Project Call for 2021 ERBE Cohort

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PhD Proposal Title:	**DRONES-ASSESS: D**isruptive **R**emote-controlled dr**O**nes with **E**mbarked **S**ensors to **Assess** Building Performances against Building Regulations Test Protocols and Standards.

Alignment with ERBE Themes:

Flexibility and Resilience:

1) Low-Cost, Fast and Accurate assessment with drones to support assessors/surveyors & retrofit co-ordinators in qualifying building performance.
2) Increased flexibility and resilience because:
   - Remote assessment can be quickly and efficiently deployed. Drones can intelligently and efficiently move within an environment and easily access areas typically difficult to access.
   - Assessors do not necessarily need to enter premises.
   - Drones measurements and test results can directly output Building Information Modelling (BIM) files and reports to stakeholders.
   - Drones measurement systems and test procedures can be quickly updated.
3) Assessment needed to:
   - Identify key renovation measures and cost-effectively lower energy demand.
   - Validate work quality of refurbishment and certify the prediction of buildings' energy use.
   - Provide resilience of installed equipment and services via quality assurance, identifying maintenance needs and optimising the operation of Building Energy Management Systems.

Technology and System Energy Performance:

4) Assess:
   - Building size and components
   - Fabric hygrothermal performances
   - Building surrounding
   - Identify integrated and surrounding building services
   - Fault detection systems

Comfort, Health and Safety:

5) Assess:
   - Potential fire safety issues
   - Wireless (WiFi and GSM network) communication issues
   - Future Capabilities to assess i) ventilation systems, ii) air quality, iii) natural and artificial lighting conditions, iv) acoustics performances, v) water quality, vi) Gas detection

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PhD Proposal Abstract:

Introduction

The Renovation Wave requires us to quickly and efficiently renovate the building stock. To do so one first needs to accurately, cost- and time-efficiently assess building performance at scale in terms of energy, sustainability, health, comfort and safety. A user-centric centric approach (least disruption, attractive solution) is needed while providing the necessary information to stakeholders.

Background

Building surveyors examine the quality of a building and advise on ways to improve it in terms of safety, quality (health and comfort), energy and sustainability following building regulations. Quantity surveyors will assess and specify material/component quantity, type and size within the procurement process.

Building assessors and surveyors currently manually assess the building fabric and services using a range of tools and techniques. The process is disruptive to the occupants, slow and costly with further complex accessibility issues (in particular to high rise buildings). State-of-the-art deep retrofit techniques require surveyors to acquire point-cloud images of the outdoor and indoor building fabric to generate 3D maps integrated into a BIM process for stakeholders to coordinate their work.

Solution: Unmanned Aerial Vehicles (UAV)

UAV, also referred to as drones, demonstrated significant benefits in the built environment to assess building forms, hygrothermal issues, and gas leaks. Using visual and thermal payload systems, potentially complemented with LiDAR technology, 3/4D CAD models can be generated using structure-from-motion photogrammetry software. Visual and thermal rendering of the spaces enable the detection of cracks, damages, heat losses through building components, thermal bridges, air leaks, and to identify moisture issues and origins.

Benefits

Drones are low-cost, fast, contact-free, highly manoeuvrable and able to carry heavy payloads systems producing accurate, robust and detailed building performance measurements. Drones can be used in and around buildings, fly over high altitudes and can reach hard-to-access regions such as high rise buildings or large estates. Replacing labour-intensive manual assessment with a semi-automated process whereby one (or more) drone(s) performs a range of standard tests will deliver significant benefit to building surveyors and assessors. This will further benefit Housing Associations, Local Councils, difficult to decarbonise properties especially with accessibility issues.

Core challenges and considerations to be addressed to scale up the technologies with a **fully automated drone-based building inspection** include:

A) improving data acquisition and processing,

B) optimising drone operation,

C) facilitating efficient data processing,

D) identifying and addressing users concerns to occupants, professionals and policymakers for the development of standardised drone assessment procedures.

Objectives

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This research project aims to develop a prototype drone with advanced payload systems capable of photogrammetry, LiDAR and infrared acquisitions to quickly and accurately perform a suite of measurement and test protocols applied in building standards. The objectives are to demonstrate the assessment of a building topography, structures, components, hygrothermal performances, fire safety while addressing key stakeholders' concerns.

Scope

Focusing on residential houses (or low rise buildings), one or a cohort of complementary drones and advanced payloads serving various functions will be designed to assess building facades primarily from the outdoor perspective. The drone will integrate visual and thermal image cameras, and potentially other sensors, selected to provide accurate, calibrated, reliable, energy- and cost-efficient data. Data acquisition will exploit test protocols following standard codes. Data processing, communication, storage, security and privacy will follow regulations. Operation of the drone must be safe, non-destructing, and energy efficient.

Methodology

- Review standard building tests and protocols, assessors' practices, barriers, and impacts to a drone design, operation, data acquisition and processing.
- Conduct empathic design research with assessors to identify hidden issues within the process. Storyboard the process of assessing the building. Review desired measurements and identify possible future requirements.
- Design, using commercial products, and protype a drone for flight payload capabilities, manoeuvrability, environmental flight conditions and safety.
- Review and design methods for the automatic generation of flight path planning for site acquisition and detailed execution.
- Validate data results with case studies, their applicability, compatibility within a BIM environment, satisfaction to key stakeholders and develop a standardized scientific approach to survey residential buildings using drones.
- Disseminate to building assessors, BIM professionals and policy makers in priority.

PhD Proposal Summary and PhD Candidate Profile:

This research project aims to develop a prototype drone with advanced payload systems capable of photogrammetry, LiDAR and infrared acquisitions to quickly and accurately perform a suite of measurement and test protocols applied in building standards. This 4-year research project will be based in TU Dublin with 6 months in UCL. It will tackle cross disciplinary challenges using advanced technologies and processes.

The desired candidate must have an electronic, signal and data processing background. Desired skills and knowledge include the development of or integration of systems to robots or drones, programming (e.g. python, C++, Java), infrared and RGB models generated using 3D photogrammetry software e.g. Pix4D, Bentley Systems, Rhino3D CAD or DroneDeploy modelling software. Knowledge of the built environment is not mandatory as the student will be trained to acquire the required knowledge. The candidate will be fluent in English, shall have a positive problem-solving attitude, demonstrate scientific rigor, communicative (oral and written) skills, creativity, ambition and with a goal-oriented mind.