Internet of Things UK Research and Innovation Programme (2015-2018)

An Interim Evaluation for the Department of Digital, Culture, Media & Sport

June 2018

SQW

Contents

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Executive Summary

Programme Overview

1. Government designed the Internet of Things UK Programme (IoT UK) in 2014/2015. Led by the Department of Digital, Culture, Media and Sport (DCMS), alongside the Office for Life Sciences, Innovate UK and the Engineering and Physical Sciences Research Council (EPSRC), the programme provides an estimated £30m of government funding between summer 2015 and summer 2018 to help advance UK development of the Internet of Things (IoT) for economic and social benefit.

2. The programme includes five projects, each of which includes a number of different elements. **CityVerve** – a smart city demonstrator led by Manchester City Council and Cisco; **Two IoT NHS Test Beds** using IoT technologies in services for people with dementia or diabetes, in Surrey and the West of England; **PETRAS IoT Research Hub** – a programme of academic research into IoT uses, opportunities and challenges; work by two **Catapult Centres** – the Digital Catapult is providing help for UK IoT entrepreneurs and programme co-ordination and communications; the Future Cities Catapult has published guides and "toolkits" on the business case for IoT in the public sector; **Accelerator schemes** for small businesses – R/GA and Startupbootcamp provided three-month long services to small cohorts of businesses in early 2017.

3. Each project is managed locally. The IoT UK Programme is intended to achieve 'more than the sum of its parts' via central programme management and governance mechanisms and communications and project collaboration support by the Catapults.

4. The programme was subject to unforeseen delays at inception phase, largely due to changes to its main sponsor department (from the then Department for Business, Innovation and Skills, to DCMS and, for health projects, the Office for Life Sciences) and subsequent government decisions. This, and further delays in the inception of projects 'in the field', led to the total government cash funding (£30m) being a quarter (£10m) less than the original budget (£40m). Despite this, the programme is well placed to deliver its activities on time, and within its revised budget.

Evaluation Approach

5. The methodology for this interim evaluation is based on the recommendations of the Evaluation Scoping Study for the programme undertaken by SQW for DCMS

(March 2017)[1]. This recommended that the interim evaluation should make an early assessment of the progress made by the programme in meeting a set of outcomes that had been defined in the scoping study as the key evaluation questions (set out in Figure 1), via analysis of monitoring data, stakeholder consultations, and beneficiary case studies.

Figure 1: Key Evaluation Questions

To what extent has the IoT UK Programme

- Demonstrated economically viable IoT applications, products & services?
- Led to scaling-up of IoT activity by programme participants?
- Led to replicated IoT activity beyond the programme?
- Led to additional growth in beneficiary SMEs (GVA and employment)?
- Enhanced the international reputation and attractiveness of the UK for IoT investment and activity?
- Influenced stakeholders (e.g. standards bodies, policy makers, investors) beyond the programme?
- Generated and shared learning and knowledge on IoT for programme participants?

6. The Scoping Study recommended that contribution analysis – a theory-based evaluation technique – is used to assess the cause and effect of the programme, at both the interim and final evaluations.

7. Rather than seeking to identify "what would have happened in the absence of the intervention?", contribution analysis asks, "is there strong evidence that the intervention – rather than other factors – was critical in causing the outcomes observed/reported?". The approach seeks to allow the evaluator to build up evidence to demonstrate the contribution made by the intervention to the outcomes in question, while also identifying the other factors which may have plausibly contributed to these outcomes (e.g. market opportunities, business strategy, regulations, other interventions).

8. This interim evaluation has used a combination of programme sponsors and participants' self-reported background and monitoring information, and qualitative consultations and case studies with programme participants and beneficiaries. We have drawn together a 'contribution story' for the IoT UK Programme, and sought to discern whether the programme amounts to 'more than the sum of its parts'.

[1] SQW 2017 – Internet of Things UK: Programme Evaluation Scoping Study and Baseline: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/678697/IoT_UK_programme_-_evaluation_scoping_study.pdf

9. Alongside the emerging outcomes of the programme, this evaluation has also considered issues relating to governance and delivery, including financing, project management and co-ordination.

Key Findings

Programme Rationale

10. The rationale for a programme, rather than separate projects, was broadly felt to be sound in conceptual terms by those partners and stakeholders engaged in the research, but this had not been consistently communicated to all partners. This led both to inconsistencies in participants' understanding of the programme aims, which 'spilled over' into delivery issues, and a lack of 'buy in' from partners beyond the confines of their parent project or work package. Opportunities for delivering 'more than the sum of its parts' were missed.

11. The rationale for the programme remains valid. However, this has evolved during the course of delivery, in two key ways: first, as wider related technology areas have developed – notably AI and machine learning – there is an increasing need to ensure UK IoT innovation interacts with complementary technology areas; second, in some cases, the rationale for demonstrators to address information and uncertainty issues has moved-on to a need for the demonstration of the replicability of applications.

Delivery of Activities and Outputs

12. The evaluation has found good progress of delivery of programme activities and strong evidence of delivery of the outputs contained in the logic model for each constituent project. Overall, delivery of the IoT UK Programme at aggregate level is behind the timetable anticipated in the original business case, but it has still delivered a substantial volume of activity at project level in a condensed period of time. Without the IoT UK Programme much of the activity delivered would not have been undertaken at all, or at this scale and pace. In turn, the outputs would not have been generated, or would have been at a lower level or delayed.

13. Summaries of self-reported project activities and outputs are included in Sections 3 and 4 of this report. We found little evidence of how the programme-level co-ordination added value in delivery.

Evidence of Outcomes

14. The evidence also indicates a generally positive 'direction of travel' towards the achievement of outcomes in the medium term. Consultees were able to highlight outcomes beginning to emerge – specifically in response to the evaluation

questions on international collaboration, stakeholder influencing and, increasingly, demonstrating economic viability of IoT applications (through proxies such as investment, and SME firm level growth). Taken together, the interim evaluation suggests that the IoT UK Programme has enhanced the profile of IoT technologies and their uses in the UK, especially within participating partners, localities, and amongst wider stakeholders.

15. It is anticipated that further outcomes will begin to emerge from early 2018 through mid-2019 as activity is rolled-out and learning is generated. For example, stronger evidence on the effects of demonstrating IoT technologies and scaling-up and replication of activity. These should be captured by the final evaluation of the programme; the recommendation in the Scoping Study of a final evaluation of the IoT UK Programme in late 2018 or early 2019 remains appropriate.

16. We would anticipate that the final evaluation will shed more light on the 'durability' of some of the reported outcomes, and whether these have translated into observed impacts which address the evaluation questions. We anticipate that more progress is likely on international collaboration, stakeholder influencing and engagement and the more 'economically focussed' evaluation questions including viability and replicability of applications and use cases and firm level growth and collaboration.

17. As with activities and outputs, this positive 'direction of travel' on outcomes is owing principally to project-level activity, and the contributions of delivery partners at the level of each individual project. At this stage, the evidence that the programme has generated additional substantive and tangible outcomes and benefits that are 'greater than the sum of parts' is very limited.

18. This is underlined by our finding that the weakest evidence of progress in delivering outputs and outcomes relates to evaluation question 7 – sharing learning and knowledge across projects. Whilst participants in each individual project have clearly learned from local project partners, efforts to promote cross-project learning and knowledge sharing have had limited impact, and there is little evidence of any emerging benefits.

19. As expected, given the nature of this type of research and innovation intervention, discerning lasting impacts of the programme at this stage of delivery and stage in time is difficult, owing to time lags in realising benefits and the complexity of attribution of these impacts.

20. It is also important to recognise that the outcomes from R&D activity are rarely linear, and there may be varied routes and time-paths to impact. Any estimates of 'performance' against outcomes at a specific point in time will only ever be partial and focussed on the results of the most direct routes to outcomes that can be most

easily measured at that point. Focussing only on these most direct results can be problematic. It would significantly understate the impact of the IoT UK Programme over the longer term. Further, it would omit key aspects of how the programme and its projects may be bringing about transformative change through, for example, absorptive capacity in the UK public and private sector for the take-up of IoT application.

21. The findings in this report are therefore early-stage and indicative only of the progress made by the programme in delivering against its intended outcomes over its full delivery period.

Other Contributory Factors

22. At final evaluation stage there is also likely to be a clearer picture of attribution. Consultees and case study organisations identified a number of potential factors which may have contributed to the delivery of programme outcomes – notably firm-level knowledge and business planning, increased public understanding of IoT technologies and a willingness within the public sector to explore new technological approaches to policy challenges. At this stage they struggled to quantify the impact and contribution of these factors on the success of the programme, especially in comparison to the programme's own suite of interventions.

Points of Learning

23. We were also asked for recommendations to inform delivery of the final stages of the IoT UK Programme, and other government programmes with similar characteristics. Section 8 of this report provides recommendations, summarised below, and includes a full analysis of the rationale for these recommendations.

24. DCMS, working with other government sponsors of the programme and project leads, should seek to improve the following aspects of delivery:

- Programme monitoring and capture of evaluation information.
- Support for cross-project collaboration.

25. Attention should also be given to planning for the end of the programme and its projects and "legacy" work.

26. The recommendations relating to similar government programmes, particularly those with complex and complicated features are as follows:

- The schedule for implementation should build in a robust, formal inception and scoping stage, including the potential to change programme design, management arrangements and budgets.
- All partners should have direct engagement with the programme sponsor and understand their role.
- The programme sponsor team should be supported by a dedicated secretariat function.
- Whilst monitoring and reporting may be owned locally, or by an expert agency such as Innovate UK, there should be clear accountability to the senior responsible owner.
- All participants should be fully sighted on the aims and objectives of the programme, and how this relates to their specific project.

1. Introduction

Internet of Things Technologies

1.1 Internet of Things (IoT) technologies offer solutions to problems and interfaces where 'physical objects are connected to share data with each other and people - to help make decisions'[2]. Alternatively, the IoT can be described as 'the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment'[3]. The market of IoT is truly global – estimates of its potential range from US $1.7 trillion in 2020[4] to $11.1 trillion by 2025[5]: this offers enormous potential for improving the performance of products and services, to the benefit of consumers or users and suppliers – including in public services.

1.2 IoT is both global, and growing rapidly[6]. By 2020 it has the potential to add £81 billion and 67,000 jobs to the UK economy[7], although estimates (and definitions) vary[8]. The IoT landscape in the UK includes large multinationals, such as Amazon, Samsung, IBM, Google and Cisco, as well as major UK-based companies such as ARM, Vodafone and Arqiva.

1.3 Start-ups and early stage UK firms are also active, raising funding, and developing novel IoT applications. Some high-profile UK IoT firms include: 4NG (connecting equipment and sensors to the built environment), EVRYTHNG (using real-time data from smart products and smart packaging to drive IoT applications), Chirp (using sound to transmit data), and Concirrus (using IoT devices to develop digital insurance underwriting tools).

UK IoT Competitiveness

1.4 From an international competitiveness standpoint, the UK is a major player, but not a world leader in IoT technologies[9]. Countries such as USA, South Korea, Japan, and Finland lead the way across a range of experimental metrics (including Google searches, LinkedIn memberships, job adverts, patenting, and academic journal

[2] Innovate UK (2016) Internet of Things UK: Programme Overview. Slides.

[3] Gartner Tech Research: http://www.gartner.com/technology/research/internet-of-things/

[4] IDC Worldwide Internet of Things Forecast, 2015-2020. (June 2015).

[5] McKinsey Global Institute (2015), The Internet Of Things: Mapping The Value Beyond The Hype (https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world)

[6] The global IoT market in 2020 was estimated to be $1.7 trillion: IDC Worldwide Internet of Things Forecast, 2015-2020. (June 2015).

[7] See https://www.sas.com/en_gb/news/press-releases/2016/february/bi-data-internet-of-things-economy.html

[8] McKinsey Global Institute (2015) The Internet of Things: Mapping the value beyond the hype.

[9] SQW (2018) Internet of Things UK: Programme Evaluation Scoping Study and Baseline.

articles). East Asian and American businesses and innovations dominated the 'Top 100' rankings at the recent World IoT Conference in China[10].

1.5 Across UK industry and government there is a strong intention to raise competitiveness. IoT technologies and expertise could, for example, be a core element of the 'Growing the AI and Data-Driven Economy' and other Grand Challenges identified in the Government's Industrial Strategy[11].

Overview of the Internet of Things UK Programme

1.6 Government designed the Internet of Things UK Programme (IoT UK) in 2014/2015. Led by the Department of Digital, Culture, Media and Sport ("DCMS"), alongside the Office for Life Sciences, Innovate UK and the Engineering and Physical Sciences Research Council, the programme provides an estimated £30m of government funding between 2015 and 2018 to help advance UK development of the Internet of Things for economic and social benefit.

1.7 The programme includes five projects, each of which includes a number of different elements:

- **CityVerve,** a smart city demonstrator. Collaborative research and development (R&D) using IoT technologies to help improve public services for local citizens, such as transport, energy/environment, health and culture. Delivered by local public-sector organisations, industry and universities over summer 2016 to summer 2018.
- **Two IoT NHS Test Beds**. Collaborative R&D using IoT applications in the management and treatment of dementia (in Surrey) and diabetes (in the West of England). These projects are also part of the NHS Test Beds Programme, delivered by NHS, industry and voluntary sector organisations over summer 2016 to summer 2018.
- **PETRAS.** A programme of academic research into IoT uses, opportunities and challenges (PETRAS: privacy, ethics, trust, reliability, acceptability, security) by a consortium of higher education institutions, led by University College London and Imperial College London. Delivered over January 2016 to summer 2018.
- **Catapult Centres**. The Digital Catapult is providing help for UK IoT entrepreneurs; leading on external communications for the IoT UK Programme; publishing topical reports and analysis, for example on emerging IoT industries and case studies to show what IoT can do for all

[10] See: http://en.wiotc.org/content/?107.html

[11] BEIS (2017) - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf

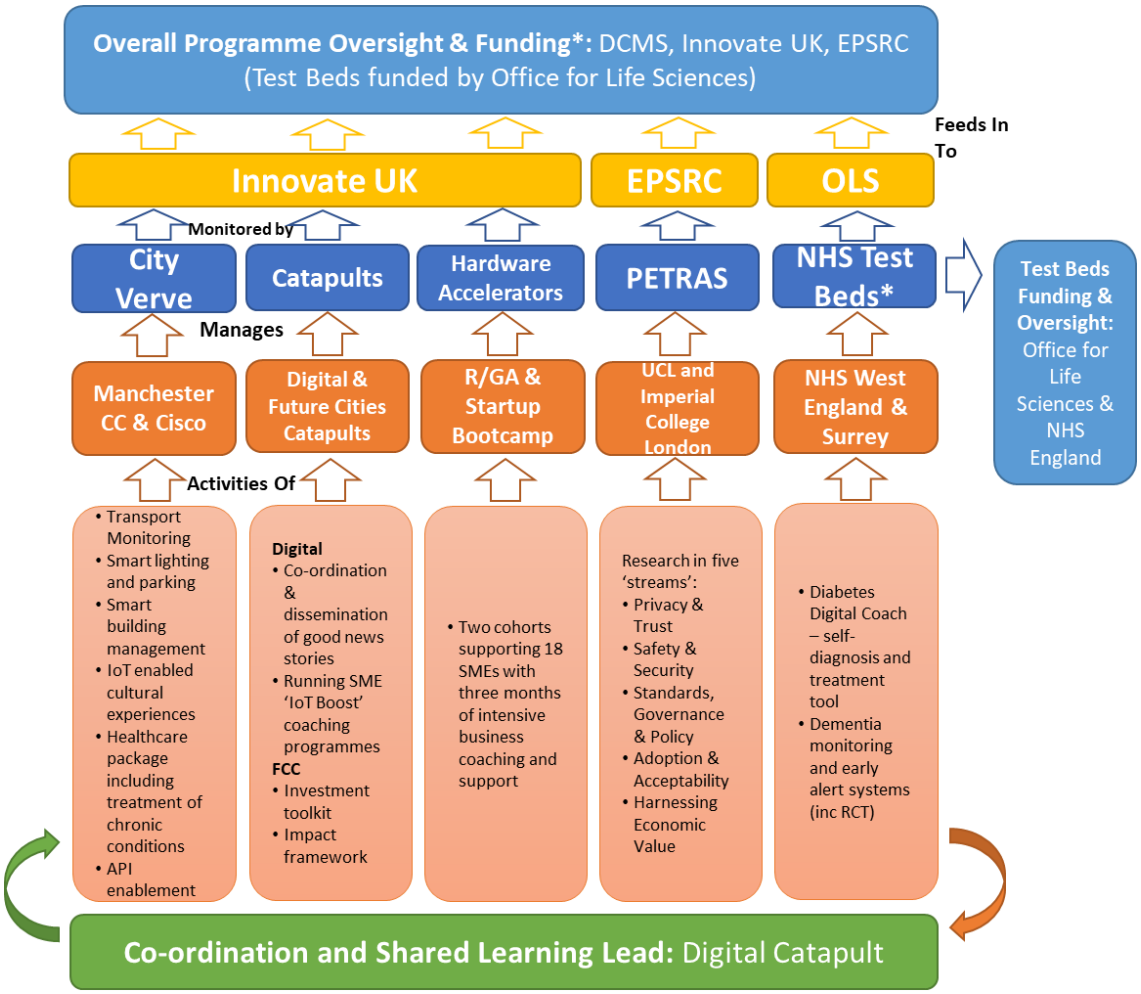
sectors; and supporting a programme of co-ordination and collaboration and knowledge-sharing between people and organisations involved in IoT UK projects. The Future Cities Catapult is publishing guides and "toolkits" on the business case for IoT in the public sector, especially in urban centres, and case studies. Delivered over July 2015 to March 2018.

- **Accelerator schemes (x2)**. R/GA and Startupbootcamp provided three-month long intensive support programmes, each working with nine IoT small businesses (18 in all) Delivered in early 2017.

1.8 Each project is managed locally. The IoT UK Programme is intended to achieve 'more than the sum of its parts' via central programme management and governance mechanisms communications, and collaboration. This includes activity by the Digital Catapult and Future Cities Catapult, and an advisory programme board, chaired by the senior responsible officer (SRO) at DCMS with other government sponsors (government officials from the Office for Life Sciences, Innovate UK and EPSRC) and the Digital Catapult. The board meets two or three times a year to consider progress, financial and strategic matters.

1.9 As mentioned above, the two IoT NHS Test Beds are part of a broader NHS Test Beds Programme, which has a separate advisory programme board. Senior programme leads are invited to the programme boards and there has been regular contact between programme sponsor teams in the Office for Life Sciences, NHS England, DCMS and Innovate UK.

Figure 1-1: Structure of the Internet of Things Programme



Source: SQW

Purpose of the Interim Evaluation

1.10 A scoping study was completed by SQW in March 2017 to advise on the approach to evaluating the IoT UK Programme[12]. This recommended a two-stage evaluation, with an interim and a final evaluation, to capture lessons from the delivery of the programme and to allow time and opportunity for benefits realisation and a proper estimation of the economic impact and 'reach' of the programme. The Scoping Study recommended that the interim evaluation should focus on progress towards benefits realisation, and formative evaluation of process and delivery issues.

1.11 SQW was commissioned by DCMS in August 2017 to complete this interim evaluation, with the following aims:

[12] SQW, 2017, Internet of Things UK: Programme Evaluation Scoping Study and Baseline, Report to DCMS. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/678697/IoT_UK_programme_-_evaluation_scoping_study.pdf)

- To assess how the programme is being implemented; what has and has not worked well and why.
- To draw out lessons for future implementation of the programme.
- To draw out lessons for future government (business, research and innovation) policy and projects.
- To provide evidence and an initial view on the extent to which, at a relatively early stage in time, the programme seems to be delivering its intended outputs and outcomes; and the extent to which early outcomes or changes are as a result of the programme.
- To summarise plans for the evaluation of the projects within the IoT UK Programme, make observations or recommendations about how these might inform DCMS plans for the final evaluation of IoT UK. If information is available on time on the evaluation of these programmes/projects and work packages, report any early stage findings.

1.12 Owing to the status of delivery of the programme in particular the CityVerve and NHS Test Bed projects starting and running late, with key fieldwork taking place into late 2017 and 2018, the process of capturing evidence of outcomes and impacts at this stage has been challenging. This evaluation presents progress against delivery and outputs generated, and captures outcomes and estimates of delivery timelines where consultees were confident to share these.

1.13 The focus of this interim evaluation is at the overall IoT UK Programme level, not each specific project. Where project matters were raised that were relevant to multiple projects or the overall programme this was drawn out in the consultations. This distinction is important: this interim evaluation has *not* reviewed in detail the processes underpinning each of the five projects or how each individual project has been implemented in practice.

Structure of this Report

1.14 The structure of the report is as follows:

- **Section 2** outlines the study methodology.
- **Section 3** reports on the activities undertaken by IoT UK Programme participants.
- **Section 4** reports on outputs delivered by programme participants.

- **Section 5** assesses the delivery on project outcomes, and assesses the 'contribution' of the programme based on the theories of change developed in the Scoping Study.
- **Section 6** synthesises consultee feedback on the process and delivery of the programme.
- **Section 7** provides information on project-level evaluation.
- **Section 8** makes recommendations for the delivery of both the final elements of the IoT UK Programme and other programmes with similar characteristics.

1.15 Four annexes are provided:

- **Annex A:** Detailed information on Evaluation Questions.
- **Annex B:** Case studies.
- **Annex C:** List of Consultees.
- **Annex D:** Project logic models (produced for the Scoping Study).

2. Methodology

2.1 This section sets out the approach and methods used for undertaking the interim evaluation. It follows closely the proposed method outlined in the 2017 Scoping Study. The section also identifies the key issues involved in undertaking the analysis.

Findings of the Scoping Study

Focus of the Interim Evaluation

2.2 The methodology for this interim evaluation is based on the recommendations of the Scoping Study. This recommended that the interim evaluation should make an early assessment of the progress made by the programme in meeting a set of outcomes that had been defined in the Scoping Study as the key evaluation questions (set out in Figure 2-1), via analysis of monitoring data, stakeholder consultations, and beneficiary case studies.

Figure 2-1: Key Evaluation Questions

To what extent has the IoT UK Programme

- Demonstrated economically viable IoT applications, products & services?
- Led to scaling-up of IoT activity by programme participants?
- Led to replicated IoT activity beyond the programme?
- Led to additional growth in beneficiary SMEs (GVA and employment)?
- Enhanced the international reputation and attractiveness of the UK for IoT investment and activity?
- Influenced stakeholders (e.g. standards bodies, policy makers, investors) beyond the programme?
- Generated and shared learning and knowledge on IoT for programme participants?

Evaluation of Process and Outcomes

2.3 The Scoping Study recommended an interim evaluation which covered both 'process' and 'outcome' elements – "focusing on how the programme is actually being delivered in practice – identifying what does and does not work well, and why – drawing out lessons for future delivery of the programme, and for future

government-funded research and innovation projects… [and] also need to evidence early assessment of progress towards outcomes by the programme"[13].

Contribution Analysis

2.4 The Scoping Study recommended that contribution analysis – a theory-based evaluation technique – is used to assess the cause and effect of the programme, at both the interim and final evaluations.

2.5 The key issues underpinning this approach are as follows:

- **The programme is both a 'complex' and 'complicated' government intervention.** As set out in the Scoping Study, it has multiple projects and a high number of participants. Manchester CityVerve, for example, has 20 delivery partner organisations (in a consortium) and is delivering numerous work packages, with emergent and uncertain outcomes. The five IoT UK Programme projects can be considered relatively risky, for example, with innovative research, products, services and IoT applications being developed and tested. This gives rise to a range of uncertainties which makes it difficult to accurately predict what types of outcomes will occur and when, and very difficult to accurately measure the specific contribution of the programme to outcomes[14].
- **Time-lags to impact are likely to vary substantially**, from some potential short-term 'wins', through to long-term outcomes from collaborative R&D activity and activities in entirely new areas.

2.6 The design and complexity of the programme rules out an empirical impact evaluation approach. Rather than seeking to identify "what would have happened in the absence of the intervention?", contribution analysis asks, "is there strong evidence that the intervention – rather than other factors – was critical in causing the outcomes observed/reported?"

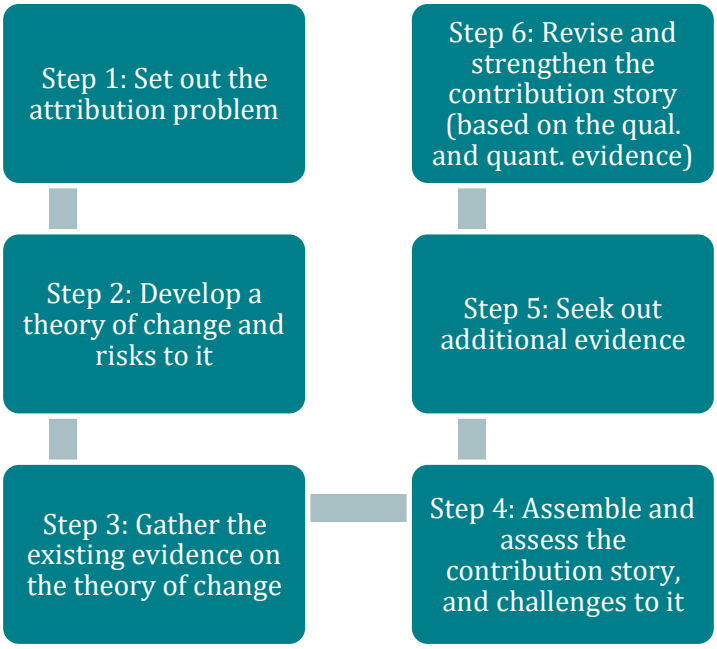
2.7 The approach seeks to allow the evaluator to build up evidence to demonstrate the contribution made by the intervention to the outcomes in question, while also identifying the other factors which may have plausibly contributed to these outcomes (e.g. market opportunities, business strategy, regulations, other interventions). This provides a 'contribution story' about the influence that the intervention itself (instead of other factors) has made to observed outcomes.

2.8 The process is based on a six-step method to gather evidence and develop the 'contribution story', summarised in Figure 2-2. If followed correctly, this can provide an 'implicit' counterfactual for assessing an intervention. The above

[13] SQW (2018) Internet of Things UK: Programme Evaluation Scoping Study and Baseline, Report to DCMS.
[14] SQW (2018) – Internet of Things UK: Programme Evaluation Scoping Study and Baseline.

challenges (the complexity of the intervention, the time lags, and potential limitations on data availability) highlight the importance of adopting a mixed-methods approach such as contribution analysis.

Figure 2-2: Six Steps of Contribution Analysis



Source: Mayne, 2008, Contribution Analysis: An Approach to Exploring Cause and Effect, ILAC Brief 16

2.9 Contribution analysis has some limitations. It is a theory-based evaluation approach, that has been used to seek to understand outcomes of the IoT UK Programme, at an interim and subsequently final stage. The findings in this interim evaluation are based on a qualitative research approach, with the evidence therefore reliant heavily on the knowledge and understanding of the evaluation's participants.

2.10 The contribution analysis also relies on identifying other factors that may have influenced the observed benefits so that the relative contribution of the intervention can be identified. Because the majority of projects that constitute the IoT UK Programme are still at delivery and 'outputs' stage, it has been difficult for participants to identify concrete examples of external factors positively influencing delivery. Most were able to speculate on what these may be, and the potential scale of impact and attribution – these comments are also noted within this evaluation for the sake of completeness and interest, and are acknowledged as such.

2.11 The final evaluation of the IoT UK Programme should seek to understand, and account for in the analysis and reporting, the issues of selection and response bias in order to ensure the robustness of its conclusions.

Research Methods

Desk Based Analysis

2.12 The first stage of the interim evaluation involved desk analysis of background and monitoring information relating to the IoT UK Programme, and the five constituent projects. This included reviewing the following documentation:

- The business case for the programme.
- 'Second level' plans and delivery plans for projects.
- Examples of monthly overview reports by the Digital Catapult (used to inform sponsors and projects and discussed in regular telephone conference calls).
- Quarterly reports by Innovate UK to DCMS.
- Example IoT UK Programme Board agendas and minutes by DCMS.
- Information on project-level evaluation plans.

2.13 We used this information, and the logic models from the Scoping Study in Annex A, to understand the programme and projects and how they were being delivered and progressing in practice, and to inform the research design for the consultations with partners and stakeholders.

Partner and Stakeholder Consultations

2.14 Consultations were undertaken with 31 programme partners. As summarised in Table 2-1, this included representatives of the programme sponsors, and delivery leads and (where relevant) delivery partners for each of the five projects. The consultations also included two external stakeholders that have not been involved directly in the delivery of the IoT UK Programme, but have an insight into the UK's IoT landscape. A full list of consultees is included at Annex B of this report.

Table 2-1: Interim Evaluation Consultees by Project

Project	Number of Consultees
Programme sponsors	6
CityVerve	6
NHS Test Beds (2 projects)	5
Accelerators (2 schemes)	2
Catapults	5
PETRAS Research Hub	7

Project	Number of Consultees
External Stakeholders	2

Source: SQW

2.15 Each consultation sought feedback on the following three evaluation aims:

- **Evidence of emerging outcomes**: focused on the seven evaluation questions agreed by the Scoping Study (see Table 2-1 above). For each evaluation question we sought evidence on (i) the relevance to the project (ii) outcomes generated to date (iii) outcomes expected in the future, and (iv) perspectives on other factors that may have contributed to realisation of the outcomes. The information collected informed our analysis of whether the programme and projects have delivered on the 'theories of change' summarised in the logic models developed in the Scoping Study, and where the co-ordination activity for the IoT UK Programme has delivered 'added value', for example by providing links between programme partners, or communications highlighting the work of specific companies, projects or use cases which were showing potential.
- **Feedback on programme delivery and design**: focused on views on aspects which worked well and less well in the delivery of the programme, in order to inform future approaches and the design of other government programmes with similar characteristics. This included insights on programme design, management and governance, delivery; and whether these arrangements supported partners to deliver a programme that was 'more than the sum of its parts'. The findings of these questions feed directly into the analysis in Section 6.
- **Information on project level evaluation plans**: where appropriate, this focused on gathering information from lead project delivery partners. In some cases, these plans were still developing, with practical evaluation of several projects and work packages not yet underway due to delays in project inception. In other cases, no formal evaluation work is planned (see Section 7). Whilst fuller evaluation evidence at a project level should be available at the point of the planned final evaluation, this may still be 'too early' for firm conclusions on the economic or social value of the IoT projects, which are likely to be realised over a longer period.

Case Studies

2.16 Ten case studies have been prepared on the development of IoT applications or technologies, focused principally on activity delivered by SMEs participating in the programme as beneficiaries, and in two cases as delivery partners. The case

studies aimed to capture firm level impacts of the IoT UK Programme, at this early stage, where evidence is available. The case studies enabled the collection of a mix of quantitative and qualitative evidence to assess the effects and contribution of the programme.

2.17 The case studies were nominated by project sponsors, who were asked to identify potential cases that would enable the interim evaluation to test the routes to outcomes for participants in the programme and "lessons learnt". This included participants who had expressed positive and less positive experiences of the programme. An initial shortlist of 21 potential case studies was agreed with the client and contacted by the SQW team, with the final 10 case studies in this report representing the sample of those who responded and agreed to be consulted.

2.18 The case study research consisted of three elements:

- Reviewing project documentation, where available.
- An in-depth face-to-face interview with the project lead at the organisation, e.g. SME.
- Where appropriate, short telephone consultations with relevant partners to provide further detail and to calibrate the evidence provided by the project lead.

2.19 The focus of the case studies was on capturing evidence of realised or developing outcomes: supporting the development of a UK based IoT SME community was an important aim of the programme. The case studies particularly sought to capture evidence of (realised or expected): demonstration of economically viable IoT applications, products and services; scaling-up of IoT activity by programme participants; and additional growth in beneficiary SMEs (GVA and employment). These outcomes are related directly to the experiences and potential benefits of the programme to individual SMEs. The other outcomes identified in the evaluation questions, and any wider effects, were also captured in the research, where evident.

2.20 Each case study has been written up into a concise summary of the key findings around the partner's experiences of the programme, the observed benefits and outcomes realised, and the contribution of the programme to these outcomes, taking into account the potential influence of other factors. Each has been reviewed and signed-off by the case study lead at the lead delivery organisation. These are attached at Annex C.

Analysis

2.21 The analysis has included three elements:

- **Contribution analysis** – as summarised above, this analysis captures the relevant outcomes of projects to date for each of the evaluation questions; and assesses the contribution of the IoT UK Programme to these outcomes, taking into account other factors that may explain them. The analysis also considers the potential 'added value' of the programme, over and above the early outcomes generated by the five individual projects. This informs a programme level 'contribution story' which indicates the areas where the design and delivery of the IoT UK Programme has driven progress against the evaluation aims.

- **Synthesis of process evaluation evidence** – this analysis is based on feedback from participant and stakeholder consultations, specifically regarding what worked well and less well in the design and delivery of the programme. The SQW team undertook internal workshops to identify common themes across each project, and to understand the root cause of potential issues. These conversations inform an analytical structure based around the themes of programme rationale, design and implementation. Our feedback is based around these themes. We offer findings on how and where the design and delivery of the programme has, based on the evidence provided in the consultations, impacted the realisation of benefits and outcomes, and where there might be learning for other government programmes.

- **Summary of evaluation evidence –** each project within the programme has a different approach to evaluation. The evidence from the consultations, and a review of evaluation planning documents, where relevant, has been used to codify the evaluation processes in place for each of the five projects. This report also gives a brief update on progress against delivery of this evaluation work, and comments on how these arrangements might inform plans for the final evaluation of the IoT UK Programme.

3. Assessment of Inputs and Activities

3.1 This section provides an overview of programme inputs and activity, including the activities delivered to date by the programme across the five projects, and programme co-ordination and communications activity. This provides the context for the subsequent discussion of outputs and outcomes, and the formative assessment of programme design and delivery. The section also provides a recap on the logic model for the programme, and sets out factual information on planned and actual government expenditure.

Logic Model Approach

3.2 The Scoping Study developed a series of logic models for the programme, and for each of the five component projects. The purpose of the logic models was to identify: the **context** within which the programme (and each project) was designed and implemented; the **rationale** for government interventions (i.e. why the government should intervene in IoT markets); the **inputs** and **activities** that would be used and delivered to deliver against this rationale; and the **outputs**, **outcomes** and **impacts** that the programme was expected to generate over (and potentially beyond) its delivery period.

3.3 The logic model for the IoT UK Programme as a whole is set out in Figure 3-1. The project-level logic models are at Annex D. It was not within the scope of this interim evaluation to revise the logic models. However, the extent to which the underpinning rationale in the logic models remained consistent and relevant in mid/late 2017 (two years into delivery) was tested with partners and stakeholders, both at an overarching programme level and for each individual project.

3.4 The evidence from the consultations is that the rationales identified in the logic models remain valid, and have not shifted markedly over this period. As one consultee noted regarding their own specific project:

> *"The principles, history and partners are still the same and thus the rationale still makes sense. The real issue is with benefits realisation."*

Figure 3-1: IoT UK Programme Logic Model

Context

- IoT offers enormous potential for improving the performance of products and services, and benefiting buyers (including in the public sector), suppliers, and citizens
- Trends encouraging development and adoption of IoT include: advances in sensor and battery technology; low power wireless communications; and data management, storage, analytics and applications
- Countries leading in IoT R&D and adoption will have advantages in terms of economic, social and environmental development
- The UK has established advantages for competing in IoT (e.g. digital infrastructure; UK IoT companies; research base; industry strengths, e.g. advanced electronics, software development; consumers who are early technology adopters)

Rationale for intervention

- Wider rationale for government investment in research and innovation, including with emerging technologies
- Markets are likely to under-provide IoT standards, regulation and solutions
- Information asymmetry and uncertainty, for example specialist technical and/or market knowledge of IoT is a barrier to public sector and other buyers' and citizens' awareness of IoT and benefits of using IoT technologies and services
- Buyer and pubic concerns, for example privacy, security and ethical risks, and challenges such as collaboration and data management are also likely to hamper IoT adoption
- Network failures, for example due to lack of coordination or fragmentation in collecting, analysing, and sharing data (on e.g. health, transport, environment) at local and regional levels
- Targeted publicly-funded intervention can help address these issues, leading to more efficient socio-economic market outcomes

Inputs

- Government investment of up to £32m over three years (2015 to 2018)
- Management/governance inputs from sponsors - DCMS, Office for Life Sciences, NHS England, Innovate UK and EPSRC, and from the Digital and Future Cities Catapults
- Cash and 'in-kind' contributions from a large number of delivery partners

Activities

- Five IoT UK projects: collaborative R&D - CityVerve smart city demonstrator Manchester and two health and care demonstrators in Surrey (dementia) and West of England (diabetes); the PETRAS IoT Research Hub; Digital and Future Cities Catapults; and accelerator schemes for IoT hardware businesses
- This work relates to: research, innovation, technology, enterprise, communication, co-ordination and collaboration

Source: SQW (2017) – Internet of Things UK: Programme Evaluation Scoping Study and Baseline

3.5 That said, there is some evidence of the rationale evolving to some extent during the course of delivery so far. This is not unexpected given the way in which the wider IoT market and technology base continues to develop outside of the programme. Two specific points are noted:

- The relationship of IoT with wider related technology areas – notably artificial intelligence and machine learning – was identified by a number of consultees as an area where there is an increasing rationale for government intervention to manage alignment and shared learning and encourage R&D activity. This does not detract from the importance of IoT in itself, but an emphasis on ensuring that IoT innovation interacts with other technology areas was seen as an increasingly important role for the programme.
- In some cases, the original rationale around the need for demonstrators to address information and uncertainty issues has moved-on to a focus on a need for the demonstration of the replicability of applications i.e. the rationale has evolved from proof of concept type activity, to more practical demonstration of the real-world viability of IoT applications.

Overview of Delivery Progress

3.6 Overall, delivery of the IoT UK Programme at aggregate level is behind where it was anticipated in the original (business case) timeline at this interim evaluation stage. However, it has still delivered a substantial volume of activity in a condensed period of time. In some cases, notably PETRAS and Catapults, activity is on course or completed. Delivery of demonstrator projects (CityVerve and Test Beds) is behind schedule, but due to be completed in 2018.

3.7 These demonstrator projects have "backloaded" major aspects of their fieldwork and trials into 2018, largely due to delays in inception, contracting arrangements and unforeseen administrative issues including securing planning permissions and engagement from project or external partners (for example, for citizens to participate in NHS trials for the Test Beds, and to allow live trials of IoT tech on trams and buses in Manchester).

3.8 The delays with delivery of project-level activities have led to contingent delays in the realisation of outputs and outcomes anticipated within the programme business case and logic model (discussed in Sections 4 and 5 respectively).

Programme Budgets and Actual Costs to Government

Planned Government Expenditure

3.9 In March 2015 the programme was allocated a budget of just over £40m over three financial years (2015/16 to 2017/18), of which £3m was capital funding for demonstrator projects (later confirmed as CityVerve and the two IoT NHS Test Beds). Table 3-1 sets out the original programme and project budget allocations.

Table 3-1: IoT UK Budget Allocations £'m (March 2015)

Project	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	Total (all years)
City Demonstrator					
Capital	1	1	0	0	2
Resource	1.35	4.05	2.7	0	8.1
Accelerators					
Resource	1	2.5	2.5	0	6
Research Hub					
Resource	1.7	3.3	3.3	1.7	10
Catapults					
Resource	1.75	1.15	1.15	0	4.05
Health Demonstrator					
Capital	1	0	0	0	1
Resource	1.35	4.05	2.7	0	9.1
Total	**9.15**	**17.05**	**12.35**	**1.7**	**40.25**

Source: DCMS, Office for Life Sciences

Issues Impacting Government Expenditure

3.10 Delays and issues with programme and project implementation led to actual government expenditure on the programme being less than originally budgeted. The key points/factors that framed or contributed to this underspend are as follows:

- The business case for government investment was prepared and approved by the then Department for Business, Innovation and Skills (BIS) (now the Department for Business, Energy and Industrial Strategy or BEIS) and HM Treasury in March 2015, with the above budget. BIS (now BEIS) is the government department in charge of science, research and innovation and associated large programme budgets, including for Innovate UK and Research Councils.
- At that time, HM Treasury decided that the then Department of Health (DoH) (now the Department of Health and Social Care or DHSC), should hold the £10

million budget for, and sponsor, the health and social care demonstrator projects. DoH assigned this role to the Office for Life Sciences (OLS), a BIS/DoH joint unit. It was later agreed by OLS and NHS England to manage the health and care IoT projects as part of the wider NHS Test Beds Programme.

- In May 2015, as part of a "machinery of government change", the BIS teams working on technology sector and digital economy policy were transferred to DCMS. This included a transfer of the £30m BIS programme budget for IoT UK to DCMS. The relevant team's personnel remained the same at this juncture, but changed completely in November 2015.
- DCMS had limited prior experience with, and capacity for, sponsoring research and innovation interventions and had not previously co-sponsored large projects with the relevant government "arm's length bodies" Innovate UK and EPSRC. The IoT UK Programme budget was, relatively speaking, much larger for DCMS than for BIS.
- In mid-2015, following the above changes, and in the context of the Spending Review for budgets after March 2016, DCMS ministers asked for an internal review to consider if the programme should proceed. It was agreed in the early autumn of 2016 that the programme should be implemented.
- A mistaken assumption by Innovate UK and DCMS sponsors about the funding mechanism for IoT SME accelerator schemes led to it becoming too late in the 2015/16 financial year to deliver the planned schemes. The £1.0m budget for that year could not be spent or benefits to SMEs delivered.
- As noted above, £10 million was originally allocated to the Department of Health (Office for Life Sciences) for health IoT projects. The original intention was for this to fund one large demonstrator project. After the competition for funding[15] two projects were selected: they had a total budget envelope (£6m) lower than the available funding (£10m).

3.11 Taken together, some of these events led to delays in initiating some projects. In particular, there was a three-month delay in launching the IoT cities demonstrator competition (later won by CityVerve), and it became too late to implement accelerator schemes in the 2015/16 financial year.

3.12 Later in 2015/16 other factors further impacted on delivery and expenditure:

- The formal initiation process with CityVerve, required before government spending on the project began, took six months to complete, rather than the anticipated one to three months. The CityVerve consortia had not finalised its delivery plans (e.g. proposed IoT use cases) and participants' split of

[15] https://www.england.nhs.uk/ourwork/innovation/test-beds/

work/spending, and had difficulty reaching formal collaboration agreements. There were also issues with SME delivery partners financial checks.

- In setting DCMS budgets for financial year 2016/17 in early 2016, DCMS increased the budget for CityVerve, to take account of the revised timetable for implementation. Initial forecasts for costs to government had been provided by 20 CityVerve participants, with a "health warning" that costs may change as forecasts had been provided early in CityVerve's initiation. DCMS paid for this by reducing the 2016/17 budget for accelerator schemes by £1.5m or 60%. But as noted above, there were delays in the set-up of CityVerve, so the additional money did not turn out to be needed and was therefore not expended.
- Government funding for CityVerve began in July 2016, nine months later than envisaged in the original business case, and three months later than expected when decisions were taken on 2016/17 government budgets.

3.13 These changes have led to a total forecast cost to government for the programme of £30.4m, some £10m (or 25%) lower than the original budget. The change for each project is set out in Table 3-2 below. In addition, there were significant cash contributions to the programme from participating businesses and universities: these are not included in the table. The key points are as follows:

- Total costs of the PETRAS Research Hub, and Catapults have been essentially consistent with the original total expected costs.
- Much less than expected was spent on accelerator schemes: £1m for two schemes in one financial year (2016/17), 83% less than the original budget of £6m for more schemes over three years. Innovate UK recently announced £2m funding (beyond the IoT UK Programme) for a further four IoT accelerator schemes in FY2017/18[16].
- Expenditure on IoT demonstrators in health and social care (NHS Test Beds) was substantially (40%) less than expected: £6m rather than the originally budgeted £10m.

Actual Government Expenditure to Date

3.14 Actual government expenditure is set out in Table 3-2 (for FY 2015/16 and 2016/17). Forecast expenditure for FY2016/17 and FY 2018/2019 is based on November 2017 forecasts.

[16] https://www.gov.uk/government/publications/funding-competition-investment-accelerator-pilot/competition-guidance-investment-accelerator-pilot

Table 3-2: IoT UK Programme: Actual and Forecast Government Expenditure

Project Strand	FY 2015/16	FY 2016/17	FY 2017/18 (Forecast)	FY 2018/19 (Forecast)	Total (all years), with difference from the original total budget
CityVerve					
Capital	0	0.03	0	0	0.03 (-1.97)
Resource	0.081	2.5	5.7	1.4	10.7 (+2.6)
Accelerators					
Resource	0	0.92	0	0	0.92 (-5.8)
PETRAS					
Resource	0.89	3.09	3.45	2.5	9.9 (-0.1)
Catapults					
Resource	1.66	1.09	1.037	0	4.89 (+0.84)
NHS Test Beds					
Capital	-	-	-	-	-
Resource	-	2.801	2.686	0.545	6.03 (+0.03)
Total	**2.631**	**10.43**	**12.873**	**4.445**	**30.379**

Source: DCMS, OLS and EPSRC

Project Activities

3.15 The paragraphs below provide an overview of each of the five projects that together comprise the research and innovation activity supported by IoT UK, including the focus of activity and delivery models, and progress at this interim evaluation stage.

3.16 The paragraphs highlight that parts of the programme have been subject to delays in delivery leading to changes to the scope and scale of the programme, with some de-scoping of the deliverables. This include a scaling back of the accelerator programme and changes in the CityVerve and the NHS Test Beds projects which have extended their delivery timescales.

3.17 This said, substantial activity has been delivered across projects, consistent with what was anticipated by the Programme's business case. The range and depth of activity is both impressive and broad, spanning early stage research to applied near and in-market innovation and business support. At interim evaluation stage, significant activity remained 'in the field'. The extent of delivery of this activity, or the requirement for 're' or 'de' scoping, will be an important aspect of the final evaluation.

CityVerve

Focus and Delivery Model

3.18 CityVerve aims to demonstrate the benefits of IoT technologies in a 'smart city'. The delivery area covers the 'Manchester Oxford Road Corridor' – an arterial route into the centre of Manchester from the south that passes through the universities and hospitals district, before arriving at Manchester City Centre. The area covers 243 hectares, with a 60,000-strong workforce and 72,000 students, and provides an effective 'capsule city' within which to demonstrate IoT capabilities.

3.19 CityVerve is led by Manchester City Council and Cisco. The project has a large number of delivery partners across its 19 work packages. These include public sector bodies such as Transport for Greater Manchester and the Central Manchester University Hospitals NHS Foundation Trust, large corporates including BT, Manchester Science Partnerships, Ordnance Survey and Siemens, several universities, and SME innovators, for example managing the practical application and provision of IoT technologies and solutions.

3.20 The project covers the demonstration of IoT technologies around four key themes: health and social care; transport and travel; energy and environment; and culture and public realm. The CityVerve project encompasses an array of individual projects within these themes, many of which will utilise sensors and GPS to interact with the surrounding environment and population, and to feed into big, integrated, real-time data.

Progress by the Interim Evaluation

3.21 In practice, CityVerve has made mixed progress at this interim stage across the four themes in delivery. Some have shown strong progress, whilst others have been 'back loaded' with the core delivery of activities to take place during the final two quarters of the project (March to June 2018). The following progress has been made in each category:

- **Health and social care:** delivery has been mixed, in part due to a reorganisation of local NHS governance leading to downscaling and delays on a number of anticipated work packages. Trials of smart logistics (e.g. delivery of medicines on demand) and 'VEDS', a video interface for care homes, are anticipated to be completed by the end of the project.
- **Energy and environment:** delivery is on track, notably in activities relating to building management where 'smart solutions' to legionella monitoring and energy consumption have been trialled.
- **Transport and travel:** a 'back loaded' delivery plan with plans to use IoT on selected tram and buses and for a LoRaWaN network allowing WiFi

connectivity at bus stops on Oxford Road in the final two quarters of delivery. A tech enabled cycle scheme was planned but this has not been progressed: a similar scheme has been delivered on a city-wide scale by third party firm, Mobike – this took place outside the scope of the CityVerve project.

- **Culture and public realm:** timely delivery of activities, for example 'virtual sculptures' in the setting adjacent to Manchester Metropolitan University and an AR enabled 'City Concierge App' tied to important events within the city.

PETRAS IoT Research Hub

Focus and Delivery Model

3.22 The PETRAS Research Hub – funded via the Engineering and Physical Sciences Research Council (EPSRC) – has been in operation since early 2016. The overall aim of the Hub is to become a focal point for research around privacy, ethics, trust, resilience, acceptability and security issues in IoT, and deliver wide-scale, socio-economically impactful work that spans research domains, industries and policy matters.

3.23 The Hub is comprised of a collaboration of nine universities. It is led by UCL, with Imperial College London. It represents a hub and spoke model, with five 'hubs' (UCL, Imperial, Warwick, Lancaster, and Oxford) and four 'spokes' (Cardiff, Surrey, Edinburgh, Southampton). Each 'hub' and 'spoke' partner focusses on one or more 'theme' of research.

3.24 The programme is organised around two complementary, but overlapping, programme areas. One is based around **themes** – each with a technical and social lead university – and the other based around sets of **application areas** (sets of projects that can be linked to relevant technologies and/or markets). Each application area can be aligned with one or more of the themes. See Table 3-3 below.

Table 3-3: Structure of PETRAS

Themes (technical lead, social lead)	Application areas (no. projects in August 2017)
• Privacy and trust (Warwick, Oxford) • Safety and security (Imperial, Lancaster) • Standards, governance and policy (UCL, Cardiff) • Adoption and acceptability (Warwick, Lancaster) • Harnessing economic value (Imperial, Oxford)	• Ambient environments (7 projects) • Healthcare (4 projects) • Infrastructure (6 projects) • Supply and control systems (2 projects) • Transport and mobility (3 projects)

Source: PETRAS Annual Hub Report – August 2017

Progress by the Interim Evaluation

3.25 The work of PETRAS has been varied across project strands, with some areas of commonality. One major activity, spanning each of the themes, has been to conduct a set of 'gap analyses', in order to better understand the IoT research landscape and to

identify fruitful areas for new projects to pursue. As a direct consequence of this work, PETRAS projects have expanded from the 20 or so highlighted in the table above, to more than 50.

3.26 In addition to a large quantity of publications, including research papers, co-authored reports with industry, guidance documents, White papers, and confidential reports with industry, the PETRAS institutions engage frequently in conferences and workshops to widely disseminate their research, and raise the profile of the Hub itself and its outputs.

3.27 PETRAS also engages with key research user partners (industry and public sector) to advance particular research areas. Examples include research into the implications of IoT for the legal landscape with Pinsent Masons, research in cybersecurity with the Cisco-affiliated Advanced Security Research Group, and research with BSI on issues of IoT standards. Activities, in principle, are expected to align with the defined themes and/or application areas, but in practice the research institutions involved are afforded considerable degrees of flexibility in terms of directing their own research agendas and exploring interesting, important and impactful avenues of research as and when they emerge.

3.28 The evidence indicates that PETRAS has largely delivered activity as anticipated at this interim stage. Some aspects of the project's research are expected to deliver during 2018. Reflecting the scale of the "soft infrastructure" developed via the project (in terms of partnerships, networks and relationships), the PETRAS team are actively considering legacy activity, and how the project's work might continue beyond the lifetime of the IoT UK Programme.

NHS Test Beds

Focus and Delivery Model

3.29 There are two healthcare IoT demonstrator projects, which are part of both the IoT UK Programme and the NHS Test Beds Programme[17] The latter includes seven projects in total (of which five are not IoT related) and aims:

> *'To improve patient outcomes and experience of care, at the same or lower cost than current practice, whilst supporting economic growth.'*

3.30 The two Internet of Things (IoT) Test Bed projects are the Diabetes Digital Coach (DDC) and the Technology Integrated Health Management (TIHM) project, summarised below.

- **Diabetes Digital Coach (DDC)** is a project led by the West of England Academic Health Science Network in partnership with voluntary sector organisation Diabetes UK and technology companies including Hewlett

[17] See https://www.england.nhs.uk/ourwork/innovation/test-beds/

Packard Enterprise and Oviva. Bringing together mobile health self-management tools (wearable sensors and supporting software) with the latest developments in connecting monitoring devices, the Test Bed is intended to equip people with Type 1 or Type 2 diabetes with the necessary information and technology to 'do the right thing at the right time' to self-manage their condition. It is intended to encourage more timely and appropriate interventions from peers, healthcare professionals, carers and social networks. The project set up, testing and design phase was almost completed by the point of the interim evaluation research, with an anticipated 'go live' for use by people with diabetes in January 2018.

- **Technology Integrated Health Management (TIHM)** is being delivered by Surrey and Borders Partnership NHS Foundation Trust in collaboration with the University of Surrey and health technology providers, to help people with mild to moderate dementia to safely live in their own homes for longer. Individuals and their carers are provided with sensors, wearables, monitors and other devices, which use IoT technology to monitor their health at home. This is designed to empower people to take more control over their own health and wellbeing, as well as enabling health and social care staff to deliver more responsive, timely and effective services.

Progress by the Interim Evaluation

3.31 The DDC have had issues relating to recruitment and evaluation of the project and were unable to provide the SQW evaluation team with clear evidence of activity up to the date of reporting. Progress had been made with stakeholder engagement and co-design of the approach alongside patients, but the delivery of technical solutions and field testing had not substantively commenced at the point of reporting.

3.32 Within the TIHM project, activity has included co-design activities with people with dementia and their carers to trial the technology and inform project design. Two 'living labs' have been created: one focusing primarily on technical management and alignment; the other focused on user acceptability and stakeholder involvement and training, the IoT infrastructure has been created, with over 20 devices linking into the infrastructure via an integration engine. The technology provides information to inform clinical decisions, and can issue clinical, environmental and technical alerts, based on personal baselines and readings for each individual, using machine learning. Work has been undertaken to ensure the system is compliant with NHS information governance requirements.

3.33 Over 100 participants and their carers had been recruited into the randomised control trial (RCT) for the Test Bed in December 2017, and will be the subject of the project evaluation. The RCT is currently 'in the field' and will report in summer 2018.

3.34 Following a short extension to the original timescale, both projects are planned to run until June or July 2018.

Small Business Accelerator Schemes

Focus and Delivery Model

3.35 Accelerators support the growth of early-stage firms through a highly selective, cohort-based programme of limited duration, which may or may not include the offer of physical space or facilities[18].

3.36 Two accelerator schemes for small IoT businesses were supported by the IoT UK Programme. Each offered three months of tailored support to SME businesses working to develop hardware IoT products and applications. The scheme providers, Startupbootcamp, and R/GA, were selected to Innovate UK following a competitive procurement process.

Progress by the Interim Evaluation

3.37 The schemes ran from March to June 2017, delivering support to 18 SMEs, against a target of 20.

3.38 These beneficiaries received support via a specialist mentor in their specific IoT field, for example on: developing hardware solutions from prototype to manufacture; business planning, focused on 'scaling-up' a business and 'hands on' management requirements and disciplines (e.g. HR, financial management); design; branding support; and introductions to potential equity investors. The firms supported by Startupbootcamp and R/GA respectively are listed in Table 3-4 below.

Table 3-4: SME Participants in the Accelerator Schemes

Startupbootcamp	R/GA
• Joyride • Trackener • HomyHub • ThingTrax • Woogie • YodelUP • CityCrop • Eskesso • DoorDeck	• DigiSe • Flock • Hoxton Analytics • Iota • KG • ScreenCloud • Sensible Object • Snaptivity • Winnow

Source: Project consultations

3.39 As outlined above, government funding for accelerator schemes as part of the IoT UK Programme has been substantially less than planned, reducing the number of

[18] BEIS (2017) Business Incubators and Accelerators: The National Picture. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/608409/business-incubators-accelerators-uk-report.pdf

schemes and SME beneficiaries. Innovate UK has funded four similar schemes, with funding from and managed outside the IoT UK Programme.

3.40 The two schemes completed in 2016/17 as planned. Both have an 'alumni' scheme, in which they will continue to support the start-ups in increasing their funding and growing their customer base.

Digital Catapult

Focus and Delivery Model

3.41 The Digital Catapult leads on several aspects of the programme, providing support to UK IoT entrepreneurs and external communications for the IoT UK Programme, publishing topical reports and analysis, for example, on emerging IoT industries and case studies to show what IoT can do for all sectors. They also lead a programme of planned co-ordination and collaboration and knowledge-sharing between people and organisations involved in IoT UK projects, fulfilling the role on 'IoT Central' function foreseen by the original business case. This role involves leading regular project lead conference calls, organising and leading engagement events and advising programme participants on potential collaborations across projects.

Progress by the Interim Evaluation

3.42 The Digital Catapult has carried out activities in three main areas or work packages:

- **Communications and encouraging IoT awareness and adoption:** this has included the development of content, for example blogs and case studies, published on an IoT UK website (https://iotuk.org.uk); and experimental data analysis of UK IoT activity through the IoT Nation database (https://iotuk.org.uk/iotuk-nation-database/). This database aims to provide a snapshot of businesses and organisations that make up the Internet of Things "sector" in the UK, and (as at December 2017) contains information on over 600 organisations across the UK.
- **Acceleration of IoT innovation and business:** this includes delivery of four 'IoT Boost' programmes in Sunderland, Leeds, Cambridge and Glasgow. Each worked with between 5 and 10 SMEs, offering one-month of support and mentoring to help them in the first stages of bringing a commercial idea to market. The Catapult also set up and managed an online community, 'IoT Nation', for IoT SMEs to share ideas and support one another through 'open source' collaboration. They held two SME showcases for IoT businesses (attended by a total of 51 partners, including 19 SME exhibitors).
- **IoT UK Programme co-ordination and support for project collaboration**: activity to co-ordinate, support and amplify all projects in the IoT UK programme to help the programme achieve 'more than the sum of the parts.'

In practical terms, the Catapult has acted as a 'bridge' between local project leads, other projects and government sponsors, identifying themselves as both public-facing and participant 'champion'. Activities have included: leading and providing secretariat for two groups of project and communications leads across the IoT UK Programme, with monthly overview reports; and activity to assist cross-project collaboration, for example on opportunities and to solve problems.

Future Cities Catapult

Focus and Delivery Model

3.43 The focus of the work of the Future Cities Catapult is to support public authorities in cities across the UK to better understand and consider and prepare for the use of IoT technologies in their areas. This public-sector focus is intended to complement the business focus of the Digital Catapult's work.

Progress by the Interim Evaluation

3.44 Work has included producing materials to support organisations' development of business cases for using IoT technologies in an urban environment, including:

- **IoT investment case toolkit**: two toolkits for local authorities to determine the viability of investing in IoT, specifically looking at parking and waste[19].
- **Performance and "standards in use" tools**: a series of methodologies/impact frameworks to forecast and measure the impact (economic, social, environmental, technology optimisation) of IoT solutions, intended to inform consideration and selection of IoT use cases and benchmarking against international good practice[20].
- **Reports on IoT adoption among cities in the UK, and a 'human-centric' approach to IoT:** – based on research and consultations with UK cities and industry experts to provide a snapshot of use of IoT in UK cities and drivers and barriers to adoption[21].

[19] Future Cities Catapult (2016) – Smart Parking: https://iotuk.org.uk/wp-content/uploads/2016/08/Toolkit_Smart-Parking.pdf; Smart Waste: https://iotuk.org.uk/wp-content/uploads/2016/08/Toolkit_Smart-Waste.pdf

[20] Future Cities catapult (2017) – Performance in Use Toolkit: https://iotuk.org.uk/wp-content/uploads/2016/07/Performance-in-Use-Summary.pdf ; Standards in Use - https://iotuk.org.uk/wp-content/uploads/2016/08/Standards-in-Use_Final.pdf

[21] Future Cities Catapult (2017) – IoT Adoption Amongst Cities in the UK: https://iotuk.org.uk/wp-content/uploads/2016/08/IoT_Adoption_Security_Report.pdf; Future Cities catapult (2017) – The Future of Street Lighting: https://iotuk.org.uk/wp-content/uploads/2017/04/The-Future-of-Street-Lighting.pdf; Future Cities Catapult (2017) – Social Isolation and Loneliness in the UK: https://iotuk.org.uk/wp-content/uploads/2017/04/Social-Isolation-and-Loneliness-Landscape-UK.pdf; Future Cities Catapult (2017) – Structure of the Automotive Telematics Market: https://iotuk.org.uk/wp-content/uploads/2017/04/Structure-of-the-UK-Automotive-telematics-Market.pdf

4. Assessment of Outputs

4.1 This section of the interim evaluation compiles project level outputs, benchmarked against the logic models from the Scoping Study and included at Annex C of this report.

4.2 It should be noted that these outputs are self-reported by project leads, and have not been quality checked or verified by the SQW evaluation team. Neither the Scoping Study, nor government sponsors, have specified targets or performance indicators relating to project outputs. Therefore, the tables below are presented as a narrative summary of the delivery of outputs, not a quantitative assessment.

4.3 Three points are highlighted:

- The evidence indicates that across the five projects, a significant volume of outputs have been generated at this interim evaluation stage. There is considerable variation in progress both across and within the projects, which may be expected given the varied nature of activity and time-paths to the delivery of outputs.
- In some cases, output delivery has been far higher than anticipated – for example, the number of PETRAS use case pilot projects – which may suggest that the initial expectations on the scale of outputs were too low.
- Collection of data and information against agreed outputs appears to have been inconsistent across the programme and its constituent projects, meaning that a fully comprehensive assessment of outputs is not possible. This is particularly notable in relation to the business support elements of the programme (accelerators, IoT Boost, CityVerve innovation) where data on business progress has not been collected.

CityVerve

4.4 CityVerve had broad delivery aims, aiming to demonstrate IoT applications in a range of public infrastructure and services. This was reflected in its anticipated outputs[22]. Progress in delivery against the outputs is summarised in Table 4-1. The project has delivered substantial outputs at this interim stage, for example the development of infrastructure for IoT and IoT-enabled art installations, and communicated the opportunities, usefulness and benefits of the project.

4.5 For some use cases, for example IoT and gamification in energy and environment and transport, there has been progress but more limited output generation. We observed

[22] CityVerve outputs in Table 4-1 are drawn from the project's Second Level Delivery Plan, rather than the CityVerve logic model from the Scoping Study This reflects the breadth of activity and associated outputs.

that the latter were often delivered 'at one step removed' from the project's lead organisations, Manchester City Council and Cisco.

4.6 All data in Table 4-1 is correct as of 23 March 2018.

Table 4-1: Evidence of Outputs from CityVerve

Output Description from Second Level Plan	Evidence of Delivery	Delivery Status
Two large scale IoT enabled art installations	Two installations delivered: CityVerve commission #1: 'every thing every time' – by Naho Matsuda Exhibition: 22nd June – 9th July 2017 at 4 locations, with one display live until 9th August. The measured engagement for the work is 1,034 which includes the figures recorded for Hulme Community Garden Centre and the artwork microsite – this includes people who visited the microsite and those who engaged with the interactivity onsite in Hulme. CityVerve commission #2: SUPER GESTURES – by Ling Tan https://www.supergestures.com/ SUPERGESTURES is a participatory art project co-created by Ling Tan and young people across Manchester.	Fully delivered
Developed at least four examples of 'gamification' to deliver priorities	Five examples en-route to delivery, but not yet completed. • BeeActive • Age of Energy @MMU • Transportation UC • City Challenges Go (4th game idea) • VR Bike	Partly delivery
Developed common core hardware & software base infrastructure	The following common infrastructure has been delivered: • The LoRaWAN, a wireless network covering City of Manchester and part of greater area that allows IoT devices to connect to the cloud and send their data to the platforms. • Common data centre hosted at ANS premises in Manchester. • An API portal that allows the sharing of city's data via one single API.	Fully delivered
Delivery of open source API tools for developers	Delivery of API tools for developers online at: https://developer.cityverve.org.uk/	Fully delivered
Development of common data handling platform and standards (HyperCat)	All Hypercat and data handling deliverables have been completed to schedule.	Fully delivered
No. of platforms and use cases for IoT in transport (inc. sensing trams, talkative bus stops, city concierge, ebike sharing)	Work is on-going on several use cases covering all mobility modes within the City. This includes Talkative Bus Stop (Bus): 6 Bus Stop Trial Sites, City Concierge (Walk), Next Generation Cycling(Cycle): 140 See.Sense Smart IoT Lights, Road Safety (Car & Freight): 200+ Telematic Sensors, Air Quality Traffic Management (All): 8 Solar powered sensors.	Partly delivery

Output Description from Second Level Plan	Evidence of Delivery	Delivery Status
No. of platforms and use cases for IoT in energy and environment (inc. smart parking, smart lighting, smart cleaning, next-gen BMS)	9 Use Cases delivered in Energy and Environment • IoT Infrastructure. • Smart Parking - This solution is being trialled at MSP's central campus. • Smart Lighting - CityVerve upgraded 93 luminaires in the 10 MSP central campus car parks, serving 500 spaces. • Energy Retrofit with people counting - Asset Mapping have installed gateways or sensors in the six buildings. • Healthy Water- Achieving compliance cost reduction by automating the collection of hot and cold water supply temperature readings using IoT enabled sensors. • Smart Cleaning - The Smart Cleaning solution utilises a number of devices to be used in a target dynamic cleaning schedule • Workplace Utilisation - Real-time dashboards and mobile apps reduce the time spent looking for a vacant hot-desk or meeting room. • Next Gen Building Management Systems with off-grid capability - Siemens have successfully delivered the Next Gen BMS deliverables within the Bruntwood and MSP properties in Manchester. and flexibility in near real time. • Smart Bins - Using low cost QR Code data. Development of a platform for the creation of assets, QR code production and workflow creation.	Fully delivered
No. of platforms and use cases for IoT in health and social care (inc. chronic condition management, community wellness)	No information provided.	
An open innovation program to engage start-ups and SMEs	Eight start-ups and SMEs supported with a comprehensive 8 months programme from 150 applicants.	Fully delivered
Communication and dissemination of CityVerve	Since launch, the communication and dissemination activity has resulted in: • 48k views of the website, with 17% being returning visitors. • 6.5k listens of the CityCast podcast on Soundcloud 6.5k listens of the CityCast podcast on Soundcloud. • 13k+ video views on Facebook. • 4.7k video views on YouTube. • 14.7k engagements across social media (likes, shares, comments, mentions). MCC has presented on the project to delegations from: European funded (FP7) project, Cityzen, Cities of Leipzig, Sabadell, Prague, Stavanger- Norway, Australia and Kazakhstan - c100 people from 30 organisations and 7 EU countries.	Fully delivered
Development of an economic legacy plan	This is underway and will be complete in Q8 of the project.	Not delivered

Source: CityVerve

NHS Test Beds

4.8 The key outputs for the NHS Test Beds involve the substantive delivery of project fieldwork, and related analysis and synthesis of findings related to this activity. Both the TIHM and Diabetes Digital Coach (DDC) have encountered practical issues in delivering the anticipated programme of 'in field' research: TIHM has not been able to recruit the anticipated number of volunteers, whilst DDC's attempts to 'roll out' following pilot stage have been affected by data protection and technical issues. This has a knock-on impact on the delivery of analytical and evaluation outputs.

4.9 Data for Diabetes Digital Coach is correct as at 10 March 2018. Data for TIHM is correct as at 9 April 2018.

Table 4-2: Evidence of Outputs in NHS Test Beds Project

Output Description from Logic Model	Evidence of Delivery	Status
Devices & platforms used (Digital Diabetes Coach: 12,000 patients over two years. TIHM: 350 patients with dementia [and 350 in control group not using device])	The DDC has supported delivery to 800 patients during its pilot phase, but the platform has yet to 'go live' owing to issues relating to General Data Protection Regulation. TIHM: 204 participants (101 intervention group; 103 control group not using device) were recruited to the TIHM trial. Use of the TIHM solution by those in the intervention group ended in March 2018.	Partly delivery
Production of real-time data	The DDC platform has not yet begun to produce real-time data. Within TIHM real time data have been collected by sensors, wearables and medical devices from all people with dementia in the intervention group for a 6-month period.	Partly delivery
Evaluation reports	The DDC submitted an interim evaluation report in Nov 2017, a final report is due in July 2018. TIHM - interim evaluation report submitted October 2017, final one due end of July 2018. TIHM was voted Best Mental Health Initiative of 2017 by a panel of healthcare and IT experts at the annual ehi Awards and was recently shortlisted in the HSJ Value Awards and the Patient Safety Awards.	Partly delivery
Proposals for future applications of technology	Joint discussions are ongoing between TIHM and DDC on IoT platform for long term conditions and how to take this forward to next stage. The TIHM team has submitted a proposal for Wave 2 Testbeds on using the TIHM IoT system to improve the health and wellbeing of frail elderly. Preliminary discussions have been held regarding development of a TIHM IoT system for use in populations with learning disability.	Partly delivery

Source: West of England Action Health Science Network, Surrey and Borders NHS Partnership

4.8 Delivery of outputs within the NHS Test Beds projects is mixed. Rollout of the projects has been impacted by unforeseen issues which has slowed progress against anticipated delivery schedules. Of the two projects, the DDC appears at most risk of not delivering all anticipated outputs. The delivery organisations had a major re-think of their approach to data capture and analysis at a critical point in delivery, in the context of changes in data protection regulation.

4.9 The most important outputs for the NHS Test Beds will be the analysis which follows the completion of fieldwork – the cohorts of people need to be of significant size to provide robust findings, and offer supportable conclusions and 'legacy' for the projects.

PETRAS Research Hub

4.10 PETRAS universities anticipated that a broad suite of outputs would be delivered through their investment in research. These included a mix of 'academic' outputs (citations, journal articles and publications) and practical and 'commercial' outputs focussed on collaboration with industry and the public sector, development of scalable or replicable IoT 'use cases' and securing further investment in research.

4.11 Data provided by PETRAS is correct as at 2 March 2018.

Table 4-3: Evidence of Outputs in PETRAS Project

Output Description from Logic Model	Evidence of Delivery	Status
At least 20 IoT "use case" pilot projects over three years; with at least two industrial / public sector / end-user partners per project	Delivered 67 'use case' pilot projects, with partners including Balfour Beatty, Royal Bank of Scotland, Microsoft, Ordnance Survey, Which? and BT Group.	Fully delivered
Increased funding for research by participants in the Hub from other sources	There are 12 instances of funding from other sources for PETRAS supported projects, these include support from partners such as Google, GCHQ and the Arts and Humanities Research Council.	Fully delivered
No. of published academic research papers and articles; and citations of these by others	148 reports, journal articles and publications have been produced. These cover topics as diverse as cyber-security, machine learning, using IoT in the insurance industry and the use of blockchain approaches in IoT projects.	Fully delivered
New IoT goods, services or intellectual property developed	One recorded instance of development of a 'good' – an app to support the use of 'IoT Eggs'. There are no recorded instances of registering of IP.	Partly delivery

4.12 In broad terms, PETRAS has 'over delivered' its own output targets, outlined in the Scoping Study. They have supported triple the anticipated number of 'use case' pilot projects, and worked alongside, and secured funding from, a broad mix of commercial, academic and public-sector partners. On academic outputs, approaching 150 reports, journal articles and publications have been produced, with additional outputs from presenting the results at international academic conferences.

4.13 However, no targets were set for the number of new IoT goods/services or intellectual property developed. In this area delivery is modest. It may be anticipated that the further development of the 67 'use cases' logged by PETRAS may result in more registered IP by the time of the final evaluation.

Accelerator Schemes

4.14 As outlined above, fewer than planned accelerator schemes were funded, but the two accelerator schemes have delivered the majority of their anticipated outputs. No consistent or comprehensive evidence was collected by the project to inform an assessment of the extent to which the businesses had developed their technology/products and their business and investment cases, or whether businesses had received additional funding. As such, the performance against the outputs cannot be judged fully at this interim evaluation stage.

4.15 Data provided by Innovate UK, relating to the accelerator schemes, is accurate as at 10 March 2018.

Table 4-4: Evidence of Outputs from IoT SME Accelerator Schemes

Output Description from Logic Model	Evidence of Delivery	Status
20 IoT businesses (SMEs) receive support from the two accelerators	18 businesses participated.	Fully delivered
Development by these businesses of their existing prototype technology or products; and their business and investment cases	Some evidence from consultees, but no comprehensive evidence across beneficiary cohort	Partly delivered
No. and type of events and networking opportunities	R/GA Demo Day event attracted an audience of over 240 guests at the Royal Institute of British Architects (invitation sent to a contact list of over 1,000 advisers, experts, investors, R/GA clients and leaders in the IoT ecosystem). R/GA team researched 802 start-ups (about half from the UK) and held 75 preliminary meetings with start-ups. Startupbootcamp Demo Day event attracted 350 attendees (mainly investors and corporates, as well as ecosystem partners) and 7,000 people watching online through a live-stream. Startupbootcamp received 425 applications from 61 countries.	Fully delivered
At least two participating businesses from year one receive additional (private) funding (from each accelerator)	Some evidence from consultees, but no comprehensive evidence across beneficiary cohort	Partly delivered

Source: Innovate UK

Catapults

4.16 The majority of the outputs anticipated from the two Catapult Centres' work relate to the delivery of communications and business support, research into UK IoT activity

and, in the case of the Digital Catapult, bringing together the IoT UK Programme's partners to learn and collaborate. The volume of outputs from the Digital Catapult especially, is noteworthy, providing the potential for a substantial contribution to grow understanding of, and build a community within, the emerging UK IoT sector. Similarly, the Future Cities Catapult has produced a large volume of reports and toolkits, which should help advance public sector understanding of IoT.

4.17 The data for the Digital Catapult is correct as at 10 March 2018, and for the Future Cities Catapult at 12 March 2018.

Table 4-5: Evidence of Outputs by Catapult Centres' Work for IoT UK

Output Description from Logic Model	Evidence of Delivery	Status
Digital Catapult: No. of publications (IoT UK website)	• IoTUK website launched in 2015. https://iotuk.org.uk • Blogs: 203 • Insight reports: 26 • Case studies: 25 • Good practice guides: 6	Fully delivered
No. of events delivered for SMEs and other organisations	• Seven thematic research workshops and two advisory clinics. • Two Boost programmes, running between 6-12 months each. • Each Boost partner held a series of events and mentoring activities for their cohort of SMEs. • SME Mentoring Programme meet-ups: six including Bradford, Manchester, Belfast and London. • Two SME investor events at Digital Catapult offices. • Four SME showcases.	Fully delivered
No. and types of SMEs participating in events	• 2015/16 Boost Programme: 50 SMEs across four partners. • 2016/17 LPWAN Boost: 60 SMEs across six partners. • SMEs supported: 115 "engagements" including SME Mentoring Programme. • 18 SMEs at investor days plus 18+ investors • 44 SMEs at showcases. • 2016-17: Four SME showcases including at Innovate 2017, Smart IoT London 2016, Digital Catapult offices 2017	Fully delivered
Database of UK IoT activity published online	• IoTUK Nation Database launched in March 2017. • https://iotuk.org.uk/iotuk-nation-database-launch/ • Three reports of analysis of data from the database plus blogs and films explaining the methodology.	Fully delivered

Output Description from Logic Model	Evidence of Delivery	Status
No. and type of conferences, presented growth of IoT UK community members	• Demos at three conferences (Smart IoT London, Mobile World Congress 2017 and Innovate 2017). • 39 awareness raising and speaking engagements, e.g. Royal Society; round table at the Science and Innovation network, Innovate UK Cyber Security Panel. • Registered community receiving a monthly e-newsletter: 4,467 • Social media community (Twitter): 5,706	Fully delivered
IoT technologies developed, tested and deployed	• N/A	Not delivered
Trade mission	• International outreach with 35 countries including Denmark, Finland, Japan, South Korean delegations, Taiwan, India, Hong Kong, Singapore, Canada, USA, Spain and Germany.	Partly delivered
No. and type of programme management deliverables (governance board meetings and reporting)	• 28+ monthly delivery leads' meetings, papers & minutes. • 28+ Monthly comms & PR meetings & minutes. • One programme partner day held at Manchester Science Park in April 2017 – all programme partners represented.	Partly delivered
Future Cities Catapult: Publication and operationalisation of the Performance in Use Portfolio (impact frameworks)	• Framework published on IoTUK website in Aug 2016 • Could not operationalise as the Catapult was unable to access CityVerve use case data, due to CityVerve delays and partner concerns.	Partly delivered
Publications of IoT Investment Case Toolkit; and resource toolkit for IoT demonstrator cities	• Published on IoTUK website; Aug 2016.	Fully delivered
Publication of reports on learning from demonstrator cities, and adoption of IoT in cities	• Published on IoTUK website; Aug 2016.	Fully delivered
Publication of blogs and short films on IoT; no. and types of SMEs engaged with CityVerve	• No. blogs on IoT = 7 • No. and types of SMEs engaged with CityVerve = 0	Partly delivered
IoT technology tests using CityVerve	• IoT technology tests using CityVerve - unable to access use case data so could not apply Performance in Use framework.	Not delivered
IoT investment opportunities for UK cities	• Work to identify promising proposals for IoT projects and supporting local public-sector promoters' project and investment case development.	Partly delivered

Source: Digital and Future Cities Catapults

4.18 On the whole, delivery of outputs by both Digital and Future Cities Catapults has been as planned and timely, especially where the activities evidenced by these outputs

have been wholly reliant on the Catapults – for example, production of blogs, toolkits or the delivery of business support.

4.19 Where the outputs relied partly on other programme delivery partners, output delivery has been less successful. Neither Catapult has been able to evidence, for example, use of their outputs 'in the field' in or beyond the IoT UK Programme, or examples of technologies developed. In the case of the Digital Catapult, activities and outputs relating to programme co-ordination and project collaboration have been fully delivered, but many consultees were unclear as to the purpose or added value of the activity.

5. Assessment of Outcomes

5.1 This section summarises the evidence of programme outcomes at this interim evaluation stage, drawing on evidence provided by consultees and case study participants. The section also provides an interim (and at this stage tentative) 'contribution analysis' on the contribution of the programme relative to other factors that may have led to the observed outcomes.

Analytical Approach

5.2 Our approach to analysis of programme outcomes, impacts and contribution was summarised in Section 2. The research tools were designed specifically to capture both evidence of outcomes against each of the seven evaluation questions and potential 'other factors' that may have affected their realisation, for example, external market/economic factors, regulatory, policy or political factors, and technology change.

5.3 The evidence from the consultations and the case studies have been analysed to provide a rounded assessment of the outcomes generated by the programme to date across its constituent projects, to give a sense of the 'direction of travel' within the final six months of delivery, and in advance of the programme's completion.

5.4 The detailed findings from the consultations for each of the evaluation questions, and the SME case studies, are provided in Annex A and Annex B. This section provides a synthesis of the evidence developed through this research, with two elements:

- A headline assessment of the evidence on the nature and scale of the outcomes generated at this interim point.
- An interim 'contribution story' and narrative, taking into account the other factors that may have influenced these outcomes, and the relative contribution of the programme.

5.5 In this context, it is worth noting that not all of the programme outcomes are expected to be delivered by all projects. Table 5-1 summarises the feedback from consultees as to whether each evaluation question was relevant to specific projects. For each evaluation question Table 5-1 shows the proportion of consultees who recognised this type of outcome as important to their project.

Table 5-1: Relevance of Evaluation Questions to Consultees

Project	EQ1	EQ2	EQ3	EQ4	EQ5	EQ6	EQ7
CityVerve	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓
PETRAS	✓	✓✓	✓✓	-	✓✓✓	✓✓	✓✓✓
NHS Test Beds	✓	✓✓	✓	✓	✓	✓	✓✓
Accelerators	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	-	-
Catapults	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓

Source: Stakeholder Consultations (✓✓✓ = all consultees reported relevant; ✓✓= most consultees reported relevant; ✓= some consultee reported relevant; - = no consultees reported relevant)

5.6 It is important to note that we may expect that there will be different time paths to impact / outcomes. In some cases, notably the evaluation questions on influencing stakeholders and generating learning, outcomes may potentially be realised during implementation of projects (for example, knowledge on IoT being generated as the research activity is underway). In the case of influencing business growth and leading to the replication of activity by others, or scaling-up by project participants, outcomes may take longer to flow through and will most likely follow the completion of the R&D activity focus on testing and proving the potential of IoT technologies in one context.

5.7 It is also important to recognise that the outcomes from R&D activity are rarely linear, and there may be varied routes and time-paths to impact. Any estimates of 'performance' against outcomes at a specific point in time will only ever be partial and focussed on the results of the most direct routes to outcomes that can be most easily measured at that point. Focussing only on these most direct results can be problematic. It would significantly understate the impact of the IoT UK Programme over the longer term. Further, it would omit key aspects of how the programme and its projects may be bringing about transformative change through, for example, absorptive capacity in the UK public and private sector for the take-up of IoT application.

5.8 The findings below are therefore early-stage and indicative only of the progress being made by the programme in delivering against its intended outcomes over its full delivery period.

Headline Assessment of Outcomes

Key Overarching Findings …

5.9 As outlined in Section 3, the evidence indicates that the activity anticipated in the programme and project-level logic models. has, for the most part, been delivered over the first two years of the programme. Section 4 shows that anticipated outputs have

also been generated, albeit with considerable variation across and within projects. There is a reasoned – if complex – theory of change evident, and activities have been delivered as expected against this. Without the government funding, support, and communications under the 'IoT UK' banner much of the activity delivered is unlikely to have been undertaken – either at all, or at this scale and pace.

5.10 The evidence also indicates generally a positive direction of travel towards the achievement of outcomes in the medium term. Consultees were able to highlight some specific outcomes beginning to emerge. Noting the likely time lags to delivery of outcomes and impacts in these kinds of programmes, and the implementation issues (explored in detail in Section 6 of this report), which have led to delays in demonstrator project fieldwork, this is an encouraging finding.

5.11 It is expected that further outcomes will begin to emerge between early 2018 and mid-2019 as further activity, notably the fieldwork in demonstrator projects, is rolled-out and learning is generated. Stronger evidence is likely to emerge on the effects of the programme on demonstrating IoT technologies and scaling-up and replication of activity. Some of this outcomes and benefits realisation will be in the medium to long term; or may not be realised, for example if work is incomplete when government funding ends and projects are unable to source alternative funding.

5.12 However, whilst some outcomes are evident, the majority of the outcomes remain expected rather than realised, driven largely by the time-paths involved in research and innovation activity of this kind, and some projects being delayed.

5.13 Further, this positive 'direction of travel' is owing principally to project-level activity, i.e. the contributions of delivery partners at the level of each individual project. At this stage, the evidence that the *programme* has generated substantive and tangible outcomes and benefits, and that the interventions are 'greater than the sum of parts', is very limited.

... and on the Seven Evaluation Questions

5.14 In the context of the overarching findings set out above, the evidence captured through consultations and case studies against the seven evaluation questions outlined in the Scoping Study are summarised below. The tables at Annex A include a full synthesis and analysis of this evidence.

5.15 This interim evaluation found positive, albeit observed rather than confirmed evidence, of outcomes beginning to emerge around influencing stakeholders (EQ5) and enhancing the international reputation of the UK in IoT investment and activity (EQ6). Project partners provided specific examples of opportunities being explored in international markets, which will assist in reputation building, and the PETRAS project in particular has taken advantage of public discourse around IoT security and

privacy issues to offer solutions, thinking and research to a number of significant UK and international institutions.

5.16 The case study evidence also provided some specific examples (backing up feedback from the project consultations) around benefits for individual firms that have engaged with the programme (EQ4), either as beneficiaries (of the accelerator schemes and Catapult projects) or as participants (in one case of the CityVerve project). However, the evidence at this stage on tangible economic impact effects on firms is mixed (consistent with the lack of comprehensive monitoring data), and the case study evidence demonstrates that in some cases benefits have yet to flow through. More robust evidence on this issue may be present at the final evaluation stage.

5.17 There is limited evidence of substantial progress against EQs 1 to 3 – focused on demonstrating the economic viability of IoT applications, scaling-up of IoT by programme participants, and replication of IoT activity by those outside of the programme. This appears to be principally owing to caution from delivery partners about the potential of applications at the time of the evaluation and timing issues both within the programme, and in the generation of outcomes.

5.18 Much of the 'proof of concept' work, which is a required step toward proving economic viability, and subsequently to delivering both scaling up (by programme partners) and replication (by others), is activity which will be delivered in late-2017 and the first half of 2018. This is especially important for both the CityVerve and NHS Test Bed (demonstrator) projects: use case trials for health and social care and transport and infrastructure, which were in the early stages of delivery at the point of the interim evaluation, were those where delivery partners anticipated substantive outcomes.

5.19 This said, there has been some progress on delivery of outcomes against EQs 1 to 3 in the areas of public realm and culture and building management via the CityVerve project. Several CityVerve participants have shown strong proofs of concept which are leading to firm level scaling and the exploration of replication opportunities both in the UK and overseas. Several case study participants, especially those engaged through CityVerve and the accelerators, shared strong emergent growth stories. This suggests a broader knowledge of IoT technologies is taking hold in the marketplace and that scaling up and replication are in the pipeline.

5.20 The weakest evidence of progress in delivering outcomes relates to EQ7 in terms of collaboration and sharing learning and knowledge across projects. Participants in each individual project have clearly learned from local project partners (for example large corporates such as Cisco and BT) and their own delivery. However, efforts to promote cross-project learning and knowledge sharing have had limited impact, and there is little evidence of benefits at this stage. Projects are unclear of the potential benefits here, and thus focussed on localised delivery of responsibilities.

5.21 This appears to be a major missed opportunity for the programme. The projects are different, but the scale of insight and knowledge across the programme on IoT – from research into implications for cyber security and data protection, through to the practical application of IoT hardware in city and health environments and beyond – is substantial. There appears to be a recognition amongst partners that there is scope to do more here. We return to this issue in Section 6.

Further Evidence from the In-Depth Case Studies

5.22 As noted above, there is limited evidence at this stage on firm-level outcomes from the programme. This is based, in part, on the evidence base for the evaluation. (where we have not engaged with all firms involved in the programme, consistent with the recommendations of the Scoping Study), but also reflects issues around monitoring data (as discussed in Section 4 in relation to the accelerators), and time-paths to outcomes.

5.23 The analysis above drew on the evidence from the case studies (see Annex C for full details). The focus of that analysis was particularly on the firm-level outcomes (i.e. those focused on the benefits for the beneficiary organisation), which are worth reflecting on in some more depth. They provide, at this interim evaluation stage, primary evidence on the effects of the programme – and its relative contribution to other factors – for those that have been involved.

5.24 Three points are important in considering the case study evidence:

- Seven of the ten case studies were focused explicitly on SMEs, or involved SMEs. Three of the case studies covered research projects, where there was not (as had been expected) any substantive SME engagement.
- The case studies involved a mix of organisations that were direct beneficiaries of the programme and those that were involved in the delivery of the programme. This provides a rounded view of the potential and realised effects of the programme.
- The case studies covered all five projects in the programme: two were from CityVerve, two from accelerators, two from the Digital Catapult's IoT Boost project, three from PETRAS and one from an NHS Test Bed.

5.25 The findings of case studies are encouraging, demonstrating the ways in which there are benefits being realised at this interim point, and reflecting continued global uptake of IoT technologies and ideas, especially by corporate customers seeking efficient business practices. The evidence is most positive around support in the development of economically viable IoT products and services, and the scaling-up of this activity. There are also specific examples of where firms have secured growth (mainly in terms of employment) following support.

5.26 This said, across the outcomes identified in the case studies, the level of attribution to the programme is mixed. In some cases, the programme is reported to have been key in generating the outcomes observed – for example SMEs benefiting from direction and mentoring for their business. In other cases, the level of contribution by the programme is limited relative to other factors. This mixed picture is not unexpected in research and innovation support programmes, where the benefits are often unevenly skewed across beneficiaries. More robust evidence on the attribution and contribution of the programme may be apparent in the final evaluation, especially if this includes a more representative approach to engagement with SMEs.

5.27 The principal focus of the case studies was on firm-level benefits in terms of developing IoT applications, scaling-up of activity, and business growth. However, the case studies also provide evidence on the wider outcomes generated by the programme, notably the PETRAS and NHS Test Bed projects, with a focus on influencing stakeholders.

5.28 As noted above, the two PETRAS case studies were principally focused on research projects with emphasis on developing insight and understanding of the practical development of IoT applications, involving testing in real world environments. Important to both projects was influencing stakeholders. For example:

- The 'BitBarista' project generated significant media attention. This was regarded as important in engaging a wider community of interested but non-technical stakeholders, raising awareness around the technical and, especially, social aspects of IoT – all of which will be important for IoT adoption.
- Applied use of IoT at the Queen Elizabeth Olympic Park engaged important stakeholders with the potential utility of IoT: working in partnership with major public-sector organisations including the London Legacy Development Corporation and Greater London Authority, the team produced a report explaining the steps associated with implementing IoT projects in public spaces, and the challenges associated with it.

5.29 This theme of influencing stakeholders was also in evidence in the NHS Test Beds example. The participant in the programme reported they had received opportunities to raise the profile of the work being undertaken by partners on the project and its expected benefits, with the programme opening doors to national promotion and awareness raising. This has included a piece with national media, which has led to subsequent commissions for other media articles covering the application. As noted by the case study lead:

> *"We have benefitted from more than just the money – there has been a BBC programme and an article in The Guardian regarding the project. From that we've done several other articles for The Guardian, and this has provided some concrete benefits from a PR perspective."*

5.30 Three other points are noted:

- The case studies provided one example of potential outcomes around the replication of IoT activity in the future. An SME reported they are in active conversations about replicating applications developed through their project with partners in Australia and China, thereby contributing to the growth of knowledge of UK IoT capability overseas. The case study lead noted:

  "The application works, we've got past proof of concept stage and we've had both local and international interest in using the 'skin' of the application in their cities. Much of that was pushed by the local project manager, but we've basically been 'on standby' to speak at events and conferences as we see that this cuts both ways"

- In all cases, the programme was not the only decisive factor in generating outcomes: other factors were required, including significant inputs and activity by the firms in progressing their ideas outside of the activity supported by the programme. This finding is not unexpected, and supports the evidence from the consultations that the programme is often working alongside other factors and initiatives to lead to outcomes. Examples of feedback from the case studies included:

  "We came into the programme with a product that worked, and we believed in it. But we're a proper business now. So, I can't say it was the only factor, but it's been transformational."

  "Our expectations have been surpassed. Fingers crossed our involvement has allowed us to develop a viable commercial product we can take forward. But we really had to work hard – sometimes we were pushing, prodding and knocking the door down to get things done."

- The case studies highlight further the time-paths to outcomes and impacts for IoT activity, with a wide range of benefits anticipated for the future, rather than realised at this point. This is not unexpected, but remains important at this interim evaluation stage. In many cases it remains too early to say what the effects of the programme will be for its participants and beneficiaries. As one consultee in a case study organisation noted:

  "Programmes like this can be very beneficial, but you have to stick with it. I'd be nervous of people making judgements based on two years' worth of data."

Contribution Story and Narrative

5.31 Drawing on the full range of evidence discussed above (and set out in full detail in Annexes A and B), we can provide an integrated contribution analysis for the programme at this interim evaluation stage by:

- Assessing whether the 'theory of change' postulated in the programme logic model is being delivered in practice, including the nature of activities and evidence on emerging outcomes.
- Considering what other possible factors may be helping to deliver against the evaluation outcomes observed.
- Providing an interim commentary on the level of effects that is attributable to the programme itself.

Assessment of Practical Delivery Against the Theory of Change

5.32 As noted in paragraphs 5.9-5.13, the evidence indicates that the nature of activity anticipated in the programme-level and project-level logic models been delivered, although progress with some projects is somewhat behind what was originally expected at this stage, which affects the timing of benefits realisation. There is a reasoned – if complex – theory of change evident. The evidence also indicates a generally positive direction of travel towards the achievement of outcomes in the medium term.

Other Contributory Factors Noted by Consultees

5.33 The evidence on other factors influencing outcomes was limited from the consultations with project partners. This reflects the relatively early stage of project delivery and the limited emergence of outcomes that may be influenced by external factors rather than the direct outputs generated by project delivery. It is more likely that the final evaluation will gather evidence of these external factors as outcomes are more likely to be observable at this stage.

5.34 The case studies identified some specific factors affecting individual organisations' outcomes, but no consistent themes emerged. Some case study participants considered that they had achieved strong growth alongside – or even in spite of – their involvement in the IoT UK Programme. For several, the attribution of growth the IoT UK project was weak.

5.35 A theme that emerged from the consultations was that wider industry, public sector, the public and policy makers are beginning to better understand potential uses and benefits of IoT technologies. For example, several SME firms engaged with the accelerators and City Verve projects had achieved growth outside the programme and engaged UK and international customers. This suggests a 'normalisation' of IoT use cases in the wider public consciousness. The case studies also highlighted the importance of raising the profile of IoT with both specialist and non-specialist audiences.

5.36 It is worth noting that those firms which seemed to exhibit the greatest successes did not outwardly identify as IoT businesses, but offered platforms that used IoT technology to drive efficiencies and experiences.

Outcome Level Contribution Assessment

5.37 Table 5-2 provides a summary contribution analysis at the interim evaluation stage for the IoT UK Programme for each of the seven evaluation questions, drawing on the evidence discussed above.

Table 5-2: Association/Attribution of Outcomes to the IoT UK Programme

Has the programme …	Evidence of activities to deliver theory of change?	Credible evidence of existing or future outcomes?	Evidence of attribution to programme and/or other factors?
… demonstrated economically viable IoT applications, products & services?	Mixed evidence Delays in project delivery mean the bulk of activity showing this is currently 'in the field'. There are some positive examples relating to public realm, culture and building management.	Yes – especially relating to culture and public realm and building management, although most outcomes remain expected not realised.	A mix of strong and weak attribution dependant on local experiences. Strong evidence amongst some case study participants, though others report outcomes 'despite' the programme.
… led to scaling-up of IoT activity by programme participants?	Limited evidence. PETRAS has scaled up the number of projects being delivered, and several SME partners have 'pivoted' toward IoT from other priorities, but few other examples identified.	Some isolated examples of outcomes beginning to be delivered, but best evidence expected from ongoing fieldwork.	A mix of strong and weak attribution dependant on local experiences. Some scaling up is directly due to the programme; elsewhere this has been driven by partner firms.
… led to replicated IoT activity beyond the programme?	Modest evidence. Some partners anticipate exploring opportunities, but anticipated rather than realised. Focus is on external actors, so limited evidence of outcomes anticipated.	Yes – good dialogue with international and UK partners regarding replicating ideas and concepts. Especially the case with City Verve.	Strong if realised, but this will be contingent on realisation of these outcomes which at this stage is uncertain, and where realised contribution in practice (not theory) will need to be tested fully
… led to additional growth in beneficiary SMEs (GVA and employment)?	Strong evidence Range of support actively delivered across projects including accelerators, IoT Boost and CityVerve innovation support.	Yes – several businesses have shown rapid expansion, capitalisation and increase in customer base, although the data is not comprehensive and may include some response bias.	Mixed. For some partners it has been fundamental in reshaping their business, for others it has played little role in their success.
… enhanced the international reputation and attractiveness of the UK for IoT investment and activity?	Strong evidence. PETRAS are engaged in international research dialogue through conferences. Other projects have isolated examples of international interest in their work.	Yes. International engagement with PETRAS research and strong engagement with trade activity into and out of the UK which are leading to commercial opportunities for replication.	Mixed. The programme has been important in most cases, but other factors related to the profile of participants, and increasing focus on IoT challenges internationally have been important in outcomes realised/anticipated.

Has the programme …	Evidence of activities to deliver theory of change?	Credible evidence of existing or future outcomes?	Evidence of attribution to programme and/or other factors?
… influenced stakeholders (e.g. standards bodies, policy makers, investors) beyond the programme?	Strong evidence (from project partner perspective). Good evidence of investors engaging with IoT tech; PETRAS offering support to public and private sector organisations; strong engagement with standards bodies.	Yes – although much of this is confidential given the nature of the work; especially PETRAS on security and privacy. Effects on stakeholders will need to be tested in the final evaluation.	Mixed. The programme has been important in most cases, but the increased profile and interest in IoT has been an important contributory factor to the outcomes realised/anticipated, providing an environment where the programme outcomes are seen as valuable.
… generated and shared learning and knowledge on IoT for programme participants?	Mixed evidence. Substantial activity within each project which have promoted learning. Significant examples include PETRAS conferences, inter-firm collaboration within City Verve and sharing of ideas and knowledge between the NHS Test Beds. However, limited cross-project sharing and learning – the activity to promote this was led by the Digital Catapult, with mixed engagement from project partners.	No credible current evidence that this outcome will be realised substantially in the current programme delivery model and approach.	Limited evidence of outcomes means assessment of attribution not appropriate.

Source: SQW

Integrated Programme Contribution Assessment

5.38 Taken together, the interim evaluation suggests that the IoT UK Programme has enhanced the profile of IoT technologies and their uses in the UK, especially with participating partners, localities, and amongst wider stakeholders. The latter is based on the observations of programme participants only, not the perspectives of the wider stakeholder cohort that will be engaged at the final evaluation stage. The evidence suggests that, without the support, government funding and communications under the projects' and IoT UK banner much of the activity delivered would not have been undertaken – either at all, or at this scale and pace.

5.39 There is emerging evidence that the programme is beginning to deliver tangible outcomes, despite the delivery delays outlined. It is expected that further outcomes will begin to emerge from between early 2018 and mid-2019 as further activity is rolled-out and learning is generated. Stronger evidence is likely to emerge on the effects of demonstrating IoT technologies and scaling-up and replication of activity. Some of these outcomes and benefits realisation will be in the medium to long term; and seem likely to be contingent on additional funding, most likely from public sources, for these IoT projects.

5.40 Consultees were not able to identify any strong evidence of other contributing factors to outcomes, other than their and colleagues' own endeavours, for example in SMEs' business management and participants driving forward local projects. At this stage, consultees' emphasis in demonstrating the progress and performance of the programme has been on highlighting the activity and outputs, which are both informed principally by internal factors, rather than outcomes, which are more likely to be influenced by external factors.

5.41 Overall, at this interim stage, the relative contribution of the programme to advancing the development of IoT appears positive, albeit modest. This is an early-stage assessment. Going forward, it may be expected that other factors – be these related to market demand and expectations, or engagement by programme participants and beneficiaries in other forms of R&D and business development activity – may become more visible and important to contributing to the observed outcomes.

5.42 Three points are important in this context:

- The majority of the outcomes (benefits) remain expected rather than realised, due largely to the time-paths involved in R&D activity of this kind, but also owing to key projects within the programme being further back in delivery at this stage than originally anticipated.
- The positive direction of travel is owing principally to project-level activity, and the drive and focus provided by delivery partners at the level of each individual project.
- At this stage, the evidence is limited that the programme - the combination of the projects in a single programme model - has generated substantive and tangible outcomes. The 'IoT UK brand, however, appears to have been valuable – particularly in an international context.

6. Formative Evaluation of Programme Design and Delivery

Introduction

6.1 This section summarises feedback from the consultations relating to the design and delivery of the programme. It seeks to offer insight into what went well, and what went less well. This consultation evidence identified three key themes (rationale, design and inception, and implementation and delivery) and specific issues within each theme that offer insights for the final stages of delivery of the programme and other similar government programmes.

6.2 The section is structured as follows: first, the analytical framework is outlined; second, a programme-level summary is provided; and third, the detailed thematic findings and issues (that underpin the programme-level findings) are set out.

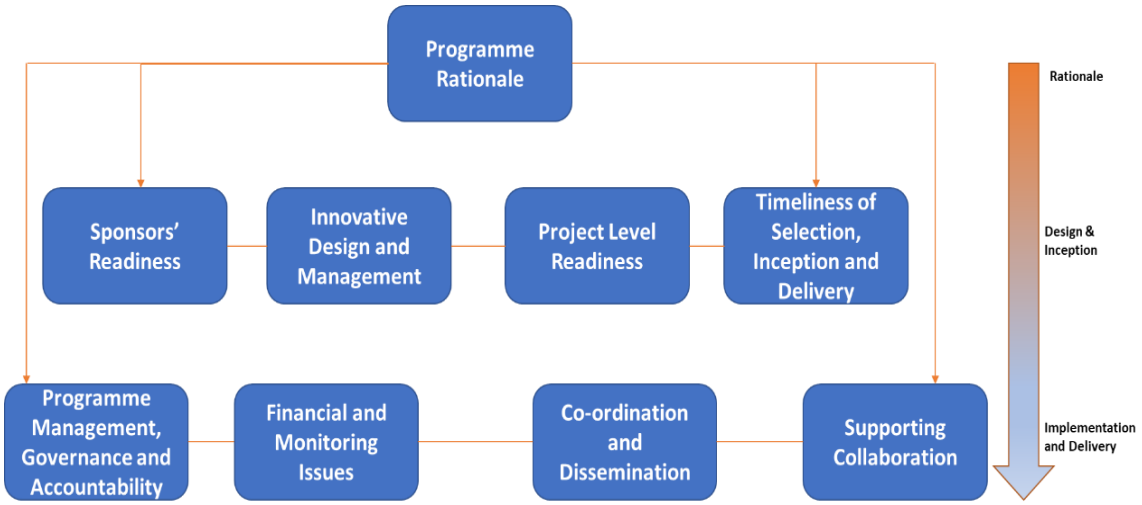
Analytical Framework

6.3 The consultation process sought to cover all aspects of programme delivery from the perspective of both sponsors and delivery partners (participants).

6.4 Within each of the three key themes there are specific issues, shown in Figure 6-1 overleaf. These form the basis for our detailed analysis of the programme's design and implementation. It is important to note that these themes and issues are connected, for example, issues at rationale or design stage often lead to issues during implementation.

6.5 As outlined in Section 1, the focus of this evaluation is at the programme level, not each specific project. Where project matters were raised that were relevant to multiple projects or the overall programme this was drawn out in the consultations. This distinction is important: this interim evaluation has not reviewed in detail the processes underpinning each of the five projects or how each individual project has been implemented in practice. Where project level process issues were discussed, however, that are informative to the analysis and understanding of the overall programme, these are reported here.

Figure 6-1: Analytical Framework for Formative Assessment



Source: SQW

Programme-Level Findings

6.6 In broad terms, consultees felt that the IoT UK Programme had not added up to 'more than the sum of its parts'.

6.7 The rationale for a programme rather than supporting separate projects with no linkages or integrated structure was broadly felt to be sound in conceptual terms by those engaged in the evaluation, but this had not been consistently communicated to all partners. This led to inconsistencies in participants' understanding of the programme aims which 'spilled over' into delivery issues; and a lack of 'buy in' from partners beyond the confines of their specific project. Opportunities for achieving 'more than the sum of its parts' were missed.

6.8 The combined impact so far of the individual projects can, in our view, be seen as being a relative success. But implementing these within the programme as a whole and the central communications and co-ordination activity, led by the Digital Catapult, does not seem to have 'added value' over and above projects' achievements.

6.9 Issues with the programme design, management and governance arrangements were heightened by government changes and delays during programme and project level inception. Many consultees felt that the programme would have benefitted from an inception period, although this may not have controlled for unforeseen issues at sponsor or project partner level.

6.10 The programme also suffered from inconsistencies in implementation. Notably the programme co-ordination functions have not worked as hoped. Alongside this, monitoring and financial arrangements and distance between the project sponsors and delivery partners have led to negative 'feedback loops' and affected participants' views of and engagement with the overall programme.

6.11 These issues have generated important learning for the final stages of implementation of the IoT UK Programme, and other government interventions. The specific elements (related to rationale, design and inception and implementation) are considered in detail below. Note that these may be interrelated and reinforcing.

Programme Rationale Issues

6.12 The consultation evidence indicates that the rationale for government intervention in IoT markets, and what government sponsors were seeking to achieve at the strategic level – that is, to support the development and adoption of IoT in the UK – were well recognised and accepted.

6.13 Clarity of purpose was also evident at the level of each individual project, each with specific underpinning aims consistent with the projects' varied design and focus. There was clarity on what the projects within the programme were seeking to address, and what they hoped to achieve.

6.14 However, the consultations also indicated that the rationale for *integrating* these very different component projects into a programme structure, with overarching management, communications and governance arrangements was not clear or well established at the outset, and this has remained the case throughout the delivery period to date. Notably, delivery partners consulted for this interim evaluation had limited awareness of the reasons for the integrated programme approach and what it was seeking to achieve.

6.15 As a result of this, there appears to have been mixed engagement and participation by project delivery partners in the co-ordinated programme activity. Delivery partners felt they had little incentive to engage in activity beyond their specific project. This led to a 'vicious circle', where their limited engagement further limited the potential benefits from the programme approach. Where there has been collaboration, this appears to have been 'opportunistic', rather than managed or facilitated. More could have been achieved here.

6.16 The consultation evidence also suggests that the programme approach became primarily identified in participants' minds with progress and financial reporting and management, when the sponsors' intention was to foster collaboration, shared learning and knowledge transfer.

6.17 The potential for the IoT UK Programme to generate value 'greater than the sum of the parts' has not, therefore, been realised in practice.

Programme Design and Inception Issues

Sponsors' Readiness

6.18 As discussed in Section 3, the programme was impacted by a series of changes to scope, leadership and funding which left sponsors behind on delivery schedules from the outset. The main responsibility for management and oversight moved from a government department with strong corporate experience of delivering complex innovation programmes with significant budgets (BIS) to one with little experience of such programmes (DCMS).

6.19 Consultee feedback acknowledged practical and cultural challenges driven by these changes and the impact on projects, notably shortened timetables for demonstrator project delivery requiring delivery teams to 'run before they could walk'.

6.20 According to some consultees, this was further compounded by a 'diffuse' management and governance structure, with several organisations responsible for monitoring and oversight. There were poor 'lines of sight' between the programme's overall sponsors and advisory board and those responsible for practical delivery. For example, several consultees were unaware that DCMS were the ultimate 'sponsors' of the programme, or even that their project contributed to a broader programme.

Innovative Programme Design and Complicated Management Arrangements

6.21 The IoT UK Programme is novel, and different in design from standard models of government funding for research and innovation, for example where Innovate UK or Research Councils fund projects and organisations (usually universities or individual firms) to undertake research, often considering 'top up' funding on a progress and results basis. The IoT UK Programme brings together a mix of practical demonstration of IoT technologies in the field (CityVerve, NHS Test Beds), support for IoT firms (accelerators, Digital Catapult), research into the practical usage of IoT (PETRAS), support for uptake of IoT technologies by the public sector (Future Cities Catapult, CityVerve, NHS Test Beds) and communications and co-ordination activity to support the projects and growth of a UK IoT community, and its reputation in the international market (Digital Catapult). All of this activity was intended to be drawn together by the Digital Catapult, sharing lessons and knowledge and promoting collaboration, in their role in the programme's central co-ordination.

6.22 As outlined in the Scoping Study[23], the IoT UK Programme also has both 'complex' and 'complicated' characteristics:

[23] SQW (2018) – IoT UK Programme Scoping Study and Baseline

- 'Complex' – multiple partners to the programme; outcomes are emergent (cannot be pre-determined) and uncertain; cause and effect are not well defined.
- 'Complicated' – multiple components and partners to the programme; recipients get something different; works in expected ways in different contexts; multiple causality.

6.23 This type of programme structure necessitated multifaceted and "devolved" programme and project management and governance arrangements. As outlined in Section 3, local delivery partners for each project were responsible to their direct project leads and boards: Manchester City Council and Cisco in the case of CityVerve, the Surrey and Borders Partnership NHS Foundation Trust and the West of England Academic Health Science Network for the IoT NHS Test Beds; University College London and Imperial College London for PETRAS; and senior organisational management for the two Catapult Centres and accelerator schemes.

6.24 Government organisations Innovate UK and EPSRC respectively led for government on project oversight and monitoring, each with programme managers and a senior responsible officer. They were funded by central government departments DCMS and the Office for Life Sciences, each of which had a programme lead and senior budget owner, and an advisory programme board. The Digital Catapult was assigned a role in facilitating collaboration and knowledge sharing between projects, programme co-ordination and communications.

6.25 Consultees thought this complexity: led to uncertainty and inconsistency of sponsors' approach; and impeded communications within the programme and participants' understanding of how each project, or work package within a project, fitted into the broader IoT UK Programme. It also led to numerous issues with management, governance, financial management and evaluation, which are explored later in this section.

6.26 Three further issues were identified in the research:

- Some project-level consultees felt that DCMS was a risk averse sponsor, concerned principally with progress and financial matters (which are of course important), perhaps not appreciating the risks integral to complex R&D projects such as the potential for under-delivery, or the fact that some investments may not lead to concrete economic outcomes, which some delivery partners were more used to. This view reflects the role of project-level partners in the delivery of the programme, with different responsibilities and interests to DCMS' role as the main programme sponsor.
- The Digital Catapult took a hands-on role, for example, in collating information from projects and linking project and communications leads through regular telephone conference calls, in which participation was varied. The majority of

consultees, however, considered that the Digital Catapult's activities did not sufficiently catalyse or facilitate cross-project working and knowledge development. Given the issues noted above around project-level understanding of the purpose and value of the programme and collaboration, arguably the Digital Catapult should have adopted – and been encouraged by DCMS to adopt – a more directive and robust approach to communicating the rationale for the overall programme, and managing project-level participation in cross-project working and coordination activity.

- Linked to this, sponsors DCMS and Innovate UK considered that the programme management role and activities envisaged for the Digital Catapult were more wide-ranging than had been discharged in practice. The Digital Catapult had been expected by DCMS and Innovate UK to perform the role as a "secretariat" for the programme, which was not delivered. The Digital Catapult consultees similarly considered that the programme lacked a proper "secretariat" function, but did not feel they had been given a remit to fulfil this role. There seem to have been miscommunication and different expectations between sponsors and the Digital Catapult, with insufficient clarity on requirements of this role in the Catapult's formal delivery plans or other documents. We return to this below in '*Co-ordination & Dissemination*'.

Project Level Readiness

6.27 Readiness and capacity was also a challenge for some projects. Several projects appointed and had to induct specialist project managers before beginning work. In some instances, these individuals decided to pause delivery processes in order to redress issues from the inception stage, which caused further delays to delivery.

6.28 Lack of localised knowledge and experience of delivery of complex and complicated innovation programmes led to further issues in implementation and delivery – including ownership, contracting arrangements and governance – which are discussed later in this report.

Timeliness of Project Selection, Inception and Delivery

6.29 Timing of delivery has been a major challenge for the programme. Delivery is behind the schedule envisaged in the business case of early 2015. This is not unexpected in a research and innovation programme with multiple projects, working in a complex and innovative technology context, but has had some practical impacts on the realisation of outcomes and impacts at this stage of the programme. The following key points emerged through the consultations:

- First, the issues discussed in Section 3 on the overall management of the programme and sponsors' decisions led to delays in selecting projects, inception and starting delivery of a number of component projects. Several

projects took time to scope out and find solutions to project specific problems, meaning the R&D or 'test and check' aspects of delivery have been delivered at the end of the programme, others – notably the accelerator schemes – were de-scoped as they could not be delivered within the timescale of the grant and budgets could not be rolled forward from one financial year to the next.

- A number of key work packages within projects – notably the Diabetes Digital Coach Test Bed and the transport aspects of CityVerve – were envisaged at business case stage to be delivering in 2016, but were only starting 'core delivery' in late 2017, at the time of this interim evaluation.
- These decisions and delays led to financial issues and the downscaling of specific projects, notably accelerators and Test Beds, and a reduction in anticipated government spend from around £40m to around £30m.
- There were specific issues relating to inception and set-up, and therefore delivery, of some projects, some of which are addressed in further detail later in this report. These included: set-up by NHS England and OLS of a central co-ordination function for NHS Test Beds; 're-assessment' of business plans and proposed IoT use cases by the CityVerve project team and board; and issues relating to the negotiation of partnership agreements and data ownership in CityVerve. The focus of this interim evaluation is not on the detailed implementation of individual projects, but these project-level issues affected the IoT UK Programme as a whole. Generally, these delays were beyond the control of the programme's sponsors.

6.30 Consultees noted issues of 'fit' between projects' timetables. Partly by design, but mainly due to the delays already discussed, there was not a common timetable for delivery of the projects. This led to confusion for delivery partners, who were working to differing timetables and were not familiar with government spending rules. As outlined in Section 3, in some instances, notably accelerator schemes, government budgets were not spent. A common theme from the consultations with delivery partners was that, on reflection, many of the issues around timing might have been mitigated with a formal 'inception phase' for the programme, to address the potential issues and risks relating to management, financial matters and governance; and allow for 'proof of concept' and use case testing prior to field deployment.

6.31 This could have been accompanied by a 'tapered' approach to budgeting, 'backloading' the bulk of the government budgets to years 3 – or even 4 – of the programme. This is likely to be an observation made with the benefit of hindsight, but it was made regularly by consultees, and this learning may benefit future government programmes.

Programme Implementation and Delivery Issues

Programme Management, Governance and Accountability

6.32 The "devolved" programme management model has hindered effective governance and accountability. Whilst partners we consulted were aware of their local project reporting lines, they were often not aware of how and where this fed into the IoT UK Programme more broadly. Several consultees were not even aware that DCMS were the ultimate 'owners' of the programme.

6.33 This was a particular issue for the two IoT NHS Test Beds, which as outlined in Section 3, were part of two programmes, the Test Beds Programme and the IoT UK Programme. Consultees felt the 'split sponsorship' arrangement negatively impacted on their understanding, and engagement with, the IoT UK Programme, and increased administration, for example progress reporting. Delivery partners consulted from these projects were more favourable about support from the Test Beds Programme, which included evaluation advice and organised events and other opportunities to share learning, than the IoT UK Programme. The NHS Test Beds Programme approach to this offers the potential for learning to inform future programmes.

6.34 More broadly, three key issues emerged from the interim evaluation around management, governance and accountability:

- Several partners noted that they were reporting to 'many masters' at different levels of the programme and felt unable to differentiate the roles of DCMS, Innovate UK, the Digital Catapult and localised project management arrangements. This was time consuming and drew attention away from delivery.
- The advisory IoT UK Programme Board was perceived by both board members and delivery partners as somewhat distant from the delivery and oversight of projects. The information shared at Board meetings did not, in members' view, properly communicate progress towards achieving intended timescales and outcomes; and there were not clear 'levers' for the board to fix issues and expedite delivery at project level.
- There seems to be an overall sense that the programme lacks a driving force or 'organising mind'. This could be down to changes in staffing at sponsor and project level, and/or to a lack of clarity from inception stage on roles, responsibilities and reporting structures at inception stage, for what was a technically and logistically complex government intervention.

6.35 Arguably, given the different emphases in project focus and activity, a less complex structure may have been more effective with simply an IoT UK 'brand' under which activity could be promoted, bilateral relationships between projects and sponsors, and loosely-managed co-ordination (e.g. an annual learning event). This may have

helped both in reducing the administrative burdens on projects in terms of management and monitoring, and to facilitate constructive knowledge sharing between projects.

Financial & Monitoring Issues

Financial Issues

6.36 As outlined in Section 3 and above, the programme has had a number of financial issues, with reductions in budgets, and issues in managing allocations across projects. Several projects have also struggled to deliver budgets in line with their forecasts. We do not repeat these issues in detail here, however it is also noted that some delivery partners in 'demonstrator' projects receiving grant from Innovate UK reported that they were working up to six months 'in arrears'. Several reported that this was placing considerable strain on the financial wellbeing of their business.

Monitoring Arrangements

6.37 There was mixed feedback on programme and project monitoring arrangements, with more variance of views among consultees than may be expected, even for a programme of this nature and complexity.

6.38 In some cases, because delivery partners did not recognise that they were delivering as part of a wider programme there was confusion when they were asked for feedback, reporting and inputs from individuals other than their project's own project management office or Innovate UK monitoring officer (MO). They felt that there should have been a ready flow of information between project managers and sponsors. Requests set off an administrative 'chain of causation', which led to a large amount of activity within delivery organisations to meet requests and monitoring requirements. This impacted on both localised delivery and participants' views of and confidence in the IoT UK Programme.

6.39 There was mixed feedback regarding Innovate UK's monitoring arrangements, which were used by CityVerve, accelerators and the Catapults. Some consultees reported that they valued the rigour, challenge and insight of individual MOs, which they thought had helped improve outcomes and provide participants with a 'dashboard of indicators' to inform investment processes and business planning. However, more common was feedback that partners, especially in 'demonstrator' (collaborative R&D) projects, had found the monitoring process challenging. Consultees felt the detail requested by Innovate UK went 'over and above' what they considered to be an appropriate level; regular 'check-ins' and clarifications had led to a loss of project time; and, in the view of some, the monitoring process led delivery partners to take fewer risks and stifled potentially innovative investment decisions for fear that these would be unpicked.

6.40 Whilst robust monitoring systems are key, the interim evaluation suggests that a more streamlined, systematic and consistent approach would have been desirable. The monitoring expectations and reporting procedures should also have been made explicit at the outset. This provides important learning for any future similar interventions.

Co-ordination & Dissemination

6.41 As reflected in the findings above, the management and governance of the IoT UK Programme is complex. Given the intention for the programme to deliver 'more than the sum of its parts' a large amount of responsibility hinges on work, in particular by sponsors and the Digital Catapult, to facilitate opportunities to share ideas and findings across projects, and internal and external communications and dissemination of news and opportunities relating to the programme.

6.42 The box below quotes the role of an 'IoT Central' (Digital Catapult) function as described in the original programme business case. This envisaged active co-ordination of project collaboration and dissemination of information regarding programme successes as a means to further knowledge, and the reputation of the UK IoT sector.

Extract from IoT UK Programme Business Case (BIS, March 2015, unpublished)

IoT Coordinator ('IoT Central'): *IoT Central will be accountable for the overall coordination of the programme ensuring genuine collaboration between the demonstrators, research hub and incubators. The UK has many IoT related initiatives but it is the lack of directed programme management that means each activity is sub-critical. IoT Central will have responsibility for promoting the take up of IoT by looking a range of key issues including security, user acceptability and funding models. It will consider the particular challenges of driving IoT in business to business, business to consumer and in public sector areas. It will focus on ensuring that the research hub and the demonstrators look at game changing initiatives which could have a pivotal impact on driving take up of IoT and crucially of public sector transformation.*

Recognising that not all relevant activities will come under one umbrella, IoT Central should provide the focal point for a "distributed innovation cluster" across the UK that enables existing centres of excellence to integrate into a national programme. This should include collaboration tools, connectivity, data linkage to standards such as Hypercat and equivalent (developed with BSI and others), and flexible IT and business services.

Supporting Collaboration

6.43 Consultees offered some positive feedback on this area of work. Regular "IoT UK delivery group" and "communications and PR leads" calls for sponsors and project and communication managers arranged by the Digital Catapult were regarded as useful by some in understanding the headline content and progress of projects.

Consultees also regarded the work in co-ordinating communications output under the IoT UK 'brand' was strong. However, as noted at paragraph 6.26, the majority of consultees considered that the Digital Catapult's activities did not sufficiently catalyse or facilitate cross-project working and knowledge development.

6.44 The majority of consultees, and case study participants, reported ad hoc and personally led engagement with other aspects of the IoT UK Programme. For most, this was deemed as 'non-core' to the everyday business of delivering their direct responsibilities to their project; the incentives to engage were neither outlined nor understood. Most consultees recognised the potential for 'missed opportunities', but were unable to define what these opportunities may have been, in the absence of full working knowledge of other projects.

6.45 This said, within projects there were some good examples of co-ordination. The PETRAS Research Hub seem to have been especially proactive in making links through academic conferences and knowledge transfer through the 'Researchfish' platform. The NHS Test Beds Programme management structure has fostered and encouraged learning across the entire Test Beds Programme.

Opportunities for Trade and Investment

6.46 Several consultees felt that the 'convening power of Government' to provide trade and investment opportunities for participants was under-utilised. Many observed little or no organised interaction between participants and the Department for International Trade (and its predecessors), despite a stated ambition that the IoT UK Programme should boost the UK's international reputation for IoT technologies. Some opportunistic activity was facilitated by project partners.

Communications and Media

6.47 The majority of the consultees felt that opportunities were missed to encourage media coverage of the programme. The IoT UK website, managed by the Digital Catapult, was broadly seen as useful in drawing together IoT case studies and highlighting the innovation and progress of projects, but consultees thought these could have had a much broader appeal than was realised. The media coverage achieved was, for many, 'preaching to the converted' via trade and digital periodicals. Several participants felt 'human interest' uses of IoT technologies, for example those developed by small businesses in the accelerators, might have been candidates for national TV, print or online coverage, and felt disappointed that this did not materialise. Where there was national coverage – such as BBC News reporting on the Surrey dementia project – this did not result from programme-level efforts.

Intellectual Property and Data Management

6.48 The lack of clear, common architecture and protocols for data sharing has been a problem throughout delivery for some projects. Much of the activity being undertaken within the programme also deals with the production of proprietary intellectual property (IP) by project partners. Consultees felt sponsors had an under-developed view of how these issues were impacting on programme delivery; and could helpfully have provided advice and guidance on these issues across the programme to help inform project-specific requirements, drawing on the shared expertise of sponsors and projects.

6.49 Matters to do with the ownership of project outputs, data, IP and 'assets' led to delays during inception with some projects' contracting arrangements, some of which have had a knock-on effect on the pace and quality of delivery. Some delivery partners have been cautious about sharing proprietary data, even for project monitoring purposes, as they fear this may assist competitors who are working within the project.

Public Sector Procurement

6.50 Local public-sector procurement rules and practice, and participants' limited understanding, also seem to have led to delays. Businesses, some who had not worked with government or local public-sector organisations previously, found arrangements complex and bureaucratic. Lead organisations in the public-sector found it difficult to adapt their relatively rigid structures to accommodate innovative approaches to new problems. This is an area where standardisation and adaptation seems likely to be required in order to realise public sector benefits of IoT technologies in the longer term.

7. Plans for Project-level Evaluation

7.1 This section outlines the practical steps in place to evaluate the five constituent IoT UK Programme projects. This is based on consultations with evaluation leads on each project, and review of evaluation planning documentation.

7.2 We were also asked to report any early stage findings from the project-level evaluations, if these were available at the time of this interim evaluation. This has not been possible: no information from project-level evaluation is available at this time.

Overview of Approach to Evaluation

7.3 Responsibility for evaluation for most projects was placed on project leads. With the exception of the NHS Test Beds, government did not specify requirements for evaluation, for example as a condition of project selection or government grant funding. Sponsors report that this approach was consistent with Innovate UK's approach to collaborative R&D programmes and EPSRC's approach to large research programmes. The projects fall into two groups regarding planning for project-level evaluation:

- CityVerve and each of the two IoT NHS Test Beds projects include separate plans for formal impact evaluation.
- The accelerators, Catapults and PETRAS projects do not include plans for formal impact evaluation. In some cases, there are plans in place for research to inform project leads' understanding of the effects of the project.

7.4 The paragraphs below summarise the plans on place for these two groups respectively.

Projects Planning Formal Impact Evaluation

CityVerve

7.5 The evaluation of CityVerve, led by the University of Manchester (UoM) with help from project delivery partners, is detailed in a work package within the "second level delivery plan" for CityVerve. It comprises the following elements:

- **Development of use-case, thematic and project-level key performance indicators (KPIs)**. Project-level KPIs to capture project impact, scalability, and replicability. Also, the development of citizen/community-related KPIs to assess impact on individuals.

- **Cross-thematic data analytics**. Collation and analysis of CityVerve datasets, and other linked datasets, to draw cross-thematic insights on performance to inform policymaking and service design.
- **IoT access technologies review**. Assessment of the characteristics, capabilities and likely future market role for access technologies utilised in CityVerve.
- **Use case impact assessments**. Based on KPI measurements, an assessment of the impact of use cases, including an assessment of the opportunities to extend CityVerve and areas for future IoT and smart city innovation. This will cover use cases in transport, energy and environment and health and social care.
- **Performance-in-Use assessment**. A macro-level social, economic and environmental impact assessment of CityVerve.
- **Business model innovations and assessment**. An assessment of business models at the use-case, thematic, and city level; the assessment will draw on the principles of 'ecosystem thinking' and 'disruption strategies'.

7.6 Consultations for this interim evaluation with project-level evaluation leads at UoM and the Future Cities Catapult indicated that progress to date on the evaluation has been limited. Scoping work by partners on development of KPIs was on-going at the time of the interim evaluation research in late 2017. Work has been delayed owing to changes in the scope and shape of the overall CityVerve project. These consultees considered that the robustness of the evaluation would be contingent on the success of the fieldwork due to be delivered in late 2017 and early 2018: this will, for example, provide the data underpinning the analysis.

7.7 The Future Cities Catapult has played an important role in preparing this evaluation. This has included collecting baseline data and building the analytical framework for data analysis and their 'Performance in Use' toolkit[24]. This comprises three aspects:

- **Economic impact framework:** this seeks to capture the 'type'[25]and aims of the project, an assessment of their scope and reach (in terms of user groups, geography etc) and their implementation costs. It analyses these alongside efficiency savings found through data capture, including revenue savings, lowering of planning costs and allowing for the implementation of methods such as variable pricing.
- **Social impact framework:** this aspect of the toolkit seeks to capture and quantify qualitative and people centred aspects of the intervention's objectives. These include metrics such as health and wellbeing, quality of life and job satisfaction. They involve use of a 'theory of change' model, similar to

[24] https://iotuk.org.uk/wp-content/uploads/2016/07/Performance-in-Use-Summary.pdf

[25] Types include City, Business and People focussed IoT.

the overall logic models for the IoT UK Programme, to map the delivery of outcomes and determine causality.

- **Environmental impact assessment:** this aspect of the toolkit uses a life cycle assessment based in ISO 14040 and ISO 14044. This captures data relating to outcomes such as global warming, energy consumption, water consumption and waste. The process of assessment involves data analysis of information provided by IoT sensors used to promote better decision making, and through systems integration. This assessment provides a 'project handprint' which shows the environmental impacts, and paths towards their reduction. Many IoT applications – especially those in the building management sphere – are likely to have significant environmental benefits.

7.8 The summary set out above provides the level of information that was available to the programme-level evaluators for this interim evaluation. The plans for evaluation appear to be detailed, particularly in terms of the development of KPIs, where a draft report has been produced setting out in detail the proposed coverage and approach.

7.9 However, in considering the plans for evaluation, four points are noted where greater clarity would be valuable:

- First, there is limited information on how the 'counterfactual' will be identified across the research strands, that is what would have happened in the absence of the project, therefore demonstrating the 'additionality' of CityVerve activity, notably in terms of economic impacts. The plans at present appear to focus on collecting KPI data and understanding the 'gross' effects of activity.

- Second, and linked to the above, an assessment on the anticipated 'robustness' of the evaluation plans would be valuable, including whether empirical impact evaluation techniques are proposed for the impact assessments. Whilst not applicable in all cases, such techniques are considered by government[26] to provide the most robust assessment of cause and effect for policy interventions. They typically involve establishing a control/comparison group (i.e. counterfactual), so that the outcomes of a treatment group can be compared with those for the control/comparison group.

- Third, we consider that it would be appropriate for further detail on the methods proposed for the impact assessment to be provided to DCMS and Innovate UK, including an assessment against the What Works Centre for Local Economic Growth Maryland Scale[27], and if this is not relevant (e.g. where

[26] See, for example, The Magenta Book: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220542/magenta_book_combined.pdf
[27] Potentially using the What Works Centres Guide: http://www.whatworksgrowth.org/public/files/Methodology/16-06-28_Scoring_Guide.pdf

theory-based approaches are proposed), the justification for this, and how the work will be realised practically.

- Fourth, further details on the timing of the evaluation outcomes, the timing of the evidence gathering, and how this will inform the final evaluation of IoT UK. We understand that project level evaluation evidence will be provided by the end of the project in mid-2018. It may, however, take time for impacts to emerge. This should be considered in the forward planning, including how evaluation activity will be resourced and managed once central government funding for CityVerve ends.

NHS Test Beds

7.10 Government funding to the Test Beds sites was provided on the condition that independent evaluations of each Test Bed should be put in place. In addition, a "national evaluation partner" (Frontier Economics and NatCen) was commissioned by government sponsors to synthesise the findings of the Test Beds' independent evaluations, and provide support to the evaluation teams where requested, though not to undertake evaluation activity. The national evaluation partner provides support to evaluation teams across the Test Beds Programme, but the shape, focus and methods of any evaluation is decided by the Test Bed sites' independent evaluation teams.

7.11 Both evaluations are currently in the field and due to conclude in 2018, prior to the recommended final evaluation of the IoT UK Programme. The findings should inform the outcomes and impacts analysis and help give a strong sense of future direction for IoT technologies in healthcare, which will benefit the overall conclusions of this stage of the evaluation.

Diabetes Digital Coach (DDC), West of England

7.12 DDC commissioned, and at the time of this interim evaluation were carrying out, an evaluation, to report in summer 2018. This evaluation will use a 'theory of change' model and cover two aspects of the project's delivery:

- **Process evaluation:** designed to examine and evaluate the effectiveness of DDC's implementation and delivery
- **Economic and impact evaluation:** this will map the costs of the intervention, outcomes for service users and the change in cost to the health service as a result of the intervention. It will also use data collected in the evaluation to extrapolate and project future cost savings of a more widespread rollout.

7.13 SQW sought further information on the impact evaluation activity undertaken by DDC. This was not received in time for examination and inclusion in this evaluation.

Technology Integrated Health Management for Dementia, Surrey

7.14 The TIHM project planned to use a randomised control trial (RCT) to evaluate the impacts and effectiveness of the intervention. This evaluation is being led by the University of Surrey, and is due to report in mid-2018. The plan was for the RCT to select volunteers at random – in this case dementia sufferers and their carers – to receive the intervention (the treatment group), and a separate group to receive 'usual' care approaches (the control group). The evaluation would then track the impact of the IoT enabled care approach by comparing key outcomes for the 'treatment group' against the 'control' group of those receiving more traditional treatment.

7.15 RCTs are considered the 'gold standard' of evaluation by HM Treasury's Magenta Book[28] but are not without their challenges. Sample identification and recruitment – both for the 'treatment' and 'control' group – can prove difficult in some circumstances, as has been the case for the TIHM project. Project managers initially planned for 700 citizens participating (350 in each of the two groups). By December 2017 around 100 participants had been recruited for the 'treatment group' and 100 for the 'control group'.

7.16 Whilst evaluation with this number of citizen participants will still offer some developing conclusions, there is a recognition by the project that this may not provide sufficiently robust evaluation evidence on the extent to which use of IoT generates benefits.

Projects not Planning Formal Impact Evaluation

Catapult Centres

7.17 The Catapults' work for the IoT UK Programme will not be subject to formal project-level evaluation. Both Catapults are subject to impact evaluation of their overall work as part of an evaluation programme by their sponsors, BEIS and Innovate UK, with evaluation undertaken at the level of each individual Catapult. The Digital and Future Cities Catapults were also covered by a recent consultants' review of the Catapult programme for BEIS[29].

7.18 The interim findings of the Catapult-level evaluations have not been published. It is therefore not possible to comment on the extent to which the work of the Catapults on the IoT UK Programme is covered.

[28] HM Treasury – The Magenta Book:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220542/magenta_book_combined.pdf
[29] Ernst & Young LLP (2017) – UK SBS PS17086 Catapult Network Review
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/662509/Catapult_Review_-_Publishable_Version_of_EY_Report__1_.pdf

Accelerators

7.19 There are no plans to undertake an impact evaluation of the accelerator schemes run by R/GA and Startupbootcamp. We note Innovate UK's decision to fund further, similar projects in 2017/18 (outside the IoT UK Programme), which suggests this sponsor has a degree of confidence in the intervention. Some of the participating small businesses we consulted for this interim evaluation reported positive experience with the schemes, but others offered robust feedback on the quality and relevance of their experience to the future of their business. The experience of firms engaged in the two schemes will be covered by the recommended final evaluation of the IoT UK Programme as a whole (with planned engagement with SMEs).

7.20 Given that both schemes are now complete, a more robust approach to evaluation at a project level is not considered viable. In our view, government sponsors should consider evaluating any similar accelerator schemes in the future.

PETRAS Research Hub

7.21 There are no plans to undertake an impact evaluation of PETRAS. The project uses a Research Councils UK monitoring tool, 'Researchfish', which is used to collect information on number of engagements with research outputs, research impact and citations. This is fed back to the EPSRC in bespoke reports for each of the nine hub institutions and thematic 'constellations'. The project also produces case studies to publicise and disseminate the findings of the research projects, alongside the production of short articles and workshop events.

7.22 The project has also committed to the production of an annual report, the first of which was completed in 2017, with details on the activities and outputs and outcomes of the project, including examples of how 'impact' is being generated.

7.23 Given the scale of government investment in the project, approaching £10m via the IoT UK Programme, plus university and partner contributions, a more systematic approach to capturing evidence on the outcomes and effects of the project may have been appropriate, including to provide evidence to inform the overall IoT UK Programme evaluation. Again, the key issue is around the 'additionality' of the research activity, and the subsequent outcomes that this may support.

7.24 Given the nature of the PETRAS activity, a formal theory-based evaluation may be appropriate. We recommend this should be considered by project sponsors and delivery partners in advance of the final evaluation of the IoT UK Programme in order to provide a more comprehensive and systematic evidence base to inform that work and capture fully the potential contribution of the project to the IoT research landscape in the UK.

8. Lessons and Recommendations

8.1 This final section of the report draws out the key lessons from this interim evaluation, and the implications for DCMS and other government sponsors of the IoT UK Programme, to inform delivery of the remainder of the existing programme, and the design and delivery of other government programmes.

On Evaluation …

Project Evaluations

8.2 The review of project level evaluation planning indicates that the coverage and potentially robustness of evaluation evidence is mixed across projects. This has clear potential implications for the evidence that will be available to inform the final programme-level evaluation.

8.3 Section 7 provided detailed feedback and recommended actions to enable the best possible examination of constituent projects, and capture of evidence to support both projects' impact and that of the overall IoT UK Programme. In summary, we recommend:

- **CityVerve** should provide clarity on the methods to capture economic impacts, and which empirical impact evaluation techniques are proposed. This should include an assessment against the Maryland Scale or justifications for a more theory based approach.
- **PETRAS** requires a more systematic approach to capturing evidence on the outcomes and effects of the project, in order to provide evidence of additionality to inform the overall IoT UK Programme evaluation. Partners should consider putting in place plans for a theory-based evaluation of the project to ensure that the outcomes and impacts of the (significant) public funding that has gone into the project are evaluated robustly.

Timing of and Arrangements for the Final IoT UK Programme Evaluation

8.4 The recommendation in the Scoping Study of a final evaluation of the IoT UK Programme in late 2018 or early 2019 remains appropriate[30]. By this point all programme activities will have been completed, and some of the 'time lag' outcomes may have begun to appear, but the delivery period will still be close enough that partners and wider stakeholders will be able and willing to offer insights and feedback.

[30] SQW (2018) – IoT UK Programme Scoping Study and Baseline page 37

8.5 The Scoping Study also recommended an approach for the final evaluation. Having completed this interim evaluation, we now recommend some modest changes to this approach, drawing on this experience. Table 8-1 sets out recommendations on proposed changes to each aspect of the final evaluation design.

Table 8-1: Suggested Changes to the Final Evaluation Arrangements

Aspect of Research	Changes Recommended/Rationale
Analysis of monitoring data	No change
Analysis of secondary data	No change
Stakeholder consultations	Change recommended. The target of 50-60 consultees for the final evaluation is ambitious, if focused specifically on programme participants and stakeholders. This aspect of the fieldwork for this interim evaluation, with only two-thirds of the number of consultees envisaged for the final evaluation proved challenging. 'Evaluation fatigue' is also likely to be an issue at final evaluation stage. We therefore recommend prioritising consultations with people with knowledge of, or potentially influenced by, the programme, but who have not been involved directly in its management or delivery. The Scoping Study recommended consultations with 10-20 non-participant stakeholders (out of 50-60 consultees in total). In order to fully capture and verify outcomes relating to replication, stakeholder influencing and international reputation we recommend increasing this number to a maximum of 40 telephone consultations. Potential consultees would include representatives of public sector bodies engaging with PETRAS, and from international cities interested in replicating CityVerve work. International perspectives on the contribution of the programme in enhancing the UK's reputation in IoT will be important, and this is likely to be evidenced mainly through qualitative research. A broader evidence base from stakeholders will also be important to gather further evidence on the other factors that may have contributed to outcomes, which will be important for the final contribution analysis. The final evaluation would then involve consultations with a maximum of 20 programme participants, covering all five projects deliverers, sponsors, and relevant senior management (making a maximum total of 60 consultations).
Telephone survey of SME beneficiaries	Change recommended. This aspect of the fieldwork is of vital importance to capture economic viability and firm level growth. We recommend it be extended to include SME delivery partners as well as beneficiaries, within the 100-150 SME participant consultees previously recommended. The telephone survey should start with the ambition to engage all of these businesses in order to gain the fullest possible picture of the IoT UK Programme's firm-level impact. This survey should ensure that it covers all aspects of SME engagement, including accelerators, IoT Boost and the innovation and SME engagement aspects of CityVerve.
SME case studies	Change recommended. 10-15 case studies is a sufficient number, as previously recommended. We recommend that the scope of this research is extended to the development of new IoT 'use cases' that may be scalable, replicable or influential in the future. This will better capture the enduring impacts of projects, for example PETRAS and 'proof of concept' trials undertaken within CityVerve and Test Beds.

Source: SQW Scoping IOT Scoping Study, as amended

On the Final Stages of IoT UK Programme Delivery ….

Programme Completion

8.6 We recommend actions to maximise programme outcomes during the final period of delivery in the first half of 2018, and the potential for the programme to generate added-value (in addition to its component projects); and to improve information for the final evaluation.

8.7 DCMS, working with other government sponsors of the programme and project leads, should emphasise and seek to improve the following aspects of delivery:

- Programme monitoring and capture of monitoring and evaluation information.
  - ➢ Programme sponsors should take an active role in programme oversight, ensuring that projects are actively capturing evidence of outcomes, working with project leads to guide priorities for the final months of projects; and to shape any plans for project "legacy".
  - ➢ Programme sponsors should ensure that the coverage of programme monitoring data is comprehensive, as far as is practical. Co-ordinating data and information into a single repository to inform the final evaluation should be a priority.
- Support for cross-project collaboration.
  - ➢ In realising this, there are many potential opportunities for participants and wider stakeholders to share the sharing of learning and expertise and collaborate in the final stages of implementation. Findings could emerge from projects of wider value or that may endure beyond the lifetime of the programme. Partner conferences and learning events tied to the conclusion of the programme may be one way to facilitate this learning and collaboration.

Programme Legacy

8.8 Sponsors and local project leads should begin planning for the end of the programme and ensure that planned activities relating to "legacy" are completed. This evaluation has found that the rationale for government intervention underpinning the programme remains, including market failures which if not addressed may impede IoT innovation and adoption. For example, several projects – notably CityVerve, PETRAS and the NHS Test Beds – reported that funding for further work to complete or build on projects is unlikely to be found solely from the local public sector, universities or private sector. This is not unusual in large-scale innovation programmes designed to 'test and learn' on new technologies, and the reasoning is complex, related to the issue of risk and negative externalities associated with

investment in innovation and development of new products and services in emerging technology areas.

8.9 It is important in our view that any future DCMS or wider government decisions on funding and interventions for IoT and related research and innovation should focus on the logic for intervention and evidence of impacts, and not the issues relating to design and implementation of the IoT UK Programme, examined in Section 6 of this report. The final evaluation, and the repository of relevant information monitoring data recommended above, should seek to provide the most robust evidence possible of the economic and social impacts of the intervention to inform any future interventions, based on the full contribution analysis.

On Other Government Programmes …

8.10 This interim evaluation provides useful learning for the design and implementation of other DCMS and wider government research and innovation interventions with similar aims and features. Arrangements for other programmes will obviously need to meet their specific requirements and will operate in different delivery contexts, but there are nonetheless potentially useful lessons from IoT UK – notably in design and inception stage, programme oversight and governance and communications.

8.11 These recommendations are particularly relevant for programmes that are complex and complicated, i.e. having multiple components and partners to the programme with emergent and uncertain outcomes. For relatively risky interventions (involving innovative research, products, services and applications) that include a range of uncertainties, it is difficult to accurately predict what types of outcomes will occur and when, and also, to accurately measure the specific contribution of the programme to any outcomes.

Programme Design

8.12 At the business case development and appraisal stage, the rationale for the proposed programme design and structure, and management and governance arrangements, should be carefully considered. If the recommended arrangements are complicated, consideration should be given to whether and how this will lead to additional benefits than alternative, simpler arrangements. Further, if such complicated arrangements are considered appropriate, the roles, responsibilities, reporting requirements and expectations of those agencies involved should be identified clearly and unambiguously at the outset.

Inception, Scoping and Budgeting

8.13 The schedule for programme implementation should build in a robust, formal inception and scoping stage, including the potential to change programme design,

management arrangements and budgets. This would have addressed some of the issues of ownership and responsibilities within the IoT UK Programme.

8.14 Consideration should be given to a budget profile 'tapered' to allow the bulk of spend in the latter period of delivery, to reduce financial issues down the line, and associated administration costs for government and participants.

Management Arrangements and Accountability

8.15 The specific management, accountability and governance arrangements for any future intervention similar in nature to the IoT UK Programme will need to be developed to meet the particular requirements and delivery context within which the intervention operates. However, the lessons from this interim evaluation suggest a number of 'design principles' that government should look to consider as far as practical in the design of any future interventions of a similar model, that is with a number of constituent projects under a broader programme structure.

8.16 Three principles have been identified:

- **All partners should have direct engagement with, and understanding of the role of, the programme sponsor**. Within the IoT UK Programme there are 'many masters' at both local project and programme level and this has led to a lack of clarity and mixed messages. Any future intervention of this nature would benefit from a single 'organising mind', which should be the programme sponsor, and this office should be recognised by all parties as the programme's senior responsible owner.

- **The programme sponsor should be supported by a dedicated secretariat team/function**. This should be responsible for the collection and analysis of monitoring data, the management of any programme governance structure, the production of policy positions and the active co-ordination of learning and knowledge transfer between the programme delivery partners. Ideally this will be based locally to the programme sponsor and SRO. Responsibility for this role should be unambiguous, underpinned by an agreed terms of reference or delivery plan leaving no scope for any uncertainty for the programme sponsors, managers or participants.

- **Whilst monitoring and reporting may be owned locally, or by an expert third party such as Innovate UK, there should be clear accountability to the SRO for this data**. The SRO and team should have access to any monitoring products subject to commercial confidentiality where these have a direct bearing on the understanding of programme progress and outcomes. Where monitoring is undertaken by a third party, grant agreements should allow access to key information for programme sponsors and important

delivery partners (such as DCMS and the Digital Catapult in the example of the IoT UK Programme).

8.17 Underpinning these principles, it is also important that the case for a programme structure, and how this will realise benefits, is considered fully in the development and appraisal stage. A key message from this interim evaluation is that the activity delivered by the individual projects supported by the IoT UK Programme is starting to generate benefits, and the potential for significant benefits over the longer-term is clear. However, this has been achieved by projects, rather than the 'central programme' structure and activity that was put in place. Put simply, the projects have performed quite well, but the programme has not realised its potential to add-value to this activity in a consistent or substantive way.

8.18 Identifying clearly defined and well-specified outputs, and putting in place appropriate monitoring systems to ensure comprehensive data is collected against these outputs should also be a priority for any future similar programmes. This should include putting in place mechanisms to track the performance of businesses supported by the programme post-delivery.

Communications with Participants

8.19 All participants should be fully sighted on the aims and objectives of the programme from the outset, and how this relates to their specific project. In the case of the IoT UK Programme, we found conflicting feedback on this, with several consultees unaware that they were part of a 'greater whole'. Some of these aims may only apply to a few partners and beneficiaries, but they should be clearly communicated to all, in order to ensure a greater sense of understanding and collective ownership of the programme.

8.20 During implementation, the programme SRO and their team should regularly work with and communicate with participants, and seek to ensure that all participants and beneficiaries are fully sighted on the purpose, aims and intended outcomes of the overall programme; how these this complement and further the aims and activities of the specific projects within it; and management arrangements. This is to encourage understanding, collaboration and collective ownership of the programme. Some matters may not apply to all projects or people working on them, but should nonetheless be clearly communicated to all to provide transparency, and maximise the scope for collaboration and joint-working across participants.

Annex A: Evaluation Question Analysis Tables

EQ1: Demonstrated economically viable IoT applications, products & services?

Evidence of outputs & outcomes across projects

- A wide range of 'activity' has been delivered (or is planned to be delivered) across projects to test the viability of IoT applications/products/services, however at this stage, there is limited evidence of this activity being translated into outputs and outcomes of demonstrated IoT technologies in the market.
- The evidence indicates some encouraging proxies for economic viability around investment identified in the case studies and evidence from the Accelerator schemes and Catapults that suggest there is scope for the programme to deliver against this outcome in the future.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• Demonstration research launched in 2017, with activity on-going. Examples include: ➢ Work packages focussing on transport – specifically monitoring the tam and bus networks ➢ Work packages focussing on improving health and social care – notably video enabled diagnosis and 'on demand' medical supplies	• PETRAS is not focused on demonstrating the viability of specific application, products and services. • However, case study evidence indicates the potential for 'research' activity to inform assessment of economic viability e.g. via 'BitBarista', part of the Smart Transactions in Public Spaces project	• Demonstration research underway (Dementia) or to launch in early-2018 (Diabetes) meaning that no evidence at this stage of economic viability	• Firms supported by Accelerators securing private investment – this suggests confidence by the investor community that economically viable applications, products, or services will be developed by firms supported by the programme	• Participants in the Digital Catapult's IoT Boost programmes have secured investment and expanded workforces (see case study evidence below)

Evidence of programme 'added value'

- Some evidence that programme has added value in the demonstration of economically viable application/products/services at this stage by highlighting opportunities to corporates such as Cisco and BT

External Factors

- No major or consistent external factors identified at this stage as contributing to the progress that has been made; this is to be expected given the focus on activities and outcome proxies, which are linked directly to programme delivery

• No evidence identified to date of practical joint-working to share technology or market insight on viability across projects	• A number of external contextual factors were identified by consultees as potential 'barriers' to progressing viable IoT technologies, including the uncertainties around the UK's exit from the EU and the potential effects of this on investor confidence

EQ2: Led to scaling-up of IoT activity by programme participants?

Evidence of outputs & outcomes across projects

- It is 'too early' to draw firm conclusions on the contribution of projects to the scaling-up of IoT activities, as many projects remain in the delivery stage and therefore focused on the core initial activity funded by the programme.
- However, there was evidence that project leads are in some cases beginning to plan beyond the life cycle of the programme, and that this will include scaling-up activities in the future.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• No evidence identified at this interim evaluation stage of scaling-up of activity by participants in City Verve, consistent with the focus on delivery of existing project plans across the workstreams	• Activity has been 'scaled-up' in two respects (i) following a gap analysis, the number of projects has expanded from 20 to over 50 (ii) the number of partners has expanded from 40 to c.120. Both were reported to reflect the significance of PETRAS research, and the interest and relevance accorded to this by industry. Consultees also indicated that the scale of academia-industry collaborations has also been scaled up. • However, the 'scale-up' remains within the remit of the programme, so does not represent formally scaling-up	• No evidence at this stage of scaling-up, but there is evidence of consideration of scaling-up in the future which will be dependent on the findings of the trials that are (or soon to be underway): ➢ The Surrey Dementia Test Bed reported considering the use of the application to other long-term conditions ➢ The West of England Diabetes Test Bed reported considering is considering rolling-out the activity to other geographies • Further, an SME delivery partner reported they had '*been scaling-up … outside of the programme budget, and continued to do a lot of our own IoT*	• Potential evidence of an effects on engagement by delivery partners in IoT activity, with one partner (RGA) subsequently applying successfully to deliver a follow-up IUK IoT Accelerator programme • Case study evidence of the programme leading to an increase in engagement in IoT activity as a result of the programme	• Participants in the Digital Catapult's 'IoT Boost' programme have secured contracts with a number of public sector organisations including local authorities in Manchester, Watford and the Midlands – these cover use cases in both the environment and building management and healthcare sectors

		development' which 'we wouldn't have done it to the same extent without the programme, it got us thinking about this space'		

Evidence of programme 'added value'	External Factors
• No evidence identified that linkages between partners and projects facilitated by the programme has led to any scaling-up by programme participants at this stage • This is perhaps not unexpected given the progress in delivery with 'first round' activity still underway in most cases	• The wider NHS Test Beds programme also important in driving scaling-up of NHS Test Beds activity; unpicking the influences and attribution here is challenging • Feedback that lack of long-term funding and stability has made focus on scaling-up difficult, as sources of financial support for activity following the completion of the programme are uncertain

EQ3: Led to replicated IoT activity beyond the programme (by non-participants)?

Evidence of outputs & outcomes across projects

- There is limited evidence of replicated IoT activities to date. However, due to the early stage of most activities, this is to be expected and there is evidence of replicated activities are 'in the pipeline' across several projects.
- Extent to which replication has occurred will need to include evidence from non-participants which was not included in the interim evaluation

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• No evidence identified at this stage of replication, however, a number of potential routes to outcome identified: ➢ "Near miss" applicant cities who may be interested in replicating activity, if support is made available, dependent on the final outcomes and impacts in Manchester ➢ The "Triangulum Project" initiative, of which Manchester City Council are a partner, could provide potential for replication of City Verve best practice in other European Cities	• Consultees reported influence on raising awareness across government and industry on issues (e.g. cyber security), leading to higher engagement in IoT in strategy and policy development. This is observed by PETRAS and needs to be tested with non-participants • Work with industrial users are reported to have led to a closer research focus on the security aspects of IoT enabled industrial control systems (i.e. panels and dashboards for the control of industrial processes): outputs are expected on this research in the future	• Limited evidence identified of replicated activity at this stage, although the Test Beds attributed the development of a number of tools and applications which may be replicable to participation in and experience from the programme • As noted in EQ3, there may be the potential for future replication of the technology and approach to other long-term conditions e.g. learning disabilities for the Surrey Test Bed, which may involve other partners to those involved I the current programme (i.e., replication alongside scale-up)	• No evidence identified of replicated activity at this stage; this would be hard to evidence in the interim evaluation and is not unexpected	• No evidence identified at this stage; this would be hard to evidence in the interim evaluation and is not unexpected

Evidence of programme 'added value'

- Little evidence of substantive linkages which could have led to 'in programme' replicability across projects – e.g. City Verve and Test Beds.

External Factors

• Although there is some sharing of learning within the Test Beds programme, this has not amounted to any replicability of technology or approaches to problems to date	• Range of consultees noted that a lack of long-term funding (and therefore stability in resource availability) may limit replicability, as sources of financial support for activity outside the programme are uncertain • Should partner companies engage once demonstrators provide 'proof of concept', this will change the position driven by external factors

EQ4: Led to additional growth in beneficiary SMEs (GVA and employment)?

Evidence of outputs & outcomes across projects

- The majority of partners consulted indicated that it was too early to demonstrate growth in beneficiary SMEs, in GVA or employment terms. However, there is evidence of individual cases where growth appears to have been supported by the Accelerator and Catapult activities. This is based on a combination of reported effects by project delivery leads, and individual case study SMEs. By contrast, some SMEs consulted did not feel their participation had offered sufficient opportunities for either growth or technological change at this stage. The findings are therefore mixed. At this stage, the findings are based on specific examples, not a comprehensive assessment; a telephone survey of SMEs is proposed for the final evaluation.
- There is also evidence of SME participants (i.e. those SMEs involved in the delivery of the programme) securing business benefits from engagement in the programme.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• One City Verve SME delivery partner reported increasing employment from 8 to 16 staff as a result of engagement with the programme	• No evidence identified to date of SME effects, although some expected effects in near future, e.g.it was reported that an SME engaged in PETRAS is set to collaborate with a government agency on privacy and security issues relevant to building management systems, which has the potential to generate revenue.	• No specific evidence of growth attributable to participation in the Programme has been captured. Several partner SMEs reported that they expect these outcomes to materialise once proof of concept is established and they are able to replicate their applications in other fields and locations	• Reported Accelerator SME with turnover growth from £670k to £1.6m between Feb-Sept 2017 • Another accelerator SME has shown 15% month to month growth • One accelerator case study participant reported a doubling of head count subsequent to their participation	• Several participants in IoT Boost programmes have reported further hires following their engagement – one firm hired six new employees, another hired five new part-time developers.

Evidence of programme 'added value'

- Some evidence that Accelerator participants have received further support from IoT Boost, but little clarity about the mechanisms that enabled this
- No evidence yet that companies have worked 'across' project frontiers, with some feedback from partners that opportunities have been missed to link SMEs to major corporate partners e.g. Cisco

External Factors

- Where outcomes have been identified in the research, these have broadly been attributed to participation in the programme
- Several case study participants felt their own business planning and client relations had a stronger impact on growth than participation in the Programme

EQ5: Enhanced the international reputation and attractiveness of the UK for IoT investment and activity?

Evidence of outputs & outcomes across projects

- The consultations identified a significant volume of activity internationally, which has the potential to enhance the UK's reputation in this area. The extent to which this activity has in fact changed perceptions internationally was not possible to validate or test in this interim evaluation, however, the potential appears to be significant, and this should be considered in the final evaluation (e.g. via targeted interviews with relevant integrational stakeholders).
- A common theme in the consultation was that 'IoT UK' had become an internationally recognisable 'trademark' around which to pitch UK capability in the technology.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• City Verve reported engagement with several international cities – notably Adelaide, Wuhan and Melbourne – about replicating some of its demonstrators in these areas. This has yet to be realised practically, but may be an opportunity on the future to demonstrate UK expertise and excellence in this area.	• Wide engagement internationally, including through involvement by PETRAS staff in FCO missions to Japan, China, USA, Australia, the EU and the Global Cyberspace Conference in New Delhi. • In terms of IoT standards, and complementing work with BSI (see EQ6, below), reported engagement with the EU standards authorities (e.g. ETSI)	• The Test Beds have had international interactions with Japan, Singapore and Germany, and DIT is looking outside of Europe to encourage them to establish relationships	• The Accelerators reported that SMEs had 'pitched' for investment internationally, and a number had attracted equity investment from non-UK investors	• The focus of the activity is principally focused on the UK IoT market, so the scale of effects here is expected to be modest • However, it was reported that one beneficiary in the IoT Boost programme have had a 'live contractual negotiation' with a major international business partner, which is due to deliver in 2018

Evidence of programme 'added value'

- The IoT UK 'brand' has played a strong role for many partners and underpinned project-level activities
- BUT most activities have been driven locally rather than through the leveraging of 'programme support' i.e. accelerators using contacts

External Factors

- Status and profile of project partners also potentially important e.g. R/GA's established international presence helpful in securing finance alongside IoT UK
- Brexit seen as both an 'enabler' (focusing the mind on the need to engage internationally), as well as a potential 'challenge' that may influence scale of outcomes in the future

• From the PETRAS perspective, there was an initial reticence from the 'programme' towards Internationalisation efforts, but this has loosened over time and allowed for more effective engagement	• On PETRAS side, international dialogue around security and privacy issues is essential

EQ6: Influenced stakeholders (e.g. standards bodies, policy makers, investors) beyond the programme?

Evidence of outputs & outcomes across projects

- The interim evaluation identified positive evidence of observed or reported outcomes in this area from programme partners and stakeholders, with further outcomes anticipated for the future as the programme moves to it final stages and more tangible evidence emerges. From the perspective of partners, the programme and its constituent elements are regarded as widely recognised and utilised by policy makers, standards bodies, and industry
- Across the full range of projects, a wide range of stakeholders are reported by participants as being 'influenced' in some way, including: BSI, Royal Academy of Engineering, BT, Ordnance Survey, GCHQ, Home Office, the ICO, the Bank of England, NHS England, and private sector organisations that are involved in delivery Pinsent Masons, Cisco, and BT.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• CityVerve had a platform to share learning and impacts of the project at the Greater Manchester Mayor's "Digital Summit" in early December 2017	• A PETRAS affiliated researcher chairs the BSI Technical Committee on IoT standards. In four months, the committee has secured representation from major players across all aspects of the sector. • Work with government across a range of areas (e.g. IoT standards, GDPR, cyber security) was reported. One example is a review of international standards landscape for IoT which was reported to have led to further engagement, testing the potential for standards and regulatory models and the development of a policy paper with the Royal Academy of Engineering	• Some evidence of greater engagement from NHS England, largely prompted by security and privacy crises within the NHS	• Intangible benefits of engagement with potential investors.	• Digital Catapult is a Member of the BSI Technical Committee on IoT standards. • Digital Catapult held two 'Investor Days' with 51 attendees including 19 showcasing SMEs. They reported three 'likely' investments as a result of these showcases. • Two 'IoT Boost' participants have raised follow-on funding through a combination of crowdfunding and seed investment • The Future Cities Catapult reported use of the tools developed by Local Authorities in developing approaches to Smart Cities policy. Publications include:

				➢ Performance in use Toolkit ➢ Standards in use Toolkit • Influence of investors engaged in the IoT Boost programme

Evidence of programme 'added value'	External Factors
• The contribution of the programme co-ordination activity is unclear – the majority of outcomes seem to have taken place through the actions of the projects themselves • The existence of funding for 'de-risking' engagement, especially for corporate investors, was seen as the major contributory factor of the programme • Other factors played more of a role here than elsewhere – for example NHS hacking has developed interest in PETRAS and the Test Beds • This was another area where there was scope for greater use of 'Government leverage'	• A common theme identified in the consultations with partners were high-profile instances of hacking and threats to cyber security which are seen to have fostered an increased emphasis in a range of IoT areas, not least in areas of privacy, security and trust, but also in terms of the role of IoT in making public services more efficient effective or creating new policy models. This was regarded as potentially supporting engagement by policy and industry stakeholders that has supported and facilitated the work of the programme

EQ7: Generated and shared learning and knowledge on IoT for programme participants?

Evidence of outputs & outcomes across projects

- There is positive evidence that at a project level the IoT UK programme has generated learning on IoT: this is expected given the scale of investment in R&D activity supported by the programme, and the 'research' and 'testing' emphasis across the projects.
- However, whilst components of the programme have engaged with each other at some points the level of shared learning and knowledge is modest at this stage. The projects are different – with different aims from opening up new markets, to improving public service delivery, to technical research projects – but where there are opportunities for sharing knowledge (e.g. around standards, data collection, technical findings with relevance across technology uses) these do not appear to have been realised as anticipated within the programme's terms of reference.

City Verve	PETRAS	NHS Test Beds	Accelerators	Catapults
• Activity remains in the field in most cases (or soon to launch) meaning that the full learning has not yet been realised. However, the learning is anticipated to be substantial in the future, with dissemination via the development of an 'open data' API to allow access to demonstrator data for further research and interpretation, both across the delivery consortium and more widely.	• The project has: published over 70 research papers and reports; held twice-yearly meetings with attendance for all partners involved (250+ attendees in November 2017); attended a range of high profile conferences and workshops. • Consultees reported substantial confidential engagement and knowledge sharing with government and industry 'behind the scenes'	• The two Test Beds projects have met to share learning on the hardware and applications which may best deliver on their respective projects. This has been facilitated by the NHS Test Beds programme office	• No evidence of shared learning and knowledge across the two accelerators or with the wider programme components	• The Digital Catapult had a stand at the Smart IoT London Expo and are developing plans to attend the Mobile World Congress in Barcelona during 2018 – these activities are intended to raise awareness of, and shine a light on, programme participants • The Digital Catapult aimed to speak at 20 IoT related conferences in Years 2 and 3 of the programme

Evidence of programme 'added value'

- As noted above, for many this aspect of the programme was less well facilitated than they hoped and where there are significant missed opportunities.
- Others struggled to engage as they felt this went 'over and above' what they were intending to deliver.

External Factors

- Some learning – especially on the NHS side – has been driven by others. In this instance, the PMO for the NHS Test Bed programme.

Annex B: Case Studies

Sparta Digital

Summary findings

Sparta Digital was a delivery partner within the CityVerve project. Through CityVerve, the firm has developed successfully two viable IoT applications – the 'Buzzin' concierge app, and an interactive 'plinth' for display of digital artworks.

The firm has doubled in size from 8 to 16 staff to help deliver the project, and has held positive conversations both locally and internationally about developing new versions and extensions of their applications. They are developing an investment plan alongside a 'Big 4' accountancy firm.

Their initial engagement was to deliver a LoRaWan Network along the Oxford Road Corridor, but this aspect has yet to be delivered. The firm also took advantage of proximity and trust of partners to help deliver on other aspects of the projects, diversifying their business and expertise in the process.

CityVerve confirmed the merit in Sparta's decision to pivot towards development of IoT technologies to diversify and commercialise their business. It has helped them expand rapidly, and offered a sustainable, viable business model for their future.

About the Organisation

Sparta Digital was founded in 2002 as a spin-out from the University of Manchester. Their original focus was FinTech and cryptocurrencies, but they have gradually transitioned away from this sector throughout their lifespan. For the last four years their outlook has been more of a social enterprise, with a concentration on research projects which engage with the public – developing '*things which help people*'.

Their engagement with CityVerve represents 50% of their activity, with two other publicly funded projects accounting for the other 50%. These are 'Storm' – an EU backed programme which seeks IoT applications and solutions for the heritage sector; and 'Simpatico', a programme which adapts legacy council services for non-native speakers.

About the Project

Rationale for Engagement

Sparta's first engagement with IoT was through the 'Storm' project, which gave them a good understanding of the fundamentals and applications and a desire to

pursue further opportunities, especially where these related to smart cities, and may present commercial opportunities.

As a spin-out from the University of Manchester, Sparta had maintained a close relationship with the institution, and also had a relationship with Manchester City Council, who made them aware of the CityVerve opportunity. The focus of CityVerve as a smart city demonstrator, aligned strongly with the profile of opportunity that Sparta were seeking to progress. As a Manchester-based and founded firm, Sparta were particularly keen to engage with CityVerve given the location of activity, and also keen to engage with project partners (including Cisco and BT), and interested given the citizen focussed mission of the project.

Profile of Activity

The firm has delivered a varied and significant volume of activity throughout the life-cycle of the project, and this has adapted and expanded throughout the delivery period. Sparta reported they had adopted a 'can do' approach to partners, taking on new opportunities as others were unable to deliver, and in so doing expanding their knowledge and experience by delivering in new areas. Sparta's activity has focussed on two outputs and applications.

1) City Concierge App

Sparta developed a 'concierge' app, 'Buzzin', using IoT and augmented reality (AR) techniques, to support discovery and wayfinding in Manchester. Development of the functionality has been pegged to three city-wide events, starting with Chinese New Year, followed by Manchester Pride and culminating with the Manchester Christmas Markets. The app aids navigation and links with Google Maps to direct visitors to utilities such as cash machines and public toilets, whilst also offering 'push' suggestions for other attractions and allowing the Sparta team (and clients) to log usage, customer origins and dispersal within an event.

The three events have provided a useful piloting process for the app, with changes and refinements at each iteration.

2) Interactive Plinth

Working with the Manchester Metropolitan University (MMU) School of Art, Sparta developed a digital, interactive plinth as an extension to their 'Buzzin' app. This interacts with the images placed outside MMU to display 'virtual' art works, many of which have links to Manchester heritage and which had previously not been displayed publicly for conservation reasons.

The firm is due to install other 'plinths' along the Oxford Road Corridor during 2018.

Project Outcomes and Impacts

Table B-1 summarises the evidence on whether direct outcomes for the beneficiary firm have been realised at this point, and the extent to which this appears to be attributable to the IoT scheme, relative to other factors. The findings are then discussed in greater detail below.

Table B-1: Evidence of Project Outcomes against each Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	Yes	Sparta have developed two viable applications as part of the project, they are especially confident of the commercial viability of the Concierge App	Yes – the firm were not actively developing IoT enabled apps before engaging with CityVerve, so the impact is entirely attributable
.. the scaling up of IoT activity by the beneficiary?	Yes	The firm is planning to scale up its IoT capability following the lifespan of the project. Some of this will be rooted in research developed during the project, but other ideas will spin out from that activity. The firm is developing a new app 'Buskify' for buskers, based on the stem of the Concierge App. The Concierge and plinth applications are readily replicable.	Yes – the firm was already transitioning towards IoT activity, but the CityVerve project has deepened its knowledge and brought this strand of activity to the core of the business
… SME Growth (GVA and employment)?	Yes	The firm's employment has doubled during the lifespan of the project from 8 to 16 FTEs. The challenge for them is sustainability, which will be reliant on securing further funding and contracts. They are in active discussions regarding private funding, and optimistic of success.	Yes – the employment growth is a direct impact of the project, as is the firm's plan to transition towards a more IoT focussed business plan

Source: SQW

Sparta Digital are a success story of CityVerve. Although they had undertaken IoT projects prior to their involvement with CityVerve via European Innovate UK funded interventions, CityVerve was the first scheme which has enabled them to develop commercially viable and exploitable IP. The two previous projects – Storm and Simpatico – helped build the firm's capability and knowledge of IoT and offered them a route into the CityVerve programme, and thus have made a relatively important contribution to the firm's trajectory and transition.

They have used the opportunity presented by the CityVerve project to develop a commercially viable application, with in-market testing and metrics to back up their development. The firm is planning to split its operations into a research and

commercial arm, with the former focussing on their core business since 2002 and the latter providing new sources of revenue developed through their engagement with CityVerve.

Sparta are in active discussions with commercial and public partners locally and internationally regarding the 'Buzzin' app, with a view to either packaging this around other events or to offer it as a 'one stop' concierge solution for a visitor or tourist. They have held positive early stage conversations about replicating the application for use in both Adelaide and Melbourne, and presented to a Malaysian visiting delegation to Manchester. All of these opportunities have been afforded them by their participation in the CityVerve project.

Although conversations are less developed, the interactive plinths are similarly replicable, and the firm plans engagement with museums and institutions in the UK and overseas about development of these exhibits for their spaces. There are also live discussions with Manchester City Council about using this technology for other applications, such as city walking tours, in the future.

Alongside the potential for overseas growth, the firm has also experienced other positive outputs of the project, notably the development of a number of partnerships and relationships with other project delivery bodies. Sparta is looking to become a Cisco certified partner, which will enable them to be involved in world-wide Smart City projects led by Cisco.
They have also agreed to lead the development of a Transport for Greater Manchester Walking Application based on the Buzzin' app.

Future Engagement

With IoT Technologies

IoT will continue to be at the core of Sparta's business in future, dependant on them realising the opportunities presented by CityVerve. Some of this is contingent on further investment, but also on the 'green lighting' of legacy projects which may extend the utility of the technologies developed beyond the lifespan of the CityVerve project itself. The firm is at a critical point in terms of managing final delivery commitments and converting their learning and development into a tangible, sustainable business model.

With Project Partners

On-going engagement with project partners is likely, albeit contingent on decisions relating to the future of IoT technologies in Manchester and further afield. For example, Sparta is discussing further use of Buzzin' with Marketing Manchester and extension of the 'plinth' application with other partners as well as

exploring commercial discussions with international partners. Within the confines of the CityVerve project, Sparta's applications are reported to be seen as a beacon of good practice, so goodwill and confidence are evident, but this is yet to be converted into contracts and workflow. There is also potential for an ongoing commercial partnership with Cisco, but this is not yet realised.

As noted above, the Concierge App has strong interest from Australia, China and Malaysia and Sparta are hopeful of delivering for some, if not all, of these leads – all of which were introduced as a result of their engagement in the project.

Lessons Learned

The project has confirmed Sparta's decision to pivot towards development of IoT technologies to diversify and commercialise their business. It has helped them expand rapidly, and offered a sustainable, viable business model for their future.

They were keen to point out that they '*got out what they put in*' – their success has been a result of their willingness to engage with opportunities at short-notice and to take on extra workstreams outside their original remit to keep the overall project on course to deliver. This flexibility has helped improve their standing within the project (as observed by Sparta), and presented further opportunities to sell, collaborate and learn.

Learning to communicate with multiple partners across the private and public sectors, and of varying sizes, has also been vital. At times, the firm felt the need to lead and drive ideas and opportunities in order to realise outcomes; this was facilitated by physical proximity to partners as a Manchester-based firm. The need to focus on 'user centred' application of IoT technology was also a key lesson from the project; in Sparta's view, those projects within CityVerve which have been most successful had clarity in terms of 'end users' and how research would benefit users from the outset.

Winnow

Summary findings

Winnow, a registered B Corp business offering an IoT enabled solution to food waste issues, participated in the R/GA accelerator during 2016, which was part of the IoT UK Programme.

The firm's participation was a mixed experience. Support from a global design powerhouse in R/GA significantly improved their branding and 'pitch' and has helped Winnow shorten their sales process. However, they would have welcomed further support relating to hardware and product than was offered by the accelerator.

The firm has a positive trajectory – they employ 50 individuals and operate from four territories, selling to approaching 30. The next step for them is transitioning their existing contracts from 'pilots' to multi-site engagements.

About the Organisation

Winnow was founded by Marc Zornes and Kevin Duffy in 2013. The founders saw a gap in the hospitality market for a technical solution to food waste, which is a $100 billion annual cost to global industry. Winnow estimate that up to 20% of food purchased by commercial kitchens can end up in the bin which is a huge cost for businesses typically running on wafer thin margins.

Winnow's solution to the problem uses IoT sensors to monitor and measure over-production of food stuffs – for example in restaurant kitchens – displayed using a control panel on tablets and laptops. This allows users of the technology to reduce overproduction and save on food waste. The firm estimates a cost saving of between 3-8% per annum, per site, owing to reduced waste.

The firm is active in approaching 30 countries, employing over 50 people in offices in Singapore, Dubai and Shanghai, as well as London. Their environmental and sustainability credentials have been reported in the media, for example Wired, the Guardian and the Financial Times.

About the Project

Rationale for Engagement

Winnow participated in the accelerator scheme run by R/GA. The firm was known to R/GA director Matt Webb who had provided support and advice to Winnow on previous business decisions, and encouraged them to apply for the competitive accelerator scheme. The firm was drawn to the opportunity by R/GA's international reputation and networks, hoping to access these as part of their participation.

Their objectives for engagement in the scheme included to access R/GA's expertise and experience to help them better articulate and define the 'narrative' around their IoT technology, and help them to build partnerships and connections with new and existing trade customers. Winnow also sought to secure support and advice relating to product development, including manufacturing options and diversification opportunities.

Profile of Activity

Winnow's support from R/GA through the accelerator focussed particularly on developing the firm's branding and design. This included substantial support to develop company's corporate proposition and company culture. Outputs and activities included:

- A new logo.
- New visual look and feel including design guidelines, photography style and concepts for Winnow's corporate website.
- A new firm 'narrative' focussing on the positive environmental contributions of the firm, rather than the bottom line savings from using the tech.
- The programme also offered several opportunities – including mentoring and pitch days – which were less relevant to Winnow, as a relatively mature SME.

The firm had anticipated significant support in relation to product development, including manufacturing options and diversification opportunities, alongside the business development and branding offer. However, the case study research with the company indicates that limited support was provided on practical product development activity. In Winnow's opinion, this highlighted a gap in the accelerator scheme as a formal offer that would need to be addressed in any similar programmes in future. Winnow reported positive support from the programme director, Matt Webb, on this issue, which has served to fill this gap to some extent.

Project Outcomes and Impacts

The table summarises the evidence on whether direct outcomes for the beneficiary firm have been realised at this point, and the extent to which this appears to be attributable to the IoT UK Programme, relative to other factors. The findings are then discussed in greater detail below.

Table B-2: Evidence of Project Outcomes against each Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	No	The firm already had a viable application in the market prior to participation in the accelerator	-
.. the scaling up of IoT activity by the beneficiary?	No	There is no evidence of scaling-up IoT activity as a result of participation in the accelerator	-
… SME Growth (GVA and employment)?	Yes	The company has grown significantly since participation and has secured several new contracts and opportunities and engagements subsequent to their participation.	No – change in brand may have had some positive impacts but difficult to attribute.

Source: SQW, based on case study research

As noted above, the nature of support provided to Winnow was focused around business development, not technology or product development, however, the case study indicates that the firm has experienced some positive benefits linked to identifying leads via clients and contacts introduced by a delivery partner. Whilst this may take time to convert to tangible commercial returns, there is an expectation that this may lead to product improvements, and scaling up and application opportunities, as an indirect result of engagement in the accelerator scheme.

The support relating to the company 'story' offered by the accelerator programme has shown tangible impacts on their engagement with new clients and customers. This has resulted in sales being generated more quickly than would otherwise have been the case, contributing to business growth.

However, in this context, it is notable that Winnow was a viable going concern before joining the accelerator scheme. They were already operating globally and expanding their workforce rapidly. The firm expects to turnover £5m in the 2018/19 financial year, and to save '10 million meals' – equally as important for a company grounded in social responsibility and sustainability. Their growth trajectory has continued since engagement with the accelerator scheme, but the evidence suggests that this is not directly attributable to the support received. They now have offices in four major global markets, but this was already their business plan prior to working with R/GA. The accelerator has therefore made a small contribution to the growth of the firm, but other external factors have been more important to overall performance during and following engagement in the accelerator scheme.

This said, the case study indicated that the opportunity to work with R/GA – a leading international design agency – was an important benefit of the accelerator scheme, leading to high quality marketing solutions with the potential to deliver substantial benefits over the medium to long-term as the firms seeks to expand its markets. As the lead consultees noted:

"We would never have been able to afford to use an agency like R/GA without this opportunity."

Future Engagement

With IoT Technologies

Winnow is an IoT business at its core. This will not change, but they are still seeking better manufacturing and upscaling solutions which improve the overheads and pace of activity for both their software and hardware.

With Project Partners

The firm has a positive ongoing relationship with the accelerator director, Matt Webb and continues to engage a designer that they were signposted to as part of the accelerator scheme. Participation on the scheme has also led to the establishment of several positive and helpful contacts which may develop in due course. However, Winnow does not intend to have an ongoing relationship with R/GA specifically.

Lessons Learned

The firm's key learning from the accelerator relates to the importance of a strong brand proposition in selling to new customers – relatively subtle changes to their approach have led to significant gains in customer engagement.

Asset Mapping

Summary findings

Asset Mapping were a delivery partner on the 'Energy and Environment' work package of CityVerve, installing IoT enabled technology to improve the operational and energy efficiency of buildings in the demonstrator area.

Asset Mapping obtained good learning relating to the limitations of their 'human centred design' approach, and in managing client relationships through their engagement with CityVerve. However, they were unable to meet their central KPI – delivering their product into 20 buildings.

The firm has prospered over the period as a delivery partner of CityVerve. This change is not attributed to the project, but direct growth was not their principal rationale for engagement. Rather, the rationale was driven by the imperative to develop and innovate their product in real world settings; this has been realised to an extent, and the firm has applied some of the learning project towards fostering new client relationships.

About the Organisation

Asset Mapping tested its first pilot during construction of the London Olympic Park. By mapping the location and status of CCTV equipment in real-time, they projected wage savings of £5m. Subsequently, the firm has transitioned to offer a 'single pane of glass view' building management platform that 'pulls through' data from a number of sensors, cameras and building systems into a single platform which can be used by management companies and building managers and or owners to control their environment and provide 'early detection' for problems, and also provide planned preventative maintenance (PPM) regimes. The platform and offering is adaptable and customisable – Asset Mapping have experience in fitting new sensor systems, as well as using their software as a 'wrapper' for existing systems.

The firm employs 20 staff across sites in London and Poland, the latter being mostly software developers. They have around 20 partners and customers across a number of industries, ranging from building management to finance and agriculture – many of these involve the provision of a 'white label' version of their product. They undertook a first funding round in 2017, raising around £1m; they will return to the market for Series A funding in February 2018.

Asset Mapping joined the CityVerve project as a delivery partner within a work package on Energy & Environment. Specifically, it was intended that they would deliver the 'Building Retrofit Energy' noted within this workstream.

About the Project

Rationale for Engagement

Asset Mapping's engagement in CityVerve was driven by the imperative to develop and innovate their product in real world settings. They anticipated that the CityVerve programme would offer opportunities to 'test and learn' regarding the use of IoT solutions and sensors in building management. The buildings being mooted as part of the programme offered a 'blank canvas' for their operation, and could provide a number of interesting data points to improve the operations and energy efficiency and user experience within the building itself. They also wanted to 'open source' the use of their systems, to show the efficiency of usage through transparency.

Securing profile and short-term commercial benefits were secondary to Asset Mapping in their engagement with CityVerve. They were not active in the Manchester market prior to their participation in the project, but anticipated some benefits of making new contacts and networks and being able to showcase their solutions and products to potential new partners.

Profile of Activity

Asset Mapping were recommended to the CityVerve project team as an existing client of Innovate UK. Prior to engagement in this project, they had won funding as a partner in four Innovate UK-funded projects, including developing the smart city vertical for Hypercat, an IoT standard. Within CityVerve, they contracted with Cisco as a delivery partner and with Manchester Science Partnership as the core 'delivery site'.

Asset Mapping were contracted to deliver the 'Building Retrofit Energy Reduction' aspect of CityVerve's Energy & Environment work package. This involved the consolidation of systems and devices used to operate buildings, where required the use of IoT sensors would be added to enhance information and output (such as environmental sensors, or IoT gateway for buildings), and demonstrate the reduction in the cost of operations, maintenance and energy consumption. The approach used 'human centred design', an approach which seeks to outline benefits for all 'customers' – in this instance, the building's owners, tenants, staff and visitors.

It was anticipated that Asset Mapping would deliver their platform and retrofitting in twenty buildings owned by CityVerve partners on the Oxford Road Corridor by May 2018, including Manchester Science Partnerships and the NHS. The buildings were intended to be a mix of 'smart' and 'dumb and dark'; the former have some digitisation, which could be augmented to give a clearer picture of consumption,

the latter offer no insights or data on energy usage. The latter would then have IoT sensors added to enhance the systems they had and provide information that was not previously available.

This service was to be a fully integrated and digitised service using the Asset Mapping platform, providing learning and understanding of challenges in integration, and allowing both Asset Mapping and delivery partners to transition to an 'open source' approach, with a 'test and check' process including delivery and installation by third parties.

In practice, delivery is behind schedule with systems installed in five buildings by early-2018. Asset Mapping still intend to deliver on their commitment to 'connect' twenty buildings through the project, but this will be a downscaled version of the service, focused on installation of environmental sensors only, rather than full systems integration. The firm is handing back £100k of their allocated Innovate UK grant as a result of under-delivery.

The issues have been driven by issues amongst CityVerve partners which are explored in the 'Lessons Learned' section of this case study.

Project Outcomes and Impacts

Table B-3 summarises the evidence on whether direct outcomes for the firm have been realised at this point, and the extent to which this appears to be attributable to the IoT UK programme (via the CityVerve project), relative to other factors. The findings are then discussed in greater detail below.

Table B-3: Evidence of Project Outcomes against each Key Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	Yes	Asset Mapping have demonstrated the viability of their product during the life cycle of the programme. They have also gained understanding of the issues with the 'human centred design' approach.	Yes, in part
… the scaling up of IoT activity by the beneficiary?	No	Although the firm has grown within the delivery period, they have not scaled up IoT activity outside of the programme as a result of participation.	No
… SME Growth (GVA and employment)?	Yes	The firm has grown and attracted investment within the delivery period, but this is not attributable to the programme	No

Source: SQW

Asset Mapping have doubled in size during the lifespan of the CityVerve project and have a strong growth trajectory – they estimate an order book of around £4.5m across 2018 to 2020. However, with the exception of one project manager employed to deliver this project, the contribution of participation in CityVerve to

this positive performance is reportedly limited. The firm's growth has come from replicating their product in new sectors such as banking and agriculture, and scaling up delivery through the engagement of an overseas development team. The firm attracted around £1m of private investment in 2017, and anticipates a larger funding round in early 2018.

As noted, growth was not Asset Mapping's primary motivator for engagement with CityVerve, but project related issues have led to only modest attributable outcomes, relating specifically to learning regarding the product and delivery processes. This is despite external evidence suggesting the viability and utility of the product.

Asset Mapping's view (not corroborated during the fieldwork for this case study) is that their platform highlighted 'inconvenient truths' regarding the management of buildings, which were not welcomed by the delivery partners; and that this caused a brake on the roll-out of their approach. These included highlighting a 'placebo effect' in building management (tenants 'feeling' a change in temperature when told this was being rectified); and the limitations of 'human centred design' and open sourcing of data – in this instance relating to building management – where there is an uneven relationship between interested parties (e.g. landlord and tenant). From this point of view, engaging in the project has taught the firm some useful lessons in how to pitch their products, and the client-base that they should focus on.

It was also noted that the delivery of Asset Mapping's outputs may have been impacted by the activities of a separate CityVerve partner firm (Spica Technology) who had been operating in a niche area of buildings management (smart cleaning and Legionella detection) but expanded their portfolio to cover some of the same areas as Asset Mapping following the success of a pilot. This stated duplication led to some CityVerve partners not requiring the planned work to be delivered by Asset Mapping.

Future Engagement

With IoT Technologies

IoT technology remains at the core of Asset Mapping's business; they are rolling out their applications to a number of new clients across the private and public sectors and diversifying the usages to new niches. The product has been refined during the delivery period of CityVerve, but has not been materially adapted owing to findings noted through the delivery of the project. As noted above, the firm's main learning within the project has been in terms of client management and implications for business development activity, rather than technical.

With Project Partners

Asset Mapping remain open to future collaborations with CityVerve partners, and formed some positive relationships as a result of engagement. The most fruitful of these were with Ordnance Survey, BT and Innovate UK, with whom they have worked on delivery of several events, including an Action Research Day at the British Computer Society. These are likely to be the only partnerships which endure from their involvement.

Lessons Learned

As a business, Asset Mapping's main point of learning was in their better understanding the power of their platform and technology to deliver 'unwanted messages' to partners and clients in the building management sector. This may impact their approach to delivery in the future, and has helped them manage expectations relating to the engagement of some clients and partners at an operational level.

The firm also took away a better understanding of the importance of strong central coordination in driving projects as diverse and wide ranging as CityVerve. Although they had a positive working relationship with the project management team, they would have welcomed a greater level of support in solving issues and concerns at work package level.

Finally, Asset Mapping learned more about working with the public sector. Although partners were willing to engage, and understood the benefits of the technical offer, the reality of procurement and sign-off processes often held up progress and delivery. This may provide important learning for engagement in any future publicly-funded programmes or interventions.

See.Sense

Summary findings

See.Sense have engaged with the IoT UK Programme in three areas:

- With the Digital Catapult (via the 'Things Connected' LoRaWAN network, the Innovate 2017 NEC Showcase, in particular).
- With the Cambridge IoT UK Boost LPWAN Competition, funded by the Digital Catapult.
- Indirectly, with the CityVerve project (as a subcontractor to CityVerve partner, BT).

Key outcomes for the company include networking opportunities, experienced gained with LoRaWAN networks, and increased profile and credibility with potential partners and clients.

Overall, the attribution of the IoT UK Programme to the company's performance to date is modest, when set alongside other activities, but has been important for accelerating the organisation's internal knowledge development.

Further down the line the company expects new impacts to emerge, particularly through new relationships established through their ongoing engagements with the IoT UK Programme.

About the Organisation

See.Sense are a smart cities data company that specialise in intelligent, connected lights for bicycles. The company was founded in 2013 following a successful Kickstarter campaign to launch their first-generation bicycle light and now trade globally, generating sales in more than 50 countries. The company are based near Belfast, Northern Ireland, and currently employ 14 staff. See.Sense was initially set-up to solve the following cycling challenges:

- **Cyclist safety** – the lights are "contextually aware", reacting to the environment around them and varying their light intensity and patterns to gain the attention of other road users. The device also sends alerts to nominated contacts in the event of a collision.
- **Reduce instances of cycle theft** – the light sends alerts to the bike owner's smart phone when unauthorised bicycle movements take place.

The patented, "contextually aware" sensors and other technologies incorporated into See.Sense devices makes these functions possible. The firm realised that the data captured offered other potential, particularly in terms of developing a mobile network of sensors for exploitation with big data analytics. By aggregating and anonymising the data across all the devices in use in a particular location, it became possible to develop valuable datasets that could help inform

city planning and infrastructure investments. See.Sense are currently concentrating their efforts in two areas: the detection and prediction of road surface defects to support road maintenance planning; and the identification of hazard zones and gaps in provision to feed into city planning decision making.

See.Sense had engaged in a range of private and public initiatives since their first Kickstarter campaign. In terms of public support, this includes an Innovate UK-funded Knowledge Transfer Partnership with Queen's University Belfast, securing innovation funding from Invest NI (R&D support grants, Techstart NI), and involvement with projects piloting their technology in Milton Keynes (BT Smart Hub) and Belfast. See.Sense also engage internationally, including with customers in the Republic of Ireland and Australia. In terms of private support, See.Sense conducted two further campaigns to support the development of new generations of lights, including the raising of over £700k on the equity crowdfunding platform Crowdcube in 2016.

About the Project

Rationale for Engagement

See.Sense first engaged with the IoT UK Programme following a discussion with a representative of the Digital Catapult at an event in mid-2016[31]. At this time, See.Sense were in the early stages of developing their big data analytics offer, but were open to public support opportunities to help advance the technologies and software platforms involved. During these initial discussions with the Digital Catapult, an opportunity was identified to access a newly developed LoRaWAN network (a part of the Digital Catapult's 'Things Connected' programme) – a communication protocol and system architecture for wireless, low-power, wide-area networks (LPWAN). Although the company already had access to their own, smaller scale LoRaWAN network to conduct testing, the opportunity to access a much more significant network was attractive. The company also felt they could benefit from the experience of the Digital Catapult staff and that engagement would afford further networking opportunities.

Subsequent to this first engagement, the company was encouraged to participate in the Cambridge IoT UK Boost LPWAN Competition in April 2017. The main attraction to the competition in the firm's view was to network with innovative, growth-oriented companies working in similar and related technology areas; the competition provided a platform for making these connections that the firm would not be able to access independently.

[31] The consultee could not recall the name of the event

Profile of Activity

See.Sense's engagement with the IoT UK Programme has involved a number of elements.

The See.Sense team worked with the Digital Catapult's Things Connected LoRaWAN network – in fact, they were the first company to connect to it once it became operational. The network was utilised to test and validate their technology, helping them to speed up their technological development processes. LPWAN technology is energy efficient, which means that the sharing of data over a wireless network can be achieved at a lower rate if of power consumption to the device – and, therefore, requires less frequent charging.
See.Sense were also selected to participate in the Cambridge IoT UK Boost LPWAN Competition, where they attended events, engaged in networking, and were ultimately awarded a "highly commended" accolade for their latest generation light (the See.Sense ICON).

See.Sense are also involved in activities with CityVerve, as a subcontractor to BT. Specifically, they are involved in a trial using crowdsourced data from cyclists to help get more people on their bikes. As part of this, they offered discounted bike lights to 180 local cyclists. At the time of writing, See.Sense are actively engaged in a large-scale data collection phase that started in August 2017 and will extend into the first quarter of 2018. Once completed, they will begin work analysing the data, as part of the broader CityVerve dashboard, to generate insights into city planning to be shared with CityVerve and BT. Ultimately, this data will be used to help the city identify and prioritise investments in cycling infrastructure and shape policymaking to increase rates of cycling. This involvement in the CityVerve was unrelated to See.Sense's support from the Digital Catapult, and there have been no direct linkages across the two projects within the programme.

Further engagement includes involvement in LPWAN MeetUps, run by the Digital Catapult, to network and discuss technology issues (for example, "how to use LoRa to empower citizens to transform our cities". See.Sense were also one of 11 companies selected (out of 50) for the Digital Catapult Autumn Showcase in 2016; this involved See.Sense products and technologies being put on display at the Digital Catapult's London Centre from September to December 2016.

Project Outcomes and Impacts

Table B-4 summarises the evidence on whether direct outcomes for the beneficiary firm have been realised at this point, and the extent to which this

appears to be attributable to the IoT scheme, relative to other factors. The findings are then discussed in greater detail below.

Table B-4: Evidence of Project Outcomes against each Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	Yes	The work with the LoRaWAN network has helped to validate and accelerate the development of their technology	Low/medium attribution - It is likely the same milestones would have been reached at some stage, but the support accelerated progress by 3-6 months
.. the scaling up of IoT activity by the beneficiary?	No – not directly	The work with the Digital Catapult has most likely assisted with securing contacts with Dublin and Manchester. Support from the Digital Catapult and through the IoT Boost competition has helped to expand the company's network.	Low attribution – the same outcomes would have been achieved any, but the has helped accelerate their experience and knowhow to improve the quality of work underway.
… SME Growth (GVA and employment)?	No	No change to employment or sales as a result of engagement to date, however this is expected in the future.	-

Source: SQW

The attributable outcomes that See.Sense have managed to realise through their engagement with the IoT UK Programme are modest, but important. The support has *not* led at this stage to tangible business outcomes for the firm in terms of turnover or employment effects. However, the support *did* accelerate their know-how around the deployment of their technology across LoRaWAN networks, and is supporting their knowledge development in terms of big data analytics. It is likely that these advances are bringing forward the point of potential commercial returns, providing some evidence of 'timing additionality' from the firm's engagement with IoT UK.

Over time, See.Sense have seen their profile and credibility increase. They regard their engagements with the Catapult and the IoT UK Programme as contributing to this in different ways. For example, the Digital Catapult and IoT UK "brands" and initiatives – such as the IoT Boost competition – have been valuable in terms of creating networking opportunities that will likely result in future collaborations. Their invitation and participation in the Innovate 2017 Showcase at the NEC has also helped to boost their profile.

However, other factors have also played an important role. For example, their pre-existing relationships locally (Belfast City Council) and with large IoT-active

companies (e.g. BT and CISCO) have been important contributing factors alongside the engagement with elements of the IoT UK programme. Accolades and experiences unrelated and pre-dating their involvement with the programme have also been important - such as winning BT's SME Award for Connected Cities, and their involvement with BT on the MK:Smart initiative in Milton Keynes.

In terms of the company's development to date, it was felt that they would most likely still be engaged in the activities they are currently progressing even without their direct engagement with the Digital Catapult and the IoT UK programme. However, what they have been able to learn, and the quality in terms of experience that they have been able to tap into, has helped to accelerate internal knowledge development and is expected to generate new opportunities in the future. The programme has therefore acted as important part of a broader package of influences and factors that have been mutually reinforcing in supporting the development and growth of the business.

Future Engagement

With IoT Technologies

IoT technology forms a crucial part of the future work of See.Sense: it is not only integral to their current offer, but will become increasingly more important as they make further advancement and investments in big data analytics capability. The firm are at a very early stage in their development and exploitation of IoT technologies and platforms to generate insights for cities which will be a key focus of the firm going forward. See.Sense are actively monitoring new developments in the technology area, and the activities of public and commercial organisations in this space, to support their ongoing development.

With Project Partners

See.Sense remain engaged with both the Digital Catapult and BT (initially engaged via CityVerve), and expect these partnerships to continue in the future. With the Digital Catapult See.Sense will continue to engage, largely through events and networking opportunities (such as Meetups). In addition, it is also likely that See.Sense will form collaborations in the near future with some of the SMEs they have met though their historic engagements with the Digital Catapult, particularly via the IoT Boost competition. It is unlikely that these nascent relationships would have been established without their engagements with the Digital Catapult. With BT, the future relationship will be external to IoT UK Programme, however, CityVerve provided an opportunity to further strengthen the relationship.

Lessons Learned

The success that See.Sense have been able to achieve in less than five years is highly related by the firm to their willingness to engage with public and commercial innovation support in the UK and internationally. Their engagements with the Digital Catapult and IoT UK Programme have met their expectations. They form an important part of the mix of activities they will progress into the future, which in itself provides a strong signal to the value and quality of support that has been provided. The company have a roadmap that sets out their future plans to go on exploiting LPWAN networks and other advances in related technology areas to create new, improved products and services, promote cycling, and contribute to making cities smarter. They will continue to engage, and seek to engage further, with the DC and other partners of the IoT UK Programme to achieve these objectives.

In terms of key lessons drawn from their involvement to date, the ecosystem provided Digital Catapult and the IoT UK Programme that enabled See.Sense to progress from an informal discussion at an event, to more formal engagements via the IoT Boost competitions, highlights the value of programme's structure. However, signposting and developing synergies across different activities has been limited. Although the company's involvement in the CityVerve project materialised indirectly – through their relationship with BT, as opposed to connections made via the Digital Catapult or IoT UK programme - a more 'managed' to ensure that the different elements of the programme were aligned, could create better opportunities for shared learning and knowledge transfer.

BitBarista

Summary findings

The BitBarista project, led by Edinburgh University and funded by the PETRAS Research Hub, uses a coffee machine embedded with IoT technology and a Bitcoin wallet to research a range of socio-economic issues associated with IoT technologies and smart-transactions (use of non-monetary consideration to 'pay' for services or goods) in public spaces.

As part of the project, the BitBarista team have engaged with local organisations in Edinburgh as locations to put the machine and conduct their research with their staff. Wallet.Services, an IoT SME, engaged with the BitBarista team in this capacity, later building on this relationship to engage in a collaborative project.

In terms of outcomes, the biggest benefit of the project to date has been its effectiveness as a use-case or tool for communicating with various organisations about IoT and distributed ledger (or blockchain, including Bitcoin) technologies. The team at Edinburgh University, Wallet.Services, and a range of other organisations have benefitted in this respect, which has led to new and enhanced relationships with a range of partners. As this is a research project, several papers have also been published, with more in development.

Background

BitBarista is a proof of concept, self-service coffee machine designed by a team at the Centre for Design Informatics at Edinburgh University, funded as part of a PETRAS grant for a project on Smart Transactions in Public Spaces (STiPS). The principal focus of STiPS is to understand what "smart transactions" are and how transactions between a variety of stakeholders occur in public spaces (i.e. parks, cafés, the office, at home). The principal expected outputs from this work are a range of socio-economic, cultural and ethnographic studies to aid the ongoing development in, and understanding of, IoT technologies in public spaces.

The BitBarista machine was one of the first STiPS initiatives to get underway. It was selected due to the "highly domestic, highly social" nature of coffee making and consumption. Three study areas were planned to better understand the potential issues and future models for applying IoT devices in public spaces:

- To demonstrate the properties and potential of Bitcoin.
- To explore perceptions of value transactions with a novel Internet of Things device.
- To explore reactions to and perceptions of the machine itself, and what it means to do business with a self-sufficient machine, in particular.

Key features of the machine make this research a possibility. Essentially, the BitBarista is a 'hacked' coffee machine that incorporates a Raspberry Pi, an internet-connection, and a range of sensors. The machine also has its own

Bitcoin wallet, which allows it to not only accept Bitcoin as payment for a cup of coffee, but also to pay out Bitcoin to people in exchange for performing a range of tasks to keep it running. For example, refilling its water and coffee stocks, as well as the performance of maintenance and cleaning. This effectively makes the machine a unique, "autonomous economic agent" and an interesting case not only for testing the research questions posed by the research team, but also for demonstrating the technologies involved to a range of individuals.

As part of interacting with the machine, purchasers of a coffee are asked to vote on where future coffee supplies come from. The machine collates data on coffee suppliers from around the globe - collected from the internet in real time – and filters this information to provide four options, the supply with the least environmental impact, the highest social responsibility, lowest cost, and highest quality. This functionality allows for the testing of decision-making dynamics in a public setting, as well as the willingness of individuals to engage with such a device and share information.

About the Project

Partner Engagement

The BitBarista project engages with partners as host locations to put the machine in and conduct their research "in the real world". In total, three phases of research have been conducted in three different locations:

- The office of Wallet.Services, a local distributed ledger/blockchain technology start-up based in Edinburgh.
- The Research and Knowledge Exchange Office at Edinburgh University's Design Studio.
- The Evergreen Studio (a creative co-working space located in central Edinburgh).

This case study focusses on the first of these hosts, Wallet.Services. As a result of this engagement, the firm have subsequently gone on to collaborate formally with the PETRAS programme alongside Edinburgh University, the B-IoT project (described below), which launched in early-2018.

In terms of their rationale for engaging with the project, Wallet.Services' involvement materialised through the networks of the BitBarista team, particularly through engagement in Scottish Blockchain Meetup events. Moreover, as a local start-up active in the technology scene engaged in commercial activities directly relevant to the technologies involved in the BitBarista work, they were generally interested to be part of the research. The

university team were particularly keen to involve Wallet.Services due to their experience and knowledge of the technologies involved. As a prototype machine, Wallet.Services were able to add further value to the project, beyond their participation in the research, by providing feedback and suggestions for technical changes and upgrades. Prior to this work, Wallet.Services had not engaged collaboratively with Edinburgh University or the PETRAS programme.

Profile of Activity

Practically, the BitBarista project involved the deployment of the machine into different locations to gather data on its use. Wallet.Services hosted the BitBarista for a four-week period in March 2017 as research participants. The team also use the BitBarista as an exemplar "use case" to demonstrate IoT and blockchain (including Bitcoin) to a wide range of audiences. Wallet.Services and the BitBarista team have also co-presented at a local Scottish Blockchain Meetup.

The BitBarista research also forms part of a broader suite of related activities conducted by Edinburgh University (some funded by PETRAS, others from different sources). Each of these projects share a core focus: an aim to gain a better understanding of IoT and blockchain technologies, particularly how individuals engage with them, and how they may be exploited in the future. Research outputs from this work are used to inform future research and to ready the landscape for the widespread adoption of the technologies involved. BitBarista also forms part of a suite of complementary activities in this respect. Other projects include BlockExchange, the After.Money project, and GeoCoin.

Project Outcomes and Impacts

Table B-5 summarises the evidence on whether direct outcomes have been realised at this point, and the extent to which this appears to be attributable to the IoT UK Programme, relative to other factors. The findings are then discussed in greater detail below.

Table B-5: Evidence of Project Outcomes against each Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	Yes	The evidence gathered from individuals at Edinburgh University suggest that the BitBarista has been useful in terms of being a helpful demonstrator to engage partners and clients in the potential of technologies like blockchain, including for Wallet.Services.	Low attribution
.. the scaling up of IoT activity by the beneficiary?	No	Following the success of the BitBarista research, the team are collaborating with Wallet.Services on a new, PETRAS-funded project, Blockchain IoT, which is just getting underway. This project is likely to generate a	Medium

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
		further use case for IoT and Blockchain in the sustainable transport space.	
… SME Growth (GVA and employment)?	No		

Source: SQW

As a research-based project, BitBarista's intended outputs include research papers, videos, blogs, and thought leadership articles. Intended outcomes include the generation of new insights into on how IoT and blockchain technologies shape economic behaviour, which feed into further avenues for research, and potentially into areas with commercialisation opportunities. To date, the project has resulted in one research paper, with two in development. In addition, several blogs and articles have been disseminated. The BitBarista has featured in a BBC Click episode, and has gone "on tour" with RBS, Tesco Bank, Finance Scotland, and to PETRAS (showcased in the Digital Catapult's London Centre) as a valued use case demonstrator for IoT and blockchain technologies. This has been the case for the BitBarista team, and also for Wallet.Services while they had the machine in their office.

For Wallet.Services, their participation in the project helped them to develop a closer relationship with the BitBarista team. The result of this is involvement in a PETRAS-funded collaborative research project, titled: "Blockchain Technology for IoT in Intelligent Transportation Systems" (B-IoT) alongside Edinburgh University and other PETRAS partners. The intended output of this project is another demonstrator/"use case" similar to the BitBarista, but for applications in transport. Ideas currently being explored include ways to incentivise behavioural change and promote sustainable modes of transport through intelligent transport systems using IoT and blockchain technologies.

Future Engagement

The Future for BitBarista

There are no plans to commercialise the BitBarista at present, nor are there any planned future deployment for research projects. The lessons learned, and the value of the BitBarista experience will, however, feed into future work. For example, the team leading on BitBarista are currently engaging with the European Union to explore ways in which blockchain can be used in the energy market, where the BitBarista story is utilised to help those involved grasp the technologies involved with an accessible "use case".

Future Engagements with Wallet.Services

As highlighted, Wallet.Services have followed up on their engagement in the BitBarista project by engaging formally with Edinburgh University on a PETRAS funded initiative, Blockchain-IoT. At the time of writing, this project is at an early-stage.

As a blockchain start-up actively involved in IoT and related technologies, Wallet.Services are currently working with the Scottish Government to conduct research to inform Scottish Government's distributed ledger/blockchain technology strategy, as well as work via the Scottish Government's CivTech programme to enable better digital interactions between citizens, business and government services. This work is currently unrelated to their work with Edinburgh University/PETRAS, but it was suggested that there may be possibilities to build on their BitBarista-initiated relationship and engage in this area in the future.

Lessons Learned

The scale of success of the BitBarista project, in terms of the profile it has achieved, was a welcome surprise to the Edinburgh University team. The project has been featured widely, including in a BBC Click Episode, and has been used as a tool to show what IoT and blockchain are, and what they can do, by a number of organisations, including RBS, Tesco Bank, Finance Scotland and the wider PETRAS team.

> *"People need things like [BitBarista] to help understand what blockchain is doing"*

The profile achieved has helped to similarly raise the profile of other work the Edinburgh University team are engaged in, thereby increasing its impact. This has further been noticed and utilised by the extended PETRAS network, and is increasingly being used to promote other programme activities, where relevant. The suggestion is that the BitBarista has been particularly effective as it represents a "gateway" use case, providing an accessible, "conversation starter" to help people understand IoT and blockchain technologies. The sentiment was also echoed by Wallet.Services, who have used the BitBarista example as a vehicle to engage with partners and clients with the technology, particularly while they hosted the machine, but also subsequently.

The profile achieved has helped to similarly raise the profile of other work the Edinburgh University team are engaged in, thereby increasing its impact. This has further been noticed and utilised by the extended PETRAS network, and is increasingly being used to promote other programme activities, where relevant. The suggestion is that the BitBarista has been particularly effective as it represents a "gateway" use case, providing an accessible, "conversation starter" to help people understand IoT and blockchain technologies. The sentiment was also echoed by Wallet.Services, who have used the BitBarista example as a vehicle to engage with partners and clients with the technology, particularly while they hosted the machine, but also subsequently.

Flock Cover

Summary findings

Flock participated in the R/GA accelerator, taking an early stage business 'idea' to a viable, purchasable product (via an app) in 12 weeks.

Flock was a very 'early stage' business when it joined the accelerator (with three employees) and has doubled in size, with scope for more scale in the future. The R/GA accelerator is seen by the firm to have played a major role in realising this positive performance: at the outset, Flock was a firm with a 'good idea' and technical capability, but needed support to package their business as a viable, sustainable proposition.

Following their participation in the R/GA accelerator, the firm has partnered with global insurance underwriters Allianz, to offer the world's first 'pay as you fly' drone insurance product.

About the Organisation

Flock was founded by Antton Peña, a UCL graduate student who had developed an algorithm to calculate risk related to drone flights. Ed Klinger joined the company as its first employee having met Antton through his own research into drones at Cambridge Business School. The firm was awarded three Innovate UK grants to develop the capability and utility of the algorithm into a commercially viable proposition, totalling £35,000 over 2016/17. The firm subsequently raised £300,000 in private capital to develop the technology and take forward the growth of the company.

The firm provides 'pay as you fly' cover for drone flights, underwritten by Allianz, which can be purchased through a bespoke app. The app also acts as a claim portal.

About the Project

Rationale for Engagement

As an ambitious new start-up, Flock were actively seeking further development and funding opportunities when they became aware of the R/GA accelerator. The R/GA scheme was particularly attractive to Flock as they were aware of R/GA's wide profile as one of the leading global design and marketing agencies, and were keen to secure support and expertise on design and branding issues. This was seen to fill a gap in their own knowledge and skillset, and offered a different type of relationship and specialism to other UK based accelerators. Put simply, the design and branding focus of the R/GA accelerator was what the firm needed to support growth, rather than technical support.

Profile of Activity

Flock benefitted from a 12-week structured programme of support through the accelerator. The support covered all aspects of the development of the business, including market insights, advice on PR and branding and participation in demonstration days which gave an opportunity to present their technology to potential partners and investors. The programme allowed flexibility to attend these sessions as necessary or useful, allowing them to focus on development of the business and minimising the resource required for the accelerator if this was expected to be not relevant for the firm.

Direct outputs from the support provided through the accelerator included a new firm logo, a purchasable app which integrated the firm's existing risk algorithms with a user friendly 'front end' which allows customers to purchase 'pay as you fly' drone insurance with a few taps of a screen, and a website fully designed by R/GA.

The firm estimates the commercial value of this support at between £100-200k (i.e. it would have cost up to £200k to secure inputs at an equivalent quality support from the market if they had not participated in the accelerator scheme). However, further to this substantial cost-saving for the business, Flock highlighted the opportunity that the accelerator provided to access very high-quality support; this 'added-value' was regarded as equally important as the financial value. Alongside this support, the firm also received access to coaching and mentoring and the opportunity to pitch the product to investors – some of whom have become partners in the company.

> *"R/GA's clients include huge brands like Nike and Tiffany and we got the same treatment, the effort and support from the team was as though we were a £1m client."*

Project Outcomes and Impacts

The table summarises the evidence on whether direct outcomes for the beneficiary firm have been realised at this point, and the extent to which this appears to be attributable to the IoT scheme, relative to other factors. The findings are then discussed in greater detail below.

Table B-6: Evidence of Project Outcomes against each Evaluation Question

Has engagement led to …	Realised?	Evidence	Attributed to IoT UK?
… the development of economically viable IoT applications?	Yes	The accelerator scheme allowed Flock to package their algorithm within a usable, downloadable app.	Yes, in part
.. the scaling up of IoT activity by the beneficiary?	Yes	Flock secured a partnership with insurance underwriter Allianz as a direct result of the improvements to their offer developed as a participant in the accelerator. This has allowed them to take a viable, purchasable IoT enabled product to market and move beyond proof of concept work.	Yes, in part
… SME Growth (GVA and employment)?	Yes	The firm has grown from 3 to 7 FTE since joining the accelerator, and secured a further £300k of investment	Yes, fully

Source: SQW

Participation in the R/GA accelerator delivered significant benefits for Flock, meeting fully the firm's objectives from engagement at the outset. At the point of joining the accelerator scheme, Flock was a firm with a 'good idea' and technical capability, but needed support to package their business as a viable, sustainable proposition. R/GA's expertise in PR, design and marketing was therefore an ideal fit with their needs as they joined the programme.

As a result of their participation in the accelerator, Flock have achieved the following outcomes:

- Development of a viable, sellable product.
- Partnership with a major, multinational insurance underwriter (Allianz).
- Secured funding of £300k from partners including Innovate UK and R/GA.
- Expanded from 3 to 7 FTE staff, with two more posts advertised at the time of the case study research.
- Taken the product to market and developed a customer base.

The firm estimates that participation has led to scaling up of their IoT activity 'by a factor of 10'. Flock view the scheme as fundamental in bringing their product to market, through development of a marketable, usable proposition and helping secure their insurance partnership. The firm were confident in their idea, and that the growing popularity of drone tech as both a commercial and 'hobbyist' market presented an exploitable opportunity but the accelerator has allowed them to gain 'first mover' advantage.

Further to specific business benefits participation in the scheme also led to important development of new networks with other CEOs, which offers a 'support

network' through which to troubleshoot problems, explore new ideas and seek new contacts and support.

Attribution is very strong: Flock joined the R/GA scheme early in their business lifecycle, therefore participation has had a direct impact on positive outcomes. As noted above, Flock knew they had identified a new market for insurance, and had developed a means to fix a new problem (how to insure expensive equipment quickly, on a 'by use' basis) but did not have a means of taking this to a mass, and growing, market prior to their engagement.

Participation provided not only a means to directly engage the market – via a downloadable app with good user experience and design principles – but introduced the firm to Allianz, who provided both insurance expertise and gravitas to the proposition. In this sense it was fundamental to their subsequent growth and success. But this was facilitated by the boom in the drone market, which grew 36% in revenue terms to $4.5bn in 2016, according to research firm Gartner[32]. Flock's idea and technical know-how therefore combined with the opportunities and branding expertise provided by R/GA to allow them to exploit a gap in a global growth market.

No other external factors were seen to have contributed to the outcomes directly, although they have been reliant on the on-going input of staff in terms of the development of the technology, and built on the earlier investment by Innovate UK. The subsequent investment secured has also been important in realising the benefits, with the partnership with Allianz also essential in bringing the product to market at scale. However, the overall attribution of the accelerator to the business outcomes experience is very strong.

Future Engagement

With IoT Technologies

IoT technologies are at the core of Flock's business model. Participation in the accelerator allowed them to develop a 'market ready' product, with further product development and innovation expected going forward.

With Project Partners

Flock maintains good relationships with the accelerator project director, and R/GA is now an investor in the firm having committed £150,000 of capital following the completion of the accelerator period. These relationships offer a continuing formal support network, offering coaching. Mentoring and access to

[32] https://www.gartner.com/newsroom/id/3602317

onward networks and contacts who may further support the business. They have developed positive personal relationships with other participant CEOs who they use as a 'support network' to troubleshoot problems and to discuss ideas. They have also met a number of potential investors, some of whom – such as Innovate UK and Allianz – have already provided further financial backing.

Lessons Learned

Several key learning points have emerged as a result of Flock's involvement in the accelerator:

- First, the importance of branding and having a strong, marketable and accessible 'product' (in this instance, insurance policies, available at the tap of a screen) in the evolution of a successful business model.
- Second, that accelerator schemes need to offer flexibility to meet the specific needs and tailored requirements of participants; this is helpful both in securing participation and continued commitment.

"Tales of the Park" at the Queen Elizabeth Olympic Park

Summary findings

The "Tales of the Park" project was a social IoT demonstrator located at the Queen Elizabeth Olympic Park from September to December 2017. The project was principally designed to provide a "playful, interesting and fun" way for the public to engage with the security issues that surround sharing information with, and via, IoT technologies. It also represented an example of deploying IoT in a public space.

The project involved a partnership between University College London's (UCL's) Centre for Advanced Spatial Analysis (CASA), the London Legacy Development Corporation (LLDC) and the Mayor's Office. Intel and Google also supported the project.

Research papers are currently being developed based on the data collected over the deployment period. Other outcomes include a deepening of relationships between the partners, and learning in terms of deploying IoT devices "in the wild". Some of the learning will feed into future projects, including the development of the UCL East development adjacent to the Olympic site.

Background

"Tales of the Park" was an IoT demonstrator deployed at the Queen Elizabeth Olympic Park, in a partnership between University College London's (UCLs) Centre for Advanced Spatial Analysis (CASA), the London Legacy Development Corporation (LLDC) and the Mayor's Office. The purpose of the project was to research some of the security issues around IoT and "natural language interfaces", and to provide a "playful, interesting and fun" way to engage the public in these issues in public spaces, such as:

- What implications does IoT have for privacy?
- How can we build trust with IoT devices?
- What might the broader social implications of IoT's increasing prevalence be?

Practically, the project consisted of 15 "creatures" (including 3D-printed garden gnomes, otters, and bats), distributed around the QE Olympic Park. They communicate with each other, sharing information, and are tasked with being the park's digital "guardian spirit". Technically, the project is designed around Google's "Physical Web" technology and low energy Bluetooth beacons to connect people, things and places. Visitors to the park with "Physical Web" enabled smartphones are able to communicate with the creatures using QR codes to find out more about the park and events going on, as well as exchanging personal

information and stories about the area. These exchanges aim to "humanise" IoT devices, thereby raise the public's understanding and their awareness of some of the implications of the technology. For example, when communicating with multiple creatures, it becomes clear that the information you have shared with one has been exchanged with others. With the prevalence of technologies such as Amazon's Alexa or Facebook's chatbots (based on the same technologies), understanding the implications of data sharing with IoT devices will be critical for the ongoing development of the technology area. Through the project, the research team are able to understand and quantify how much information users are comfortable sharing and gauge levels of trust in IoT-based technologies.

Although there are no direct commercial opportunities as part of this project for individual SMEs of firms, developing and disseminating a greater understanding of the security issues that surround IoT, and addressing any implications that arise to help create a more secure IoT landscape, will be important for realising the full economic potential of the technology.

About the Project

Rationale for Engagement

The "Tales of the Park" project forms part of a broader suite of work through PETRAS seeking to deploy IoT technologies in public spaces to increase understanding of the ways in which people engage with IoT, and research some of the ethical, trust and security issues in this context. As the objective was to deploy IoT in a public space, the nature of the project was contingent on finding a willing partner for the project. The project team approached LLDC and the Mayor's Office, who alongside Intel and the Future Cities Catapult provided a letter of support for the "Tales of the Park" grant, with a planned deployment at the QE Olympic Park. This provided a public space within which to practically deploy IoT. A motivation for this to talk place on behalf of the LLDC and Mayor's Office was to understand the challenges associated with deployment.

Profile of Activity

The activities involved in delivering the "Tales of the Park" project included the practical deployment of IoT in the public realm. Including negotiating access to the site, developing the devices and technology involved. The creatures themselves were manufactured by the CASA team, and were named and painted by young people aged between five and twelve, from Academy Achievers, a community organisation based in Newham. Over the course of their deployment, from September to the end of December 2018, the devices have been capturing data that will form the basis of research papers in Spring 2018.

The "Tales of the Park" project was also integrated to another project involving the same partners (UCL, LLDC, the Mayor's Office and Intel), the Intel Collaborative Research Institute (ICRI) Capstone project. The data collected by the network of creatures distributed around the park, including weather data, was fed into a real-time, 3D, and augmented reality model of the park.

Finally, as part of the project a separate grant with Google was secured to procure 100 of Google's Bluetooth beacons to deploy around the park. Google's motivation for joining was to gain insights into the use of their devices in a novel application.

Project Outcomes and Impacts

The principal outputs and outcomes of this work are research-based. As the deployment of the creatures has only recently come to an end, these papers are currently in development and expected in the future. In total, four are planned, including a report, in collaboration with the LLDC, on how to practically deploy IoT in public spaces, which will help support and inform future projects of this nature. Funding has also just been allocated to developing a RoadMap for IoT in the Park, with the LLDC and PETRAS, which will support a longer-term plan for the logistics of deploying IoT in public places.

This currently represents a major challenge to progressing IoT activities in public spaces, and the project is anticipated to provide important learning that can inform the development of economically and technically viable products and services in the future.

Aside from research outcomes, a further outcome of the project has been the deepening of relationships with the partners involved. Particularly in terms of ICRI Intel, LLDC and the Mayor's Office, which will support future engagements between the partners, such as the development of UCL East on the Olympic site – where IoT is likely to be more fully embedded in the development's planning.

Other outcomes include the profile the work has generated. It has featured in the media, as well as other outlets, such as the Intel Industry yearbook. It was reported that this has helped to raise the profile of IoT – contributing to the UK's reputation in IoT over the longer-term – and, more specifically, of the work of the project partners involved – raising the profile of other streams of related work across the PETRAS network.

Future Engagement

With IoT Technologies

IoT technologies form an important means for researching key areas of interest to the Centre for Advanced Spatial Analysis team at UCL. However, as their grant

ends in March 2018, the team will likely focus on other, related areas, including Artificial Intelligence. As part of their PETRAS work, they will continue to progress with studies to explore the technical, ethical and social issues associated with the IoT network.

With Project Partners

In terms of the continuation of the "Tales of the Park" work, much of the learning (in terms of the research insights, but also in terms of the challenges in practically deploying IoT technologies in public places) will be transferred into planned future deployment of IoT technologies as part of UCL's ongoing developments in the area. UCL are currently developing UCL East, a new campus and research lab, including the Future Living Institute (opening in 2021), within the QE Olympic Park site. The PETRAS work with the Park has directly fed into the plans for these development, and the majority of the IoT-related work being planned on the site would not be taking place without the UCL teams involvement with LLDC and the Mayor's Office on the "Tales of the Park" and ICRI Capstone projects.

Lessons Learned

The principal lessons learned to date mostly relate to practical experiences in deploying IoT devices in the public realm. As noted above, this learning is currently being developed into a report and Roadmap in collaboration with LLDC. This work highlights the importance to engaging with key stakeholders at the outset to secure buy-in. The learning from this process will feed into future IoT deployment projects by the partners involved, including as part of the UCL East development.

The project also highlights the value to engaging with local communities in order to understand their perceptions around new technologies, such as IoT. Novel, use-case applications, like this project, are regarded as important for paving the way to shaping perceptions and changing behaviours in such a way that the potentials to IoT can be unlocked in adherence with key PETRAS concerns (privacy, ethics, trust, etc.).

Harnessing Economic Value

Summary findings

The Harnessing Economic Value theme is one of five main PETRAS research themes. The research focusses on the relationship between the social impact of IoT and the creation of economic value.

Activities completed to date include research into the "State of the Art" of the technology area, and a "Gap Analysis" to inform future research. Other activities include participation in events, workshops, and the provision of technical advice to commercial partners (including Lloyds Register Foundation and XIAN.io, a German SME).

Outputs to date include research papers, and the gradual deepening of collaborative relationships across the PETRAS network, and with commercial partners. Key activities are also ongoing, shaping the strategies of large companies and laying the foundations for new business models and approaches harnessing the socio-economic value of IoT systems.

Background

Harnessing Economic Value (HEV) forms one of the five research themes within the PETRAS project, led by Imperial College London alongside other PETRAS partners. The purpose of this theme is to conduct research across three areas, as follows:

1. The relationship between the social impact of IoT and the creation of economic value.
2. How to increase, predictively, the efficiency of complex IoT systems.
3. Explore new, innovative business models with key user partners.

As a result of IoT innovations, prevailing economic models will be challenged, and new possibilities for innovative ecosystems, novel business models, and market opportunities will arise. As more and more objects become IoT devices – parts of an expansive network of connected energy meters, autonomous vehicles, smart fridges, etc. – such innovations not only provide opportunities to generate socio-economic benefits, but will also raise important implications in terms of PETRAS concerns.

The HEV PETRAS theme is associated with a range of sub-projects. This case study focusses on Imperial's engagement with commercial partners on applications of IoT technologies unlocking new economic opportunities in the insurance market, particularly as part of the Designing Dynamic Insurance Policies using IoT (DDIP-IoT) project. This project focusses on "how real-time, adjustable insurance policies can be designed and managed using IoT

technology", and involves a collaborative partnership between Imperial College London and Lloyd's Register Foundation.

About the Project

Rationale for Engagement

Imperial collaborated with Lloyd's Register Foundation. The Imperial team suggested that Lloyd's Register Foundation's primary motivation to join the project was highly related to their overall involvement in PETRAS work – to understand the implications of IoT to their prevailing business model, keep abreast of relevant changes in the sector, and prepare strategically for future risks and opportunities identified.

Profile of Activity

The HEV stream major activity to date has been in assembling a "state of the art" report and a Gap Analysis report. These examine interesting applications of IoT and related technologies globally which may have commercial applications, and seek to identify core PETRAS-related implications that such technologies raise, to feed into and inform future work. The examples presented in the report span a range of areas, including insurance, healthcare, the interface with blockchain technologies, and integrated transport systems. The team also regularly participate in events, workshops and conferences to disseminate their work and raise awareness of the topics they cover. Examples include a series of Chatham House events on the following areas:

- At the Intersection of Data Privacy and the Internet of Things.
- The Legal Implications of the Internet of Things.
- The Internet of Things and Risk Management: How Innovation is Changing the Nature of Risk.
- The Journal of Cyber Policy: Understanding the Internet of Things.

The team are actively involved in collaborative work with a range of commercial partners as part of this work, including Lloyd's Register Foundation and Pincent Masons. The HEV Technical Lead also engages in advisory work with private companies (including XAIN.io, a German blockchain SME with an IoT portfolio). Further engagements are planned, including with other SMEs.

Project Outcomes and Impacts

The Harnessing Economic Value work is a research-based project, focussed on research outcomes. It is designed to lay the foundations for new economic paradigms, most of which will take several years to realise outputs/outcomes such as new business models or market opportunities. The team at Imperial are currently working with commercial partners, but the work focusses largely on the strategic side, i.e. helping companies involved to understand the challenges that new technologies will pose to their prevailing business models, and collaborative work together to define future platforms to ensure that these new models are safe, secure and trustworthy. To date, outputs include book, chapters, research papers, conference posters and blogs, with a range currently in development. Several have been published to date, including:

- "Economic Impact of IoT Cyber Risk - Analysing past and present to predict the future developments in IoT risk analysis and IoT cyber insurance", paper to PETRAS IET Conference.
- "The Impact of Cyber Security Frameworks on IoT in Industry 4.0", poster to PETRAS IET Conference.
- "Making Sense of Cybersecurity in Emerging Technology Areas'', book chapter in Oxford Handbook of Cybersecurity, Oxford University Press, 2018.

In terms of collaborative work with private companies, the principal example discussed as part of this case study was current work with Lloyd's to increase understanding around risk and accountability issues in the market for insurance underwriting. This work will likely shape Lloyds' future strategic decision-making.

Future Engagement

With IoT Technologies

The work underway is at a preliminary stage and is ongoing. Having completed a horizon scanning exercise to establish the current "state of the art" and "gaps" in understanding in the IoT and blockchain technology area, the team are currently seeking new avenues for research into interesting areas for commercial exploitation and knowledge gaps related to IoT technologies.

With Project Partners

Imperial continue to work the Lloyds on the implications of new economic paradigms related to IoT innovations. Future activities are also planned with new project partners in similar and related areas. For example, with Porsche and

XAIN.io, they are currently putting together a proposal to conduct some research to understand how IoT and blockchain technologies can shape car insurance properties in real time. For example, how might an insurance policy adjust in real-time in response to a range of factors (i.e. the driver, the time of day, the location, weather conditions, etc.), and how can this be done effectively and efficiently?

Lessons Learned

Work to date has highlighted the "state of the art" in the area, and the PETRAS network are actively engaged with commercial partners to explore how changes linked to IoT innovations will shape the social and economic landscape. This work has helped to support enhanced collaboration between academia, industry and the public sector.

The work so far has highlighted just how important understanding the social sphere, and cross-disciplinary context, within which IoT technologies are adopted. This work will lead to returns in terms of new revenues and more efficient processes in the long-run, but laying the foundations for new socioeconomic paradigms is the core focus of the PETRAS team at present.

Cotham Technologies

Summary findings

Bristol-based Cotham Technologies have developed a platform designed to simplify and speed-up the process for producing 'native' apps. The company are currently part of IoT Boost competition, following their selection and admission in September 2017.

To date, the company has benefitted from the networking opportunities offered by the programme. They have also established and improved links with members of the IoT UK network, particularly the Digital Catapult. Cotham Technologies were selected to participate in the Innovate 2017 showcasing event at the NEC, which helped to raise their profile and establish new relationships that may lead to exploitable opportunities in the near future.

About the Organisation

Cotham Technologies are a Bristol-based mobile software company with the mission to make the development of 'native' apps (apps designed for specific mobile devices that can be installed directly on the device[33]) an "easier, faster, and smarter" process. Currently, the development of native apps is time consuming, requires skilled developers, and expensive. For example, a typical native app can take six months of a team of skilled developers, and cost £150k to develop (although timescales and costs do vary considerably).

However, demand for native apps is high. Cotham Technologies are seeking to exploit this demand, and speed up the development process through the creation of a patented platform – called FloFrame - to allow apps to be designed, tested and deployed more quickly. This platform does not require coding, and speeds up the development process considerably – by up to 90%. The FloFrame platform also allows clients to work across IOS and Android platforms, which would typically require two parallel streams of work to achieve via a traditional, coding approach (as each platform requires different coding skills). The company currently employs seven people and has generated revenues of £100k in the last 12 months, largely through app services. The ultimate goal is to develop the platform as a Software as a Service (SaaS) to generate licencing revenues from partners and resellers.

Cotham's technology is highly relevant to a range of sectors. They are currently involved in developing applications in the utilities sector in the UK and internationally. In addition, they have developed demonstrators of their technology relevant to health and finance sector applications.

[33] Native apps contrast with web-based or hybrid apps that could be used on mobile, but that do not allow for full integration with the device itself (such as the use of the camera, security features, finger-print scanner, etc.) and tend to be lower performance and less responsive.

About the Project

Rationale for Engagement

Cotham Technologies are currently working with the Digital Catapult via the IoT Boost competition. They joined the programme in September 2017. Their involvement arose following a recommendation from the "entrepreneur in residence" at the SETsquared Business Acceleration Centre (a delivery partner for the IoT Boost Competition), with whom Cotham Technologies were introduced via a mutual contact. The motivation to engage was based on the following factors:

- Opportunities to engage with others around LoRaWAN-related issues and applications, as it links into current projects they are involved in.
- Networking opportunities, particularly the exchange of skills and ideas with other IoT Boost participants.
- To get a better understanding of ongoing technology developments and market opportunities.
- To raise their profile to gain "credibility and presence" in the market.

Outside of the IoT UK Boost competition, Cotham Technologies has not been involved in any other forms of business or innovation support directly.

Profile of Activity

Cotham Technologies has been engaged with the IoT Boost competition since September 2017. By the point of the case study, they had participated in meetings and workshops as part of the programme, which outlined the scope of support and begun to understand the opportunities to introduce them to new contacts or partners in relevant industries.

Project Outcomes and Impacts

Through their early engagement with the IoT Boost Competition, the company has already begun to explore collaboration opportunities with a fellow participant on the programme. Similar collaborations with other partners are expected in the future. Their involvement in the programme has also led to an initial contact with the lead of the Bristol LoRaWAN network. Cotham are currently exploring how the company can collaborate with other local companies on prototype applications exploiting this local resource. Cotham Technologies do not think this is something they would be able to do without their involvement in the IoT Boost competition.

The company were also selected to be on the Digital Catapult stand at the Innovate 2017 showcasing event at the NEC as a result of their involvement in the programme. Here they met, and held useful discussions with, several members of the Digital Catapult team, and also with a Korean delegation operating in relevant technology areas. They are currently in early discussions with a Korean company met at this event, with a view to collaborating in the future.

More generally, the company believe their involvement in the IoT Boost competition has served to enhance their profile in the market. They also anticipated that their involvement in the programme will provide them with additional a "credibility and presence" in the market in the future. Cotham Technologies also reported that their involvement in IoT Boost, and with the Digital Catapult more broadly, will support their ongoing learning and development, as well as provide further opportunities to be introduced to, and network with, potential partners and collaborators.

However, as part of the wider business support offer provided through the SETsquared Business Acceleration Centre, the company have also been able to engage in workshops to help them in terms of business planning and marketing, which the company has found very useful.

Finally, although Cotham Technologies have not experienced any changes in turnover or employment that can be attributed to the IoT Boost programme at this stage – not unexpected given the shirt time period that has elapsed from the initial engagement – they do anticipate outcomes of this nature in the future. In particular, they are hopeful that some of the new contacts they have made through their engagements (with others on the IoT Boost competition, as well as introduction made as part of their involvement with the Innovate 2017 showcase) will result in business opportunities.

Future Engagement

With IoT Technologies

The platform developed by Cotham Technologies spans may sectors and technology applications. IoT technologies form a crucial part, and monitoring ongoing developments in this technology area is regarded at critical to the company's development.

With Project Partners

Cotham Technologies are currently at the early stages of their involved in the IoT Boost competition. They will continue to engage in the competition as planned, and explore the opportunities that this affords.

One important area of future engagement with the Digital Catapult is the company's engagement in a large-scale deployment of their technology in Cambodia with their partner Freestyle, an Australia-based IoT partner, for a smart metering application. This work predates, and in unrelated to, their involvement with the Digital Catapult. However, during the Innovate 2017 showcase event at the NEC in November 2017, Cotham Technologies held discussions with the Digital Catapult team about this work. They received considerable interest from the Digital Catapult team, and are now looking into opportunities to profile and promote this work as an example of a real-world use case of IoT and LoRaWAN based technologies. These opportunities represent a "happy coalescence", to the mutual benefit of both parties involved.

Lessons Learned

It is perhaps too early to draw learning lessons. However, the case study suggests that Cotham Technologies 'open' approach to engaging and networking activity has proved useful in establishing important contacts and early indications of possible collaborations and partnerships. This has been complemented, and supported, by the approach to the delivery of the IoT Boost programme by the Digital Catapult, which seeks to facilitate and catalyse networking behaviours and collaborations between participants. Cotham Technologies expect similar benefits to emerge as part of their future engagement in the programmes, as well as with other parts of the IoT UK network (particularly, the Digital Catapult).

Intelesant

Summary findings

Intelesant is a small start-up enterprise, and has undertaken various previous projects with NHS partners. Intelesant's main product is Howz, which is the subject of the Technology Integrated Health Management (TIHM) trials, one of the two IoT UK NHS Test Beds.

Intelesant use machine learning to understand the daily routines of people with dementia. Howz provides a non-invasive mechanism for ensuring an individual is safe and well in their home, by monitoring energy usage and other vital signs. IoT technology is at the heart of Intelesant's business, and is fundamental to achieving its organisational aims and strategy.

It is too early to evidence any outcomes emerging in terms of demonstrating the economic viability of the product, scaling-up of activity or effects on business growth. However, involvement in the programme has offered opportunities and benefits for Intelesant, including increased understanding regarding information governance requirements within the NHS, the formation of new relationships, and increased profile of the development work and its expected benefits. This provides the potential for substantial commercial benefits for Intelesant in the future, driven in part by their engagement in the IoT UK Test Beds programme. Intelesant continue to work with public and private partners to roll-out the product at scale and pace.

About the Organisation

Intelesant is a small start-up enterprise, incorporated in 2012. The organisation comprises 6 permanent members of staff, and has undertaken various previous projects with NHS partners. Intelesant's main product is Howz, which was in development for approximately 12-months prior to the Internet of Things UK (IoT UK) and NHS Test Beds programmes commencing. Howz is the subject of the Technology Integrated Health Management (TIHM) trials, one of the two IoT UK NHS Test Beds.

Intelesant use machine learning to understand the daily routines of people with dementia. Intelesant operate on a distinct business case model, whereby products are marketed directly to consumers (specifically, older people and those with dementia, as well as their family members), rather than NHS organisations. Intelesant's product (Howz) provides a non-invasive mechanism for ensuring an individual is safe and well in their home, by monitoring energy usage and other vital signs.

Outside of the IoT and NHS Test Beds programmes, Intelesant works with a range of other organisations to trial and market the product, including NHS Trusts, EDF Energy and the Greater Manchester Academic Health Science Network. Intelesant has undertaken extensive user engagement via focus groups

and in-home testing of products with 500 people with dementia, as part of its ongoing collaboration with EDF Energy.

About the Project

Rationale for Engagement

Intelesant's leads initially heard about the NHS Test Beds programme approximately 6-months before the programme launch, and were motivated by the opportunity to implement the Howz technology at scale and build new relationships with NHS organisations and other partners. Intelesant leads attended the launch and engagement event at the Oval, and met with a wide range of NHS and SME representatives. There was a clear alignment between the TIHM project aims and Intelesant's product development activity and strategic vision.

> *"I was very impressed with the vision outlined [for this project], to use IoT approaches to develop machine learning technology to identify health deterioration at an earlier stage. We'd been doing this in our business, it's a subject that's core to what we do – analysing data to make predictions. I was very impressed with the leads from Surrey University and how they described it… It was a great vision."*

Profile of Activity

Intelesant was involved in preparing and participating in the application and pitch for IoT funding. Since inception, the Intelesant lead has undertaken the elected role of innovator representative on the TIHM project board. An Intelesant colleague provides clinical input and advice to the project. Intelesant's product Howz has been used within the TIHM technical solution.

Project Outcomes and Impacts

Overall, it is too early to yet evidence any outcomes emerging in terms of demonstrating the economic viability of the product, scaling-up of activity or effects on business growth.

> *"I think that it has taught me a lot re working with the NHS and working on collaborative projects. I think that if the project can continue and become more focused, it could turn out to be really valuable to us. Up to now though, other than new networks and learning, it has not translated to short term impacts for us."*

However, there are indications that involvement in the programme has offered opportunities and benefits for Intelesant. Project involvement has increased Intelesant's understanding regarding information governance requirements within the NHS, supported by the work of project partners Royal Holloway (University of London). If the project is sustained to enable benefits to be realised, the firm is confident that it will offer valuable evidence to inform future engagement with NHS partners.

> *"In terms of reputation, it's done us no harm being involved in the programme, and it has enabled us to sustain the pre-existing relationship with Lancashire partners."*

The IoT programme and TIHM have enabled Intelesant to forge new relationships with the University of Surrey, which helped to overcome specific technical challenges in the deployment of the product in a real-world setting.

> *"This project has given us greater understanding of how to apply this product to the NHS, to a particular use in supporting people with dementia. Any changes to the product will be relatively marginal now – and targeted towards commercialisation in the NHS. "*

Being part of the IoT programme has also offered opportunities to raise the profile of the work being undertaken by partners on the project and its expected benefits, with the branding of the programme opening doors to national promotion and awareness raising. This is expected to offer opportunities to help spread the technology at scale and pace if the anticipated benefits are realised. This provides the potential for substantial commercial benefits for Intelesant in the future, which will have been driven in part by their engagement in the IoT UK Test Beds programme.

> *"We have benefitted from more than just the money – there has been a BBC programme and an article in The Guardian regarding the project. From that we've done several other articles for The Guardian, and this has provided some concrete benefits from a PR perspective."*

Future Engagement

With IoT Technologies

IoT technology is at the heart of Intelesant's business, and is fundamental to achieving its organisational aims and strategy. The technology is in place to make significant improvements to the lives of elderly people and their carers, and the product has been tested and refined. Intelesant continues to work with public (e.g. Greater Manchester AHSN) and private (e.g. EDF Energy) partners to roll-out the product at scale and pace.

Moving forward, Intelesant's ambitions include further implementation and commercialisation of the product via engagement with the insurance and utilities sectors, amongst others.

With Project Partners

This project has forged new relationships with future potential collaborators, specifically the University of Surrey technical leads and NHS Surrey and Borders Foundation Trust. This is expected to offer future collaboration opportunities.

Outside of this programme, Intelesant is also involved in the Lancashire NHS Test Bed project (providing an unfunded contribution, building on pre-existing relationships).

Lessons Learned

Several key learning points have emerged as a result of Intelesant's involvement in the programme:

- **Extended timeframes are required for evidence to fully emerge:** Given the nature of the project, it is not realistic for benefits to be fully realised within the two-year programme timeframe. There needs to be a recognition by partners and funders, as well as the innovators, service users and the NHS, that outcomes will be realised over the longer-term.

> *"Programmes like this can be very beneficial, but you have to stick with it. I'd be nervous of people making judgements based on two years' worth of data."*

- **Financial support is vital**: The funding provided as part of the IoT UK Test Beds programme was vital for enabling the project to occur. This is particularly important for projects involving changes to clinical pathways

and patient care within the NHS, with a need for 'dual running' of innovative approaches alongside 'business as usual' services and pathways until the evidence fully emerges. This requires funding for NHS commissioners and providers.

> *"You can't replace anything in the NHS until you have the evidence [that it works and is safe to do so]. Changing the clinical pathway and how patients relate to clinicians takes time, you need to run a parallel process to change anything like this. That absolutely can't happen without programme funding like this."*

- **Clarify the parameters in terms of product 'readiness':** Whilst Intelesant's product development was relatively advanced prior to the IoT and NHS Test Beds programmes, other innovators' products were at an earlier stage of development and required larger amounts of funding for refinement. This variation in product readiness risks jeopardising partner relationships, and can create tensions regarding the sharing of intellectual property across the consortium.
- **Secure shared agreement on the end goal:** Project partners have recently agreed on their shared expected outcomes for the project, and timeframes for realising these. Reaching this aligned understanding and shared vision up front, and ensuring this informs project evaluation, may offer opportunities to progress in a more focused and targeted way in future programmes.
- **Ensure the evaluation methodology aligns with project phasing:** The TIHM project evaluation involved a randomised control trial (RCT), with equal numbers of people with mild to moderate dementia and carers being recruited into each cohort. However, in hindsight the TIHM intervention was not yet sufficiently well-defined and stable for the RCT, and the RCT approach constrained the scope for agility and responsiveness to emerging requirements.

Annex C: List of Consultees

Table C-1: List of People Consulted for this Interim Evaluation

Project Strand	Name	Position with Respect to the IoT UK Programme (or Job Title)	Organisation
Project Sponsors	Helen Mainstone	Programme Manager	DCMS
	Jonny Voon	Lead Technologist	Innovate UK
	Maeve Walsh	Former Budget Owner	DCMS
	Neri Ineneji	NHS Innovation	Office for Life Sciences
	Dr John G Baird	Lead for RCUK Digital Economy Theme	EPSRC
	Amy Galea	Deputy Director, Strategy Group	NHS England
CityVerve	Mark Duncan	Strategic Lead - Resources & Programmes	Manchester City Council
	Peter Shearman	Head of Innovation Technology	Cisco
	John Rigby	Senior Research Fellow	University of Manchester
	John Davies	CityVerve Lead	BT
	Simon Navin	Head of Digital	Ordnance Survey
	Anne Dornan	Head of Innovation	Manchester Science Park
PETRAS	Jeremy Watson	Director, PETRAS	University College London
	Emil C Lupu	Deputy Director PETRAS	Imperial College London
	Graca Carvalho	PETRAS Impact Champion	University College London
	Dr Mike Short	Chair of PETRAS Steering Group	Telefonica (O2)
	Carsten Maple	Privacy & Trust Lead	University of Warwick
	Irina Brass	Partner	Pinsent Masons

Project Strand	Name	Position with Respect to the IoT UK Programme (or Job Title)	Organisation
	Prof Rachel Cooper	Chair of Design, Lancaster. Co-Investigator, PETRAS	Lancaster University
NHS Test Beds	Dr Elizabeth Dymond	Deputy Director of Enterprise	West of England Academic Health Science Network
	Helen Rostill	Project Lead	Surrey Test Bed
	Tom Dawson	DDC West of England industry participant	ResconTechnologies
	Payam Barnaghi	TIHM Surrey participant	University of Surrey - technical lead
	Tim Benson	DDC West of England participant	R-Outcomes
Accelerators	Matt Webb	MD	R/GA IoT Venture Studio UK
	Raph Crouan	MD & Project Director	Startupbootcamp IoT
Catapults	Fin Kelly	Project & City Finance Lead	Future Cities Catapult
	Tom Leaver	Programme Manager	Future Cities Catapult
	Ray Lambe	Senior Responsible Officer for the Catapult's work for IoT UK	Digital Catapult
	Jessica Rushworth	Head of Policy	Digital Catapult
	Amy Taylor	Programme Manager	Digital Catapult
External Stakeholders	Matthew Evans	Executive Director, SmarterUK & Internet of Things Programme	Tech UK
	Stephen Pattison	VP Public Affairs	ARM

Source: SQW

Annex D: Project Logic Models

CityVerve Logic Model (i)

Context

- IoT offers enormous potential for improving the performance of products and services, to the benefit of buyers (including in the public sector), suppliers, and citizens
- Increasing connectivity and access to public information presents opportunities for local authorities to manage cities more cost-effectively, and improve services for citizens
- Cities around the world are using IoT and other smart city technologies
- The global market for smart cities applications could be $400 billion p.a. by 2020 (Arup, 2013)
- Manchester has devolved powers and responsibilities (e.g. NHS budget): its authorities have stated commitments to innovative solutions to local needs and challenges, focus on the continued growth of the digital economy, and more efficient and effective local services

Rationale for intervention

- Wider rationale for government investment in science and research because the size of the scientific, innovation and technological problem is too large for individual private actors to tackle
- Markets are likely to under-provide standards, regulation and solutions
- There is information asymmetry and uncertainty as a result of high levels of specialised technical and/or market knowledge relating to IoT which limits the awareness, accessibility and benefits of using smart city technologies and data (e.g. travel, health, energy) by 'central purchasers' (e.g. local authorities, NHS and social care providers) and the general public
- Rationale for Innovate UK funding industry/public sector led collaborative R&D
- Network failures due to lack of coordination (or fragmentation) in collecting, analysing, and sharing data at city level
- Potential for publicly-funded R&D projects to help address these issues, improve public infrastructure and services, and generate positive spillover effects (e.g. network, knowledge and market)

Inputs

- Government (DCMS) funding of up to £9.78m ((2016 to 2018; grants from Innovate UK); cash contributions from delivery partners (Cityverve consortium) £5.89m, plus 'in-kind' contributions
- ICT infrastructure and services supplied by Cityverve participants and other businesses, e.g. telecoms, sensors, devices, software, data services
- Management and governance inputs by 20+ Cityverve consortium members including: Manchester City Council, Cisco, BT, Siemens, Ordnance Survey, Central Manchester University Hospitals NHS Foundation Trust, Transport for Greater Manchester, University of Manchester, Manchester Metropolitan University, Manchester Science Partnerships, SMEs, and the Future Cities Catapult

Activities

Large collaborative R&D programme; underpinning and central "digital infrastructure platform" on which IoT solutions (see below) provide access to a range of data to firms, public sector organisations and others

19 "work packages" to design, build, and test IoT technologies and applications across four themes:

- Health and social care (e.g. chronic conditions, wellness, nursing home care)
- Transport and travel (e.g. bus stops, road safety, cycling)
- Energy and environment (e.g. lighting, parking, air quality monitoring)
- Culture and public realm (e.g. work with the community, social media, art)

CityVerve Logic Model (ii)

Intended outputs

- Platform developed, devices and infrastructure installed, services running and "use cases" demonstrated and implemented by 2018; and work with small businesses and public communications. For example:
  - Two IoT art installations
  - 1,200 "talkative" bus stops; 2,000 road safety devices; 6,000 water monitoring devices
  - Smart lights and smart parking sensors
  - Four competitions (and showcase workshops) p.a. (each funding at least four start-ups or SMEs)
  - Public communications
  - Business models developed for smart city IoT services/infrastructure

Intended outcomes

- Greater effectiveness and efficiency of the relevant public services and utilities
- Improvement in the quality and cost effectiveness of the relevant IoT/ smart city solutions
- Increased proportion of local businesses and local residents/workers aware of the local projects; improved attitudes (perceptions of benefits) towards these kinds of projects
- Improved communication, co-ordination and collaboration between public and private organisations in Manchester (and with other towns and cities)
- Network, knowledge and market positive spillovers generated
- Spillover learning on cities applications of IoT for other UK "central commissioners" of public infrastructure and services (e.g. local authorities) and providers (businesses)
- Increased opportunities for commissioners and providers to be aware of and consider using these technologies to address local requirements
- Demonstrating the value of CityVerve or specific innovations within the programme, and to other areas/cities
- Testing/ proving IoT and related technologies e.g. improved data accessibility, sharing and analysis
- Replicability, scalability, and sustainability of CityVerve, or specific innovations, to other areas/cities, and associated business opportunities
- IoT Innovations open/accessible to others (e.g. through the use of Hypercat standards)

Intended impacts

- Improvements in Manchester public services for citizens
- Improved economic competitiveness of UK businesses offering smart city related goods and services
- Improved international global reputation of Manchester as a smart city
- Economic impacts (increased UK GVA, employment, productivity, cost savings, exports)
- Improved public sector efficiency and effectiveness
- Wider social benefits (e.g. health, environment, transport, culture)

PETRAS Logic Model (i)

Context

- IoT offers enormous potential for improving the performance of products and services, to the benefit of buyers (including in the public sector), suppliers, and citizens
- Government and others' stated aims for UK performance and international standing for science, research and innovation
- As well as opportunities, IoT brings significant challenges, threats and risks e.g. privacy, economics, ethics, security, public trust, user acceptability
- The UK is strong in IoT research; and there is strong international competition

Rationale for intervention

- Wider rationale for government investment in science and research because the size of the scientific, innovation and technological problem is too large for individual private actors to tackle
- Markets are likely to under-provide standards, regulation and solutions
- The network nature of IoT leads to high spillovers, which lead to the private sector underinvesting in R&D
- Addressing challenges with IoT could reduce barriers to its UK development and adoption; expand or even open new markets
- Academic-led research can inform other publicly and privately-funded IoT projects and interventions
- UK has a strong research base in IoT, but there is scope to improve the wider "innovation ecosystem" – e.g. collaboration and "feedback loops" between academic researchers, industry and IoT buyers and users

Inputs

- Led by University College London, Imperial College London and seven other research institutions, with 60+ public/private/voluntary sector partners in specific projects
- Government funding (DCMS): £9.8m (2016-2018); grants from EPSRC; £13m+ cash and 'in-kind' contributions from consortium partners
- Monitoring and governance by research institutions: PETRAS Steering Board, operations group, research and user group

Activities

- PETRAS IoT Research Hub: large programme of inter-disciplinary, academic-led research
- Numerous projects (one to three years) on "cross-cutting" research themes (privacy, economics/ethics, trust, reliability, acceptability and security); and pilots of IoT applications ("use cases")
- Two 'calls' by the Hub for applications for research funding: the first to address gaps arising from initial projects; the second focusing on impact. Funds from the Hub to further projects aligned to the Hub's research themes
- Knowledge transfer activities, e.g. 'impact champion' roles and events, to assist collaboration with other IoT UK projects, engage research users and policy makers
- Activities to showcase research outputs and outcomes to a wider audience e.g. website, workshops for the public
- Activities to facilitate collaboration between projects, and internships and secondments between participating research institutions and partners

PETRAS Logic Model (ii)

Intended outputs

- At least 20 IoT "use case" pilot projects over three years; with at least two industrial / public sector / end-user partners per project
- Increased funding for research by participants in the Hub from other sources
- Published academic research papers and articles; citations of these by others
- New IoT goods, services or intellectual property developed

Intended outcomes

- Increased understanding of the opportunities and challenges from IoT
- Greater identification and influencing of solutions to opportunities, challenges and risks arising from the development and adoption of IoT applications , e.g. privacy, public trust, security, standards and interoperability, IoT "architecture", social and behavioural barriers
- Increased IoT-related research and development in the UK
- Increased collaboration between the organisations participating in PETRAS and beyond
- Increased awareness and demonstration of PETRAS issues
- PETRAS researchers' work and solutions are available to, and implemented by, policy makers
- Perceived value and relevance of pilot projects by UK and international buyers and suppliers
- Improved management and governance of IoT applications in the UK, e.g. current and potential buyers, suppliers/provider, regulators and policy makers

Intended impacts

- Enhanced reputation of UK IoT-related academic research: UK regarded as international centre of excellence
- Economic impacts (increased UK GVA, employment, productivity, cost savings, exports)
- Increased UK competitiveness within IoT markets
- Social benefits of IoT (health, environmental, social, improved service delivery)

NHS Test Beds Logic Model (i)

Context

- IoT offers enormous potential for improving the performance of products and services, to the benefit of buyers (including in the public sector), suppliers, and citizens
- NHS England's *Five Year Forward View* (2014) introduced 'Test Bed' sites: local projects for health and care innovation
- Test Beds combine technologies and service innovation, testing them together in service delivery and generating evidence in 'live' clinical settings
- Currently seven Test Beds, including two using IoT: Diabetes Digital Coach (West of England) and Technology Integrated Health Management for people with dementia (Surrey)

Rationale for intervention

- The Test Beds Programme seeks to address three problems that have constrained innovation in the NHS: (i) innovations are often implemented in isolation from each other, and from the infrastructure on which they depend (infrastructural failure); (ii) innovations are often introduced on top of existing working practices and infrastructure (network and infrastructural failure); (iii) lack of robust evidence about the effects of innovations in the real world (e.g. clinical settings) as opposed to experimental or research settings (information failure)
- Test Beds aim to address these failures through enabling self-management of health conditions, providing real-time data about a person's health; bringing together different innovations (also leading to spillover effects)
- Reduce barriers and increase opportunities for NHS and business collaboration

Inputs

- Up to £6m government (DoH) funding: grants from Innovate UK
- Two collaborative R&D IoT projects in Surrey (dementia) and the West of England (diabetes)
- Management and governance inputs by sponsors and delivery partners: research institutes, private firms (tech sector) NHS trusts, clinical commissioning groups
- Private firms' cash and "in-kind" investment

Activities

- Test existing technology, e.g. devices, data services, software
- Build and test applications/ labs and platforms to support devices
- Recruit participants and volunteers (e.g. trials)
- Train participants and volunteers
- Conduct technical pilot
- Conduct full trial
- Evaluation of results and reporting
- Develop proposals for future applications of technology
- Communications, including with affected people (with diabetes and dementia) and the general public

NHS Test Beds Logic Model (ii)

Intended outputs

- Devices & platforms used and updated (Surrey: 350 people with dementia [and 350 in control group not using device]; Digital Diabetes Coach (West of England): 12,000 people over two years)
- Production of real-time data
- Evaluation reports
- Proposals for future applications of innovations and technology

Intended outcomes

- Development of new, improved health services and/or more efficient ways of delivering the services (e.g. time/cost)
- Innovators/businesses demonstrate the value of IoT innovations to participating health service/ICT commissioners and other potential buyers
- Increased public sector awareness of the potential benefits of IoT in health and care and the goods/services available
- Improved health/outcomes for participants (service users)
- Increased self-management of conditions by participants (service users)
- Opportunities identified for IoT applications to address NHS requirements
- Improved integration between primary, secondary and social care
- Increased NHS learning capability
- Greater adoption of IoT technologies
- Development of partnerships between public and private sector organisations
- Financial / operational sustainability of the Test Beds

Intended impacts

- Increased UK reputation and competitiveness in health IoT technologies
- Enhanced citizen health and wellbeing
- Economic impacts (increased UK employment due to healthier workers; and time and cost savings for NHS)

Accelerators Logic Model (i)

Context

- IoT offers enormous potential for improving the performance of products and services, to the benefit of buyers (including in the public sector), suppliers, and citizens
- Design and manufacture costs of IoT hardware has fallen in recent years, whilst demand for hardware has increased, driven by falling costs and shift towards cloud-based applications
- The number of start-up businesses and SMEs manufacturing hardware prototypes has increased rapidly, with high demand from these firms for business and finance support, e.g. angel investment, crowdfunding
- Start-up businesses and SMEs find it challenging to get products to markets and grow

Rationale for intervention

- There is information asymmetry and uncertainty as a result of high levels of specialised technical and/or market knowledge relating to IoT hardware which limit firms' access to IoT support (finance, innovation and wider business support)
- Potential to generate positive spillover effects (e.g. network, knowledge) – these externalities are not factored into by private providers of business and innovation support services for IoT hardware businesses
- Capability failure exists where IoT hardware innovators/ firms lack the necessary skills, resources, absorptive capacity to capture opportunities to commercialise products
- Particular challenges arise for these firms between development of hardware protoype, a minimum viable product to manufacturing at scale ("valley of death")
- As a result of these failures, mechanisms are needed to coordinate, manage and focus delivery of IoT technologies, applications and services - including accelerators to help companies overcome challenges
- Incentivise provision of specialist "design to manufacture" services for IoT businesses in the UK

Inputs

- Up to £980k Government (DCMS) funding (June 2016 – March 2017) - Innovate UK procurement. Funds to be determined for possible additional schemes in 2017/18
- Cash and "in kind" contributions from two accelerators: R/GA Ventures and Startupbootcamp

Activities

- The two accelerator schemes IoT hardware businesses to participate
- Two accelerators work with selected small and medium sized IoT hardware businesses (c. 20) over several months
- 'Design-to-manufacture services' for participating IoT hardware businesses, to help them bring their products to market, including: mentoring; legal and financial advice; events (e.g. marketing; software development; hardware design & production); networking with potential business partners e.g. manufacturers, investors, customers; help with securing finance e.g. facilitating access to investors/venture capitalists; presentations by participating businesses; follow-up finance or other assistance
- Communications, e.g. websites, blogs

Accelerators Logic Model (ii)

Intended outputs

- 20 IoT hardware businesses (SMEs) receive support from the two accelerators
- Development by these businesses of their existing prototype technology or products; and their business/investment cases
- No. and type of events and networking opportunities
- At least two participating businesses receive additional (private) funding within year one (from each accelerator)

Intended outcomes

- Increased provision in the UK of "design-to-manufacture" services for IoT hardware SMEs
- Commercialisation of participating businesses' IoT products
- Participating SMEs contribute to / benefit from the wider IoT UK programme
- Increased investment in and business growth (turnover, employment, exports) of participating SMEs
- Increased capabilities of the IoT hardware companies in the development of IoT technologies

Intended impacts

- Increased UK reputation within global IoT markets as a location for IoT innovation and enterprise
- New, potentially high value UK IoT hardware businesses
- Economic impacts (increased UK GVA, employment, productivity, cost savings, exports)

Catapults Logic Model (i)

Context

- IoT offers enormous potential for improving products and services, to the benefit of consumers and suppliers, and public infrastructure
- IoT could generate c.$19 trillion for the public and private sectors globally within the next decade (source: Cisco)
- Digital Catapult (DC) and Future Cities Catapult (FCC) are two of the 11 Catapult Centres in the UK designed to help close the gap between concept and commercialisation, unlock opportunities and reduce innovation risk for innovators, entrepreneurs and SMEs
- DC helps grow UK's digital economy by rapidly advancing UK's best digital ideas to market
- FCC advances urban innovation by bringing together cities, businesses and universities to develop the solutions cities need for a strong economy, resilient environment and an improved quality of life

Rationale for intervention

- Increase the pace of development and adoption of IoT in businesses and the public sector in the UK
- There is risk and uncertainty for IoT firms and the public sector as a result of high levels of specialised technical and/or market knowledge relating to IoT
- Capability failure exists where firms lack needed skills, resources, absorptive capacity to capture the opportunities in IoT
- Institutional failure means new mechanisms are needed to coordinate, manage and focus delivery of IoT technologies, applications and services
- Potential to generate positive spillover effects – these externalities are not factored into by private providers of business support for IoT

Inputs

- Up to £4m Government (DCMS) funding over three years (summer 2015 to March 2018) - grants from Innovate UK to the Digital and Future Cities Catapults, plus 'in-kind' contributions from partners
- Digital and Future Cities Catapult staff and events, services and facilities for UK entrepreneurs and businesses in IoT
- External consultancy services selected through competitive procurement to deliver particular activities

Activities (Digital Catapult)

- Communications to raise awareness of what IoT can do for organisations and encourage adoption of IoT (e.g. case studies showing economic and social impact of IoT implementations in the UK; blogs; research and analysis on IoT activity in the UK; publications (e.g. analysis, guidance); presentations at conferences
- Activity to help accelerate and develop commercial IoT solutions for market - interventions for early stage UK firms and researchers (e.g. "Boost scheme for SMEs"; "clinics"; "thematic research days")
- Co-ordinate, communicate, support and "amplify" the overall IoT UK programme and its projects (e.g. establishing a community of interest; IoT UK website and "brand"; programme management; meetings with UK and international businesses, public sector, investors)

Activities (Future Cities Catapult)

- IoT "investment case toolkit": guidance to assist local authorities in constructing investment cases for IoT interventions
- IoT "performance in use portfolio": methodologies/ impact frameworks to measure the impact of IoT solutions in specific areas (economic, social, environmental)
- Support Manchester CityVerve; use tools and techniques developed by FCC to monitor, analyse and optimise benefits of CityVerve IoT interventions
- "Standards in use" guidance: how city authorities can assess themselves against smart city standards; role of the city council in technology R&D (e.g. demonstrator) projects; resource tool for city demonstrators; communications on the potential of IoT for cities; report on IoT adoption among cities in the UK

Catapults Logic Model (ii)

Intended outputs

- Digital Catapult: no. of publications of different types; no. of events delivered for SMEs and other organisations; no. and types of SMEs participating in events; no. and types of SMEs supported (incl. mentoring); analysis of IoT activity published online; no. and type of presentations; growth of IoT UK community; IoT technologies developed, tested and deployed; programme management, e.g. co-ordination, reports, risk identification and management
- Future Cities Catapult: publication and operationalisation of the Performance in Use Portfolio (impact frameworks); publications of: IoT Investment Case Toolkit; resource toolkit; reports; blogs and short films; no. and types of SMEs engaged with CityVerve; IoT technology tests using CityVerve; IoT opportunities created for cities

Intended outcomes

- Increased UK awareness and R&D and investment in / adoption of IoT technologies and applications, including smart cities
- Commercialisation of IoT technology and products by SMEs
- Improved business and innovation support for IoT SMEs
- Increased trade and investment in and adoption of UK IoT solutions
- IoT UK programme achieves "more than the sum of the parts", e.g. collaboration/ knowledge-sharing between projects and participants; SME participation; opportunities for SMEs in R&D projects; communications

Intended impacts

- Increased competitiveness and global reputation for UK in IoT markets
- Economic impacts (SME growth, increased UK GVA, employment, productivity, exports)
- Wider social benefits (health, environmental, improved service delivery