out into the wider University. We are also very fortunate to have two guest speakers, from academia and industry, offering their own take on succeeding in PGR examinations and finding career opportunities.

Please enjoy the conference, take the opportunity to engage with other participants, and seek out inspiration and motivation to accelerate your future research and careers.

David Eastwood

Head of Postgraduate Research
Department of Mechanical and Aerospace Engineering

Conference Schedule

Time	Agenda	Location
09:00 – 09:15	Registration & Tea, Coffee, Pastries	Event Space
09:15 – 09:30	Welcome Address, Professor Alistair Revell	Blended Theatre 1 (GA.056)
09:30 – 09:40	Conference overview including voting instructions, Dr David Eastwood	Blended Theatre 1 (GA.056)
09:40 – 10:40	Keynote lecture: Preparing for a PhD viva 'With the living voice – viva voce', Professor Paul Mativenga	Blended Theatre 1 (GA.056)
10:40 – 11:00	Break	Event Space
11:00 – 12:00	3 Minute Thesis Presentations	Blended Theatre 1 (GA.056)
12:00 – 13:30	Poster Session & Pizza Lunch	Event Space
13:30 – 14:30	3 Minute Thesis Presentations	Blended Theatre 1 (GA.056)
14:30 – 15:00	Poster Session & Refreshment Break	Nancy Rothwell Building Event Space
15:00 – 16:00	Invited talk and Q&A: A Career in F1 Dr Andrew Crook, Mercedes AMG F1	Blended Theatre 1 (GA.056)
16:00 – 17:00	Prize Presentation with Closing Address and Drinks Reception Professor Alistair Revell	Event Space

3MT Presentation Schedule

Session 1: 11:00 – 12:00

Aerospace

Archie Dobson

“Smoothing Out The Wrinkles in Aerodynamic Design”

Daniel Ouzounian

“Infrared thermographic detection of changes in boundary layer state around a circular cylinder”

Hazem Az Eldin

“Regenerative Hopping on Deformable Terrain: Towards Energy-Efficient Jumping Robots”

Huanxia Wei

“Flow Control Towards Bicycle Aerodynamic Drag Reduction”

Jaymal Bechar

“Data handling for emissions reductions in Aviation”

Mirza Baig

“A Mission-Driven Systems Toolkit for Electric Propulsion Systems: Digital Twins and Scaling Models for Autonomous Earth-Orbit and Interplanetary Missions”

Michael Sidebottom

“Swimming in the air: Why do miniature insects use swimming-like flapping kinematics?”

Muhammad Aqeel Abdulla

“Performance Prediction Of A Micro-Turbojet Engine Operating On Sustainable Aviation Fuel”

Sharun Arumugam

"A Unified Adaptive Locomotion–Manipulation Framework for Space Infrastructure Operations"

Tom Rottier

"Flight dynamics of unpowered avian landings"

Akshat Naik

"Scavengers: Piezoelectric Inverted Flags Harvesting Energy from Ambient Wind"

Solids

Yunji Fu

"Stochastic generation method for Response spectrum compatible pulse-like ground motion based on Berlage Waveform decomposition"

Zhixin Liang

"Experimental and theoretical insights into chemo-thermo-mechanical processes in oil well cement under subsurface environments"

Ahmad Fauzi

"Suppression of Aeroelastic Response and Flutter of Rotating Beams and Blades Using Viscoelastic and Smart Materials"

Junhao Wang

"A comprehensive and systematic pulse-like ground motion identification and classification method"

Ali Khodadadi

"Vibration Based Composite Health Monitoring"

Session 2: 13:30 – 14:30

Manufacturing and Bioengineering

Bernard Franckel

"Engineering research, but perhaps not as you thought!"

Charles Kolya

"Circular Supply Chains: A Meta Review Informed Archetype for High Value Manufacturing Network Design"

Joseph Kurebwa

"Efficient methods for industrialisation of process and performance simulation in Arc Directed Energy Deposition"

Lukas Weber

"Melt electrowriting of a bacterial polyester for shoulder tendon repair"

Xu Siyu

"How Do We Build Tungsten for Fusion?"

Ahmed Omara

"Learning from Snails: Toward Hybrid Multimodal Hard–Soft Robots for Extreme Environments"

Rebecca Bennett

"The Influence of Textile Structure on Aerodynamic Drag in High Performance Sportswear"

Rebecca Downs-Ford

"3D Bioprinting of Bilayered Skin Models Using Alternative Dextran-Based Hydrogels"

Molly Pritchard

“Design and Bioprinting of Cryopreservable Collagen-Based Bioinks for Off-the-Shelf Tissue Engineering”

Luiza Manfrinato Pedrotti Da Rosa

“Gold nanoparticles delivery platform in bone tissue model”

Talha Akhtar

“Effect of cuff stiffness in oscillometric blood pressure measurement: A finite element study”

Adrian Perez Barreto

“Bioengineering the future: bioprinted skin for regenerative medicine”

Manhal Mumtaz

“Development of Structurally Optimised Bioabsorbable Implants for the Reduction of Stress Shielding in Long Bone Fixation”

<u>Nuclear</u>

Bradley Moresby-White

“The effect of crystallite reorientation on the behaviour of nuclear grade graphite”

Cui Mao

“Decontamination, treatment and retrieval of radiocarbon from nuclear graphite waste”

Gregory Blom

“Migration of metallic fission products and the subsequent physio-chemical changes within nuclear graphite”

Thermofluids Group

Mihnea Cazacu

“Enhancing Mixing and Reaction in Porous Media with Viscoelastic Instabilities”

Reuben Petty

“Development of numerical modelling approaches for accurate prediction of Natural Circulation Loops”

Sami Own

“Modelling and Simulation of a Small-Scale Barometric Desalination Unit”

Aerospace

Nathan Shankar

“CLEAR-IR: Clarity-Enhanced Active Reconstruction of Infrared Imagery”

Poster Presenters

Poster Number	PGR	Research Group
1	Padrig Owens	Aerospace
2	William Thompson	Aerospace
3	Aan Yudianto	Aerospace
4	Mairi Johnston	Aerospace
5	Jawaria Nadeem	Aerospace
6	Mirza Baig	Aerospace
7	Arij Alruwaii	Manufacturing
8	Tsitsi Moyo	Manufacturing
9	Victoria Omeire	Manufacturing
10	Ziyuan Wang	Manufacturing
11	Lukas Weber	Manufacturing
12	Kurnia Putri Utami	Manufacturing (Medical Engineering)
13	Andong Lu	Solids
14	Mohammed Mawoli	Solids
15	Eoin Muller	Solids
16	Yang Yang	Solids
17	JinJiang Li	Solids (Microsystems)
18	Mujahid Shaik	Thermofluids
19	Lucas Starepravo	Thermofluids
20	Kadir Demirci	Nuclear

Poster Voting

You can vote for the best poster via scanning the QR code below. Please note the following:

- This form will close at **15:00** on the day of the event, Friday 23rd January.
- You may only submit the form once — only your first response will be considered.
- Votes cast for yourself will not be counted.

MAE PGR Conference 2026 - Poster Voting Form

3MT Judging

Academic colleagues from the Department will watch each presentation and judge against the official 3MT criteria, and can provide individual feedback if requested.

The awards winners for the Poster and 3MT competitions will be announced at the end of the day, with prizes sent electronically to the winners.

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POSTGRADUATE RESEARCH

3 Minute Thesis Abstracts

Regenerative Hopping on Deformable Terrain: Towards Energy-Efficient Jumping Robots

Hazem Az Eldin*, Ben Parslew, Kate Smith

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Keywords: jumping robots, deformable terrain, energy regeneration, energy efficiency, cost of transport

Jumping offers a compelling mobility mode for terrains where wheels and continuous contact struggle, especially on soft or deformable ground such as sand-like substrates relevant to planetary exploration. However, repeated hopping is typically energy-intensive, with substantial losses during impact and stance that limit endurance and practical deployment. This research investigates how ground compliance reshapes jump dynamics and energy flow, and whether energy regeneration during landing can reduce the net energetic cost of repeated hops.

The work develops a simulation-led framework that links jump behaviour, ground interaction, and energy accounting into a consistent set of performance metrics suitable for comparing designs and control strategies. Rather than focusing on a single mechanism, the aim is to establish general insight: where energy is stored, where it is dissipated, and under what conditions negative work can be recovered without introducing additional losses that negate the benefit. Current efforts focus on implementing regenerative actuation modes, defining clear per-hop energy measures, and identifying the drivetrain and control characteristics that make regeneration effective.

The longer-term outcome is practical guidance for designing and operating hopping robots that can sustain repeated jumps more efficiently on challenging terrain, supporting future exploration and inspection applications.

Data handling for emissions reductions in Aviation

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Keywords: LTO, Machine Learning, ADS-B

Aircraft Landing and Take-Off (LTO) operations are a major source of near-surface air pollutants, including nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM, including ultrafine particles), sulphur oxides (SO_x), and volatile organic compounds (VOCs) [1]. These emissions degrade air quality in communities surrounding airports and are associated with myriad adverse human health outcomes [2]. Despite this, current approaches for quantifying and interpreting LTO-related emissions remain limited by fragmented data sources, inconsistent modelling assumptions, and weak integration between aircraft operational data and atmospheric observations. Improving the representation of LTO emissions is essential for developing robust airport-scale air-quality assessments and for evaluating the effectiveness of operational mitigation strategies. Most emissions inventories rely on simplified assumptions regarding thrust settings, flight profiles, and meteorological conditions, which can obscure the true variability of near-surface pollutant release. Simultaneously, large volumes of operational flight data and atmospheric measurements are increasingly available but remain underutilised in an integrated modelling context. This research proposes the development of a harmonised data-handling and analysis framework, linking aircraft operational activity during LTO phases with emissions estimation and atmospheric context. The approach draws on open-access and institutional datasets, including Automatic Dependent Surveillance-Broadcast (ADS-B)–derived flight trajectories, airport emissions inventories, and meteorological and air-quality data. An initial catalogue of available flight, aero engine, and atmospheric datasets has been compiled, providing a foundation for subsequent modelling and analysis. Preliminary work focuses on evaluating data quality, coverage, and interoperability across these sources, alongside a systematic review of existing LTO emissions methodologies. Early analyses indicate substantial variability in climb-out and approach profiles, suggesting that standardised LTO assumptions may misrepresent emissions magnitude and spatial distribution. Machine learning approaches, particularly neural networks – appear to have the highest accuracy in prediction – often between 5-10% error to observed values where available. The broader outcome of this research is to provide a stronger empirical basis for cleaner air in airport environments.

References

[1] Arter CA, Buonocore JJ, Moniruzzaman C, Yang D, Huang J, Arunachalam S., *Air quality and health-related impacts of traditional and alternate jet fuels from airport aircraft operations in the U.S.,* Environment International 2022 Jan 1;158:106958.

[2] Munzel T, Gori T, Babisch W, Basner M., *Cardiovascular effects of environmental noise exposure.*, European Heart Journal. 2014 Mar;35(13):829–836.

Smoothing Out The Wrinkles in Aerodynamic Design

Archie Dobson [1*], Alistair Revell [1], Alex Skillen[1]

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Keywords: Generative AI, Optimisation, CFD

Aerodynamic Shape Optimisation (ASO) can design more efficient vehicles and shapes – however it is traditionally bottlenecked by the high computational cost associated with Computational Fluid Dynamics (CFD) and local convergence limitations of gradient-based adjoint methods, leading to slow and small improvements. My PhD looks to explore the current shift in design optimisation, not looking for single next step improvement, but as a probabilistic process which explores the many possible improvements over the design landscape, providing the designer with not only improved designs, but data on how this is an improvement.

The framework I will develop, attempts to build a generative model that interacts directly with the unstructured meshes that define shapes in CFD. The core idea is to combine rotationally equivariant Graph Neural Networks (GNNs) [1], that naturally operate on meshes, with diffusion modelling [2], a technique that learns to transform initially noisy or imperfect shapes and designs into higher-performance ones through a sequence of iterative refinements.

The goal is to iteratively denoise or refine the inital geometry towards an improved aerodynamic state. Achieved through training and conditioning on coarse flow information and aerodynamic performance metrics. Through interacting directly with the native-mesh description of the shapes, we avoid restrictive shape parameterisations allowing us to scale to more complex geometries.

Success will be demonstrated by producing high-quality candidate designs with fewer expensive simulation-driven optimisation loops, with robust performance over a range of shape and flow conditions.

References

[1] J Lino, Mario, Stathi Fotiadis, Anil A. Bharath, and Chris D. Cantwell. *Multi-scale rotation-equivariant graph neural networks for unsteady Eulerian fluid dynamics. Physics of Fluids* 34, no. 8 (2022): 087110. https://doi.org/10.1063/5.0097679.

[2] Ho, Jonathan, Ajay Jain, and Pieter Abbeel. *Denoising Diffusion Probabilistic Models.* arXiv:2006.11239 (2020), http://arxiv.org/abs/2006.11239

Gold nanoparticles delivery platform in bone tissue model

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Keywords: Bone injuries, Gold Nanoparticles, Quercetin, Regenerative Medicine

Bone injuries caused by trauma, infection, or surgery remain a major clinical challenge. Although autologous bone grafts are considered the gold standard for bone repair, their clinical use is limited, driving the development of biomaterial-based artificial bone scaffolds as promising alternatives. These scaffolds provide appropriate mechanical support, biocompatibility, controlled biodegradability, and osteoinductive potential, while also serving as platforms for the delivery of cells and bioactive molecules, such as growth factors, cytokines, and drugs, to enhance bone regeneration. In this context, gold nanoparticles (AuNPs) have attracted considerable interest in bone tissue engineering due to their excellent biocompatibility, tunable size and shape, high reproducibility, and efficiency as carriers for biomolecular delivery [1]. Quercetin (Qu), a natural bioflavonoid abundantly found in fruits, vegetables, and medicinal plants, has been shown to promote osteogenic differentiation in multiple cell types [2,3]. Therefore, this project aims to develop a physiologically relevant *in vitro* bone tissue model to formulate, test, and validate an AuNP-based delivery system. This will be achieved by combining gelatin-based hydrogels, 3D bioprinting, and primary mesenchymal stem cells (MSCs) to generate 3D constructs that recapitulate key structural and functional features of bone tissue. AuNP-mediated transfection will be evaluated based on quercetin delivery efficiency and osteogenic marker expression. Ultimately, this work aims to establish an innovative therapeutic delivery platform with potential applications in bone injuries, contributing to advances in regenerative medicine.

References

[1] Yang, Dae Hyeok et al. A review on gold nanoparticles as an innovative therapeutic cue in bone tissue engineering: Prospects and future clinical applications. **Materials toda**y. Bio vol. 26 101016. 12 Mar. **2024**, doi:10.1016/j.mtbio.2024.101016

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Flight dynamics of unpowered avian landings

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Keywords: aerodynamics, flight dynamics, bird flight

Flight and landing performance are governed by fundamental physical laws that constrain both the dynamics and feasible designs of flying systems, whether biological or engineered. An improved understanding of how these laws constrain animal locomotion can therefore provide insights into its evolutionary development. Here, the flight dynamics of avian landings are explored to understand what constraints it may impose on their evolution. A non-dimensional model of a point mass acted upon by aerodynamic and gravitational forces is used to examine the flight dynamics of landings and determine minimum touchdown speed solutions. Theoretically, the model is able to attain zero touchdown speed without any additional energy input provided the required initial speed can be attained. While theoretically possible these flight trajectories are not commonly observed in birds due to the large spatial displacements that occur. This implies that birds may opt to expend additional energy (i.e. through flapping their wings) to reduce the spatial requirements of landing. Landing on the ground imposes constraints on the possible flight trajectories and makes it impossible for a bird to touchdown with zero speed. As such ground landings require additional hindlimb (legs) or forelimb (wings) musculature or some combination of the two to remove this residual kinetic energy and land on the ground. It is hypothesized that this requirement may have shaped the evolution of avian morphology as they transitioned from terrestrial to aerial locomotion.

A Unified Adaptive Locomotion–Manipulation Framework for Space Infrastructure Operations

Sharun Arumugam [1*], Kate Smith [1], Simon Watson [1], Ben Parslew [1], Manu Nair [1], Matthew Goundary [2], Michael Oates [2]

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Keywords: Space robotics, Locomotion–manipulation, Variable gravity environments, Adaptive contact mechanics, On-orbit servicing

Human activity in space is expanding beyond exploration towards the construction, servicing, and maintenance of large-scale orbital and planetary infrastructure. However, existing space robotic systems deployed to maintain or service such orbital assets remain poorly suited to these tasks. Wheeled rovers are limited by terrain, while free-flying robots in microgravity suffer from drifting, instability, and restricted physical interaction. As missions increasingly span variable-gravity environments from orbital platforms to the Moon and Mars, there is a growing need for robotic approaches capable of robust movement and interaction without relying on astronauts. This research investigates a unified adaptive locomotion–manipulation framework for space infrastructure operations. Rather than separating locomotion and manipulation, the framework explores how the same robotic limbs can be used for movement, anchoring, grasping, and force application through adaptive contact mechanics. The focus is on the fundamental principles governing contact and coordination in variable gravity, rather than on a specific robotic platform.

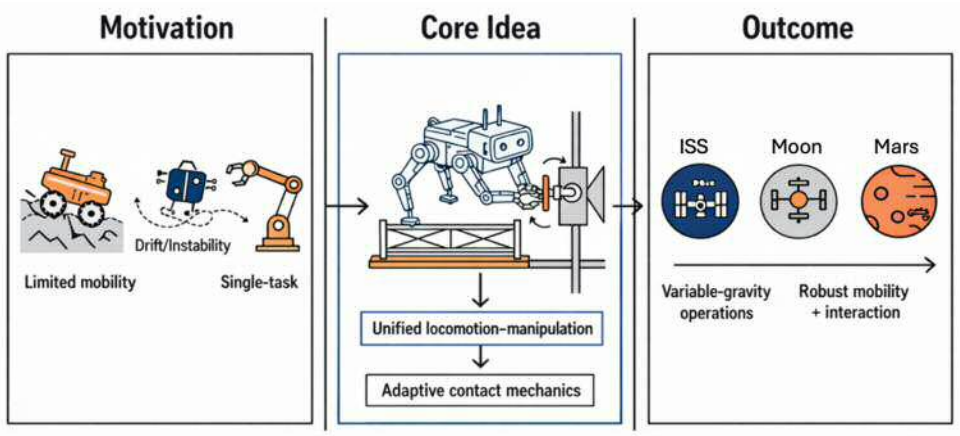

Figure 1. Unified locomotion–manipulation framework for orbital and planetary space operations.

References

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Swimming in the air: Why do miniature insects use swimming-like flapping kinematics?

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Keywords: Miniature insects, Low Reynolds numbers, Flapping wing flight, Bristled wings

At the very edge of powered flight exist miniature insects with typical wing lengths of less than 1mm (see Figure 1a). The flight challenge faced by miniature insects is characterised by extremely low Reynolds numbers within the region of 10, the reality of which was aptly described in a brief review by Dudley [1]: ''*a 1 mm insect moves through air as would a bumblebee through mineral oil*'' – implying the formidable effects of air viscosity at miniature scales. One distinguishable feature of miniature-scale flight is that of 'drag-based' flapping kinematics, which are as closely related to the motions of swimming as they are to flying (see Figure 1b). The exact reason why miniature insects use drag-based kinematics, rather than the classical lift-based approach used by non-miniature insects, is not obvious – hence, in this study we have investigated the above problem via low order quasi-steady aerodynamic modelling. As a starting point, we use the quasi-steady approach to model kinematic profiles which use either the lift or the drag component *only* for generating the vertical force vector. Ultimately, it is found that pure-drag-based kinematics become more favourable when we begin to consider flapping half-strokes that are asymmetric about the half period. When stroke asymmetry is increased, it is found that a force imbalance arises, via which viscous drag can be used to counteract the gravitational force. As such, the present study suggests that the reason why miniature insects do not use the conventional lift-based approach for flight, is a matter of taking advantage of their highly viscous environment to improve aerodynamic efficiency.

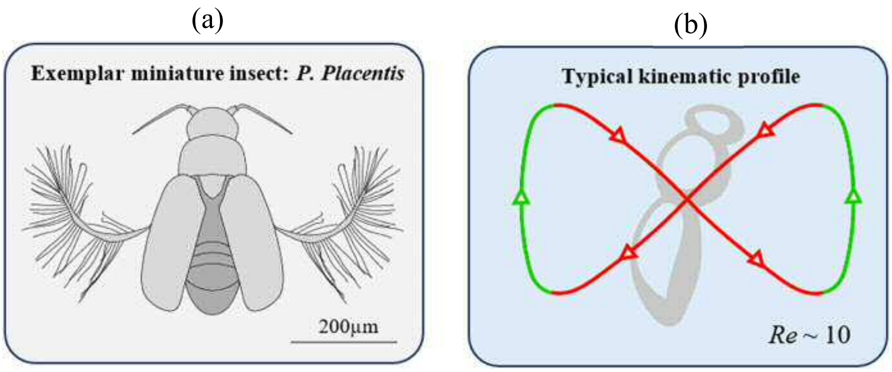

Figure 1. (a) Colloquially known as featherwinged beetles, the *Paratuposa Placentis* is a species of miniature insect whose wing morphologies are largely composed of long hair-like bristles extending from a central membrane. (b) Typical figure-of-eight flapping profile employed by the featherwinged beetle which generates an overall vertical force vector that has significant contributions from both the lift and the drag component.

References

[1] Dudley Robert, Flight among the Lilliputians, J, Exp. Biol. 224 (9) (2021)

Performance Prediction Of A Micro-Turbojet Engine Operating On Sustainable Aviation Fuel

The accurate prediction and replication of gas turbine engine behaviour is critical to the evaluation of performance and efficiency of modern propulsion. The lack of high-quality experimental datasets for small-scale gas turbines limits the ability to validate such models across a range of operating and fuel conditions. To address these limitations, a combined experimental and computational framework has been established consisting of a fully instrumented turbojet engine test-rig and on open-source gas path simulation tool, GSPy [1]. Together, these platforms establish a transparent environment for validating engine performance, analysing combustion behaviour, and supporting future developments in model-based diagnostics and digital twins.

The engine test rig was designed to reproduce the operating processes of a turbojet engine under controlled laboratory conditions. The AMT Olympus engine is a single-spool engine that contains a single radial compressor and an axial flow turbine. It can operate at a maximum rotational speed of 108,000 revolutions per minute (RPM), achieving a pressure ratio of 4:1, an air mass flow rate of 450 g/s, and a fuel consumption rate of 11 g/s The engine produces a thrust of 230 N at the maximum RPM and a minimum thrust of 50 N. Measurements include thrust via load cells, fuel flow rate using a mass flow meter and pressure and temperature readings across each engine station using thermocouples and pressure transducer. The high-frequency data acquisition system allows to capture both the steady-state and transient performance. There were significant design considerations when developing the engine test rig, for example the separation of lubrication system and fuel system to prevent contamination, ensuring reliable operation and accurate emissions assessment when testing a range of fuels, including those derived from sustainable feedstocks.

Complimenting the experimental setup, GSPy provides a modular Python based framework for one dimensional gas path simulation. Each engine component from the inlet, compressor, combustor turbine and the nozzle is represented by energy and mass balance equations and are solved iteratively to ensure thermodynamic closure. GSPy's architecture allows off-design performance prediction, and the integration of custom fuel compositions. By coupling experimental data with the simulation outputs, the foundation for training neural network and digital twins has been constructed [2].

To assess the performance of the engine when burning sustainable fuels and validate the GSPy model, the micro-turbine was tested using five fuels. The five fuels were pure JetA-1, pure Sustainable Aviation Fuel (SAF) produced by the Gas-to-Liquid (GTL) process, 75% blended GTL with JetA-1, 48% blended GTL with JetA-1, and pure SAF produced by the Alcohol-to-Jet (ATJ) process. For each fuel, several test points were conducted based on throttle percentage, from 0% (proxy ground idle condition) to 100% (proxy take-off condition), which aligned as closely as possible with the Landing and Take-Off (LTO) cycle emissions test points. In addition to the experimental test, for the model validation, various fuel properties were used based on measurements using the same fuel from [3], for example, the specific energy, which ranged from 43.01 to 44.25 MJ/kg.

The framework bridges the gap between empirical testing and analytical modelling, providing a foundation for assessing the performance of a small-scale gas-turbine. This interaction enables the development of a robust combustion model and supports the construction of a hybrid digital twin architectures for sustainable and adaptive propulsion research [2].

References

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Efficient methods for industrialisation of process and performance simulation in Arc Directed Energy Deposition

Joseph Kurebwa

Accurate prediction of residual stresses in Arc Directed Energy Deposition (Arc-DED) is essential for structural integrity assessment but remains challenging due to the high computational cost of modelling complex thermal histories. This study develops and evaluates a computationally efficient macroscopic thermo-mechanical modelling framework for Arc-DED, adapted from weld-modelling approaches, aligned with the R6 structural integrity assessment procedure, and validated against experimental data.

The framework was developed and assessed using the NeT-TG9 Arc-DED benchmark, comprising 5 AISI 316L layers. A coupled thermo-mechanical workflow was implemented to compare conventional moving torch simulations with reduced-order bead-lumping and pass-lumping techniques. Both methods reproduced the residual stress distributions of the moving torch model, with pass-lumping reducing computational time by up to 92%.

To assess scalability beyond straight-wall geometries, a novel L-shaped Arc-DED benchmark incorporating a corner feature and consisting of 50 AISI 316L layers was fabricated and characterised. Time-of-flight neutron diffraction provided reliable multi-peak strain measurements across both mid-wall and corner regions. The pass-lumping approach was then applied to the L-shaped geometry and captured the principal features of the experimentally measured residual stress distributions despite the increased geometric complexity.

The results demonstrate that reduced-order thermo-mechanical modelling approaches, when carefully developed and validated, can deliver accurate and computationally efficient residual stress predictions for Arc-DED components, supporting their application to complex geometries and industrially relevant modelling workflows.

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Keywords: Strategic Decision Making, Decision Theory, Engineering, Wicked Problem.

Engineering research, but perhaps not as you thought!

The decisions we're making are getting harder. We have so much more information at our fingertips and so many more solutions. Even deciding what to eat, where to buy ingredients, and how to cook them is more complicated than it was 20 years ago. Think about the decisions that we make for a project that lasts three months, six months or a year. Imagine the difficulty of making decisions on a project that lasts 10 years, involves many people, and must work. That's a strategic planning decision.

A plane or a building aims to be completed on time and on budget. A plane or a building is designed to achieve many objectives, but above all, the primary goal is to avoid tumbling down to earth. However, most of the world doesn't adhere to this primary goal. Strategic projects fail. Huge companies fail. Take the example of North American IT companies investing billions to achieve AI dominance. These companies generally make strategic planning decisions based on expert intuition. Yes, informed by rigorous analysis, but accepting a level of risk that others would find unacceptable. Their engineering projects risk failure, yet they go ahead to deliver a good-enough solution as quickly as possible to beat the competition and thereby achieve efficient allocation of resources.

But what if a project cannot fail and involves the same culture? I hypothesise that for a long-term wicked problem requiring engineering solutions, existing engineering decision-making methods will not be effective. It's a philosophical meta-problem that I believe needs engineering-led scientific methods to research.

My first challenge is systematically examining the literature. The field of business has produced thousands of research papers aimed at accelerating the strategic decision-making process to achieve long-term competitive advantage. Encouraging, but unlikely to satisfy the field of engineering. The field of engineering has produced thousands of research papers on strategic decision-making that the field of business might dismiss as, at best, tactical or operational. A research gap seems to exist.

I anticipate challenges in designing a scientific experiment to test any hypothesis. Doubtless, it will need a thought experiment. My candidate wicked problem is how the UK will successfully achieve its net-zero by 2050 plans. Zero-emission vehicles (ZEVs) are a critical part of the plans; however, fundamental components of ZEVs rely on rare earth elements (REEs) that the world once saw as commodities and encouraged a single country to dominate. They are now vital for ZEVs, and for some, their supply is problematic. In this context, how might the UK approach strategic planning to avoid this problem and thereby ensure it achieves its net-zero by 2050 plans?

Circular Supply Chains: A Meta Review Informed Archetype for High Value Manufacturing Network Design

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Keywords: ***circular supply chains, systematic literature review, circular economy, system-of-systems, PESTLE, industrial ecology***.

Manufacturing processes depend heavily on the supply chain, and it is an integral component in value delivery. The design of a supply chain poses a problem about scheduling and routing resources, using partners' data in computational algorithms. Circular economy objectives complexify this problem with value-retention processes, reverse logistics and the mitigation of negative externalities. This paper conducts a systematic literature review into circular supply chains and proposes an archetype for network design in high value manufacturing. Our meta-review of 67 articles studies circular supply chains through the dimensions of: policy, economics, society, technology, legality and environment. Complementing the latest research, our approach helps to uncover the archetypical features of circular supply chains. The archetype we discover decouples value from utility in a manufacturing-focused conceptual framework. We argue that a system-of-systems approach, based on industrial ecology, could provide a blueprint for future circular supply chain designs.

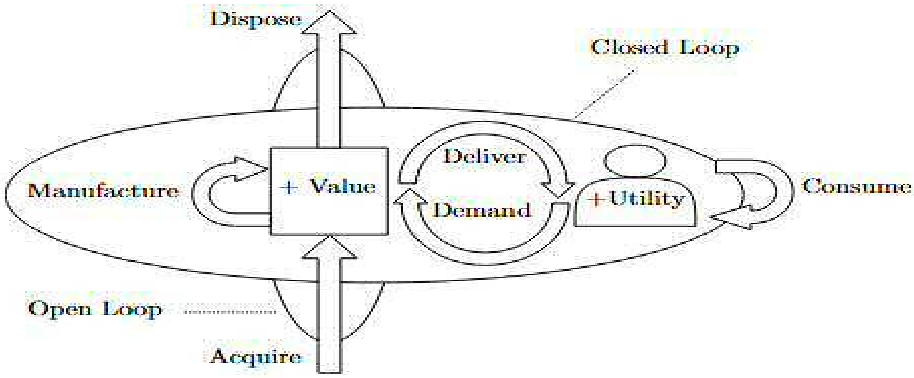

Figure 1. Archetypical representation of manufactured value at the firm level. The support activities of acquisition, manufacturing, disposition and delivery are strategic and can be prescribed. The activities of demand and consumption are not directly controllable by the firm and can only be described. Demand should be coordinated with product take-back, however, and is dependent on consumer utility. The closed loop processes retain and realise value with the consumer, whereas the open loop processes exchange resources on an industrial scale. Reverse logistics is then about the coordination of inbound materials from both consumers and industry.

Melt electrowriting of a bacterial polyester for shoulder tendon repair

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Keywords: melt electro-writing, PHA, tendon, biofabrication, scaffold

Introduction

Rotator cuff tears account for approximately 40% of shoulder pain cases. Although decellularized grafts are widely used to restore the tendon–bone interface, incomplete healing occurs in 10–70% of patients,[1,2] highlighting the need for scaffolds that better mimic the native tissue gradient.

Materials and methods

This study aims to engineer bioactive and mechanically stable scaffolds for tendon-bone repair. As a first step, the melt electrowriting (MEW) processability of medium-chain-length poly-(3-hydroxy-alkanoate) (mcl-PHA), a biodegradable bacterial polyester, for tendon–bone repair was investigated. mcl-PHA was synthesized via microbial fermentation and characterized by differential scanning calorimetry and oscillatory rheology. MEW printing was monitored using light, fluorescence, and scanning electron microscopy. Scaffold-induced cell viability and alignment were evaluated in fibroblasts and osteosarcoma cells using live/dead staining.

Results

mcl-PHA exhibited low glass transition temperature (≈ –40 °C) and low melt viscosity (200–570 Pa·s), enabling MEW processing at reduced temperatures (40–60 °C) and pressures (< 200 kPa). After process optimization, fibre diameters close to 10 µm and layered meshes with fibre spacings down to 100 µm were achieved. Fibroblasts aligned along parallel fibres with increasing alignment at smaller spacings (**Figure 1** (top)), whereas osteosarcoma cells showed more random organization on larger grid architectures (bottom).

Figure 1. Effect of different MEW patterns of mcl-PHA on cell alignment in fluorescence microscopy: (top) fibroblasts on lamellae with (1-3) varying fibre spacings, (bottom) osteosarcoma cells on grids with (1-3) varying pore sizes. All prints consist of 3 layers. Used stains: Calcein – cyan, EthD-1 – magenta, Hoechst 33342 – yellow.

Discussion

These results demonstrate that mcl-PHA can be processed by MEW with high fidelity and supports architecture-dependent cell alignment, making it a promising material for engineered scaffolds targeting rotator cuff tendon regeneration.

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How Do We Build Tungsten for Fusion?

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Keywords: Wire Electron Beam Additive Manufacturing, Tungsten, Plasma-Facing Components, In-line Monitoring, Quality Assurance

Fusion energy promises a clean and sustainable future, but only if its materials can survive the most extreme environments on Earth. Plasma-facing components sit at the very edge of fusion reactors, directly exposed to intense heat and particle bombardment. Tungsten is the material best suited for this role, and also one of the hardest to manufacture.

Imagine trying to shape one of the hardest metals known, while keeping it completely free from oxygen, and doing so at the scale of large reactor components. This is the challenge faced by traditional manufacturing routes for tungsten plasma-facing components. Quality problems are often discovered only after the part is finished — when it is already too late.

Instead of treating manufacturing as a black box, this research takes a different approach: the process itself can be seen as it happens, and adjusted in real time. By observing thermal and process signals during fabrication, potential defects can be anticipated rather than inspected after failure.

The vision is simple: smarter manufacturing for more reliable tungsten components, helping to bring practical fusion energy closer to reality.

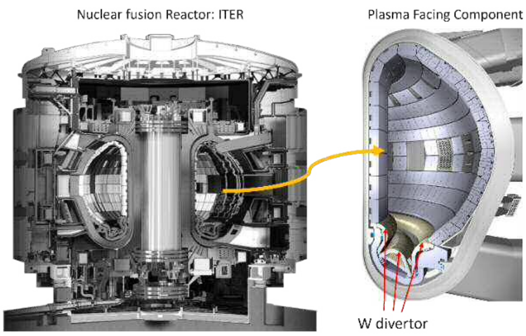

Figure1. *ITER tokamak device structure diagram (left)*[1] *cross-section of plasma-facing component (right)* [2]

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Decontamination, treatment and retrieval of radiocarbon from nuclear graphite waste

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Keywords: Nuclear graphite; Thermal oxidation; Radiocarbon; Waste management

Approximately 300,000 tonnes of irradiated nuclear graphite worldwide will require long-term management, yet geological disposal remains unapproved and costly, motivating the development of alternative treatment strategies. Thermal oxidation has demonstrated potential for graphite gasification; however, an effective method for the controlled release and isolation of radiocarbon (^{14}C) from nuclear graphite is still lacking. This project investigates thermal oxidation as a scalable treatment approach to optimise ^{14}C release while minimising stable carbon (^{12}C) loss. Laboratory-scale tube furnace experiments are conducted under CO_2, steam, and oxygen atmospheres, with quantitative gas analysis used to characterise off-gas composition and assess the influence of oxidation conditions on the $^{14}CO/^{14}CO_2$ ratio, which is critical for downstream gas processing.

Radioactive off-gases, including $^{14}CO_2$ and tritium (^3H), are captured and analysed, while oxidation-induced changes to graphite microstructure and pore accessibility are examined using surface area and porosity measurements. This work aims to support the safe, efficient, and environmentally responsible management of nuclear graphite waste through enhanced radiocarbon recovery.

The effect of crystallite reorientation on the behaviour of nuclear grade graphite

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Keywords: Irradiation creep, CTE, Nuclear graphite, HTGR, AMR

With the objective of decoupling emissions from economic growth, many countries are looking to advanced nuclear reactors to deliver low-carbon baseload power and industrial heat [1, 2]. Several of the proposed designs utilise graphite as a neutron reflector/moderator and as a structural component. Graphite is therefore a fundamental component in these reactor types and can dictate the lifetime of the reactor [3]. As such, it is essential that reactor operators have a complete understanding of the behaviour of graphite under the high fast neutron fluence and temperatures experienced during operation. A crucial phenomenon in determining lifetime under these conditions is irradiation-induced creep. As a form of irradiation-induced plasticity, irradiation creep increases reactor lifetime by relaxing the stresses generated by gradients of irradiation and temperature, while also affecting material properties, most importantly the coefficient of thermal expansion (CTE) [3, 4]. Despite its importance in extending reactor lifetime, there is no accepted mechanism for irradiation creep in graphite and how irradiation creep causes a change in CTE. At present, designers and operators of graphite-moderated reactors are using empirically based relationships to predict this behaviour. This could lead to difficulties when the operating regime of the new reactors goes beyond the regime of the available data, itself based on a now-obsolete graphite grade. An improved understanding of the mechanisms behind irradiation creep and the change in other material properties, particularly CTE, will provide improved confidence in the predicted behaviour of graphite-moderated reactors. The main hypothesis of the project is that the change in the CTE of graphite due to irradiation-induced creep is linked with the reorientation of the graphite crystallites within the bulk structure. The main aim of the project is to measure any reorientation of graphite crystallites due to creep-related processes and relate this to changes in measured CTE.

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Migration of metallic fission products and the subsequent physio-chemical changes within nuclear graphite

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Keywords: Abstracts, Writing, Conference, Manchester, Nuclear Graphite, HTGR, Fission products, XPS

Globally a new generation of reactors are under construction known as generation IV. High Temperature Gas Cooled Reactors (HTGR) are one of these proposed reactor type. A proposed fuel for HTGR reactors is the TRi-structural ISOtropic (TRISO) fuels which under operational conditions could release metallic fission products into the surrounding graphite structural components [1], [2]. Graphite is a permanent structural and moderating component of reactors which dictates end-of-life. Fission products pose a risk to decreasing end-of-life of reactors by graphite damage.

Therefore, to quantify the migration and retention of metallic fission products in the nuclear graphite grades, we will investigate fission products implantation in two different nuclear grades of graphite (IG-110 and NBG-18) using ion irradiation. The distribution of deposited ions has been analysed using X-ray photoelectron spectroscopy (XPS) to determine differences in chemical distribution profiles between grades. Additionally, the effect of ion irradiation on the graphite matrix has been investigated using Raman spectroscopy and X-ray Diffraction (XRD) to characterise any damage or migration effects. This work hopes to further investigate migration of fission products under high temperature reactor conditions (750 – 950 °C) using *in-situ* heating XPS with the aim to provide important insights into the distribution, transport and retention of fission products within the graphite components for future reactors.

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Stochastic generation method for Response spectrum compatible pulse-like ground motion based on Berlage Waveform decomposition

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Keywords: Stochastic generation method; Pulse-like ground motions; Temporal and Spectral non-stationarity; Response spectrum compatibility

Motivated by the growing need to evaluate seismic hazards in near-fault regions and the global scarcity of recorded pulse-like ground motions [1], this study proposes a stochastic method for generating response-spectrum-compatible pulse-like ground motions based on Berlage Waveform (BW) decomposition. A total of 128 recorded pulse-like ground motions were decomposed, demonstrating that their velocity time-histories can be efficiently represented by a limited number of BW components defined by six parameters . By randomly generating these parameters, filtering candidate BW components using the target response spectrum (PSA or PSV) and target Amplitude Envelope Curve (AEC), and iteratively assembling them, artificial pulse-like ground motions can be produced that satisfy both response spectral compatibility and time-frequency energy distribution. It also verifies that the method is applicable when using a Design Response Spectrum (DRS) and a designed AEC, enabling the generation of pulse-like ground motions in regions lacking recorded data, thereby enhancing performance-based earthquake engineering applications for structures seismic design.

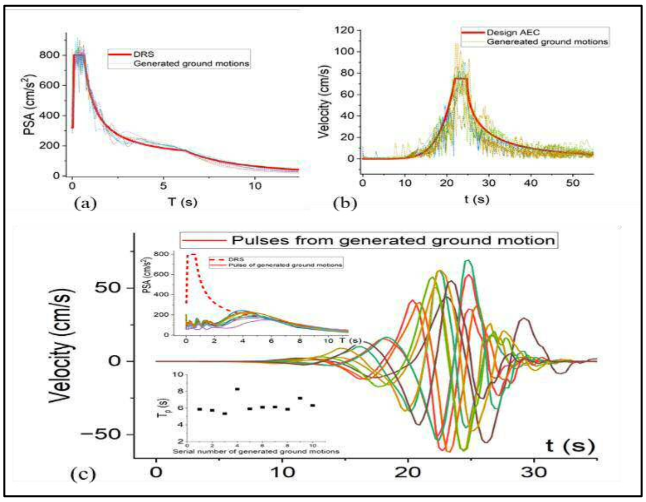

Figure 1. (a) PSA, (b) AEC, (c) pulse components of 10 randomly generated response spectrum compatible pulse-like ground motions based on DRS and designed AEC

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Title of abstract for your presentation

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Abstract

The failure of a carbon fibre composite vertical tail on a commercial aircraft in 2005 highlighted critical limitations in traditional inspection techniques for composite structures. At the time, widely used methods such as tap testing relied heavily on operator experience and subjective interpretation, allowing internal damage to go undetected (Marks, 2007). This work addresses the need for more reliable, physics-based approaches to assess the structural health of composite components.

This research presents a multiscale numerical framework for modelling woven carbon fibre composites, linking micro-, meso-, and structural scales. At the microscale, representative fibre–matrix architectures are modelled to extract effective material properties. These are then transferred to the mesoscale to capture the woven composite behaviour, before being used in full structural-scale models of composite plates. This hierarchical approach enables accurate prediction of stiffness and mass distributions without excessive experimental testing.

Using the derived multiscale properties, the dynamic response of composite structures is simulated, with particular focus on natural frequencies and vibration modes. Since every structure possesses a unique dynamic signature, internal damage that alters stiffness and mass is expected to produce measurable changes in vibration behaviour. The results demonstrate the capability of the framework to establish a baseline dynamic response that can support vibration-based damage detection.

The proposed approach supports the development of non-destructive, lightweight, and potentially in-situ monitoring techniques for aerospace composites. In the long term, this could contribute to affordable structural health monitoring systems capable of detecting internal damage during service, including possible future applications in on-board aircraft monitoring.

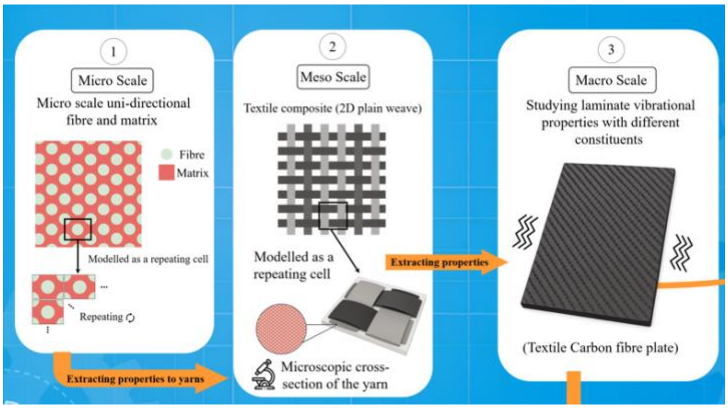

Figure 1.) A graphical example of the multiscale modelling framework, showing micro-scale fibre–matrix representation, meso-scale woven architecture, and structural-scale composite plate used for vibration analysis.

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Experimental and theoretical insights into chemo-thermo-mechanical processes in oil well cement under subsurface environments

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Keywords: Cement; In situ X-ray CT; Multi-field coupling; High-Temperature and High-Pressure (HTHP); Damage evolution; CO2 corrosion;

Cementitious materials have been extensively used in subsurface environments as well cementing, buffering, or engineering barrier for geological CO_2/H_2 storage, geothermal energy extraction and high-level radioactive waste disposal, etc. However, their long-term durability under harsh high-temperature, high-pressure and corrosive underground environments is not well understood. In this work, we investigate how oil well cement degrades when exposed to coupled chemo-thermo-mechanical degradation factors. We combine multi-scale experiments, including nanoindentation, scanning electron microscopy, in-situ CT triaxial compression, with advanced modelling techniques to quantify damage evolution from microstructure to macro behaviour. Our results reveal how microstructural changes drive mechanical deterioration and provide predictive constitutive models for cement performance. This work offers a clear path to improving the long-term sealing integrity of cement in challenging underground environments.

Development of Structurally Optimised Bioabsorbable Implants for the Reduction of Stress Shielding in Long Bone Fixation

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Keywords: Bioabsorbable implants, Stress shielding, Structural optimisation, Finite element analysis

Stress shielding is a major limitation of conventional metallic fracture fixation implants, arising from the stiffness mismatch between implant and bone and leading to reduced physiological loading, impaired bone remodelling, and delayed healing [1]. This challenge is particularly significant in long bone fixation, where appropriate load sharing is essential to stimulate natural regeneration. Bioabsorbable implants offer a promising alternative by providing temporary mechanical support and gradually degrading to allow progressive load transfer to the healing bone; however, their effectiveness is strongly influenced by both implant geometry and material behaviour.

This research investigates the development of structurally optimised bioabsorbable fracture fixation implants, with computational modelling used as the preliminary design tool. Finite element analyses are employed to study bone–implant interaction under physiological loading conditions, enabling detailed assessment of stress and strain distribution within the fractured bone. Unlike conventional design approaches that focus primarily on material substitution, this work emphasises geometry-driven mechanical optimisation as a means of controlling load transfer. Structural and parametric optimisation techniques are applied to tailor implant architecture and stiffness, with the aim of reducing stress shielding while maintaining adequate mechanical stability during the healing process.

Insights gained from the computational framework are used to guide the selection and development of suitable bioabsorbable materials, including polymers, ceramics, and biodegradable metals [2]. These materials are characterised through in-vitro testing to evaluate mechanical properties, degradation behaviour, and biocompatibility, ensuring consistency with the mechanical requirements identified through simulation. The performance of the proposed implant designs is further assessed through mechanical testing and biological evaluation to examine implant degradation and bone response.

By integrating finite-element-driven structural optimisation with material characterisation and experimental validation, this research proposes a unified design framework for the next generation of bioabsorbable orthopaedic implants.

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Enhancing Mixing and Reaction in Porous Media with Viscoelastic Instabilities

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Keywords: Viscoelastic flow, Porous media, Elastic instabilities, Computational fluid dynamics, Mesh-free method

Flow in porous media is of great importance for a wide range of processes, from contaminant transport and soil remediation to subsurface energy applications and catalytic reactors. At low flow rates, however, pore-scale mixing is slow and diffusion-controlled, which can limit effective reaction rates and affect product selectivity. This project explores how viscoelastic fluids (which exhibit both viscous dissipation and elastic stress storage) can overcome these diffusion-limited constraints. Unlike Newtonian fluids, viscoelastic fluids can develop flow instabilities even when inertia is negligible, producing chaotic-like motion that significantly enhances mixing and transport [1]. To investigate the underlying flow behaviour, we simulate viscoelastic flow in model 2D porous media using the Local Anisotropic Basis Function Method (LABFM), a high-order, mesh-free numerical approach [2]. We will then aim to solve the transport equations in the resulting velocity to advect and diffuse a passive tracer and reactive species. This will allow us to quantify mixing quality and reaction yield and selectivity. By assessing how viscoelastic instabilities can shorten characteristic mixing lengths and enhance reactions in confined porous systems, this work seeks to establish an alternative route to turbulent-like mixing at low Reynolds number. These findings will help guide the development of more energy-efficient and sustainable technologies that rely on controlled transport and reaction in confined geometries [3].

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Modelling and Simulation of a Small-Scale Barometric Desalination Unit

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Abstract

This research introduces an innovative and sustainable approach to desalination system, offering a more efficient and eco-friendly process. The method involves distilling freshwater from brackish water or seawater at near-ambient temperatures by exploiting a passive vacuum created by a barometric column to render a near vacuum pressures operating conditions. This setup allows the evaporation process to take place at a much low temperature which can be generated by low-grade green energy sources, such as solar energy. The required vacuum pressures are naturally achieved within the headspace of water columns with a height equal to the local barometric head.

The system, illustrated in Fig1, comprises an evaporation chamber, with a built-in a flat plate solar collector as an energy source, a condenser heat exchanger, and three ten-meter height columns serve as the saline water column; the brine withdrawal column; and the freshwater column, each with its own holding tank installed at ground level. These components are interconnected and managed via circulation pumps and control valves, forming a configuration that is not only cost-effective to construct, operate, and maintain but also easily integrable with other systems. By utilizing renewable energy sources, particularly solar power, the design ensures a low-temperature desalination process that is both environmentally friendly and economically viable.

By leveraging principles of thermodynamics, fluid mechanics, and heat transfer, this study develops a comprehensive MATLAB simulation model to evaluate the potential of the Barometric Vacuum Desalination System (BVDS). Theoretical analysis demonstrates that this configuration is not only

feasible but also highly efficient in producing high-quality freshwater. Moreover, it highlights the system's scalability, sustainability, and adaptability to resource-constrained environments, making it a promising solution for addressing global water challenges in remote regions where under groundwater are available.

This research advances the field of sustainable desalination technologies, addressing critical global water challenges. The system demonstrates efficient operation under diverse conditions, delivering potable water with minimal environmental impact. Additionally, the findings emphasize the scalability and economic viability of BVDS, particularly for remote and arid regions.

Future research will focus on optimizing the system for large-scale applications and incorporating advanced energy storage solutions to enhance performance and reliability.

Keywords: desalination; distillation; thermal; membrane; vacuum; barometric column; solar energy; low grade energy; solar energy; energy input, freshwater; saline water, brine, system performance, pressure; temperature.

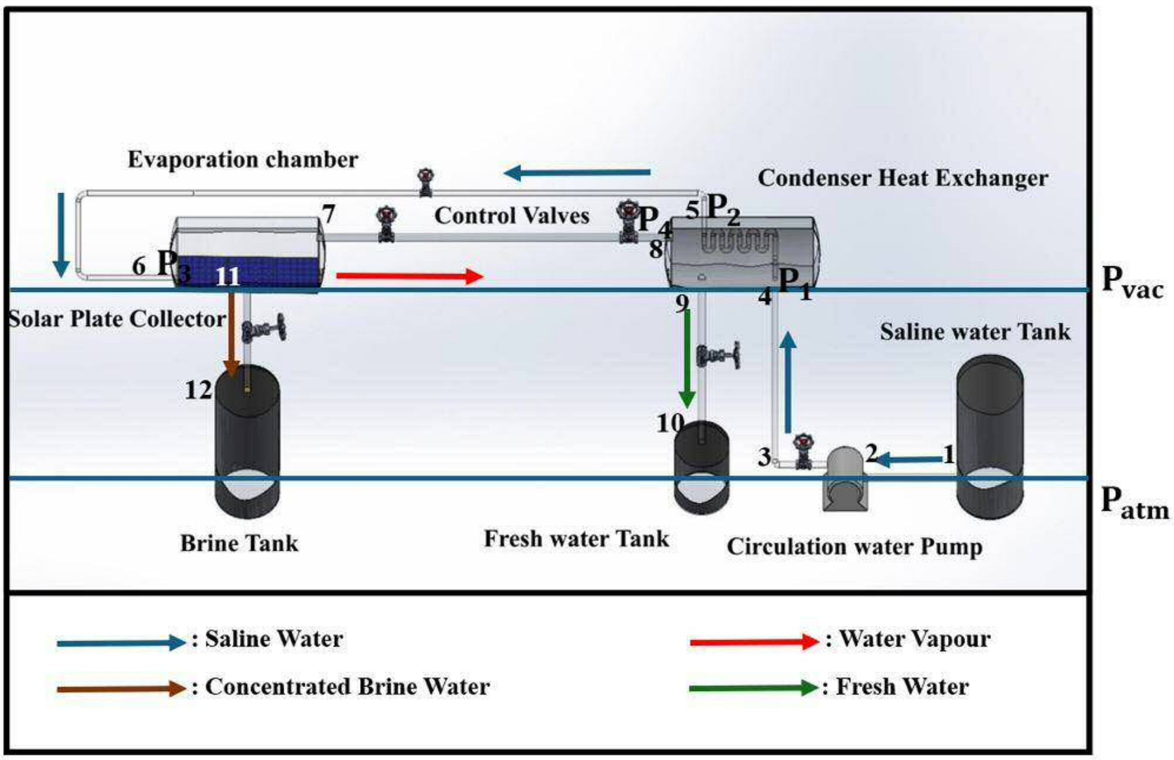

Fig. 1. Illustration Diagram of the Proposed Configuration

Development of numerical modelling approaches for accurate prediction of Natural Circulation Loops.

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Keywords: Natural Circulation Loop, Natural Convection, Passive cooling, Computational Fluid Dynamics.

Natural Circulation Loops (NCLs), where flow is driven exclusively by buoyancy forces arising from temperature differences around the loop, present passive cooling systems useful for a number of applications including cooling within nuclear power plants. The passive cooling these systems provide is attractive in scenarios where reliability is of great importance. The interaction between buoyancy forces and friction forces around the loop can lead to large instabilities, making it challenging for numerical methods to present accurate predictions of flow behaviour. The validation of Computational Fluid Dynamics (CFD) models for NCL analysis is essential to contribute to a better understanding of the complex flow behaviour within these geometries, development of 1D system codes for industrial applications, and proper CFD predictions themselves. A significant portion of current analysis is done without detailed validation data or high-grade CFD data, as these become more available, more practical, lower-cost models can be properly investigated and validated. My research will start with an in-depth literature review alongside initial 2D simulations of single-phase loops. This will lead into more detailed 3D studies, comparing my CFD results to recently available LES data and new detailed validation data, to present new insights into NCL behaviour and prediction.

Effect of cuff stiffness in oscillometric blood pressure measurement: A finite element study

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Keywords: Blood pressure measurement, Cuff stiffness, Oscillometric envelope

Oscillometric blood pressure (BP) devices estimate BP from cuff-pressure oscillations induced by arterial volume changes, which depend on cuff stiffness. Such stiffness dependent oscillations shifts can bias the systolic and diastolic BP readings derived by oscillometric algorithms. This work presents a 3D finite element model of the human upper arm including soft tissue, hyper-elastic brachial artery, and a cuff to quantify how cuff stiffness governs oscillometric signals. Dynamic analysis was performed in ABAQUS by considering three cuff elastic moduli (154, 220, and 300 MPa), taken from Ref. [1]. The cuff was inflated to 150 mmHg (above systolic BP), while a pulsatile arterial pressure of 70/109 mmHg was applied during inflation-deflation cycle. The comparison of envelopes in Figure 1 shows that increasing cuff stiffness shifted the peak of the normalised envelope to higher cuff pressures. This peak shift is accompanied by circumferential buckling, and stiffer cuffs showed more uniform deformation, indicating altered pressure transmission to artery through the cuff-tissue coupling. The stiffness-dependent shift in the envelope peak indicates that cuff mechanics can systematically change oscillometric features used for BP estimation, reducing comparability across cuffs and motivating stiffness-aware calibration and cuff design.

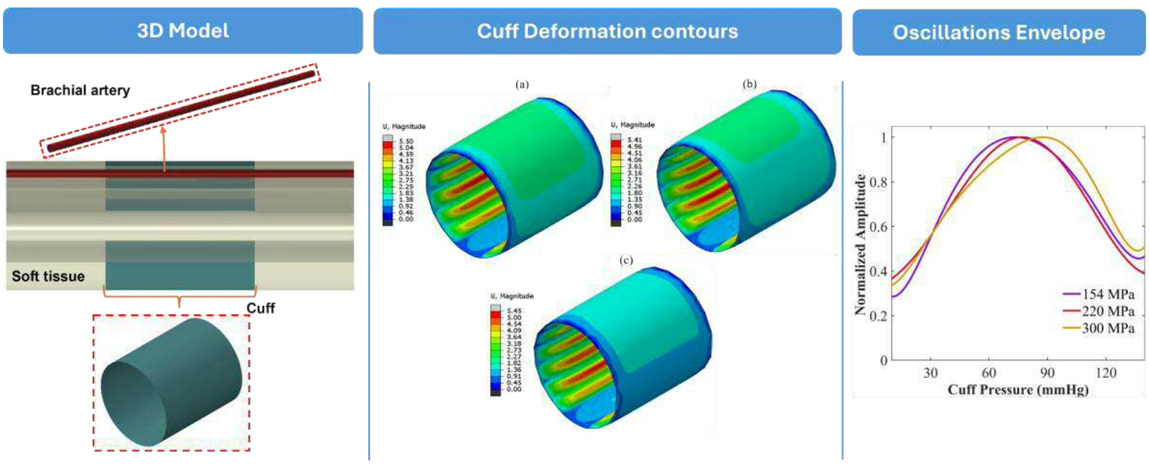

Figure 1. Overview of the finite element model and effect of cuff stiffness. **Left**: 3D Upper-arm model. **Middle**: cuff deformation contours for (a) 154 MPa (b) 220 MPa (c) 300 MPa. **Right**: normalised oscillometric envelopes for corresponding cuff elastic moduli.

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A Mission-Driven Systems Toolkit for Electric Propulsion Systems: Digital Twins and Scaling Models for Autonomous Earth-Orbit and Interplanetary Missions

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Modern satellites that observe the Earth or travel to the Moon and Mars rely on electric propulsion to stay in orbit, manoeuvre efficiently, and operate for many years. However, these propulsion systems are tested on Earth in vacuum chambers that cannot fully reproduce the real space environment. As a result, spacecraft often behave differently in orbit than engineers expect, creating uncertainty, risk, and reduced autonomy. **[1-4]**

This project aims to develop a **systems-toolkit** that helps engineers better understand how electric propulsion systems behave in real space missions, not just during ground testing. Instead of treating propulsion as a single component, this toolkit brings together propulsion hardware, spacecraft systems, mission trajectories, and the space environment into one connected framework. [7-9]

A key part of this research is the use of **digital twins**, which are virtual representations of physical systems that are updated using real data. In this project, digital twins will be used to link ground-based models with data collected during flight, allowing spacecraft to compare "what should be happening" with "what is actually happening" in space. This includes accounting for environmental effects such as extreme temperatures, low-density space plasma, limited power, and radiation. [5]

By combining system-level scaling models with digital twins, the toolkit will help improve decision-making both before launch and during missions. Over the course of the PhD, this work will extend from Earth-orbiting satellites to future missions that use electric propulsion to travel to the Moon and Mars. Ultimately, the research aims to improve the reliability, efficiency, and autonomy of spacecraft, making long-duration and deep-space missions safer and more accessible. [4-6]

This project aims to develop a **mission-driven systems toolkit for electric propulsion** that integrates propulsion subsystems, spacecraft system constraints, and trajectory requirements within a unified scaling and analysis framework. The toolkit will support early-stage design and operational decision-making across multiple EP technologies by linking fundamental propulsion parameters including thrust, specific impulse, efficiency, and power to higher-level mission objectives such as transfer time, payload delivery, and system resilience – .

Through data assimilation, this digital twin architecture is expected to reduce ground-to-orbit prediction error, improve health monitoring, and support adaptive control strategies during flight – . Hence, the expected outcome is a scalable and modular systems toolkit that enables mission-informed propulsion design, improves qualification fidelity, and supports autonomy-ready EP operations. By embedding digital twins within a broader systems-scaling framework, this work seeks to improve the reliability, efficiency, and accessibility of EP-enabled missions to the Moon, Mars, and beyond.[10][11][15].

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The Influence of Textile Structure on Aerodynamic Drag in High Performance Sportswear

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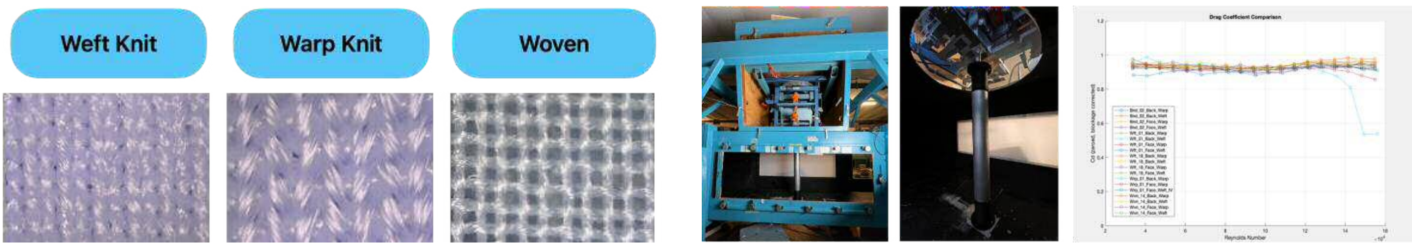
Keywords: Textiles, Aerodynamic, Drag, Surface, Stretch

Textile materials, when engineered and used in the correct manner, are able to make a tangible difference to the performance of an elite athlete. As the objective of many sports is to cover a defined distance in as short a time as possible, it is crucial to reduce the aerodynamic drag experienced by the athlete.

There exists a gap in prior research on the aerodynamics of fabrics: the direct comparison of the main types of textile constructions (Figure 1a) in both relaxed and stretched states and their effect on the aerodynamic performance of garments.

This study has three main area of focus; the physical attributes of the textile, such as stretch and permeability, surface roughness profile and ultimately the aerodynamic drag properties.



a) b)

Figure 1 – a) The three main types of textile construction, and b) Wind tunnel set up with results

A defining method by which the surface roughness of a textile is measured and compared to its aerodynamic performance is not evident in prior research. By testing and comparing different contact and non-contact methods of assessing surface roughness, in both relaxed and stretched states, an accurate and reliable method has been found which can provide an early indicator of aerodynamic performance. The reliability of this method will be proven through wind tunnel testing. Initial testing was carried out using a cylinder setup (Figure 1b).

The fabrics tested to date were not rough enough to create a drag crisis (resulting from turbulent rather than laminar separation) over the Reynolds numbers tested and therefore a floating element flat plate protocol is now being explored to accentuate and measure the effect of skin friction drag.

The study will pay particular attention to the structure, form and composition of the material to establish clear correlations and principles linking textile construction with drag performance, thus providing clear development direction for future elite sportswear.

Suppression of Aeroelastic Response and Flutter of Rotating Beams and Blades Using Viscoelastic and Smart Materials

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Keywords: Rotating Blades, Flutter, Viscoelastic damping, Piezoelectric damping, Hybrid damping,

Modern civil turbofan engines use long, lightweight fan blades to improve efficiency and reduce emissions. But when the blades become thinner and more flexible, they become more prone to flutter, a self-excited vibration where unsteady aerodynamic forces transmit energy into the structure, causing vibration to grow. Flutter can restrict the operating envelope, increase maintenance costs, and cause conservative designs which incur additional weight[1].

This project develops a hybrid damping strategy for rotating blades that combines two complementary, low-power ways of removing vibrational energy. First, a thin viscoelastic layer is used to converts vibration into heat (effective over a broad range, especially at higher frequencies). Second, small piezoelectric patches are utilized to convert vibration into electrical energy that is safely dissipated through a piezoelectric shunt circuit, enabling targeted damping of critical low-frequency modes without continuous external power. The treatment is further explored by optimising patch placement and tuning the system for multi-mode damping.

The research integrates (i) reduced-order aeroelastic modelling to predict stability margins, (ii) high-fidelity CFD/FEA simulations to quantify unsteady aerodynamic work and modal damping, and (iii) experimental validation on a lab-scale rotating beam/blade rig to confirm performance under certain boundary conditions.

Recent experimental work on simple structure indicate that the hybrid approach can increase damping better compared with either treatment alone, while adding minimal mass and maintaining practicality[2]. By improving flutter robustness, this work is hoped to support research to produce lighter blades, wider safe operating ranges, and more efficient next-generation propulsion systems, with potential transfer to compressors, turbines, and wind-turbine rotors.

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Scavengers: Piezoelectric Inverted Flags Harvesting Energy from Ambient Wind

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Keywords: wind energy harvesting, piezoelectricity, aeroelastic energy harvesting, fluid-structure interaction, sustainable energy.

Interest in harvesting energy from ambient sources has grown recently with the increase in use of micro-electronics such as remote sensor networks. The Piezoelectric Inverted Flags (PIFs) (schematic shown in Figure 1(a)) aim to fulfil this need by ‘scavenging’ energy from ambient wind. PIFs utilize the fluid-structure interaction between a flexible foil in an incoming air flow (Figure 1(b)) coupled with piezoelectric elements to generate electricity. Presently, however, their power density is two orders of magnitude lower than horizontal axis wind turbines which are the most common source of wind energy [1]. This research investigates this fluid-structure interaction via wind tunnel tests using different silhouette shapes for the flag, visualizing the flow using PIV and comparing different piezoelectric materials. With the findings we aim to bridge the gap in power density between PIFs and other wind energy sources and, thus, present a novel and sustainable source of small-scale wind energy.

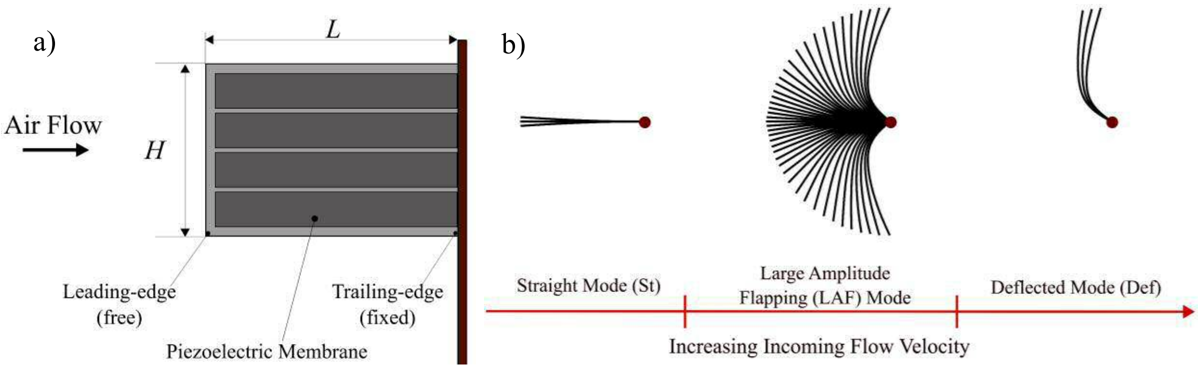

Figure 1. (a) A schematic of a PIF with a rectangular silhouette indicating the direction of air flow; (b) schematic showing the different stages of the PIF fluid-structure interaction.

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Learning from Snails: Toward Hybrid Multimodal Hard–Soft Robots for Extreme Environments

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Keywords: Soft robotics, Snail-inspired robots, Multimodal mobility, Biomimetic design, Soft–rigid hybrid mechanisms

Snails move in ways that are surprisingly effective, even though their bodies are soft and their motion appears slow and simple. By staying in constant contact with the ground and using coordinated pedal waves along the underside of their bodies, snails are able to move reliably in situations where many robotic systems struggle. This makes them an interesting source of inspiration for new types of robots. This talk begins by introducing how snails move and why their motion is relevant to engineering. It then reviews existing snail-inspired robots, which generally fall into two groups: rigid designs with clearly defined moving parts, and soft designs made from flexible materials. While these approaches differ in how they are built and controlled, both aim to capture aspects of biological motion. The talk also highlights potential uses for snail-inspired robots, including medical devices, environmental sensing, and inspection in hard-to-reach spaces. The main results of this work come from studying how real snails move. By carefully tracking their motion, we identify repeating movement patterns, or "gaits," created by traveling waves along the snail's foot. These measurements show that snail movement follows organised and predictable patterns rather than random sliding. A simplified description of these patterns captures the essential features of snail locomotion and provides a clear way to translate biological motion into robotic design. Overall, this work shows how careful observation of animal movement can lead to practical ideas for building robots that move more reliably in the real world, as shown in Figure 1.

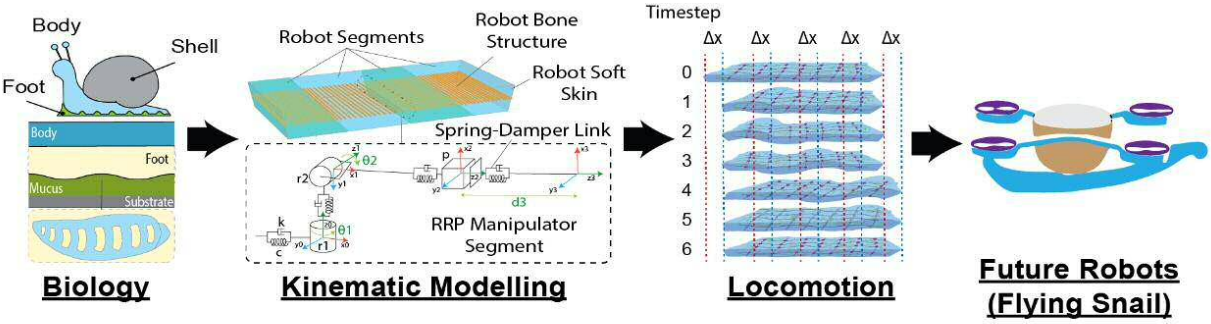

Figure 1. Graphical abstract showing the transition from biological inspiration of snails, to future robot designs, highlighting kinematics and locomotion profiles for forward motion

Bioengineering the future: bioprinted skin for regenerative medicine

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Keywords: Bioprinting, Regenerative medicine, Biomaterials, Tissue engineering

The development of human tissue models is crucial not only to address the shortage of organ donors but also to reduce reliance on animal experiments in research. Millions of patients worldwide need skin grafts, especially those suffering from complex wounds, such as burns, ulcers, or trauma-related injuries. Traditional treatments for these wounds are often limited, slow, or unavailable due to donor scarcity, which highlights the urgent need for alternative approaches. Bioprinting offers a promising solution by precisely layering living cells to create structures that closely resemble natural tissues. Using this technique, we produced skin-like models that support cell growth and organise into layers similar to human skin (Figure 1). Key cellular markers were analysed by confocal microscopy, confirming that the printed tissues display comparable cell types and organisation to real skin. This demonstrates that bioprinting can generate reliable, human-relevant models for research and therapeutic purposes. Ultimately, these advances point towards a future where organs and skin could be printed on demand, improving patient outcomes, accelerating drug testing, and reducing reliance on donors and animal models, transforming the landscape of regenerative medicine.

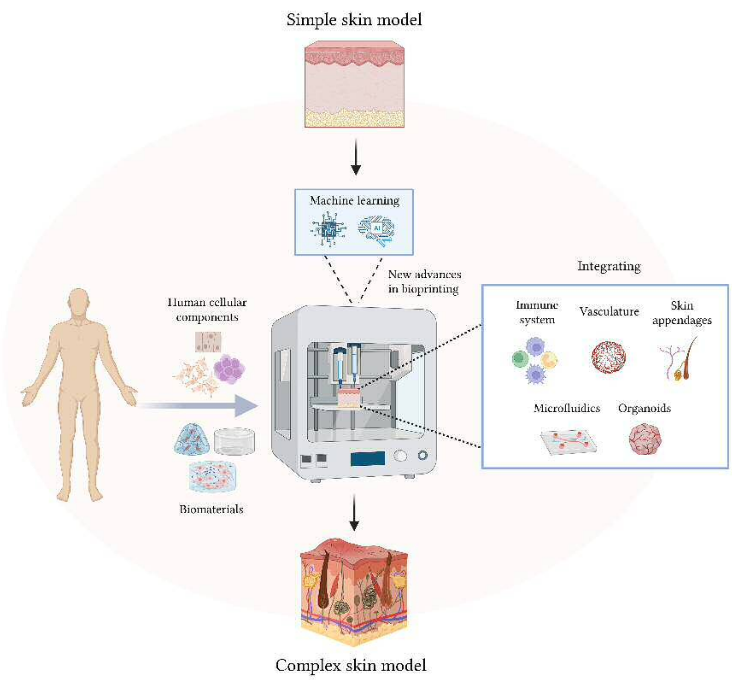

Figure 1. A graphical representation of the components used to engineer bioprinted skin models aimed at addressing complex wounds.

Design and Bioprinting of Cryopreservable Collagen-Based Bioinks for Off-the-Shelf Tissue Engineering

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Keywords: 3D Bioprinting, Bioink, Cryopreservation

3D Bioprinting promises to transform healthcare and biomedical research by enabling the fabrication of patient-specific tissues and organs, as well as advanced in vitro models for drug testing and disease modelling. However, its widespread clinical and commercial translation remains limited by technical and regulatory hurdles, as well as practical constraints. A major limitation is the declining cell viability and bioactivity over time, batch-to-batch variability, and the lack of robust long-term storage solutions for cell-laden bioinks which therefore hinders the scalability and reproducibility of 3D bioprinting.

Cryopreservation, the storage of biological materials at ultra-low temperatures, pauses cellular metabolism and biochemical activity, thereby preserving cell viability and functional integrity during long-term storage. By enabling the freezing, storage, and distribution of bioinks without compromising their biological, physical, or chemical properties, cryopreservable bioinks offer a promising route towards standardised, reproducible, and time- and cost-efficient bioprinting workflows.

This PhD project therefore aims to design collagen-based, cryopreservable bioinks capable of maintaining structural integrity, print fidelity, and cell viability following a freeze–thaw cycle. The project will investigate the incorporation of macromolecular cryoprotectants, polyampholytes, and bio-derived additives within natural and semi-synthetic hydrogels, including collagen, GelMA, and HAMA. Post-thaw performance will be evaluated through comprehensive material and biological characterisation, including rheological and photorheological analysis, print fidelity assessment, and in vitro cell viability and metabolic activity assays in bioprinted constructs.

Ultimately, this research seeks to enable the production of bioprinted tissues that are functionally comparable to those fabricated from fresh bioinks, while reducing batch-to-batch variability and accelerating bioprinting workflows through centralised manufacturing and off-the-shelf bioink availability.

CLEAR-IR: Clarity-Enhanced Active Reconstruction of Infrared Imagery

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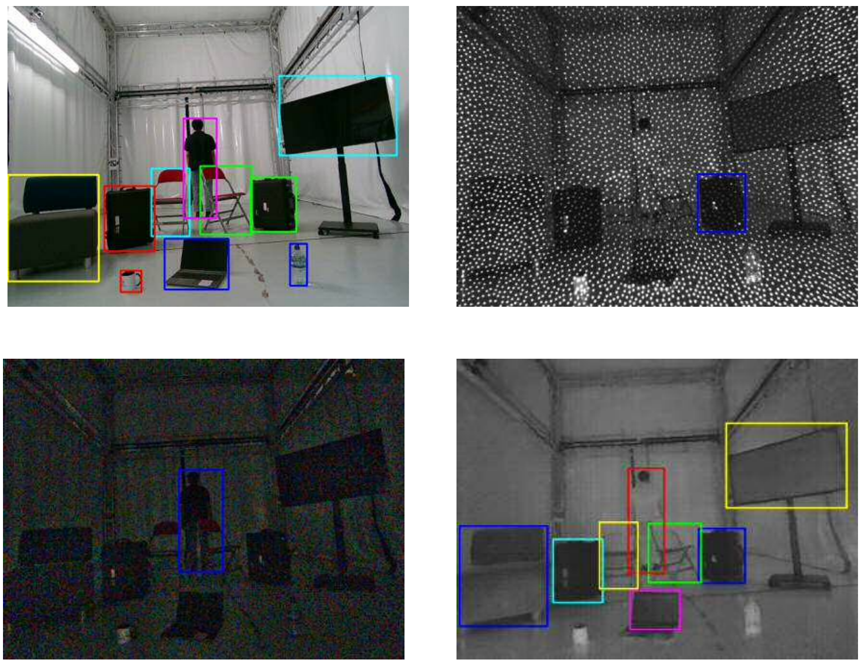
Keywords: Infrared Imaging, Image Reconstruction, U-Net, Low-Light Perception, Robotics

This work [1] presents a novel approach for enabling robust robotic perception in dark environments using the infrared (IR) stream. IR stream is less susceptible to noise than RGB in low-light conditions. However, it is dominated by active emitter patterns that hinder high-level tasks such as object detection, tracking and localisation. To address this, a U-Net inspired architecture is proposed that reconstructs clean IR images from emitter populated input, improving both image quality and downstream robotic performance as observed in Figure 1. This approach outperforms existing enhancement techniques and enables reliable operation of vision driven robotic systems across illumination conditions from well-lit to extreme low-light scenes.



(a) (b)

(c) (d)

Figure 1. Objects detected using YOLO in (a) Bright scene (b) Infrared scene (c) Enhanced dark scene (d) Enhanced infrared scene

References

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A comprehensive and systematic pulse-like ground motion identification and classification method

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Keywords: pulse-like ground motion classification; shock-waveform decomposition; single-pulse identification; multiple-pulse identification; fault orientation

Abstract: Ground motions occurred in the near-fault region generate strong pulses in the velocity-time history, resulting in inevitable damage to structure. To accurately and effectively extract these pulses, we introduce Shock-waveform Decomposition (SWD) [1], which is a multi-parameter with physical meaning and self-adaptive signal analysis method. It has been proven that SWD method can identify, extract and represent the dominant pulse(s) from pulse-like ground motion (PGM) with the corresponding number of leading shock-waveform (SW) components with sufficient details. Therefore, in the present study, an optimum classification method on single PGM (SPGM), double PGM (DPGM), triple PGM (TPGM) and PGM with more than 3 pulses is established based on SWD method. Specifically, Principal component analysis, unsupervised machine learning classification method (K-means clustering analysis) and support vector machine are used successively to distinguish whether it is PGM and the specific multiple PGM category. Based on the proposed classification approach, about 217 SPGMs, 14 DPGMs and 3 TPGMs in fault-normal or fault-parallel direction have been found out of 1869 three-component near-fault ground motion recordings in PEER Next Generation Attenuation-West2 database, among which identified 67 SPGMs in this study are unrecognized as pulse by PEER database. Furthermore, a state-of-the-art PGM dataset (including earthquake records up to December 31, 2025) has been established based on the proposed classification method. The validation of proposed classification method has been conducted through comparing with four benchmark studies, indicating that the proposed method performs more robustly and accurately. Besides, the period (T_P) of both single and multiple pulses are determined by a built-in parameter ω through $T_P=2\pi/\omega$, where ω represents the center frequency of each SW component in the general SWD formulation, offering a simple way without additional procedures.

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3D Bioprinting of Bilayered Skin Models Using Alternative Dextran-Based Hydrogels

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Chronic wounds represent a significant global health challenge, with 40-60% of cases failing to heal within 3 months, often requiring advanced therapies such as collagen-based dressings to manage excessive inflammation. Existing 2D and 3D organotypic models frequently fail to replicate the complex structural and functional organisation of native skin, resulting in limited translational success for both research and clinical applications. Consequently, there is an increasing demand for more reliable, high-throughput in vitro models that can reduce the need for animal testing while meeting the rigorous requirements of the chronic wound therapy industry.

While typical components found in the skin, such as collagen and hyaluronic acid, have previously been employed in the creation of wound models, these materials are associated with high costs, challenges in reproducibility, and variability. Additionally, the 3D printing of collagen-based bioinks is hindered by issues related to low viscosity, inadequate mechanical strength, and difficulties with crosslinking. Dextran, a biocompatible polysaccharide, has garnered attention as an alternative for 3D bioprinting due to its favourable rheological properties, gelation behaviour, and biodegradability. However, its potential as a scaffold for full-thickness skin models remains underexplored.

This study investigates the use of semi-synthetic dextran-based hydrogels for 3D bioprinting of skin models. Dextran was modified with Glycidyl Methacrylate (DexGMA), and characterised using NMR and FTIR spectroscopy to confirm successful modification. Rheological assessments, along with photo-rheology and mechanical testing of the photocrosslinkable DexGMA hydrogels, demonstrated enhanced crosslinking kinetics and superior printability compared to collagen-based alternatives. Biocompatibility testing confirmed the suitability of DexGMA for the selected human dermal fibroblasts and keratinocytes, while immunofluorescence staining, and histology have highlighted matrix formation over the culture period.

We have successfully incorporated these biological components into DexGMA-based hydrogels, facilitating the development of a bilayered skin model comprising both dermal and epidermal layers. Preliminary data suggest that the DexGMA-based bilayered construct exhibits promising structural and functional characteristics that closely mimic native skin, positioning it as a viable platform for chronic wound research and therapeutic testing.

Looking forward, we intend to complicate the model further by optimising the incorporation of additional biological components, such as immune cells to improve its physiological relevance with regards to wound healing investigations. Overall, our findings underscore the potential of DexGMA-based hydrogels as a versatile material for 3D bioprinting of full-thickness skin models, offering tuneable mechanical properties, enhanced printability, and biocompatibility. These advances may facilitate the development of more reliable, reproducible models for chronic wound therapy and contribute to the reduction of animal testing in preclinical studies.

Acknowledgments

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POSTGRADUATE RESEARCH

Careers Talk:
Dr Andrew Crook

A Career in F1

Dr Andrew Crook, Head of Capability at Mercedes-AMG F1

Dr Andrew Crook obtained a PhD at The University of Manchester, with a thesis on the control of turbulent flows using synthetic jets supported by BAe Systems. Following postdoctoral research in Manchester and at Stanford University, he has worked over 20 years in the motorsports industry, and is currently Head of Capability at Mercedes-AMG F1.

Andrew will speak about how he came to work to F1, what the industry offers, and is happy to take questions from the audience.