

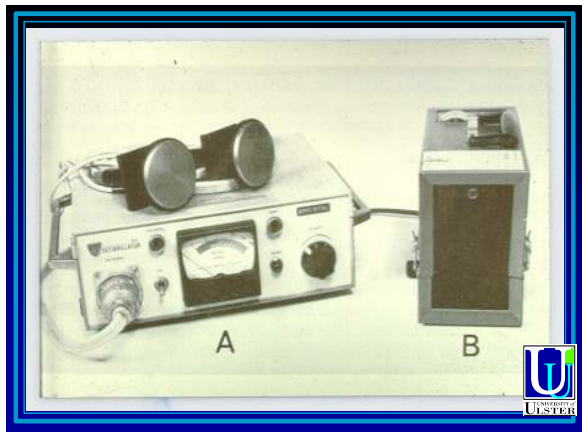
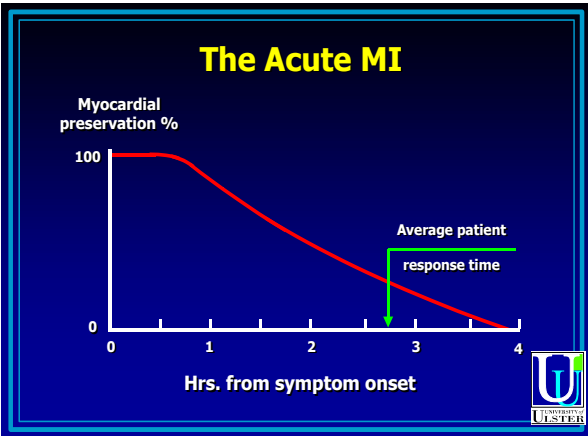
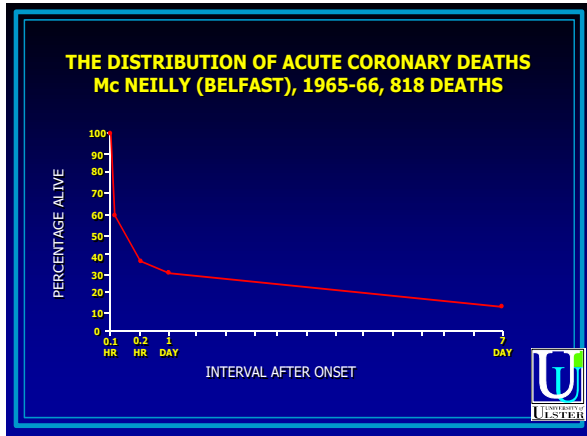
# Centre for Digital Healthcare Technology - CDHT Oct 2021 – 5G



Innovation Pillar Outline Business Cases developed in partnership with:


Development of the Innovation Pillar Outline Business Cases was supported by:

# Our Connected Health History





NIBEC

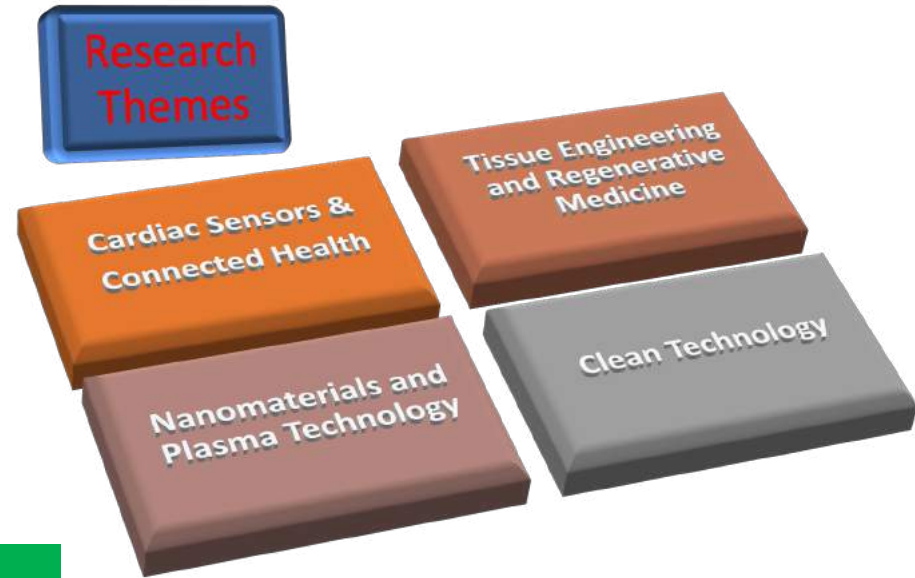


Founder J. Anderson

35 Year old – opened by Dr. Christian Bernard, 90 researchers, multi-disciplinary research centre applying nanotechnology and bioengineering to the following research themes:



C. Bernard



Affiliated Centres



The Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH) (Birmingham, Brunel, Nottingham & Ulster)

CACR

The Centre for Advanced Cardiovascular Research CACR – Focused on Heart Failure Systems and AF Detection.



ECME

The £6m Connected Health Innovation Centre (CHIC) is focused on business led research in the area of connected health.

The £8m Eastern Corridor Medical Engineering Centre (ECME) is focused cardiac engineering – Heart Failure and AF solutions via analytics, algorithms and medical grade wearables.

Technology Transfer

SURF SPEC



300 employed via spin outs



# CDHT Mission (new)

*The **Centre for Digital Healthcare Technology-CDHT** acts as a facilitator, innovation and knowledge broker and a stimulus for **ABC multidisciplinary collaborative partnerships** that **address clinical and healthcare challenges** with world-class research & development, discovery and knowledge exchange through **skills development, co-ideation, enhanced facilities and highly efficient productivity pathways.***



# Key Discovery & Innovation Leaders



Belfast Region  
**City Deal**



**Professor Jim McLaughlin**  
Healthcare Technology  
Sensors – Diagnostics



**Professor Chris Nugent**  
Software Engineering  
Ambient Assistant Living



**Professor Tara Moore**  
Ophthalmology  
Biomolecular Science -  
Experimental Trials



**Dr Mark Spence**  
Cardiology  
Belfast Trust



**Dr Paul Beaney**  
(Innovation)plus CHIC; ECME;  
Biodevices Lab and CARL

## Industry-led collaboration



## Examples of Major International Links

**USA** – UCSD, UCLA, MIT, Stanford, NCSU, **Asia**– SUST, Tsinghua University, Amity, IIT-Mumbai, Samsung - Korea

**Europe** - Cambridge, Surrey, INSA, Fraunhofer-Mainz GE Healthcare Albany; Philips Eindhoven;



#BRcitydeal



# Our Innovation success

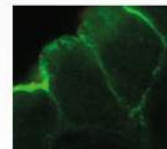


Belfast Region  
**City Deal**



## Patents

- 35 patents : wide range in the area of Medical Devices and Technologies



## IPR

- Heartsine, HeartScape, Intelesens, Laboratories Fournier, Maersk Medical, Tyco, Axis Composites, Lenis Aer

## Spin Outs

- Heartsine, HeartScape, Intelesens, Surf-Spec

## Spin-in

- SiSaf

## NIBEC Hatchery's

- Currently developing
- 10 hatchery companies

## Impact and Technology Transfer in NI and globally in NI

- 300 jobs and growing
- £50m turnover per year
- Driving medical devices

## Grand Challenges

- The \$10 Million Global Competition to put Healthcare in the Palm of Your Hand.
- Last 5 out of 360 entrants and finished joint 3rd.



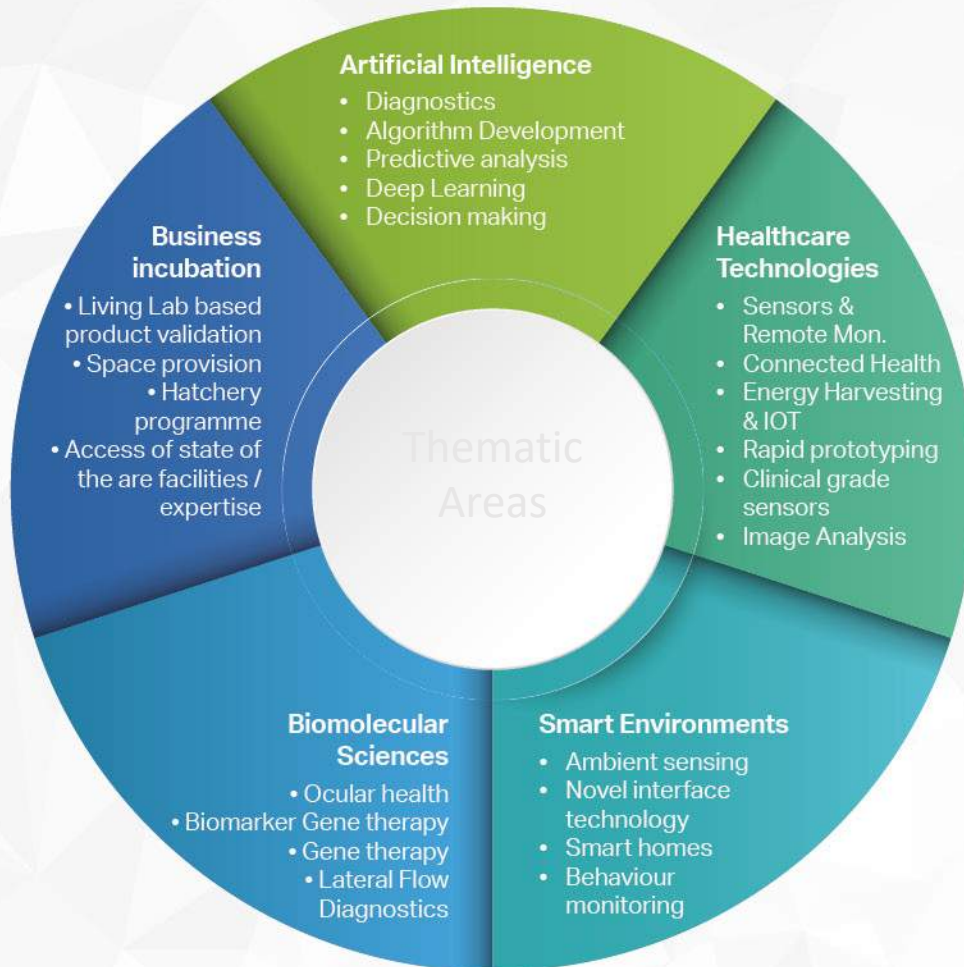


# CDHT

Key capabilities - 32 academic staff and five clinicians



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**Currently rated**

- 9th in the UK in EE;
- 14th in Mechanical
- top 10 in Biomedical Engineering
- Top 5 in Studies allied to Medicine
- The NI Turning Report - UU Computing AI section one of the top in the UK

**GBD & new site**

- CHIC
- ECME
- Biodevices Lab
- BT Lab



**Living Lab**

- RVH Cardiology
- Respiratory





# The Digital Health Technology Hub will feature:



Belfast Region  
**City Deal**

**4000 m2 of R&D facilities**, living lab space and incubation space (£45M investment in total).

World class **equipment and expertise.**

Large investment into **Living Labs** at RVH site of Belfast Trust.

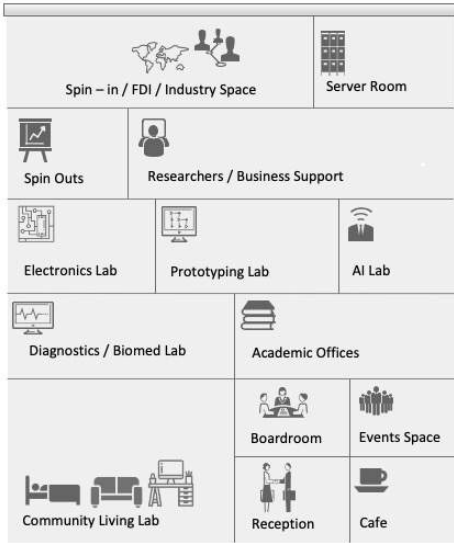
MedTech Park - **Digital Healthcare Industry** (Catalyst to Heron Rd).





# CDHT Infrastructure

## CHDT Hub



## CHDT Clinical Innovation Living Lab (at RVH)



## 3. Healthcare Research Eco-System in Northern Ireland



## 1. Clinical Living at Belfast Trust – RVH (City Deal Capital Funding – mainly Kit)



## 2. New Building at Northland House CDHT HUB (City Deal Capital Funding)



## 3. New Harbour Commission Medtech Development (Not City Deal Funding)



# Alignment with National & Regional Policy

2015

2016

2017

2018

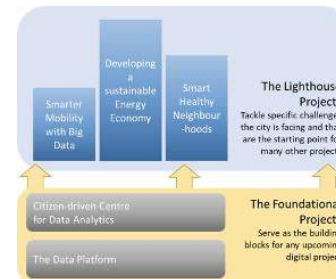
2019

2020

2021



DRAFT PROGRAMME FOR GOVERNMENT FRAMEWORK 2016-21



4 Posts from UU in Health Tech plus further 4 posts naturally in Health Tech - total academics 32 in area

CDHT Stakeholders engaging – DELL; Microsoft; PWC and BT anchor

BC Innovation Pillar  
BCRD  
CDHT SOC

CDHT and New Med-Tech (HC) Plans launched plus RVH Engagement

CDHT FDI companies – Avelino and TriVirex / others

BCRD  
CDHT OBC



# The Digital Health Technology Hub

## Supported by:



Belfast Region  
**City Deal**

**Department of Health**

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**Large Multinational  
Companies**

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**SMEs**

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**International  
Collaborative partners**

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**European Connected  
Health Alliance**

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**ECME; CHIC**

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**Interacting with  
I-Reach, GII,  
AMIC and CTRIC**

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**HIRANI**

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**Local Health Trusts  
and HSC**

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**Harbour Commission  
Belfast**

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# Markets

The end market is an expanding global one driven by a number of key factors that are causing healthcare providers to consider alternative approaches.

## Drivers

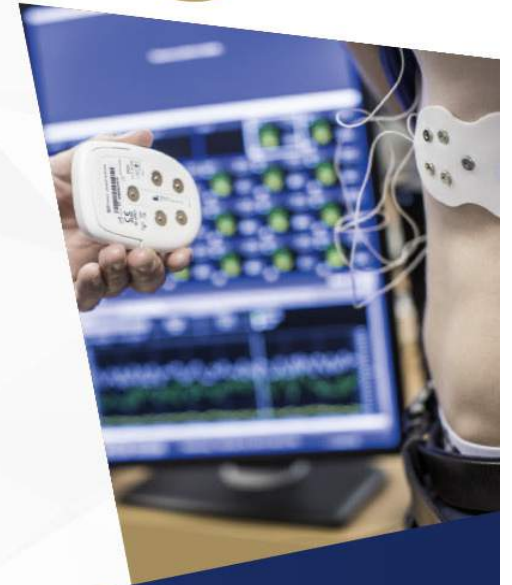
- an ageing population;
- rising healthcare costs;
- complexity of diseases;
- co-morbidity; and
- antimicrobial resistance.

**Market Growth** - Globally, the market for medical device technologies is forecast to grow to \$529 billion by 2022 driven by a number of social, economic, technological and demographic factors including an ageing and increasing population.

## Key technologies of 2025



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**City Deal**



 #BRcitydeal

## Post Covid-19

- Virtual Hospital – Clinical grade Remote Diagnostics
- POC Diagnostics
- Sensing systems; IOT; AI for enhanced decision making



# Typical Projects / Products

- **Heart Failure Diagnostics Systems** – Microfluidics and wearable patch approach to nt-pro BNP / RR etc.
- **Cardio based clinically relevant wearables** – 3 Lead to 12 lead approaches
- **Cardiovascular risk assessment in the eye** – CMOS analysis of PWV in the eye for early detection of heart disease
- **Cardio vital signs and biomarker algorithm development** - machine learning techniques for a combinational approach.
- **Early stage sepsis monitoring** use of ecg, SpO2 and RR via AI derived algorithms to early detect on set of sepsis
- **Cardio Lateral Flow Diagnostics** – development, reader and associated software
- **AI for improved Patient Flow Systems**
- **AI in improved sensitivity of AF detection** via patch electrodes, and optical approaches including ppg
- **Next generation wearable electrodes** via dry electrode and optical technology
- **Non invasive BP monitoring** via PWV techniques
- **Cognitive Behavioural and Rehabilitation Assessment Others** - Drug Delivery Patches; Microneedle patch systems, early warning infection control; Cognitive Behaviour monitoring; Non-invasive Dementia monitoring; Integrated biomarker reader systems designed for improved Lateral Flow diagnostics etc.



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# COVID-19 Research Examples

The CDHT team is currently addressing the **Covid-19 challenge** and leading a wide range of successful developments including:

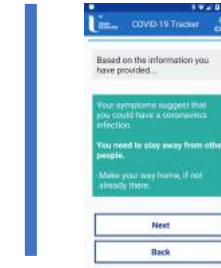
- **COVID-19 Antibody Test & App** development joint with Government led **UK – Rapid Test Task Consortium** (UU trial validation complete & UX starting in August)
- **Modelling for Government** - the lockdown and recovery phases of Covid-19 via trackers for utilities and strategy.
- **NI Stop Covid-19 Task Force** – ROI app to NI and validating for CE marking – RF/UX and compliance testing via technical trial at Ulster
- The **modelling, simulation, design and development** (joint with industry) of Incubation; CPAP and Face Aerosol Protection - **Designed Vitamaterials Visor**
- **NIR – AI COVID-19 study– EPSRC funded AI**
- **NIH, KTP and DOH funding for above work**
- **Ongoing Remote monitoring - Virtual Hospital**
- **Validation Air Flow and Purification - ILIMEX**



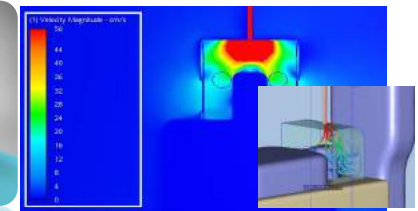
## Antibody Test

### Exclusive: 'Game-changing' coronavirus antibody test passes first major trials

Ministers draw up plans to distribute millions of free fingerprick tests after they



## PPE Design and Simulation – CPAP; Visor; Canopy; Aerosol Modelling



## Covid-19 Modelling

### Modelling The Transmission Dynamics of COVID-19

**Team Members**

Prof. James McLaughlin Head of School of Engineering	Dr. Pádraig Biglarbeigi Lecturer, School of Engineering	Dr. Rob Birk Southern Health and Social Care Trust
Prof. Doreen Finlay Research Director, School of Engineering	Dr. Mark Ng Lecturer, School of Engineering	
Dr Raymond Bond Reader, School of Computing	Dr. Min Jing Research Associate, MIBEC	

**Ulster University School of Engineering**

In collaboration with School of Computing

Contributed by: Dr Pádraig Biglarbeigi

#### Modified SEIR Model

Contributed by: Dr Mark Ng

The model predicts the infection and deaths cases, with influence of the ageing population. By including the time delay factor, it also allows governing bodies and relevant authorities to better plan for the next course of action to control the spread of the virus so relative timelines, and to predict the NHS. The model also helps to predict future infection and deaths curves such that those involved are able to plan for the next and future waves of COVID-19.

Fig. C1: The model predicting future projections and estimating R number, as well as procedures for 3 possible scenarios to have the lockdowns in place.

Fig. C2: The model predicting when lockdown has to be reintroduced for 3 possible scenarios to protect the critical care capacity.

Fig. C3: Simulation package using MATLAB/Simulink for the modified SEIR model with a single stage of control action.

#### Gravity Model

In the early stages of the pandemic, due to lack of data, statistical analysis was performed using data from other countries such as Italy, Germany, and Spain to predict the confirmed and death cases in Northern Ireland.

Fig. A1: Many worldwide data from the early stages to predict the projections in NI.

Fig. A3: Modelling the confirmed (left) and death (right) in NI using scenarios from other EU countries.

#### Generalised SEIR (GSEIR) Model

Contributed by: Dr Min Jing

The GSEIR introduces a quarantined state and considers the effect of preventive measures, key parameters such as latent and quarantined time, and D number can be determined in a relatively reliable way. These results show the trend after lockdowns are lifted under various parameters for protection area.

Fig. B1: The model comparing confirmed cases in NI with and without lockdown.

Fig. B2: Modelling the potential increase in confirmed cases after strong restrictions under different scenarios.



# Our big Covid-19 Success areas stories

## Kill Covid-19



ILIMEX Validation



## NI Stop Covid-19 App



## Diagnostics



*CE/FDA/MHRA Approved and currently on sale and delivered to the DOH*

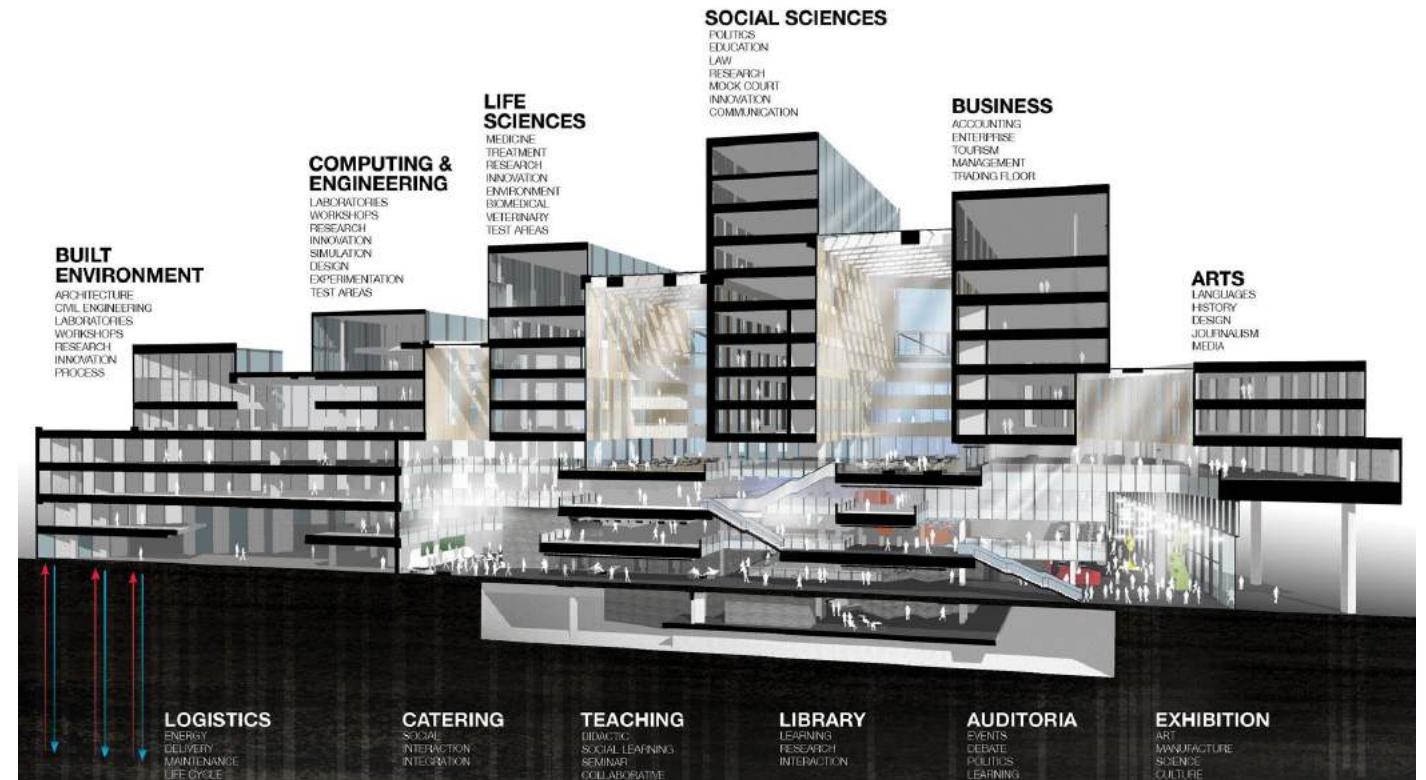


## Visor design to Vitamaterials



## Modelling Covid-19 transmission to Government

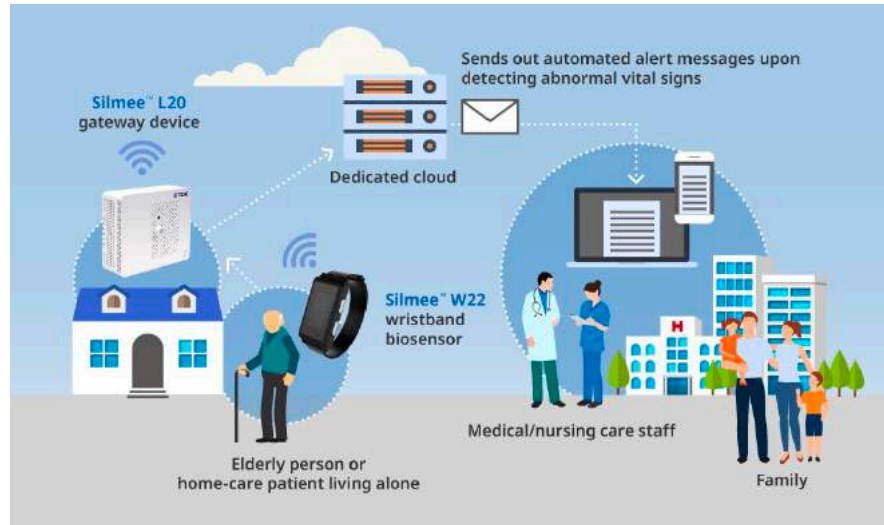
# The new Belfast Campus – Ulster University





# The new World of Health after Covid-19

- The Connected World

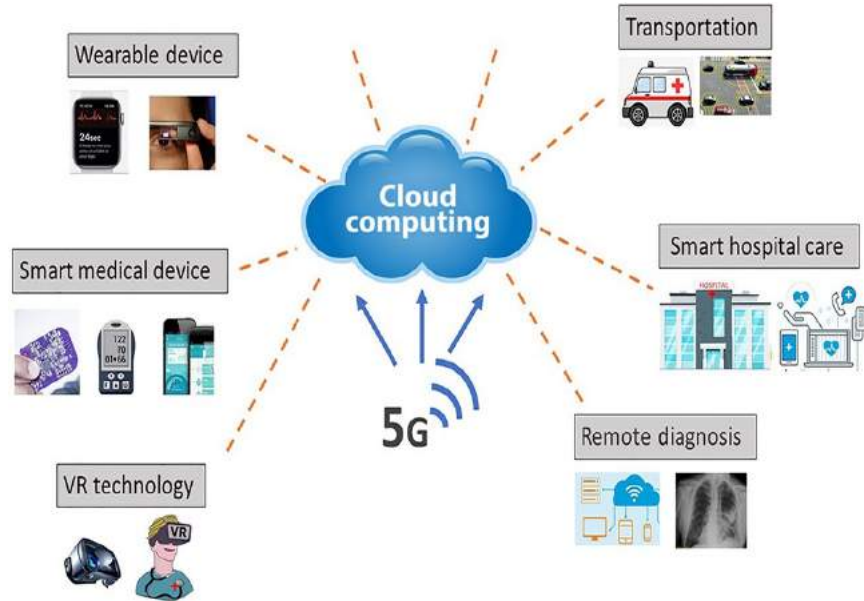


- Artificial Intelligence
- Internet of Things
- Automation
- Point of Care Diagnostics
- Smart PPE



## 5G healthcare.

Schematic drawing illustrating applications of 5G technology in healthcare. VR, virtual reality.



## Current network disadvantages.

System is not reliable

Real-time data collection is difficult

Lacks in continuous monitoring of patients

Lacks in data sharing mechanism and personalized data analysis

There are no continuous suggestions for the prevention and treatment of diabetes

## Current advantages of 5G .

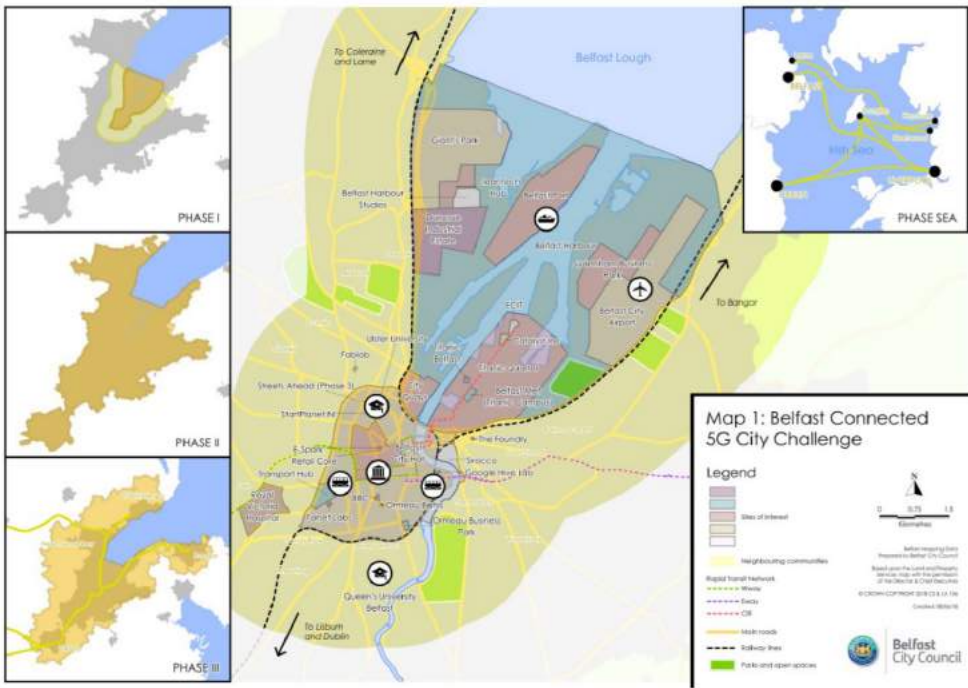
**Low cost :** Facilitates out of hospital treatment so cost of treatment is reduced

**Comfort :** It ensures that daily activities of the patients' is not disturbed

**Personalization :** By collecting blood glucose data through machine learning algorithm, it personalized treatment for patients

**Smartness :** Early detection of the disease is possible with this system



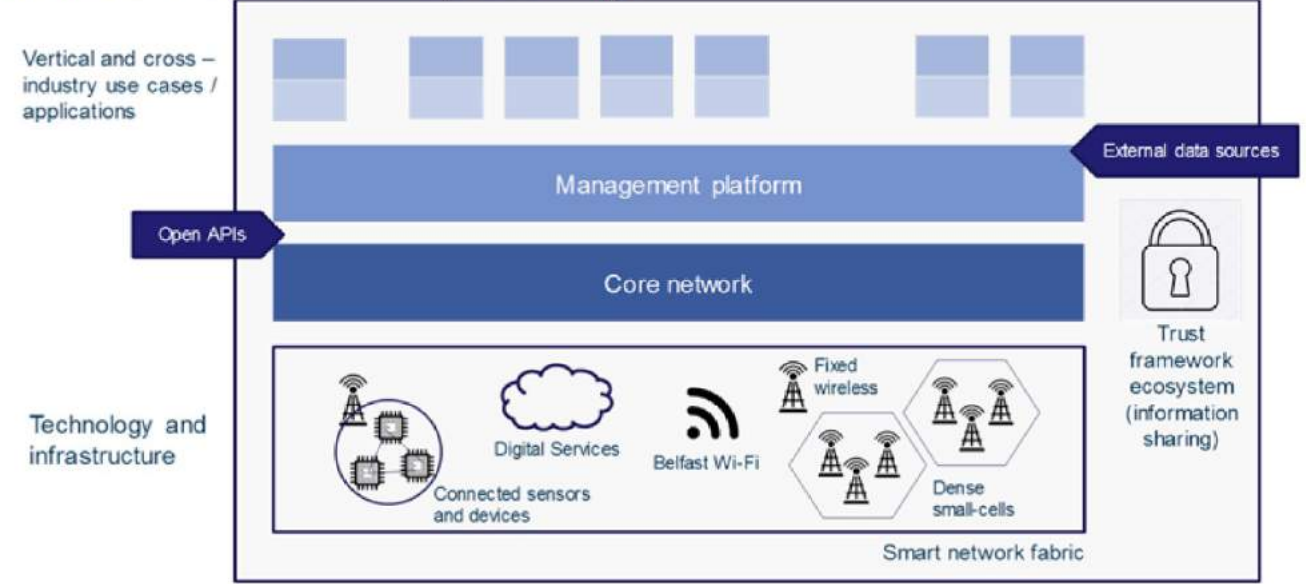


### Belfast City Council focus on

- Health and Well being
- Mobility
- Energy



### Belfast 5G testbed – conceptual design

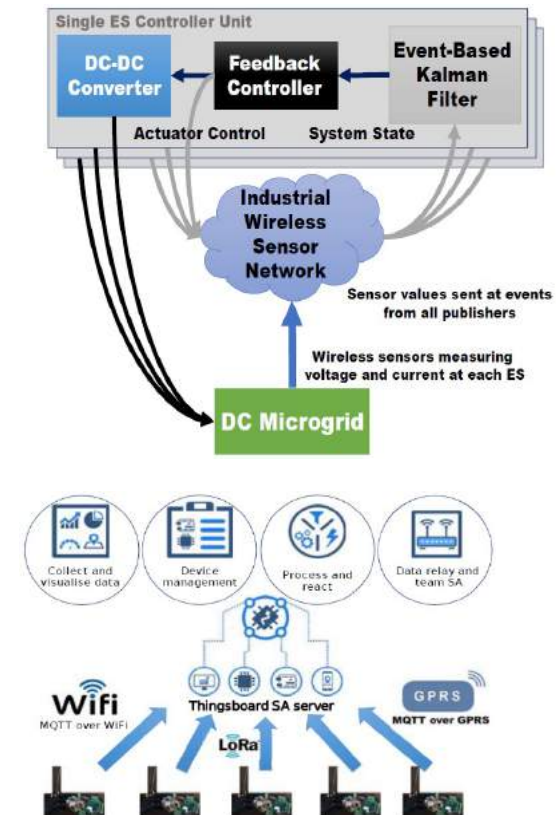
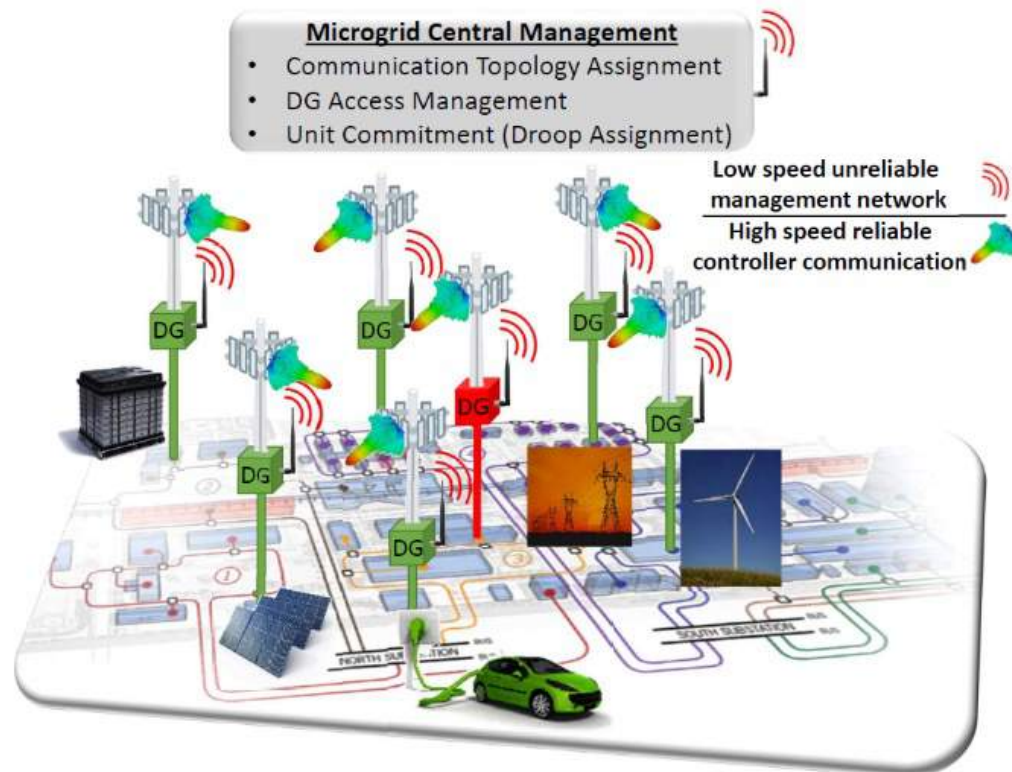


### Belfast City Council 5G City Challenge





# Future Applications: IoT Smart Energy Solutions; Microgrids and Industrial WSNs



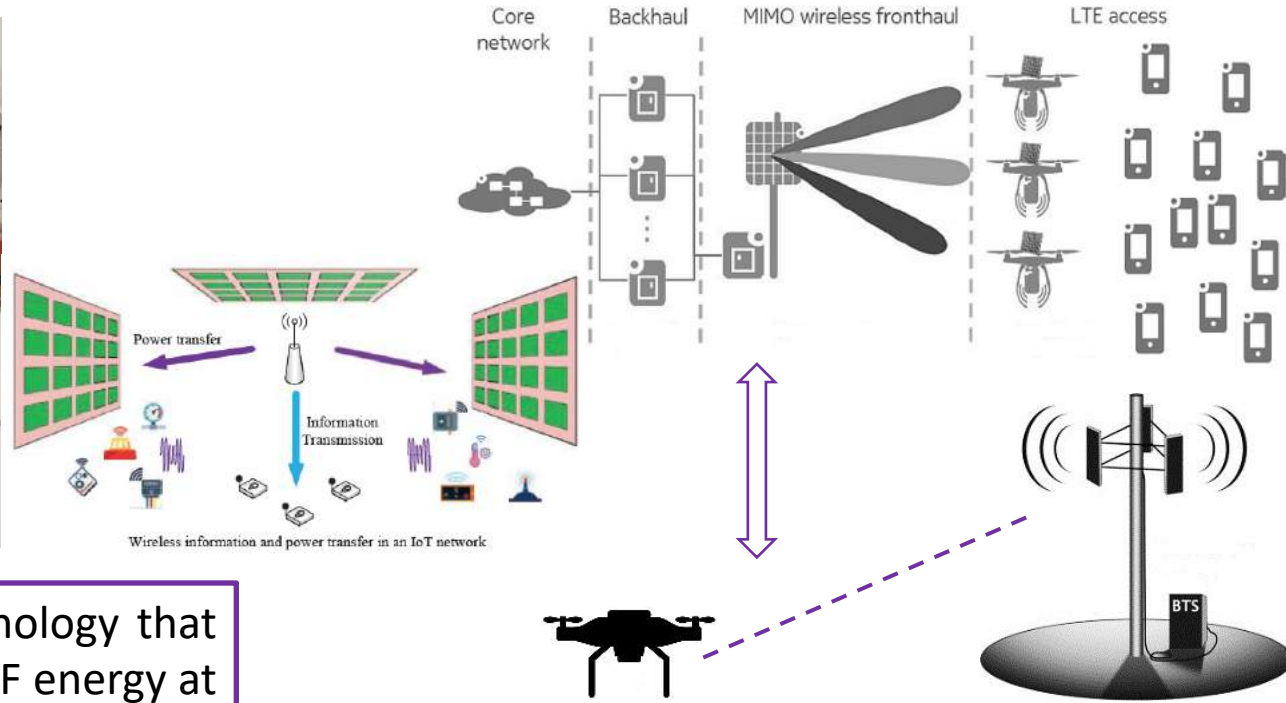
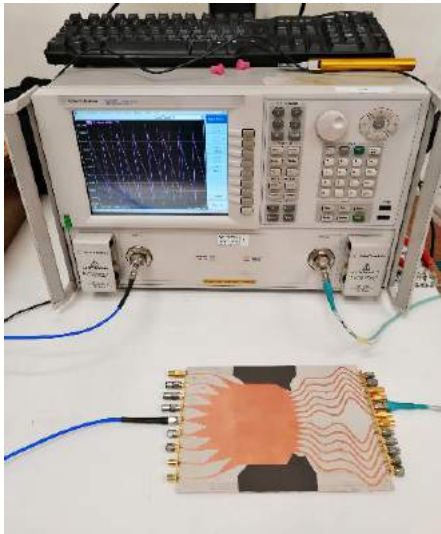
[10] S. A. Alavi, **A. Rahimian**, K. Mehran, and Y. Hao, "Plug-and-Play Event-Based Secondary Control With Resiliency to Communication Delays in DC Microgrids," *IEEE Trans. Smart Grid*, 2019.

[11] S. A. Alavi, K. Mehran, Y. Hao, **A. Rahimian**, H. Mirsaeeedi, and V. Vahidinasab, "A Distributed Event-Triggered Control Strategy for DC Microgrids Based on Publish-Subscribe Model Over Industrial Wireless Sensor Networks," *IEEE Trans. Smart Grid*, 2019.

[12] S. A. Alavi, **A. Rahimian**, K. Mehran, and J. Mehr Ardestani, "An IoT-Based Data Collection Platform for Situational Awareness-Centric Microgrids," in *IEEE Canadian Conf. Electrical & Comp. Eng. (CCECE)*, May 2018.

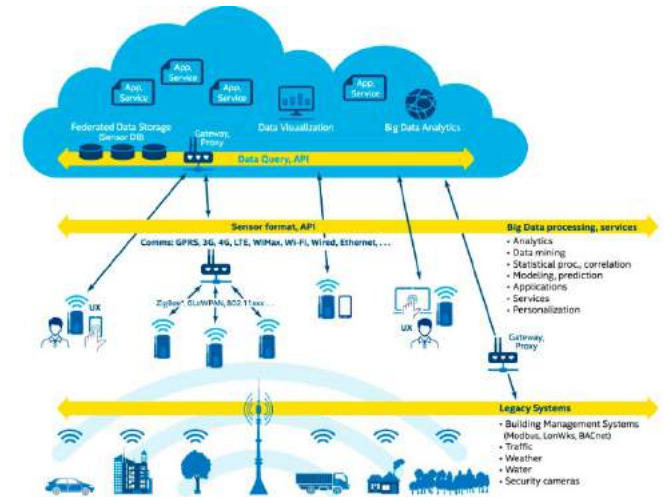
[13] T. Monajemi, **A. Rahimian**, and K. Mehran, "Energy Management Using a Situational Awareness-Centric Ad-Hoc Network in a Home Environment," in *2<sup>nd</sup> EAI SmartGIFT*, Mar. 2017, pp. 15–24.

# Future Applications: IoT Smart Energy Solutions; RF Energy Harvesting; IRS; UAVs



Wireless information and power transfer in an IoT network

## SMART CITIES



Developing the technology that will charge UAVs by RF energy at distance, using the flexible lens-based rectifying arrays, for high efficiency and power, medium-range WPT infrastructures.

Passive sensor networks, able to measure the backscatter channel between interrogator networks and batteryless tags to improve the far-field WPT.

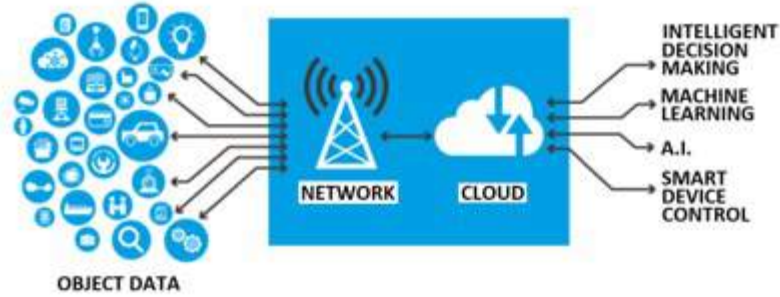


# LoRa Networks, WiFi 3g, 4g and 5g



<https://internetofbusiness.com/digital-catapult-launch-lpwan-uk/>  
<https://www.digitalcatapultcentre.org.uk/digital-catapult-announces-new-iot-regional-partners-sunderland-ulster-bournemouth/>

Supporting Diagrams



This workpackage is now focusing on industry groups and is setting up a final pilot demonstration with Randox for early February. Security, data transmission and cost evaluation will all be examined.

The project has also been awarded a PhD studentship to help generate fundamental research.

The digital fabric should support, within an open access model, the following communications technologies: Narrowband IoT, LoRaWan, 4G, 3G, Wi-Fi, SigFox, Wi-Max, 5G (mmWave, LowBand and Sub6).

*Gerry McQuade, CEO of BT's Enterprise unit, said: "Our UK-first 5G trial with Belfast Harbour last year was a powerful illustration of how 5G-led technology can transform port operations, propel the success of local businesses and drive economic growth. Today's deal with Belfast Harbour will make these benefits a reality, with the creation of a sophisticated digital ecosystem comprising of 5G, AI, IoT and Connected Vehicles. This will act as a springboard for Belfast Harbour to achieve its ambition to be the world's best regional smart port and an innovation hub for the region."*

Randox have engaged in an evaluation study and this will be updated in the next report.

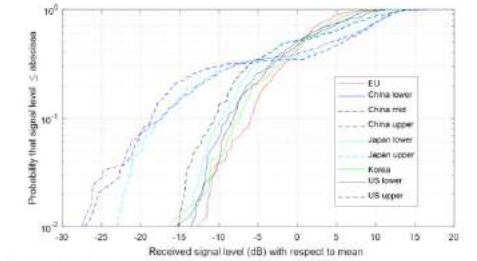


Fig. 1. Comparison of received uplink power for regionally allocated loads

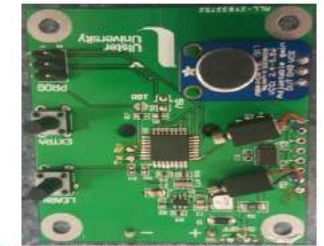
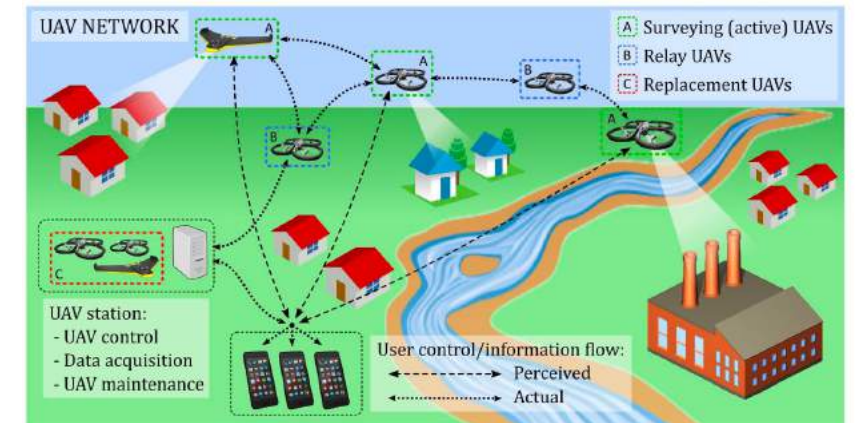


Fig. 2. Prototype planned circuit board for AI environmental monitor for the bearing equipped

Safewater



# Summary

- A proposal for new unique multimillion **R&I Digital Healthcare Technology Centre** in Belfast City Centre – positioned beside the new GBD Campus Development. Housing over 140 researchers from academia, industry and healthcare.
- A new Cardio-focused **Clinical Innovation Living-Lab** will be developed at the RVH as part of the CDHT roll-out with a **FDI-centric HC MedTech Park** under development.
- The center will address **Healthcare 4.0 challenges** as Healthcare faces a huge need for **digitisation**, home-based care diagnostics, the utilisation of **AI and IOT systems**.
- The sustainable center grows on the **success of world-class research and innovation at NIBEC- Engineering, SERG-Computing and BMI - Life & Health Sciences Health Technology at Ulster**, along with clinical excellence in the **Belfast Trust** and a high-quality set of global, SME and multinational **Industry partners**.