F150 First Floor, Cherwell Business Village, Southam Road, Banbury OX16 2SP
t +44(0)20 7235 7938 **f** +44(0)20 7235 0074 **e** hqsec@pipeguild.com **www.pipeguild.com**

2022 TECHNICAL AWARDS ENTRY FORM

Entry Deadline: Friday 22nd April 2022

Please tick which categories you are entering (entries may be submitted in multiple categories)

Landbased Pipeline Project Award	☐
Landbased Pipeline Technology Award	**x**
Utility Pipeline Project Award	☐
Utility Pipeline Technology Award	☐
Subsea Pipeline Project Award	☐
Subsea Pipeline Technology Award	☐
iICE Award	☐

1. **Brief title of entry:** AquaSpira SmartSense : an intelligent pipeline for large-scale infrastructure projects.
2. **Company name:** Aquaspira Ltd
3. **Signed:** 
4. **Date:** **21/04/2022**
5. **Company contact name:** **Neil Wallace**
6. **Telephone:** **01282 608510**
7. **Email:** **nw@aquaspira.co.uk**

8. **Precis of your entry (50 words):** The Aquaspira SmartSense pipe is the first, large-scale water transport/drainage system to incorporate embedded condition sensing technologies in a bespoke, configurable form with Digital Twin capability. The composite steel reinforced SmartSense pipe utilises recycled HDPE and steel materials in its construction and is designed for use with as-dug backfill materials.

9. **Summary of entry:**

Funded by a £260,000 Innovate UK Sustainable Innovation Award in 2021, SmartSense is the latest research innovation from an on-going partnership between Aquaspira Limited and the University of Birmingham. With the aim of developing the next generation of drainage systems capable of autonomous asset/pipeline monitoring, SmartSense's technical novelty lies in the user-configurable embedded sensing capability where different sensing technologies can be integrated into current pipeline products at the manufacturing stage. These can include the latest in fibre-optic strain and temperature, soil moisture

& compaction, linear strain & displacement, vibration and water flow/depth/temperature. Sensing configurations can be designed, verified and tested at the pre-manufacture stage using SmartSense's unique Digital Twin co-product that utilises sophisticated, high-accuracy Finite Element (FE) models of the whole pipeline system (i.e., the pipe, sensors, backfill materials and pipeline installation setting) to create a digital replicant of the proposed pipeline installation. No other pipeline technology can achieve this, making SmartSense a unique product differentiator to its competitors in the market and setting future standards for the industry.

SmartSense is rooted in robust testing with current demonstration units designed for safety-critical, high-risk parts of the national rail and road network with dynamic strain and deformation sensing being used to monitor pipeline loading, backfill compaction and longer-term soil movement. Focusing on the road/rail network that is susceptible to slope and soil instability, operational units are being performance evaluated in trials at the National Buried Infrastructure Facility at the University of Birmingham where the comprehensive testing data has been used to verify the FE models and optimise the Digital Twin design for specific user cases. A current collaboration with Network Rail's Asset management team is developing the SmartSense product line further with drainage pipeline designs incorporating additional sensing for water level, flow and sediment fill that will link in with asset maintenance and monitoring systems; therefore improving network performance, reducing down-time and lowering maintenance costs. Additionally, SmartSense provides network operators with remote verification of their asset performance reducing the need for physical inspection (i.e., less 'walking the track') and therefore improved operational safety.

SmartSense also has a sustainable design with long-lifetime, environmentally robust materials. Current products are able incorporate recyclability of up to 100% steel and 80% HDPE with in-house analysis on these materials providing comprehensive, real-world performance data for the Digital Twin FE models. SmartSense pipes can be manufactured off-site in modular, easily deployed units and, importantly, have the benefit of being uniquely designed for use with construction waste (soil, crushed rubble, etc) or as-dug materials as the backfill without loss of pipeline performance. This not only provides significant per-metre embedded decarbonisation over other pipelines (estimated as a 6-fold reduction in kg CO_2 / tonne at the same cost point) but also enhances construction site sustainability with the incorporation of recycled materials in the pipe's on-site installation.

SmartSense represents the next-generation of pipeline technology with significant carbon reduction (towards net zero for 2050) and the necessary level of monitoring/sensing capability for infrastructure owners to autonomously monitor the condition of their assets. The Digital Twin co-product provides the data-based requirements needed for compatibility with future maintenance and performance monitoring systems (i.e., paving the way for virtual and augmented reality applications) and accurate BIM-compatible data for construction sustainability and life cycle assessments. SmartSense is notable in the sector as it is the only pipeline system aligning with the Digital Built Britain programme of the 2017 BEIS Industrial Strategy where new infrastructure construction products are expected to have fully BIM-compatible components incorporated into their design phase. Current competitive pipeline products do not have this level of digital sophistication and the sector will benefit from the innovation and knowledge SmartSense will generate for all future buried infrastructure projects.

For Aquaspira Ltd, the SmartSense research programme has significantly increased the company's competitiveness, market reach and revenue with an estimated 30% increase turnover for 2022. By placing Aquaspira as the UK's leaders in composite pipeline technology, SmartSense's success has fostered innovation and facilitated product diversification into a larger, more sustainable and Covid-resilient market with the benefits evidenced by new high-value, clients such as Network Rail, Thames Water and Anglian Water. Crucially, it has allowed the company to recruit new staff, up-skill the local workforce and ensure growth in a region that has been socio-economically affected by the pandemic.

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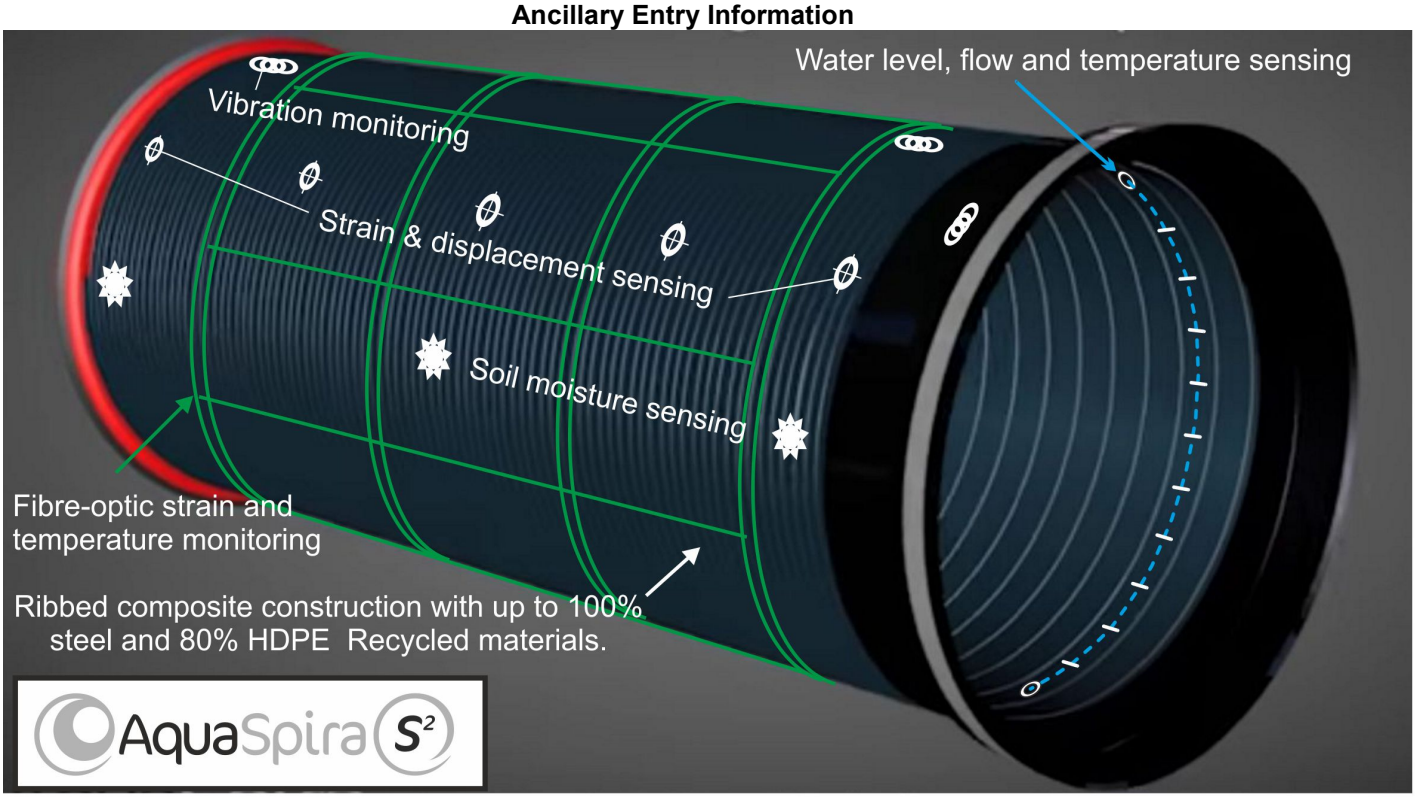
Ancillary Entry Information



Aquaspira SmartSense - embedded sensing design principle : user-configurable sensing can be incorporated into any part of the modular pipeline unit to provide bespoke sensing for case-specific applications. Sensing for soil moisture, strain (fibre-optic or strain gauges), vibration, temperature, water flow, level, etc., can be incorporated into the pipeline at the manufacturing stage. Digital twin finite element models are used to evaluate sensing performance and optimise the SmartSense sensor configuration design prior to manufacturing. SmartSense units can be modular using existing standard pipe section or fabricated as bespoke units.

Aquaspira SmartSense - Product performance evaluation : 1.8m Diameter SmartSense Pipeline units undergoing performance trials at the National Buried Infrastructure Facility, University of Birmingham. SmartSense units were subjected to multiple dynamic loads with deformations of up to 60mm at the crown. Sensing included embedded fibre-optic stain, linear strain and displacement, as well as load and deflection. Data was used to optimise sensor configuration and inform designs for drainage applications on high-risk national infrastructure projects.

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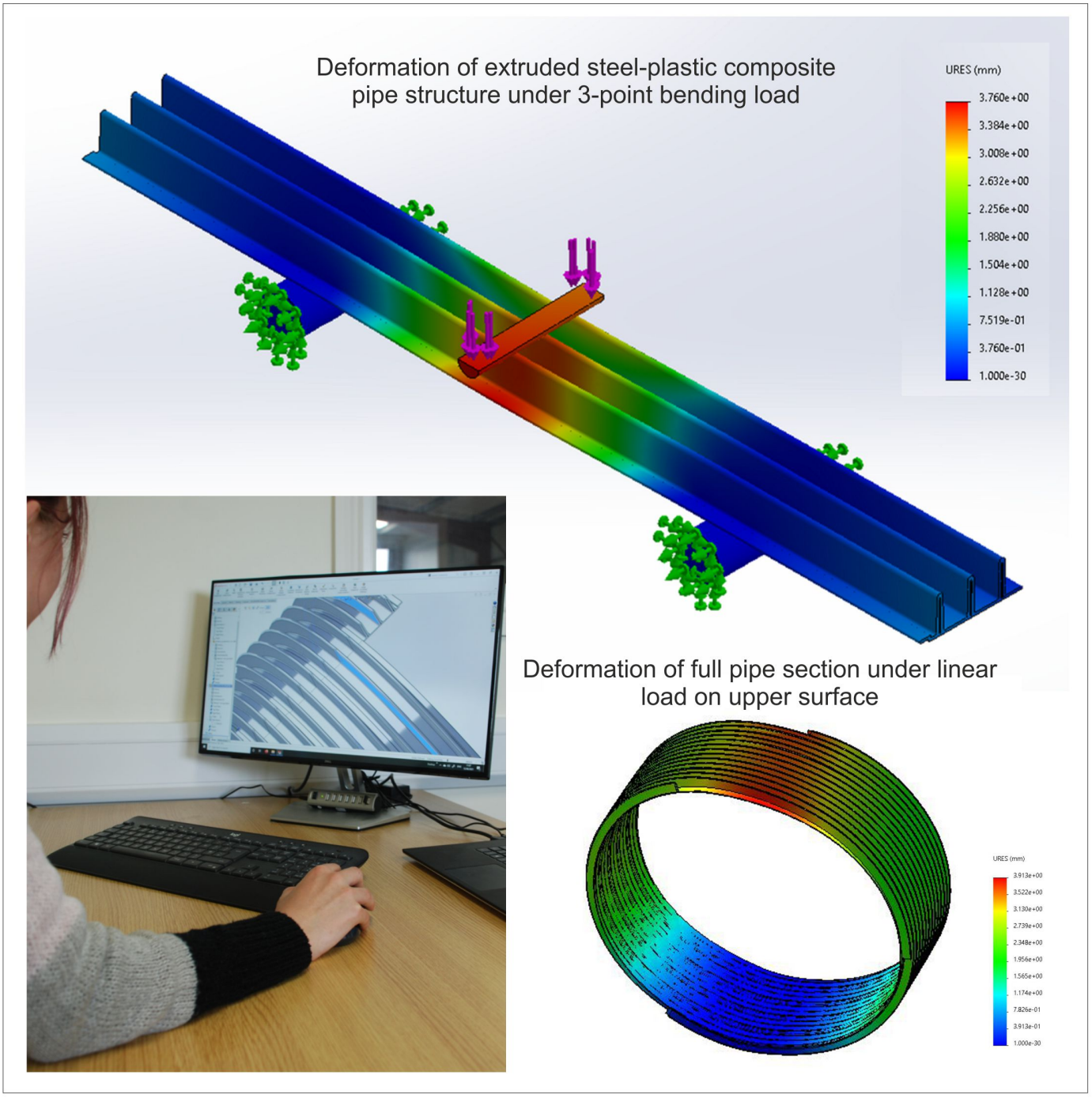

Aquaspira SmartSense Digital Twin co-product : Digital Twin finite element models allow for the high-resolution performance evaluation of the SmartSense pipe, its sensors and the environment around the pipe (backfill, installation setting, etc). The Digital Twin is used to determine the deformation under expected load conditions and evaluate the degree of strain, etc. Models can be developed for individual component parts (e.g., manufactured structures or sensor locations) and/or whole units (i.e., a full pipe or bespoke fabrication). Digital Twin models are formulated to link in with site or test sensor data in order to be up-datable and dynamic to changing pipeline conditions.

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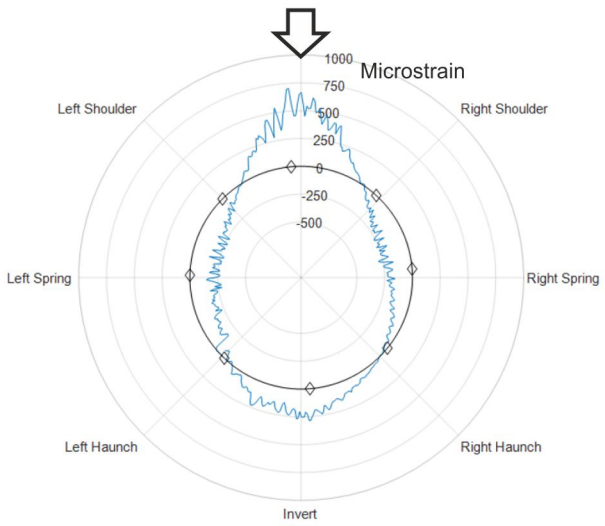
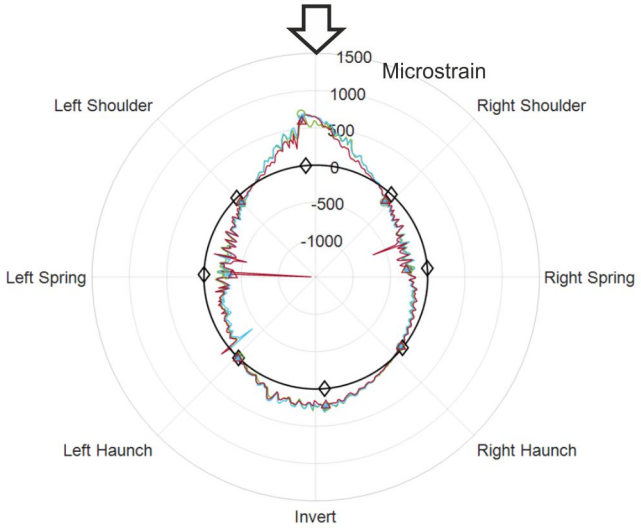
Axial, linear load at Crown
Static load with 10mm displacement



Microstrain values from circumferential fibre-optic sensor. Values show static value of strain for 10mm deformation at the crown.

Axial, linear load at Crown
Dynamic load with 10-20-30mm displacement



Microstrain values from circumferential fibre-optic sensor. Values show relative change in the value of strain for 10mm incremental increases in deformation at the crown.

Aquaspira SmartSense - Example data : Example of SmartSense's data stream from the embedded fibre-optic sensing capability. Figure shows the microstrain data collected from a circumferential embedded fibre-optic located under a point of load (axial & linear at the crown in this case). The two scenarios illustrate the high-resolution, high-precision strain data (i.e., 10s of microstrain accuracy at centimetre spatial resolutions) that can be obtained as the pipe is loaded from low to high levels of deformation displacement.