

**Buried Infrastructure Performance**

**I. Knowledge: Understanding Performance**

**A.** **Pervasive Instrumentation (BIP-7)**

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| Project number | BIP-7 (Version March 2015) |
| Priority and Duration | High priority, short duration |
| Project title | Pervasive Instrumentation |
| Aims | Complete network coverage – infrastructure & products (direct or indirect measurement)  Low cost  Self-powered |
| Why is this project important? | Universal network condition and performance |
| Who would do this project? | Supply chain led with university/utility |
| What funding mechanism? | Innovate UK, EU, Venture Capital |
| Time scale (years) | 3-5 |
| Benefits to industry | Proactive investment/maintenance  Influence regulation |
| Notes on Methodology | Narrow band tech, whole life cost |
| Volunteers from 13 March | Mike Morris, Matthew Kendall |

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| Project number | BIP-7 (Version July 2015) | |
| Project Title | Pervasive Sensing 1 | Pervasive Sensing 2 |
| Aims | Combine existing sensor technologies for static implementation to proactively maintain and monitor the underground infrastructure of waste and clean water networks to minimise human intervention and works toward zero failures. | Develop a robotic swarm sensor to proactively maintain and monitor the underground infrastructure of waste and clean water networks to minimise human intervention |
| Why is this project important? | To enable the live monitoring of network performance and allow for preventative measures to be undertaken rather than reactive. To minimise capital maintenance costs. | To enable the live monitoring of network performance and allow for preventative measures to be undertaken rather than reactive. To minimise capital maintenance costs. |
| Who would do this project? | Consortium led by Sheffield University, consisting of a team including:  - Water Company representatives  - Key Suppliers (contractors) | Consortium led by Sheffield University, consisting of a team including:  - Water Company representatives  - Key Suppliers (contractors) |
| Methodology | Combination of commercially available low cost sensors for permanent attachment to water pipes, energy harvesting for self-power, communications system sending data to base station for subsequent analysis.  Phase 1 (1 year):   * Market analysis of existing sensors * Undertake feasibility study to determine necessary data available collection from network assets   Phase 2 (1 year)   * Development of sensory prototype * Identification of methodology for collation of data   Phase 3 (1 year)   * Field testing of sensory prototype to determine performance characteristics and accuracy of data * Plan for implementation | To develop a nanotechnology sensor chip to be implemented within existing clean and waste water environments. Develop a delivery mechanism to be autonomous, low power, energy harvesting, robust and self-sufficient. Develop a communication mechanism for to convey information to a centralised network hub for analysis and decision making processes.  Phase 1   * Development of nanotechnology sensor chip   Phase 2   * Development of organisms for distribution of nanotechnology sensor chip   Phase 3   * Communication output of data from within network for analytics   Phase 4   * Prototyping and field demonstration trials |
| What funding mechanism? | Industry funding | Horizon 2020 |
| Time Scale (years) | 3 Year, 3 phases as listed | 5 years |
| Benefits to industry | Preventative measure for active monitoring of water networks | Autonomous and intervention free monitoring of live network  New materials with potential application within other fields |
| Actions | * Group to develop a new name for the project * Richard Long and Kirill Horoshenkov to recruit additional members * Kirill Horoshenkov to find additional nanoelectronics experts and pursue other funding options (pending results of Grand Challenges bid) | |

**B. Visualisation of Performance (BIP-9)**

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| Project number | BIP-9 |
| Priority and Duration | Medium priority, short duration |
| Project title | Visualisation and Understanding of Performance |
| Aims | New technologies for data visualisation and performance for buried infrastructure and wider aspects of water [e.g. develop Google Traffic map for water systems] |
| Why is this project important? | Unable to manage proactively  No appreciation then can’t value  Effective prioritisation of investment |
| Who would do this project? | Computer scientists/engineers  Supply chain  System analysts from other domains (e.g. traffic, weather) |
| What funding mechanism? | EPSRC + sensor companies + data services companies |
| Time scale (years) | 3-5 years |
| Benefits to industry | Helps public value and understand water if they can access visualisation  Reduce failures |
| Notes on Methodology | Define the metrics (predictors)  Current status |
| Volunteers from 13 March |  |

**C. 3D Modelling (BIP-4)**

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| Project number | BIP-4 |
| Priority and Duration | High priority, medium-long duration |
| Project title | 3D Hydrology (incorporating spatial and temporal variation + joint probability) |
| Aims | Produce methods/algorithms to enable ‘real-world’ hydrology to be simulated / predicted |
| Why is this project important? | All current models are based on simplified 1D methods. This has a significant impact on the reliability / applicability of current models. |
| Who would do this project? | University / CEH |
| What funding mechanism? | EPSRC |
| Time scale (years) | 3-5 years |
| Benefits to industry | To produce technique that will be ‘fit for purpose’ for future uses such as managed flood risk |
| Notes on Methodology | Many need to be stochastic or risk based |
| Volunteers from 13 March | James Shucksmith, Paul Davies, Chris Digman |

**D.** **Revolutionary Sensing Technology (BIP-11)**

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| Project number | BIP-11 |
| Priority and Duration | High priority, short duration |
| Project title | Revolutionary Asset Monitoring, Sensing and Assessment Technology |
| Aims | Develop remote, autonomous, cheap ‘data’ and intelligence collection devices |
| Why is this project important? | To increase coverage of intelligence collection  Informing predictive data analytics  Enabling remote intervention  Enabling real-time risk centred maintenance |
| Who would do this project? | Universities  Supply Chain  WaSC |
| What funding mechanism? | Partnership between industry, supply chain  Other industries e.g. oil, gas, aerospace  Potentially external leverage (EU/EPSRC) |
| Time scale (years) | 2-3 years to develop concept  5-15 years to commercialise |
| Benefits to industry | Increase understanding of asset performance and condition – moving from reactive to proactive  Reducing service failure and OPEX |
| Notes on Methodology |  |
| Volunteers from 13 March | Stuart Wrigley, Henriette Jensen, Leo Carswell, Tom Hodgson, Steve Mounce, Kirill Horoshenkov, Rob Edwards |
| Status | Has been included in EPSRC Grand Challenges Bid (April 2015), funding decision pending |

**E.** **Data and Analytics (BIP-12)**

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| Project number | BIP-12 (Version March 2015) |
| Priority and Duration | High priority, short duration |
| Project title | Data and Analytics  Collecting the right data at the right time to inform network performance and failure models to enable and optimise prescriptive analytics |
| Aims | Informing the type, quality and frequency of data collection and what technology is needed to collect the data.  Developing prescriptive analytics tools |
| Why is this project important? | Transforming network management, enabling real-time monitoring, remote control / autonomous smart networks and optimised investment decisions |
| Who would do this project? | University  WaSC  Consultant partners  IT/Technology providers |
| What funding mechanism? | Industry |
| Time scale (years) | 1-5 years |
| Benefits to industry | Reactive -> Proactive  Reducing OPEX  Optimising CAPEX investment  Reducing service failure |
| Notes on Methodology | Compile the existing knowledge on analytics – sharing across companies |
| Volunteers from 13 March |  |

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| Project number | BIP-12 (Version July 2015) |
| Priority and Duration | High priority, short to medium duration |
| Project title | MARVIN – Maximising All Residual Value In Networks data |
| Aims | Maximising the value and use of existing data and analysis   * Integrate water company data and external data sources and results of current analysis (temporal and spatial data- customer contacts, hydraulic model results etc.) * Technologies for data visualisation for buried infrastructure - accessible and simple to use * Novel presentation of integrated data * Data amalgamation using dashboards, trending… * Demonstrate the value of data   Set the agenda for next generation of:   * data collection strategies for Big Data (macro v micro).   + Informing the type, quality and frequency of data collection and what technology is needed to collect the data.   + Collecting the right data at the right time to inform network performance and failure models to enable and optimise prescriptive analytics * new predictive analytics * knowledge discovery * derived intelligence from future data * gamification of datafication |
| Why is this project important? | Foundation work for transforming network management, enabling real-time monitoring, remote control / autonomous smart networks and optimised investment decisions  Increased value (understanding, efficiencies, optimisation, insight into ‘big picture’ – new correlations and relationships, emergent properties…) of data  Drive informed strategies  Gap analysis  Data driven real time proactive applications  Reporting and trending for tracking performance  Removing manual laborious data interpretation  Transforming network management, enabling real-time monitoring, remote control / autonomous smart networks and optimised investment decisions |
| Who would do this project? | Microsoft, WRc, UoS, WSP(s) |
| What funding mechanism? | KTP 2 years (WSP + MS?)  Direct industry funding |
| Time scale (years) | Initial Phase – mock-up workshop.  1-2 years foundation project with WSP on board. |
| Benefits to industry | Added value to existing data  Helps WSP value and understand their data if they can access and visualise integrated data  Helps them run their networks better |
| Notes on Methodology | 1 or 2 day workshop to mock-up project outputs and define value and benefits  Use outputs to engage and convince WSP partner   * Obtain a leading advocate in the business   Produce project specification to secure funding as appropriate   * Engage across the business * Data security statement / strategy to tackle Cloud issues   Obtain data  Populate MS Cloud based systems  Demonstrate ML analytics  Prove benefits with metrics |
| Volunteers | SRM, JBB, MRB, PF |
| Actions | * Steve Mounce to collate notes and refine the project description * Pip Fox to organise a workshop at Microsoft (as described above) * Vanessa Speight to circulate the revised version and workshop details to recruit participants |

**II.** **Economic: Paying for Performance**

**A.** **Public Value of Water (BIP-10)**

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| Project number | BIP-10 |
| Priority and Duration | Low priority, short duration |
| Project title | Public Value of Water - ‘Water Star’ |
| Aims | Increase public awareness of water to support investment into entire water systems, avoid wasting water, etc. |
| Why is this project important? | Underlying all aspects of water  Other initiatives (e.g. performance visualisation) need this for ultimate success  Willingness to pay drives investment |
| Who would do this project? | Social scientists  Environmental groups  Advertising / celebrity / social media |
| What funding mechanism? | Research Council with participation from water companies, local councils, UKWIR |
| Time scale (years) | 2-3 years |
| Benefits to industry | Support and finance initiatives to improve water systems  Need people involved for real change |
| Notes on Methodology | Water (embedded water) certification like energy rating  Apps for customers to see their smart meter data, games, etc.  Research best ways to increase awareness  Show the bad things as well as good -> shock value, FOG  Metric for success = rate increases supported in next AMP  [Links to No Pipes/Grand Challenge BIP-1/2/3] |
| Volunteers from 13 March | Vanessa Speight, Jon Morris, Kirill Horoshenkov, Stuart Wrigley |

**B.** **Cost-Benefit Analysis of Data Collection (BIP-8)**

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| Project number | BIP-8 |
| Priority and Duration | Medium priority, short duration |
| Project title | Cost-Benefit Analysis of Data Collection |
| Aims | Understand water data to collect, when and where? |
| Why is this project important? | Overcome reluctance to deploy sensors  Understand the cost of data to correctly use it – value of open source?  Reliability, risk need to be quantified |
| Who would do this project? | Research – risk + economics, data + engineers  Policy to support investment, data sharing |
| What funding mechanism? | Research Councils + partners |
| Time scale (years) | 1-2 years per sector, several sectors at once or in sequence? |
| Benefits to industry | Supports decisions to invest in sensors  Good decisions at a lower cost |
| Notes on Methodology | Identify current state of the art and costs (mobile + stationary sensors)  Question metrics – is there a better indicator of performance, e.g. temperature?  Model deployment options and communications  Maintenance plus data costs  Develop a standard data framework for interchanges, etc.  [Links to 3D Hydrology, BIP-4: data needs to support modelling should be included] |
| Volunteers from 13 March | Steve Mounce, Matthew Kendall, Kirill Horoshenkov, Steve Fozard, Craig Gaughan, Paul Davies, Leo Carswell |

**III.** **Technology: Improving Performance**

**A.** **Live, No-Dig, Low-Cost, Rehabilitation (BIP-5, BIP-6)**

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| Project number | BIP-5 |
| Priority and Duration | High priority, medium duration |
| Project title | Live rehabilitation technology [similar in concept to BIP-6] |
| Aims | No dig  Live  Rehabilitation |
| Why is this project important? | No traffic disruption  Reduce cost  Reduce customer interruption  Quality, capacity, leakage |
| Who would do this project? | University and supply chain |
| What funding mechanism? | RCUK, Innovate UK, EU |
| Time scale (years) | 5+ |
| Benefits to industry | Reduce cost, avoid replacement, improve performance |
| Notes on Methodology | Robotics – hardware project  Require test bed (UKCRIC) |
| Volunteers from 13 March | Joby Boxall, Paul Rutter, George Ponton, Kirill Horoshenkov, Mike Morris, Craig Mauelshagen |

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| Project number | BIP-6 |
| Priority and Duration | High priority, medium duration |
| Project title | More efficient/cost-effective network rehab and repair technology [similar in concept to BIP-5] |
| Aims | Develop cheaper, quicker rehab and repair technologies  Live, remote repairs  Self-healing pipes |
| Why is this project important? | Reduce service failure, bursts, leaks, collapses, supply interruptions (customer minutes lost) |
| Who would do this project? | Universities  Supply Chain  WaSC |
| What funding mechanism? | WaSC / Supply Chain / external leverage |
| Time scale (years) | 1-5 years |
| Benefits to industry | See project importance |
| Notes on Methodology |  |
| Volunteers from 13 March | Joby Boxall, Paul Rutter, George Ponton, Kirill Horoshenkov, Mike Morris, Craig Mauelshagen |

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| Project number | BIP-13 (New Project June 2015) |
| Priority and Duration |  |
| Project title | In Network Treatment |
| Aims | Understand the potential for using the network for treatment activities in both water and wastewater systems |
| Why is this project important? |  |
| Who would do this project? |  |
| What funding mechanism? |  |
| Time scale (years) |  |
| Benefits to industry |  |
| Notes on Methodology | Hold a problem definition workshop sometime in autumn 2015 with suppliers, water companies, British Water, etc. |
| Volunteers |  |
| Actions | * Henriette Jensen to complete project description based on notes from workshop |

**IV.** **Reimagine Water Systems (BIP-1, BIP-2, BIP-3)**

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| Project number | BIP-1 |
| Priority and Duration | High priority, very long duration |
| Project title | Fewer Pipes (Managed by the Water Company) [similar in concept to BIP-2 & BIP-3] |
| Aims | Understand moving to an integrated water cycle / economy [with water supply/treatment at household level] |
| Why is this project important? | Do we have enough money for sustained growth?  Solutions to maximise benefit |
| Who would do this project? | Water company  Academics  Regulators |
| What funding mechanism? | Defra  EU  Industry  Innovate UK |
| Time scale (years) | 1-5 years |
| Benefits to industry | Is our current implementation correct?  Save future OPEX  Reduced CAPEX / energy  Sustainable development  Integrated water cycle |
| Notes on Methodology | Does the industry and regulatory framework support this? |
| Volunteers from 13 March | Steve Mounce, Andy Palmer, Graham Charnley, Matthew McEwan, Richard Kershaw, Vanessa Speight, Virginia Stovin, Joby Boxall, Emma Westling, Liz Sharp, Craig Gaughan, Rob Edwards, Matt Jones, Neil Runnalls, Kirill Horoshenkov, Issy Caffoor, Peter Drake, Catherine Biggs |
| Status | Aspects of this project related to treatment technologies to support different potential water uses have been included in EPSRC Grand Challenges Bid (April 2015), funding decision pending |

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| Project number | BIP-2 |
| Priority and Duration | High priority, very long duration |
| Project title | No (Little) Buried Infrastructure [similar in concept to BIP-1 & BIP-3] |
| Aims | How to continue to live with inadequate investment in infrastructure, including SUDS, rainwater harvesting, etc. |
| Why is this project important? | Timebomb!  Catastrophic failure impending |
| Who would do this project? | Management school? Interdisciplinary teams, urban planning |
| What funding mechanism? | EPSRC Grand Challenge |
| Time scale (years) | 5+ |
| Benefits to industry | Helps plan migration from current infrastructure model |
| Notes on Methodology | Social science, technical, funding, planning |
| Volunteers from 13 March | Steve Mounce, Andy Palmer, Graham Charnley, Matthew McEwan, Richard Kershaw, Vanessa Speight, Virginia Stovin, Joby Boxall, Emma Westling, Liz Sharp, Craig Gaughan, Rob Edwards, Matt Jones, Neil Runnalls, Kirill Horoshenkov, Issy Caffoor, Peter Drake, Catherine Biggs |
| Status | Aspects of this project related to treatment technologies to support different potential water uses have been included in EPSRC Grand Challenges Bid (April 2015), funding decision pending |

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| Project number | BIP-3 |
| Priority and Duration | High priority, very long duration |
| Project title | Distribute 2nd Grade Water in terms of quality, quantity and pressure [similar in concept to BIP-1 & BIP-2] |
| Aims | Develop point of use treatment  Establish quality requirements linked to use – redefining fit for purpose  Establish economic case |
| Why is this project important? | Enables cost effective use of existing asset base  Challenges current practice |
| Who would do this project? | Universities – engineers, social, economic |
| What funding mechanism? | RCUK |
| Time scale (years) | 5+ |
| Benefits to industry | Reduce cost of treatment  Reduce cost of water distribution |
| Notes on Methodology | Interdisciplinary |
| Volunteers from 13 March | Steve Mounce, Andy Palmer, Graham Charnley, Matthew McEwan, Richard Kershaw, Vanessa Speight, Virginia Stovin, Joby Boxall, Emma Westling, Liz Sharp, Craig Gaughan, Rob Edwards, Matt Jones, Neil Runnalls, Kirill Horoshenkov, Issy Caffoor, Peter Drake, Catherine Biggs |
| Status | Aspects of this project related to treatment technologies to support different potential water uses have been included in EPSRC Grand Challenges Bid (April 2015), funding decision pending |

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| Project number | BIP-14 (Version July 2015)  Combination of BIP-1, 2 & 3 from March 2015 |
| Priority and Duration | High Priority, Short Duration – High level overview / assessment of the opportunities, challenges and benefits |
| Project title | Reimagining the water system |
| Aims / What would the project do? | Develop a blueprint for the water system of the future (new build / retrofit / both?)   * Understanding Global best practice   + decentralised water supply/treatment   + SUDS   + Alternative raw water sources   + Grey water reuse   + 2nd Grade Water in terms of quality, quantity and pressure   + Minimising energy consumption   + Maximising energy generation   + Minimising resource use   + Maximising resource recovery * Understanding the global art of the possible * This project focuses on fundamental redesign / fantasy land rather than doing something better with what we’ve already got (which is the focus of other projects). * Rationalising the asset base * Modelling scenarios to establish the economic case (Opex, Capex (TOTEX), impact on RCV) and benefits (cost, environmental) and risk (public health, perception) * Developing a ‘pick list’ of technology, processes, opportunities, costs, benefits and risks. * Outline Stakeholder mapping |
| Why is this project important? | Aging infrastructure  Increasing energy costs  Resource scarcity / increasing costs  Current and future environmental, social and economic challenges |
| Who would do the project? | Water companies  Research orgs (Academia / Consultants) |
| What funding mechanism? | Research councils  Local Enterprise Partnerships  Water companies  Feasibility / Scoping / Modelling = an enabler towards implementation = Innovate UK |
| Time scale (years) | 1-2 years |
| Benefits to industry | Addressing current and future asset performance, cost, environmental and social challenges (affordability, climate change, depleted resources, energy costs).  The system is easier to run and more reliable  No out of hours failure  Always does what it’s designed to do  Reducing stress, improving health and well-being  Less complicated, rationalised system  More reliable system – less external regulatory pressure  A plan for the future to be proactive about opportunities and guiding / informing other developments. – Urban planning follows the water system plan. |
| Blockers / Challenges | Defining the scenarios / solution options.  Appetite for implementation of a fundamentally different approach and do the economics actually stack up?  Assess who benefits from the changes?  Focus on domestic, commercial, industrial and / or agricultural?  Risks - public perception (dual-supplies = reduced level of service) and health risk of getting it wrong (eg. cross-connection of dual-supplies) |
| Methodology | Step   1. Develop the methodology, aims, objectives and potential benefits 2. Identify Partner organisations (e.g. JRF / Kier, others) 3. Identify funding options 4. Global technology tour 5. Define scenarios – technical / process options. 6. Understanding technical performance, cost, benefit and risks of the technologies / systems / processes in different conditions / environments and limitations of use for different users. 7. Develop the blueprint 8. Communication and Education – the big ‘sell’ – Regulators, Industry, Schools   Phase 2   1. Demonstration site |
| Actions | * Group led by Vanessa Speight to recruit additional members including Big social landlords, builders, manufacturers of water technologies- Circle Housing, Peabody Trust, others * Vanessa Speight to research Innovate UK requirements and determine applicability |