Queen's Doctoral Training Programme on
Secure Connected Intelligent Design and Manufacturing

Title: DTP: Intelligent Light Weighting – Wireless based SHM for Public Transport Vehicles

This project is part of the Queen's Doctoral Training Programme in Secure Connected Intelligent Design and Manufacturing. Many of today's industrial approaches require transformative changes to ensure long term societal, economic and environmental resilience and sustainability. PhD projects in this programme explore the potential of emerging digital technologies, such as artificial intelligence, robotics, and the Internet of Things, to transform the way we design, manufacture and operate products and services.

Project description:
The pursuit of lightweight public transport vehicles is becoming increasingly prominent to enable widespread adoption of hybrid and fully electric buses. For electrically driven vehicles, weight has a significant impact on vehicle performance, where a vehicle's useful operating range is inherently linked to vehicle mass. Lighter buses allow the inclusion of larger batteries for extended range, or even providing increased passenger carrying capacity.

Key to vehicle lightweighting is reducing the structural mass of bus chassis and body components. The structural design of bus components is largely driven by fatigue or damage tolerance, considering a range of different loading scenarios such as manoeuvre accelerations, ramps, potholes, kerb impacts etc. The magnitude and frequency of these loads is highly variable and uncertain, typically dependent on bus usage (route and driver characteristics). Consequently, to account for this loading variability and uncertainty existing vehicle structures are designed for the assumed 'worst case scenario', to be robust and excessively conservative. This ultimately results in bus structures which are often over-engineered, but with potential to be significantly lighter.

Intelligent structural health monitoring (SHM) can lead to a change in this highly conservative design approach. Ubiquitous sensing using wireless connectivity can provide real-time updates of vehicle data such as acceleration (g-loads) or component strain data, which removes the uncertainty of vehicle loading. When combined with rapid structural analysis, this can facilitate live evaluation of structural integrity (e.g. following damage inducing event such as kerb impact) or updating of an individual vehicle's fatigue life (based on daily usage).

Effectively translating intelligent SHM capability into the vehicle structural design process for reduced weight presents a series of challenges:

- How can the vehicle structural design (e.g. component selection, analysis methods etc.) be adapted to incorporate the provision of regular, real-time sensing data to reduce conservatism?
- How sensitive is structural integrity evaluation to the quality and complexity of the available real-time data, and how should robustness of the structural design and analysis process be ensured in the event of data loss or inaccuracy?
- How can the health monitoring system be designed and implemented so as to minimise system complexity, but at the same time, ensure consistent quality and effectiveness of the data required to support the SHM based design philosophy?

Aims and Objectives:
The project aims to develop a robust SHM supported design (and operation) philosophy for lightweight bus structures, through a combination of wireless connectivity, rapid structural analysis tools (to enable real-time evaluation of structural integrity) and fatigue life predictions of key bus structural components.

Project Objectives:

- Review the structural design process for commercial buses, identifying/downselecting key bus components/features which can benefit from in-service SHM: to include associated structural analysis methods and compatible physical sensing systems.
- Development of SHM based structural analysis and design framework for selected case study, utilising rapid structural analysis tools and wireless structural sensing system(s)
- Design, implementation and quality assessment of a wireless based SHM system to meet requirements of the SHM based design framework.
- Evaluate the limitations/robustness of the SHM based design framework by quantifying sensitivity of structural performance predictions (e.g. design margins of safety) to variation/inaccuracy of both the rapid structural analysis tools and the real-time sensing system.

Key skills required for the post:

Knowledge of structural analysis methods (static and fatigue),
Knowledge of structural design processes,
Finite Element Modelling experience or Experimental structural testing experience

Key transferable skills that will be developed during the PhD:
The programme offers a bespoke research and training programme that aims to develop students into cross-disciplinary, industry-conscious thinkers and leaders who will influence the roadmaps of future advanced manufacturing technologies and their applications. They will have a balanced understanding of ICT (security, communications and data analytics) in the context of their application to Advanced Manufacturing and High Value Design.

Lead supervisor:	Dr Damian Quinn / Professor Simon Cotton
Other supervisor(s):	Dr Damian Quinn / Professor Simon Cotton
Guaranteed stipend:	This is a 3.5 year funded Queen's DfE DTPs studentship with Training Grant, to commence on 1 October 2020 (N.B. stipend for 20/21 is not yet known, but is likely to exceed £15,000). The studentship covers fees and maintenance and is available for UK residents (see full eligibility criteria - nationality, residency, and academic qualification at: http://go.qub.ac.uk/dfeterms). **When applying using the Queen's portal please ensure you include "DTP:" along with the project title.**
Conditional top-up available:	Add amount and condition if available from another source – there is no central funding available for this.

PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.#

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.