SOLENT LEP
INNOVATION PROGRAMME FUND

Application for the funding of a Supply Chain Technology Development Project, led by Kelda Technology.

31 October 2017

Submitted by:

Kelda Technology (Lead Applicant)
Trimline
SO3D
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University of Southampton

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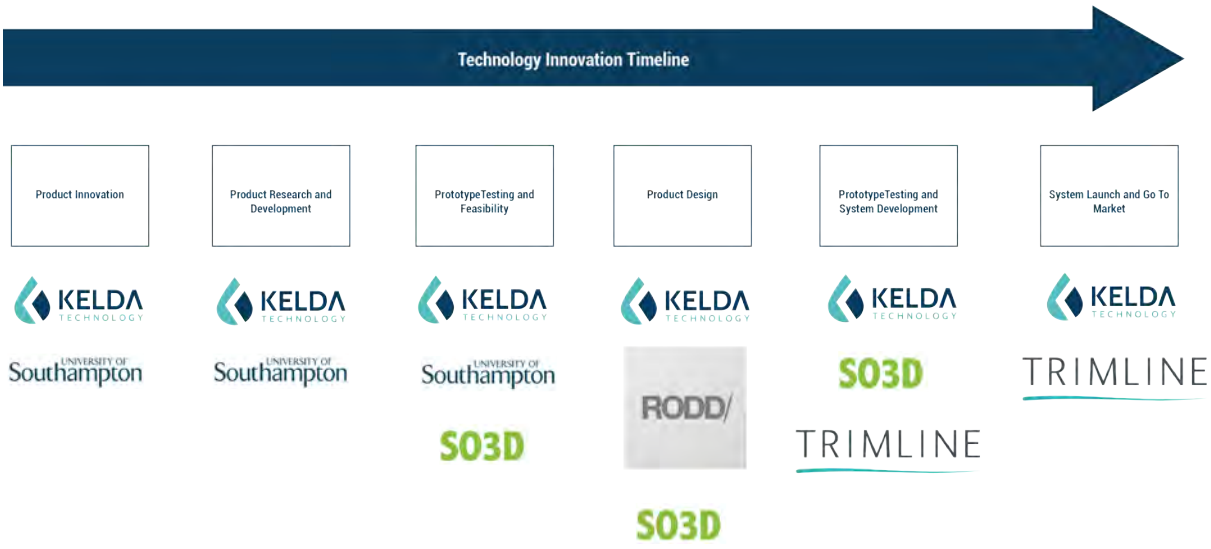
1. Executive Summary

Kelda Technology is the lead applicant for grant funding from the *Solent LEP Innovation Programme Fund*, with a *Supply Chain Technology Development Project* led by Kelda Technology, in partnership with three Solent based businesses - Trimline, SO3D and Rodd Design, alongside the University of Southampton.

This Supply Chain Technology Development Project covers technology development from inception through to market entry:



The goal of the project is to allow our innovative technology to be taken to new markets at scale, enabling access to a sales pipeline valued at more than £37million and markets with nearly £11billion in value globally. The project addresses two of the region's skills challenges by focusing on clean technology and the Internet of Things (IoT), whilst also creating a successful local supply chain from product innovation through to smart manufacturing.

The project offers immediate impact through rapid market entry and a robust and evidenced sales pipeline. In short, funding of this project will act as an enabler for Kelda Technology to transition from being a company forecast to achieve revenues of £3million in 2018, to one capable of achieving £30million within 3 years.

Demand and justification for this ambition is outlined later in this grant submission and we are forecasting a value for money of over 4:1 in directly attributable revenue, plus significant local high skilled employment creation.

Against a backdrop of global water scarcity and water stressed regions, Kelda Technology is the pioneer of water in air shower systems that are independently proven to reduce energy consumption, carbon and water consumption by 50% compared to traditional showers, without compromising user experience.

Research and development in partnership with the University of Southampton has been in progress since company formation in 2009 and today, the company has a global layer of patents protecting its innovation and a commercially proven product in market.

The Kelda Technology Shower System is comprised of three components – a digital control module providing the 'brains' to calculate the optimum mix of air and water, an air module providing the air and a patented five nozzle head that mixes and accelerates the shower spray.

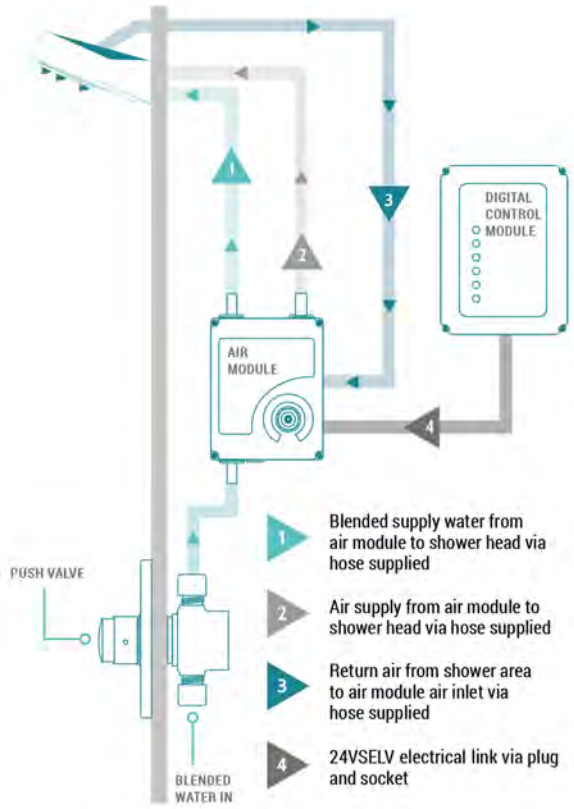


Illustration 1.1 – The Kelda Technology Shower System

Core Intellectual Property resides in the shower head and we currently have 12 patents granted and 14 pending. Full coverage can be seen in Table 4.1- Patent Coverage.

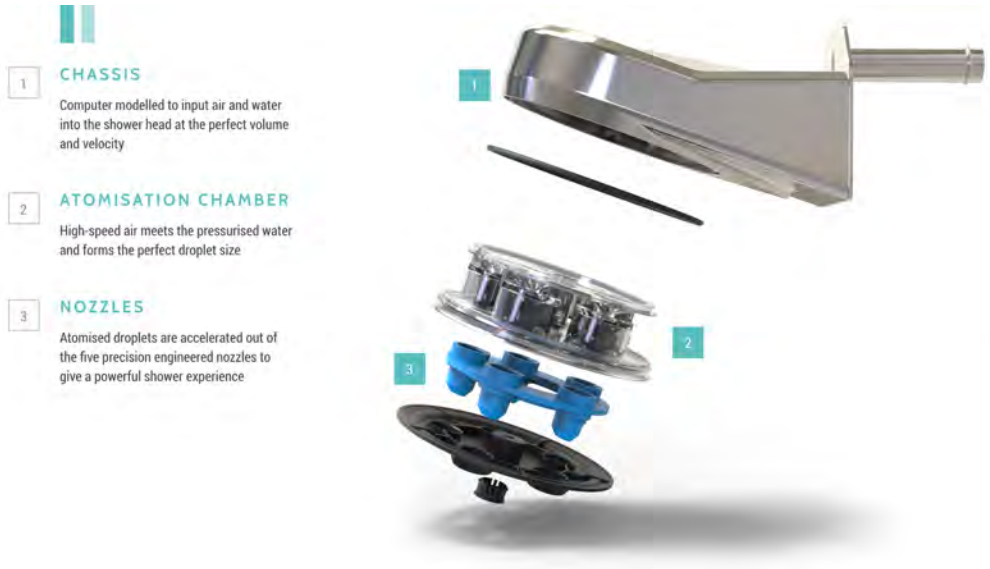


Illustration 1.2 – Kelda Shower Head

Currently we design, manufacture and sell shower systems to end user customers at a Manufacturer List Price of between £600 and £800 depending on configuration - these customers are exclusively within the gym and leisure sector, utilising our launch model shower system to drive down water and water heating costs across their estates.

The key benefits of the Kelda Shower System over traditional shower products are:

Illustration 1.3 – The Benefits of the Kelda Technology Shower System

In less than 12 months since our commercial launch, Kelda Technology has gained rapid traction for the water saving shower system in the UK and Brazilian gym and leisure sector, securing Pure Gym and SmartFit as lead customers (the largest UK and Latin American gym chains respectively), alongside pilot programmes with businesses such as Virgin Active, Nuffield Health, Bannatyne and various local authority leisure providers.

Savings for large scale operators using Kelda shower systems are in excess of £1m each and every year - our efficiency and health claims have been independently and scientifically assessed by subject matter experts:

University of Southampton

"It is confirmed that over the duration of the trial that the Kelda Technology shower system saved 50.3% of the water used by the traditional gym showers."

Professor John S Shrimpton BEng, PhD, DSc, CEng, FIMechE, University of Southampton

Department of Health

"Kelda Technology has been assessed and proven to be six times less likely than ordinary and twenty times less than aerating showers to cause Legionella."

Dr T. Makin, Legionella Advisor to the Department of Health

Due to these benefits and the market traction so far, additional demand has come from exciting, new and much larger market sectors. These sectors include maritime, hotel and student accommodation and domestic developers who, like the gym and leisure sector, are also water intensive and water conscious operators. These market opportunities are truly global and collectively ten times larger than the single market which we currently access. To access these markets, product development is required – in shower spray pattern, shower head articulation, system configuration and in product design. These improvements are essential to progress market entry beyond feasibility assessments and pilots.

To maximize the sales opportunity that exists, we must offer an improved shower head for the mid-market and premium sectors. This means there is a requirement to integrate advanced electronics into our product to maximize the Internet of Things (IoT) opportunity, enhance functional controls, design a shower system

commensurate with the aesthetic needs of domestic and high end commercial customers and drive down the overall cost of production to secure mass market volume. These product development strands are clearly defined, costed and the forecast market impacts of each strand has been robustly stress tested.

The Solent LEP grant will enable Kelda Technology to quickly capitalise on customer demand from these much larger market sectors, grow partnerships with local Higher Education institutions and businesses and create high value employment opportunities in the region as we scale up research, design, manufacturing and global sales. Funding of £250,463 is sought from the Solent LEP Innovation Programme Fund, representing 47% of total project costs. The remainder of the project funding is to be provided by private equity managed by 24Haymarket, has been secured and is evidenced in the submission Annex.

If we do not undertake this project, growth will be capped within the gym and leisure sector and we will be unable to capitalise on customer demand within the next three years. If successful, we expect to directly support double digit headcount growth, develop and formalize our relationship with the University of Southampton and significantly grow revenues of partner businesses and our own through UK and export sales.

2. Project Overview

2.1 Summary of Projects for Funding

Funding is sought for the development of a range of product enhancements and new products that will enable us to capitalise on unfilled demand for our technology and enter new markets at scale.

	Description	Partners	Timescale
Phase 1	**Upgraded Shower Head** Version 2 of our commercial shower head with increased number of nozzles, thinner and more ergonomic design and improved user experience. This will enable us to access a further 225,000 shower units in the mid market gym and leisure sector globally, with a market value of £135million.	University of Southampton SO3D	16 Weeks
Phase 2	**Directional Shower Head** A product enhancement allowing movement of the shower head for the user. This will enable us to access a further 150,000 shower units in the premium gym and leisure sector globally, with a market value of £90million.	University of Southampton Rodd Design SO3D	28 Weeks
Phase 3	**Riser Rail and Handset Shower** A hose, handset and riser rail variant of our existing shower system. This will enable us to access a further 750,000 units in the marine sector, with a market value of £450million and 5m units in the hotel and hospitality sector, with a market value of £3billion.	University of Southampton SO3D Rodd Design Trimline	28 Weeks
Phase 4	**Single Box Control Module** Version two of our control and air modules, combining two boxes into one, thereby improving performance, lowering noise, reducing air resistance, improving electronics and lowering costs. This will support our entry into all new markets.	University of Southampton SO3D Rodd Design	32 Weeks
Phase 5	**Integrated Cubicle Shower System** Incorporating head, air and electronics in one single unit that can be fitted to any mixer or electric shower set up. This will enable us to access a 10million unit Domestic shower market, with a market value of £6billion and the student accommodation sector with 2.5 million units and a value of £1.5billion.	University of Southampton SO3D Rodd Design Trimline	32 Weeks

Table 2.1 – Summary of Projects for Funding

3. Demand Drivers

3.1 Pipeline Demand

In each of our target sectors, demand from potential customers is quantifiably strong. The following table outlines the demand that Kelda Technology has for product enhancements and the new products for which funding is being sought.

Each of the current prospects listed above is at product demonstration / trial phase and revenues based on successful completion of pilot programmes have been forecast in the Kelda business plan as follows:

Sector	Current Prospects	Requirements	Pipeline Value (£)	Global Value (£)
Gym and Leisure	David Lloyd Bannatyne Virgin Active	Upgraded Showerhead Directional Showerhead Single Box Control Module Integrated Cubicle Shower System	£1.68million	£225million
Hotels	Wolseley	Riser Rail and Handset Integrated Cubicle Shower System	£0.25million	£3billion
Marine	Carnival Cruises TUI Cruises Trimline	Riser Rail and Handset Single Box Control Module	£5.7million	£450million
Domestic	Wolseley	Riser Rail and Handset Integrated Cubicle Shower System	£0.25million	£6billion
Student Accommodation	Capitaland	Riser Rail and Handset Integrated Cubicle Shower System	£30m	£1billion

Table 3.1 – Pipeline Demand Table

3.2 The Global Context and Demand

Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of water scarcity, and 500 million people are approaching this situation. Another 1.6 billion people, or almost a quarter of the world's population face economic water shortage. According to European Commission (EC) data, it was estimated that by 2007, at least 11 % of Europe's population and 17 % of its territory had been affected by water scarcity, putting the cost of droughts in Europe over the past thirty years at €100 billion.[1]

Water scarcity is among the main problems to be faced by our generation - water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. Whilst there is enough freshwater on the planet for seven billion people, it is distributed unevenly and too much of it is wasted, polluted and unsustainably managed.[2]

[1] http://ec.europa.eu/environment/water/quantity/scarcity_en.htm
[2] Human Development Report 2006. UNDP, 2006 Coping with water scarcity. Challenge of the twenty-first century. UN-Water, FAO, 2007

Kelda Technology shower systems directly, measurably and rapidly make a significant contribution to water scarcity, expenditure on water and water heating and CO2 emissions. Every shower installation globally has the potential to benefit from Kelda's patented technology – from the home, to hospitals, from gyms to camp sites and student accommodation to prisons. The market opportunity is large; the water savings are dramatic and the financial benefits to users independently proven.

Our shower solution uses less water and electrical energy; this directly protects our environment and reduces the impact on the environment had by large-scale institutions and operators.

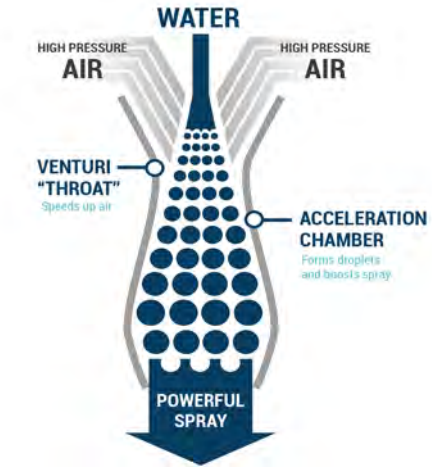
4. Innovation and Approach

4.1 The Kelda Technology Innovation

The Kelda Technology breakthrough has origins in the techniques similar to those used in a high-performance carburetor to inject the perfect mix and dispersal of fuel and air to engine cylinders at high speed. Air is pumped into the showerhead, delivered by a small blower integrated in the shower box. Critically, the air and water are kept separate until they are carefully combined and fed into the shower's nozzles. Each nozzle is internally shaped to produce what is known as a "venturi" effect.

This accelerates the flow by forcing it through a narrow neck before it is dispersed in a wider jet. Showerheads are generally flat so there is a commercial requirement that the venturi fits this configuration. The only practical way to achieve this is by folding the venturi, and to this end Kelda invented the "Flexion Venturi".

Kelda's research further established that by using a second convergent region after the initial neck (the "chamber") it was possible to control both the cone of the water spray and the size of the droplets formed, in a particular combination to produce a revolution in shower performance.



Kelda Technology's performance claims have been verified by the University of Southampton's Engineering and Environment Faculty who performed spray force testing and laser diffusion testing of droplet size.

The results show that on average a flow rate of 12 litres per minute is required for a standard shower to match the same spray momentum of a Kelda shower running at 5 litres per minute: this produces the 2.4 times the spray force performance figure.

Figure 1.1b: Schematic of Kelda Flexion Venturi
(Trademark No UK00003034891)

4.2 Business Model Innovation

Kelda Technology has four business and pricing models.

The first is a direct to end user sale, offering shower systems to customers at Manufacturer List Price, between £600 and £800 depending on configuration. This model allows for a healthy 60% margin before any volume break discounts.

The second model offers shower systems to end customers for a reduced up front cost of between £300 and £400 depending on configuration. The balance of the Manufacturer List Price is recouped by sharing water/water heating savings with the customer, allowing for the remainder of the payments to be made monthly as the savings for customers materialise.

The third model offers shower systems to end customers for a monthly lease payment over a 36 to 48 month term, allowing them to spread the payments across a defined period. This has the benefit of always ensuring that the customer saves more than they spend each month.

The fourth model is a distribution sale, whereby Kelda Technology supply shower systems to nominated and approved distributors or sales agents at a discount over Manufacturer List Price. The distributor enjoys a generous margin in return for conducting pre-sales, sales and support activity.

4.3 A Summary of Technology Innovation

Technology Readiness Level (TRL) 3 was achieved with the development of a prototype head for the UK Government Department of Energy and Climate Change in September 2013. The development of our disruptive and eco-friendly technology has subsequently benefitted from two grants. The Carbon Trust awarded Kelda Technology £75,000 in Entrepreneurs Fast Track Funding and the Department of Energy and Climate Change awarded the company £480,000 as part of the Energy Entrepreneurs Grant.

Based on this funding, a prototype was constructed and evaluated for air and water flows and operational performance. The water savings performance allowed us to validate the initial claims that the technology reduced water consumption by over 50% without compromising the shower force. From the "Proof of Concept" work, the validated model and cost saving predictions of at least 50% versus legacy systems, the specifications for the prototype demonstrator version of the unit were derived.

Prototype unit water and energy consumption were well within the design parameters of the unit and the theoretical model used in its development - this validated the design and plans. Water and air mixing methods were fine-tuned and this enabled Kelda to file an international patent, further enhancing the intellectual property of the business.

As part of TRL, 4 Kelda Technology's performance claims were laboratory verified by the University of Southampton's Engineering and Environment Faculty, who performed spray force testing and laser diffusion testing of droplet size. The results showed that on average a flow rate of 12 litres per minute is required for a standard shower to match the same spray momentum of a Kelda shower running at 5 litres per minute, thereby producing the 2.4 times the spray force performance figure.

With laboratory testing complete, Kelda Technology secured a single unit shower trial opportunity at Pure Gym in Lambeth, London. Flow rates, unit reliability, user feedback and spray force were all measured and compared with the incumbent technology on site and the data was fed back into the development programme. Rapid prototyping utilizing 3D printing enabled Kelda Technology to quickly develop a series of iterations of the shower head that were tested in laboratory conditions before being manufactured in low volume for commercial validation (TRL5).

4.4 Innovation to Address European and UK Challenges

The two principle challenges that Kelda Technology addresses are environmental and public health protection.

4.4.1 Environmental Challenges

The specific environmental challenges that will be addressed by this project relate to the "circular economy" - lowering water usage, reducing water heating requirements, cutting down the treatment of wastewater stream and decreasing CO_2 footprint.

The introduction of energy efficient, low water use shower technology is directly relevant to Roadmap2050 (initiative of the European Climate Foundation) to achieve a low carbon economy in the EU (80% GHG reduction target)[3].

Launched in 2005, the EU Emissions Trading System (EU ETS) is at the heart of the EU's strategy to reduce emissions of greenhouse gases. The system has stimulated the uptake of renewables and other low-carbon and energy-efficient technologies and whilst not directly regulating emissions in the leisure sector, the principles have been adopted at a Member State level for industries that fall outside of the EU ETS.

The Carbon Reduction Commitment Energy Efficiency Scheme[4] is the UK government scheme designed to improve energy efficiency and cut CO_2 emissions in private and public sector organisations that are high energy users.

[3] http://europa.eu/rapid/press-release_IP-15-4574_en.htm
[4] https://www.gov.uk/guidance/crc-energy-efficiency-scheme-allowances

Organisations such as hotel groups, higher education institutes and gyms and leisure chains must buy and surrender allowances equal to the CO_2 emissions generated each year. CO_2 is emitted to the atmosphere from boilers, Combined Heat and Power (CHP) units and the power stations supplying the electricity; saving energy with Kelda Technology shower units will reduce carbon emissions whilst also reducing acid rain and air pollution associated with power stations.

4.4.2 Public Health Protection

In terms of public health protection, Legionella Disease is described as '*an important cause of potentially preventable morbidity and mortality in Europe.*'[5] Of the 5,851 cases reported in the EU in 2013, six countries (France, Italy, Spain, Germany, the Netherlands and the United Kingdom) accounted for 83% of all notified cases. [6]

Kelda showers are proven to be six times safer than standard showers and twenty times safer than aerating showers in preventing the transmission of Legionella Disease and can make an important contribution to reducing the occurrence of the disease across Europe.

4.5 Intellectual Property

Kelda Technology's research and development has been supported by robust intellectual property protection, patent coverage and the continual monitoring of IP assets, risks and opportunities. To reinforce this protection, Kelda Technology has engaged specialist legal assistance in the field of patent protection. The business has taken, and will continue to take all possible steps to ensure that commercialisation is not threatened by gaps or threats to intellectual property. In May 2013, Kelda Technology began filing patents relating to the air/water development and these are shown below:

Straight Venturi	Folded Venturi	Spray Form (Golden Patent)	Multiple Convergent Sprays	Central Air Injection	Convergent Jets
GB 2454228 (Granted)	GB 2488144 (Granted)	UK, INT, GULF CO-OPERATION (Pending)	CHN CN103608121A (Granted)	UK 2492113 (Granted)	UK 2492114 (Granted)
US 9173809 (Granted)	HK 1185580 (Granted)		US 2014/0110504 (Granted)		
	AUS 2012216911 (Granted)		EU and HK (Pending)		
	CHN ZL201280009000.7 (Granted)				
	JPN 6026435 (Granted)				
	SA 2013/06157 (Granted)				
	EU, BRZ, CAN, KOR,MEX, MDV, US, VNM,THA (Pending)				

Table 4.1 – Patent Coverage

Kelda have filed three families of patents that overlay each other, providing strong protection. Novagraaf [7], Kelda Technology's patent attorneys undertook an independent review of Kelda's patents on 24th April 2013 and their conclusion was "...our expectation is that your patent portfolio will provide robust protection for the Kelda technology." Kelda Technology continues to take action to monitor, protect and enhance the intellectual property that it has developed.

[5] http://ecdc.europa.eu/en/publications/Publications/legionnaires-disease-2015.pdf
[6] http://ecdc.europa.eu/en/publications/_layouts/forms/Publication_DispForm.aspx?List=4f55ad51-4aed-4d32-b960-af70113dbb90&ID=1288
[7] http://www.novagraaf.com/

5. The Market Opportunity

5.1 Current Market Penetration

Version one of the Kelda Shower System affords us a presence within one clearly defined sub set of one market – the private sector low cost gym and leisure sector. Pilot programmes to ratify our technology are well advanced in other sectors and form the basis of our analysis of potential future markets

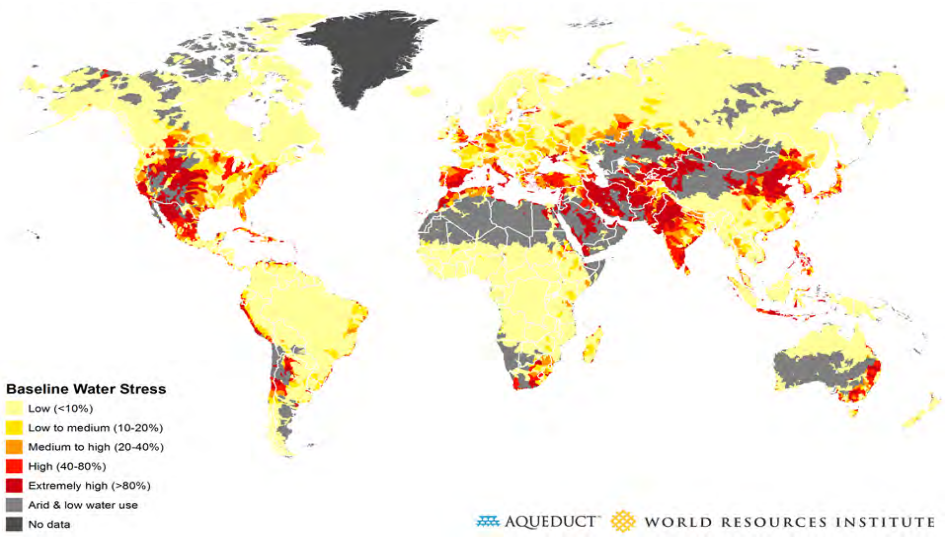
Sector	Size (Units)	Accessible Today (Units)	Status
Gym and Leisure – Low Cost	525,000	525,000	In Market / Revenue
Gym and Leisure – Mid-Market	225,000	0	Pilot Programmes
Gym and Leisure – Premium	150,000	0	Pilot Programmes
Domestic	10,000,000	0	Demonstration
Hotel	5,000,000	0	Demonstration
Marine	750,000	0	Pilot Programme
Student Accommodation	2,500,000	0	Demonstration

Table 5.1 - Total Addressable Market with Current Product

5.2 Potential Markets

The Kelda Shower System offers the greatest added value in sectors where showers are both a functional necessity and heavily used. Extensive research into water scarcity, water costs, water usage, water reliance has been carried out over the past eighteen months. This research has included geographic regions and vertical markets.

5.3 Water Stress by Region



Infographic 5.2 - Water Price by City and Region/ State / Country

5.4 Water Costs by Region

City	Water Supply and Disposal (m3) US$
Rio de Janeiro, Brazil	$11.24
San Francisco, California	$6.55
Sao Paulo, Brazil	$5.03
Cape Town, South Africa	$4.96
Berlin, Europe	$4.75
Paris, Europe	$3.76
Manhattan, New York	$3.49
Tel Aviv, Israel	$3.17
London, Europe	$3.06
Dubai, UAE	$2.97
Perth, Australia	$2.45
Johannesburg, South Africa	$2.27
Sydney, Australia	$1.72
Singapore, Singapore	$1.75

Table 5.3 – Water Costs by Region

Benchmark: Cost based on using 200 m3 per month
Source: GWI Global Water Tariff Survey 2016

5.5 Addressable Market v Water Scarcity v Water Prices

To determine market entry prioritization, a matrix of market size, water scarcity and water prices has been compiled and an abbreviated summary of this is shown below:

Largest Sectors by Shower Unit Volume	Regions with Greatest Scarcity of Water	Regions with Highest Cost of Water
Domestic Mixer Shower	Middle East	Europe
Hotel Mixer shower	South Africa	South Africa
Gym and Leisure	Brazil	Brazil
Student Accommodation	Australia	Australia
Marine	California	California

Table 5.4 - Market Volume / Scarcity / Price Summary

5.6 Market Sector Summary Benefits

With this research complete, in depth analysis was conducted into the end user benefits of Kelda Shower Systems in each of the sectors identified.

Domestic
Research in partnership with BDR Thermea, one of Europe's largest manufacturers and distributors of domestic and commercial water and space heating system has forecast that a typical family of four using a Kelda mixer shower could save 61,000 litres of water per year and reduce CO_2 emissions by 784kg annually. In the United Kingdom, this equates to £500 on metered water savings and water heating savings per year.

Hotels and Leisure
According to Green Hotelier, water accounts for 10% of hotel utility bills and as an example, a 300-bedroom hotel in the UK will use over 53,000 cubic meters of water each year, of which over one third will be from guest use in rooms. [8] Research from the UN Global Compact CEO Water Mandate[9] suggests at least 85% of water use

[8] http://www.greenhotelier.org/know-how-guides/water-management-and-responsibility-in-hotels/
[9] http://ceowatermandate.org

in hotel rooms is from showers, meaning that for the hotel used in the example above, using Kelda Technology showers would save over 13,000 cubic meters of water13,000,000 litres of water each and every year.

Gym and Leisure

Independent financial research has been conducted by investment specialists, GrowthDeck[10] in partnership with the UK's largest gym chain, Pure Gym to assess the financial benefits of investing in Kelda Technology shower units. This impact assessment has forecast that a typical gym chain with 14 showers per site would save between £800 and £1,400 per shower per year – an annual financial saving of between £11,200 and £19,600. Municipal operators such as local authority leisure centres and not for profit partnerships would benefit from greater financial savings due to the higher number of shower units typically found on each site.

Student Accommodation

In 2013, there were 19.6 million tertiary education students in the EU and over 4million of these students were studying outside of their country of origin.[11] Whilst historically student accommodation was entirely publicly funded, with churches and the state the main providers, in recent years, private sector involvement has increased exponentially. In both the private and public sector markets, reducing utility costs is increasingly important for operators and Kelda estimates that savings similar to those forecast for the domestic market are attainable.

Marine

As of 2017, there are 70 cruise liners of at least 100,000 tonnes operating globally and approximately 50 of the same tonnage in build. A typical cruise liner with 3,000 guests and 1,200 crew will use over 1 million litres of fresh water every day. Fresh water is carried on board, produced via a desalination plant and replenished on port visits. Reducing consumption of water from showers impacts on resupply costs and operating costs (fuel) due to reduced weight of water the ship is required to carry.

[10] https://www.growthdeck.com
[11] http://classof2020.nl/wp-content/uploads/2016/06/European-student-housing-Summer-2013-Savills.pdf

6. Impact

6.1 Overall Impact

Kelda Technology shower systems save water, save money and help organisations using showers to be more profitable through dramatically lower utility costs.

Water costs within our target market sectors are considerable and this is magnified when hot water is wasted, as the energy used to heat it has been wasted too. However, water is a metered and controllable resource and Kelda Technology shower units allow operators to take control of one of the largest areas of water use. Conservation of water also reduces the pumping requirement, which saves energy and reduces carbon emissions. Therefore, the impact for our target markets is threefold:

Firstly, by using Kelda Technology shower systems, commercial operators will be positively contributing to the issue of protecting scarce water resources by reducing shower water consumption by over 50%. Secondly, they will be reducing their operating costs significantly, through savings in water supply, water disposal and water heating. Finally, the environmental benefits of Kelda Technology shower systems are sufficiently strong to ensure that operators across Europe can benefit from BREEAM[12] credits, can reduce their CO_2 payments and Kelda's inclusion on the Water Technology List[13] means that UK operators can receive 100% Enhanced Capital Allowance on purchases.

6.2 Local Impact

6.2.1 Regional Implications for Employment

Kelda Technology has consolidated its position as a Solent clean tech innovation company, both in direct employment of local talent and in its partnership with the University of Southampton (UoS). If the *Supply Chain Technology Development Project* is successful in its funding application, it is expected that this can be further developed with the following additional high value employment and consultancy agreements:

Company	Heads	Project Responsibility	Duration
Kelda Technology	1	Project Manager	Perm
	1	Product Engineer	Perm
University of Southampton / Cuesta Ltd	0.25	Professor	12M Agreement
	2	Business Development Manager	Perm
Rodd Design	1	Industrial Designer	Perm
Trimline	2	Installation Engineer	Perm
Total	**7.25**		

Table 6.1 - Headcount Impact Assessment

6.2.2 Regional Implications for the Supply Chain

The Kelda Technology distribution model is built on a blend of direct sales and channel partners. We will, where possible work with organisations in the Solent LEP region and have taken this approach with the appointment of our first Marine sector distributor, Trimline Limited, a highly-regarded Southampton based marine installation enterprise. This partnership has seen early success, with trials onboard Cunard and TUI cruise liners. We expect to replicate this partnership with other local expertise.

The business also aspires to utilise local talent in the Supply Chain, sourcing components and expertise from enterprises within the region. Progress has been made in sourcing electronics capability from Hamble Le Rice and consultancy services from Hampshire based businesses.

[12] http://www.breeam.com - the leading sustainability assessment method for buildings
[13] https://www.gov.uk/government/publications/water-efficient-enhanced-capital-allowances

6.3 Unique Selling Points and Market Opportunity

6.3.1 Unmet Need

Shower users demand high flow rates for a satisfactory user experience, whilst international and regional bodies and national governments attempt to reduce water consumption through policy. As an example, the Code for Sustainable Homes in the UK states "Climate change may result in increased variability in weather patterns increasing both the risk of flooding and extended dry spells. Water consumption is likely to become an increasing national problem. Water is becoming more scarce at the same time as population and demand for water is increasing, the development of practical ways to reduce water demand is very important. In the South East of England, water demand exceeds the volume licensed for abstraction, with the shortfall being met from groundwater. Twenty percent of the UK's water is used domestically with over 50 per cent of this used for flushing WC's and washing.[14]

The EU introduced the Energy related Products Directive, Energy Labelling Directive for water heaters and the Energy Performance of Buildings Directive. BREEAM is a European wide building performance assessment that focuses on ten key factors of buildings of which energy, water and pollution are included. The US has introduced LEED and this is similar to BREEAM. This is evidence that there is government and market demand for energy and water efficient products in our core European market.

6.3.2 Added Value over Competing Solutions

The commercial shower market in Europe has remained largely unchanged for the past forty years, with manufacturers focusing on cosmetic and branding enhancements, with limited engineering development being made to the underlying technology. Water savings offered by competitive products are generated principally by reducing water flow using flow restrictors, typically to a level of 9 litres per minute. In this context, Kelda Technology shower systems offer two clear areas of added value – water efficiency and user experience.

The added value of the Kelda Technology solution is best demonstrated when comparing performance with existing technologies. In commercial trials in May 2016, the Kelda shower demonstrated average water savings of 4.2 litres per minute for every shower taken by users. Extrapolated out to daily water savings, this equates to water saving per gym of 1,474 litres of water every day.[15] This trial benchmarked Kelda showers against Rada head units and percussion valves. Rada is the leading European provider of commercial shower units and the trial evidenced clear environmental, monetary and user satisfaction benefits over the incumbent technology. A copy of the University of Southampton report on these commercial trials is submitted as part of this application at the Annex.

6.3.2.1 Water Efficiency

In the commercial trials, Kelda Technology showers were running at 4.1 litres per minute, compared with 8.3 litres per minute of market leading traditional showers. To achieve this level of reduction whilst losing nothing in user experience is a revolution in water efficiency. Linked to water efficiency is the Return on Investment (ROI) that Kelda Technology shower units deliver.

Traditional shower products from manufacturers such as Mira and Grohe are capital investments with a relatively fixed lifespan (market feedback indicates a 6-year replacement cycle) and no efficiency, ROI or user benefits. In contrast, the Kelda Technology shower system provides a very clear ROI for operators. A typical 14-unit installation will cost in the region of £5,000 for traditional shower heads and mixers. This cost has been extensively researched, both independently and with prospective customers providing breakdowns of component costs. A Kelda installation is charged at approximately £12,000 and will deliver a financial ROI in less than 12 months, whilst also bringing environmental, legislative, industry and user experience benefits.

[14] http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/documents/planningandbuilding/pdf/codesustainhomesstandard.pdf

[15] Our research shows that an average urban gym has 14 showers and that each shower is used 25 times per day over the course of a typical month.

6.3.2.2 User Experience

Reducing the flow of water without alternative means of maintaining performance will always detract from the user experience. Kelda Technology showers have demonstrated that a significant majority of users were satisfied with the shower experience, despite the showers using 50.3% less water. At the Annex is the University of Southampton's independent report demonstrating 91% of females and 73% of men felt the Kelda Shower was as good as or better than the incumbent shower.

In addition to the commercial trials, Kelda Technology conducted two sets of consumer testing. In the first of these, Kelda Technology asked volunteers to identify when a steadily increasing flow from a standard shower matched the feel of a steady Kelda flow.

Again, on average, it took a standard shower 2.4 times the flow to match the Kelda shower's strong feel. Secondly, a prototype Kelda unit was run in situ at a commercial gym with a flow rate set at 50% of the standard 9 litres per minute. When asked to rank the experience compared to the standard, Kelda scored just ahead, consistent with the assertion that "equivalence" would have been at approximately 58% reduction. A summary of this consumer testing is also included in this submission.

6.4 Competitive Solutions

Competitive analysis has been conducted of the full range of water saving shower products available in Europe, including those from Grohe, Tandrup, Mira, EcoStar, Eco Camel and Challis. Whilst recent shower handset developments have been marketed as water saving – these are typically aerating shower handsets.

Aerating shower handsets do offer water savings, however, this is purely the result of turning the water flow rate down via a restriction in the handset. They do not improve the showering experience or spray force as with the Kelda Technology units. Independent patent reviews confirm that there are no competing technologies that challenge or supersede Kelda technology.

Only one other technology exists that uses similar quantities of power/water and this is in the form of water recycling showers and is manufactured by Swedish company Orbital.[16] Market research confirms that most people find this type of shower to be unacceptable for personal hygiene reasons and cost prohibitive because it is expensive to install and maintain.

Additionally, a US company – Nebia[17] have marketed and recently launched a water saving shower that uses atomisation under water pressure. One of the major concerns with this shower technology is the droplet size which appears to be small enough to raise concerns over a potential Legionella hazard and requires a higher inlet water temperature due to the heat loss characteristics of smaller droplets. Kelda Technology shower units have been assessed and proven to be six times less likely than ordinary showers and twenty times less than aerating showers to cause Legionella.

In the commercial sector, limited competition exists in the form of products from Kohler Rada and Grohe, both well-established manufacturers within the commercial shower market. Water savings are generated principally by reducing water flow using flow restrictors, typically to a level of 9 litres per minute.

[16] https://orbital-systems.com/en-eu/
[17] http://nebia.com

Manufacturer	Capital Cost	Operating Cost	Water Saving Claims	Environmental Benefits
Kohler Rada SPA1	High	100%	10% Saving	Low
Kohler Rada VR105	Low	100%	30% Saving	Medium
Grohe EcoJoy	Medium	100%	30% Saving	Medium
Grohe Rainshower	High	100%	30% Saving	Medium
Grohe Euporia	High	100%	30% Saving	Medium

Table 6.2 - Summary Analysis of Direct Competition

For commercial use, Kelda's technology provides an equivalent showering experience with only half of the water flow rate of that of a conventional shower. This gives the operator in excess of 50% savings in water and subsequent savings energy used to heat the water. These levels of savings compare favourably with the major manufacturer products listed above and are sufficiently high to qualify for Enhanced Capital Allowance and BREEAM credits.

6.5 Market Barriers

There are number of potential barriers associated with market penetration using disruptive technology that Kelda need to overcome. Early adopters will typically be subject to product development hurdles, iterative releases of technology and strong pricing. Kelda will overcome these barriers by cooperating with already identified commercial partners and offering mutually advantageous pricing in return for case studies and referrals.

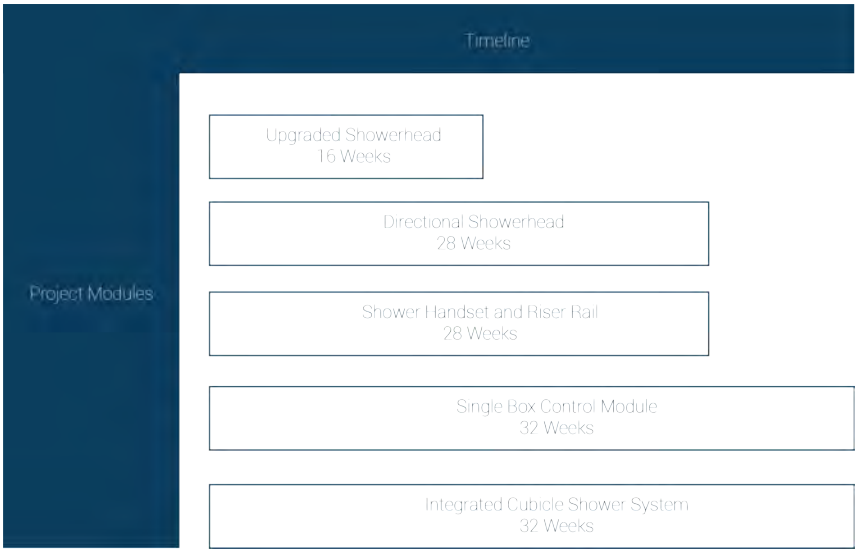
Further down the market entry cycle, those in the early majority considering the Kelda product will require confidence that new product development issues have been addressed and that Return on Investment claims have been validated in trial partnerships.

Kelda will work together with operators to demonstrate that the outcomes of the project are beneficial to all involved and do not give rise to additional environmental concerns such as failure frequency and energy consumption. Steps have been taken to mitigate against these concerns.

For reliability, alongside a robust programme of laboratory and bench testing, a trial unit has been in situ at a busy urban gym in Southampton since early 2016 to provide reliability testing and the test has been 100% successful thus far. To ensure we can validate financial benefits to customers, Kelda has worked closely with the finance and accounting department at Pure Gym to establish savings figures for each category of site, ranging from small suburban sites, up to flagship city centre sites.

7. Project Summary

7.1 Overall Timeline



7.2 Project Modules

7.2.1 Upgraded Showerhead

Why: Improve shower experience for all customers, in all markets
How: Improve spray performance and efficiency
Who: Kelda Technology and University of Southampton
Markets: All – also allows entry to mid-market gym and leisure sector

7.2.2 Directional Showerhead

Why: Improve customer satisfaction, particularly with regard to gender bias of existing head
How: Pivoting / tilting head, slimmer body, upgraded with improved aesthetics
Who: Kelda Technology, University of Southampton, SO3D and Rodd Design
Markets: All – also allows entry to premium gym and leisure sector

7.2.3 Shower Handset and Riser Rail

Why: Opens up new market sectors with latent demand
How: Evolve current shower head to create new handset with flexible air and water hose and through wall fitting
Who: Kelda Technology, University of Southampton, SO3D, Rodd Design and Trimline
Markets: All – also allows entry to Marine, Hotel and Domestic markets

7.2.1 Single Box Control Module

Why: To improve functionality, lower cost of production and increase installation options
How: Combine 2 modules into 1, reduce Bill of Materials, enhance electronics and reduce size of unit
Who: Kelda Technology, University of Southampton, SO3D, Rodd Design and Trimline
Markets: All

7.2.1 Integrated Cubicle Shower System

Why: Universal installation that is ‘plug and play’ with improved functionality, control and connectivity
How: Combine all other product modules into one shower system, styled for commercial & domestic markets
Who: Kelda Technology, University of Southampton, SO3D, Rodd Design and Trimline
Markets: All

7.3 Collaboration Partners – The Partnership

7.3.1 University of Southampton

Our links with the University of Southampton have their origins in the early development of the Kelda shower when we worked with Dr Ed Richardson. Ed is Associate Professor within Engineering and the Environment at the University of Southampton and is an Associate Professor and EPSRC Career Acceleration Fellow in the Aerodynamics and Flight Mechanics group at the University of Southampton. He leads research activities on reactive and multi-phase turbulent flows, with application to gas turbine and internal combustion engines.

We have subsequently worked closely with Professor John Shrimpton to benchmark our shower spray and refine prototypes and commercially available products. Professor John S Shrimpton is Professor within Engineering and the Environment at the University of Southampton. John specializes in the measurement and modelling of multiphase fluid mechanics, and maintains a suite of research codes and a laboratory, which specialises in optical diagnostics.

In Summer 2017, Kelda Technology commenced a 24-month Knowledge Transfer Partnership (KTP) programme with the University, with the aim of 'transferring and embedding a highly innovative capability to design a new range of Kelda showerheads utilising a two phase flow.'

The KTP is under the supervision of Dr Ivo Peters, a Lecturer in the Aerodynamics and Flight Mechanics Research Group at the University of Southampton. Dr Peters is an expert on the instabilities that form on liquid-air interfaces that grow and lead to break up into drops due to for instance when air flow passes over the surface of the liquid, as is the case in the Kelda technology.

Today, Kelda Technology operates from the University of Southampton Science Park with an office space and laboratory under lease. If successful in this application for funding, an additional laboratory space will be required and the costs involved in this expansion in research capability are detailed in this submission.

For the purposes of future engagement including this grant submission, it is proposed to engage Professor John Shrimpton from the University of Southampton via his consulting practice, Cuesta Ltd.

7.3.2 Rodd Design

Rodd is a Solent based design and innovation consultancy, formed in 2000, with a portfolio that spans product, digital and experiences across multiple consumer sectors.

Core competencies include user research, trend analysis and consumer innovation and Rodd has a proven track record in helping guide start-up ventures and early stage companies into the brands of tomorrow. Clients of note include Kenwood, Motorola, Salter Homedics the Department of Health and the Technology Strategy Board.

7.3.3 SO3D

SO3D technologies are a leading name in the additive manufacturing industry and based in Botley, Hampshire. With origins in the marine sector, the business has now grown to include the electronics, medical products, automotive, aviation, architectural and design industries. The business has expertise in research and development along with prototyping and low run productions. Importantly for the success of this project, they also specialise in 3D CAD design.

7.3.4 Trimline

Trimline create world class marine interiors using innovative approaches combined with traditional principles. Based in Southampton, they are the longest established interior refitter in the industry with over 50 years' experience in full turnkey refurbishment or ongoing maintenance marine fleets.

Uniquely within the industry, Trimline act as a one-stop-shop for marine fit-out projects, from full rebrands and resets, to general refits and refreshes – covering all interior areas, from galleys and laundry rooms to cabins and lounges. With an in house team of CAD designers and engineering specialists, the company can provide a full design package from start to finish.

7.4 Team and Resourcing

Chris Jackson, CEO

Chris has held several roles in commercialising products, including Head of Strategy at Nokia, Vice President and General Manager of the European Solutions Group at Motorola, Board Member of Symbian and Partner in the Wireless Frontiers VC fund. He has managed several start-up companies and held Sales and Marketing senior roles. Chris brings Business Development, Product Management, Business Building, and Partnering experience, and has managed Profit and Loss of an international business. He holds a BSc in Electrical and Electronic Engineering and an MBA.

Project Responsibilities: Chris's key focus will be to carry out strategic business development and direct the business against the project and company plan.

Noel Murray, CTO

Noel worked for Triton PLC while gaining an MSc in Engineering Business Management from the University of Warwick and co-designed the top selling Triton T80 Electric shower. As Technical Director at Redring Xpelair Group, he has led the technical development of shower and air products and was part of the team involved in the MBO and the subsequent sale of the business to Glen Dimplex Group. Noel joined Kelda Showers as CTO in 2014.

Project Responsibilities: Noel's key focus in this project will be to lead the business innovation project development including specifications, leading collaboration partners and sub-contractors, performing design reviews and managing testing.

Laurence Moorse, CFO

Laurence is a Chartered Accountant with approaching 20 years experience in senior financial and Board roles including Deloitte, Hamworthy plc and Quindell Plc.

Project Responsibilities: Laurence will be accountable for overseeing the overall project from a budgetary, compliance and project management perspective.

Adrian Mosley, CMO

Adrian is an award winning sales and marketing professional with over 15 years of success in the UK, North America and EMEA, with organisations ranging from VC funded startups through to FTSE 100 and NYSE listed companies. Prior to joining Kelda Technology, Adrian launched, built and led the sales and marketing at Switch Concepts, winning the Deloitte Fast 50 award and creating the world's fastest growing AdTech company with a market share second only to Google within 12 months.

Project Responsibilities: Adrian's focus will be on managing customer interaction including pilot programmes and market entry.

7.5 Overall Project Management

Overall Project Management will be the responsibility of the Kelda Technology Chief Financial Officer, Laurence Moorse.

7.6 Risk Management

The risks to this project are relatively low because we are developing from a baseline of a working and proven shower system. However, the main risk sits with potential delays in bringing the technology to production, costs exceeding the pilot trials and delays in manufacturing.

The Kelda Technology management team will handle changes to the work plan, budget reallocation, dissemination of critical results, IPR management, and disputes between parts or persons if they arise, with an ambition to clear these hurdles as soon as possible without affecting the objectives of the project.

A risk register based on the company's current Risk Register will be established identifying risks and impact – this will be subject to monthly update and review at management and board level.

7.6.1 Specific Risks Identified

Description of High Risk Items	Project Module	Proposed Risk Mitigation
Customer Acceptance and Commercialisation	All	Trials have been conducted with major organisations in the UK and abroad. These have been highly positive to date and the results of customer satisfaction validated by the University of Southampton.
Costs Exceed Funding	All	All costs have been fully costed with partners, based on full and complete specification briefs.
Design Risk	All	To date, proven Commercial Off the Shelf (COTS) components have been used and reliability/bench/lab testing completed before prototype build and pilot roll out. This methodology is planned for all future development.

7.6.2 General Risks Identified

Description of High Risk Items	Project Module	Proposed Risk Mitigation
Demand Risk	All	Financial forecasts are based on a validated sales pipeline that is updated in real time and subject to board level oversight.
Procurement Risk	All	Kelda has established partnerships with partners and the supply chain. In addition to primary partners, a key component of each project is the sourcing of alternative local suppliers to mitigate risk in procurement.

Table 7.1 - Risk assessment, only high risks are shown

7.6.3 Mitigating Risk – Our Approach

As an early stage technology company, we strive to balance new product innovation alongside risk. To do so, we adopt a set of guiding principles in how we do business:

- We avoid making decisions that are irreversible
- We always carry out pilot studies and market testing before making commitments
- Our plans always have flexibility built in from the start
- Where non-core technology can be bought in with lower risk, we do so
- We will always seek to transfer risk through contractual arrangements

7.7 Project Plans

Costs have been calculated based on outline design concepts, customer specification briefs and the below project plans are extracts from Project Libre,[18] the open source project management software used by Kelda. Please note that whilst duration of modules is accurate, start and finish dates are based on projects starting on the day the extracts were exported and should be disregarded.

7.7.1 Upgraded Showerhead

Cost: £49,000
Collaboration: Kelda Technology, University of Southampton and SO3D

		Name	Duration	Start	Finish	Pre..	Cost1
1		**Shower Head**	**140.125 d...**	**23/10/17 08:00**	**07/05/18 09:00**		**£0.00**
2		**Upgrade current shower head**	**140.125 d...**	**23/10/17 08:00**	**07/05/18 09:00**		**£0.00**
3		**Upgrade engine technology**	**80 days**	**23/10/17 08:00**	**09/02/18 17:00**		**£0.00**
4		**Design and test**	**20 days**	**23/10/17 08:00**	**17/11/17 17:00**		**£1000.00**
5		Air nozzle entry design	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
6		Air nozzle length / width	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
7		Air nozzle exit design	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
8		**Tooling and Production**	**80 days**	**23/10/17 08:00**	**09/02/18 17:00**		**£10000.00**
9		Invitation to Tender	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
10		Requote based on design	10 days	20/11/17 08:00	01/12/17 17:00	5;...	£0.00
11		Select suppliers	0 days	01/12/17 17:00	01/12/17 17:00	10	£0.00
12		Tooling	25 days	04/12/17 08:00	05/01/18 17:00	11	£0.00
13		Production	20 days	08/01/18 08:00	02/02/18 17:00	12	£0.00
14		Signoff	5 days	05/02/18 08:00	09/02/18 17:00	13	£0.00
15		Release available (ref. PURE GYM)	0 days	09/02/18 17:00	09/02/18 17:00	14	£0.00
16		**Modify engine size and nozzles**	**140.125 d...**	**23/10/17 08:00**	**07/05/18 09:00**		**£0.00**
17		Lab set up	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
18		**Design and test**	**70 days**	**23/10/17 08:00**	**26/01/18 17:00**		**£3000.00**
19		Modify engine size	60 days	23/10/17 08:00	12/01/18 17:00		£0.00
20		Modify nozzles concept assessment	30 days	18/12/17 08:00	26/01/18 17:00	17	£0.00
21		'Go / No go'	0 days	26/01/18 17:00	26/01/18 17:00	20	£0.00
22		**Tooling and Production**	**80 days**	**15/01/18 09:00**	**07/05/18 09:00**		**£35000.00**
23		Invitation to Tender	20 days	15/01/18 09:00	12/02/18 09:00	19	£0.00
24		Requote based on design	10 days	12/02/18 09:00	26/02/18 09:00	23	£0.00
25		Select suppliers	0 days	26/02/18 09:00	26/02/18 09:00	24	£0.00
26		Tooling	25 days	26/02/18 09:00	02/04/18 09:00	25	£0.00
27		Production	20 days	02/04/18 09:00	30/04/18 09:00	26	£0.00
28		Signoff	5 days	30/04/18 09:00	07/05/18 09:00	27	£0.00
29		Release available	0 days	07/05/18 09:00	07/05/18 09:00	28	£0.00

[18] https://www.projectlibre.com/

7.7.2 Directional Showerhead

Cost: £40,000
Collaboration: Kelda Technology, University of Southampton, SO3D and Rodd Design

30		**Directional Shower Head**	140.125 d...	23/10/17 08:00	07/05/18 09:00		£0.00	£0.00	
31		**Design and test**	**40 days**	23/10/17 08:00	15/12/17 17:00		£5000.00	£0.00	Will Penfold
32		Concept development	20 days	23/10/17 08:00	17/11/17 17:00		£0.00	£0.00	Will Penfold
33		Recirculation vent	20 days	23/10/17 08:00	17/11/17 17:00		£0.00	£0.00	Will Penfold
34		Prototyping and test	20 days	20/11/17 08:00	15/12/17 17:00	3	£0.00	£0.00	Will Penfold
35		**Industrial design and prototyping**	**30 days**	30/10/17 09:00	11/12/17 09:00		£10000.00	£0.00	Outsourced;Paul West
36		Invitation to Tender	10 days	30/10/17 09:00	13/11/17 09:00		£0.00	£0.00	Paul West
37		Select suppliers	0 days	13/11/17 09:00	13/11/17 09:00	36	£0.00	£0.00	Paul West
38		Instruct Industrial Design partner	0 days	13/11/17 09:00	13/11/17 09:00	37	£0.00	£0.00	Paul West
39		Create prototype	20 days	13/11/17 09:00	11/12/17 09:00	38	£0.00	£0.00	Outsourced
40		Prototype available	0 days	11/12/17 09:00	11/12/17 09:00	39	£0.00	£0.00	Paul West
41		**Tooling and Production**	**80 days**	15/01/18 09:00	07/05/18 09:00		£25000.00	£25.00	Noel Murray;Will Penfold
42		Invitation to Tender	20 days	15/01/18 09:00	12/02/18 09:00	40	£0.00	£0.00	Will Penfold
43		Requote based on design	10 days	12/02/18 09:00	26/02/18 09:00	42	£0.00	£0.00	Outsourced
44		Select suppliers	0 days	26/02/18 09:00	26/02/18 09:00	43	£0.00	£0.00	Will Penfold
45		Tooling	25 days	26/02/18 09:00	02/04/18 09:00	44	£0.00	£0.00	Noel Murray;Will Penfold
46		Production	20 days	02/04/18 09:00	30/04/18 09:00	45	£0.00	£0.00	Noel Murray;Will Penfold

7.7.3 Shower Handset and Riser Rail Kit

Cost: £40,000
Collaboration: Kelda Technology, University of Southampton, SO3D, Trimline and Rodd Design

49		**Shower Handset and Riser Rail Kit**	140.125 d...	23/10/17 08:00	07/05/18 09:00		£0.00
50		**Design and test**	**40 days**	23/10/17 08:00	15/12/17 17:00		£5000.00
51		Non return concept assessment	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
52		Non return valve inclusion in Modified Engine release?	0 days	17/11/17 17:00	17/11/17 17:00	51	£0.00
53		Non return valve design and test	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
54		Through wall fitting design and test	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
55		Hose design and spec	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
56		Handset framework	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
57		Riser rail framework	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
58		**Industrial design and prototyping**	**40 days**	18/12/17 08:00	09/02/18 17:00		£10000.00
59		Invitation to Tender	20 days	18/12/17 08:00	12/01/18 17:00	5...	£0.00
60		Select Suppliers	0 days	12/01/18 17:00	12/01/18 17:00	59	£0.00
61		Instruct Industrial Design Partner	0 days	12/01/18 17:00	12/01/18 17:00	60	£0.00
62		Create Prototype	20 days	15/01/18 08:00	09/02/18 17:00	61	£0.00
63		Prototype available	0 days	09/02/18 17:00	09/02/18 17:00	62	£0.00
64		**Tooling and Production**	**80 days**	15/01/18 09:00	07/05/18 09:00		£25000.00
65		Invitation to Tender	20 days	15/01/18 09:00	12/02/18 09:00		£0.00
66		Requote based on design	10 days	12/02/18 09:00	26/02/18 09:00	65	£0.00
67		Select Suppliers	0 days	26/02/18 09:00	26/02/18 09:00	66	£0.00
68		Tooling	25 days	26/02/18 09:00	02/04/18 09:00	67	£0.00
69		Production	20 days	02/04/18 09:00	30/04/18 09:00	68	£0.00
70		Signoff	5 days	30/04/18 09:00	07/05/18 09:00	69	£0.00
71		Release date	0 days	07/05/18 09:00	07/05/18 09:00	70	£0.00

7.7.4 Single Box Control Module

Cost: £102,000
Collaboration: Kelda Technology, University of Southampton, SO3D and Rodd Design

1		**One Box Solution Void**	**165 days**	**23/10/17 07:00**	**08/06/18 17:00**		**£0.00**
2		**1a Fan control upgrade**	**60 days**	**23/10/17 08:00**	**12/01/18 17:00**		**£0.00**
3		**Design and test**	**20 days**	**23/10/17 08:00**	**17/11/17 17:00**		**£0.00**
4		Air flow testing	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
5		Supply information to Darlington	0 days	17/11/17 17:00	17/11/17 17:00	4	£0.00
6		Production (PCBs to be upgraded)	40 days	20/11/17 08:00	12/01/18 17:00	5	£0.00
7		Release date	0 days	12/01/18 17:00	12/01/18 17:00	6	£0.00
8		**1b Air elbow, nut and hose reducer**	**80 days**	**23/10/17 07:00**	**09/02/18 17:00**		**£0.00**
9		**Design and test**	**20 days**	**23/10/17 08:00**	**17/11/17 17:00**		**£1000.00**
10		Air flow testing	20 days	23/10/17 08:00	17/11/17 17:00		£0.00
11		**Tooling and Production**	**80 days**	**23/10/17 07:00**	**09/02/18 17:00**		**£15000.00**
12		Invitation to Tender	20 days	23/10/17 07:00	17/11/17 17:00		£0.00
13		Requote based on design	10 days	20/11/17 08:00	01/12/17 17:00	12	£0.00
14		Select suppliers	0 days	01/12/17 17:00	01/12/17 17:00	13	£0.00
15		Tooling	25 days	04/12/17 08:00	05/01/18 17:00	14	£0.00
16		Production	20 days	08/01/18 08:00	02/02/18 17:00	15	£0.00
17		Signoff	5 days	05/02/18 08:00	09/02/18 17:00	16	£0.00
18		Release date	0 days	09/02/18 17:00	09/02/18 17:00	17	£0.00
19		**1c Air Filter and filter box**	**100 days**	**18/12/17 08:00**	**04/05/18 17:00**		**£0.00**
20		**Design and test**	**20 days**	**18/12/17 08:00**	**12/01/18 17:00**		**£1000.00**
21		Design and spec	10 days	18/12/17 08:00	29/12/17 17:00		£0.00
22		Prototype and test	10 days	01/01/18 08:00	12/01/18 17:00	21	£0.00
23		**Tooling and Production**	**80 days**	**15/01/18 08:00**	**04/05/18 17:00**	**22**	**£10000.00**
24		Invitation to Tender	20 days	15/01/18 08:00	09/02/18 17:00		£0.00
25		Requote based on design	10 days	12/02/18 08:00	23/02/18 17:00	24	£0.00
26		Select suppliers	0 days	23/02/18 17:00	23/02/18 17:00	25	£0.00
27		Tooling	25 days	26/02/18 08:00	30/03/18 17:00	26	£0.00
28		Production	20 days	02/04/18 08:00	27/04/18 17:00	27	£0.00
29		Signoff	5 days	30/04/18 08:00	04/05/18 17:00	28	£0.00
30		Release date	0 days	04/05/18 17:00	04/05/18 17:00	29	£0.00
31		**2e Current Electronics and wiring loom**	**100.125 d...**	**18/12/17 08:00**	**07/05/18 09:00**		**£0.00**
32		**Design and test**	**20 days**	**18/12/17 08:00**	**12/01/18 17:00**		**£0.00**
33		Design and spec	10 days	18/12/17 08:00	29/12/17 17:00		£0.00
34		Prototype and test	10 days	01/01/18 08:00	12/01/18 17:00	33	£0.00
35		**Tooling and production**	**80 days**	**15/01/18 09:00**	**07/05/18 09:00**		**£0.00**
36		Invitation to Tender	20 days	15/01/18 09:00	12/02/18 09:00		£0.00
37		Requote based on design	10 days	12/02/18 09:00	26/02/18 09:00	36	£0.00
38		Select suppliers	0 days	26/02/18 09:00	26/02/18 09:00	37	£0.00
39		Tooling	25 days	26/02/18 09:00	02/04/18 09:00	38	£0.00
40		Production	20 days	02/04/18 09:00	30/04/18 09:00	39	£0.00
41		Signoff	5 days	30/04/18 09:00	07/05/18 09:00	40	£0.00
42		**2f Digital Electronics and wiring loom (STI)**	**100 days**	**23/10/17 08:00**	**09/03/18 17:00**		**£0.00**
43		Design and test	20 days	23/10/17 08:00	17/11/17 17:00		£20000.00
44		Tooling and production	80 days	20/11/17 08:00	09/03/18 17:00	43	£10000.00
45		**2g Industrial design of box**	**50 days**	**29/01/18 08:00**	**06/04/18 17:00**		**£0.00**
46		Business approval of industrial design of box concept	0 days	29/01/18 08:00	29/01/18 08:00		£0.00
47		Design	10 days	29/01/18 08:00	09/02/18 17:00	46	£5000.00
48		Test	10 days	12/02/18 08:00	23/02/18 17:00	47	£5000.00
49		Tooling and production	30 days	26/02/18 08:00	06/04/18 17:00	48	£25000.00
50		**Full reliability testing and approvals**	**45 days**	**09/04/18 08:00**	**08/06/18 17:00**		**£0.00**

		Name	Duration	Start	Finish	Pre...	Cost1
51		Testing	35 days	09/04/18 08:00	25/05/18 17:00	49	£5000.00
52		Approvals	10 days	28/05/18 08:00	08/06/18 17:00	51	£5000.00

7.7.5 Integrated Cubicle Shower System

Cost: £137,000
Collaboration: Kelda Technology, University of Southampton, SO3D and Rodd Design

1		**In-Shower System**	**165 days**	**23/10/17 08:00**	**08/06/18 17:00**		**£0.00**
2		**2a New fan / driver**	**140 days**	**23/10/17 08:00**	**04/05/18 17:00**		**£0.00**
3		**Design and test**	**80 days**	**23/10/17 08:00**	**09/02/18 17:00**		**£2000.00**
4		Design and spec	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
5		Prototype and test	40 days	18/12/17 08:00	09/02/18 17:00	4	£0.00
6		Design on fan / driver 'go / no go'	0 days	09/02/18 17:00	09/02/18 17:00	5	£0.00
7		**Tooling and production**	**80 days**	**15/01/18 08:00**	**04/05/18 17:00**		**£0.00**
8		Invitation to Tender	20 days	15/01/18 08:00	09/02/18 17:00		£0.00
9		Requote based on design	10 days	12/02/18 08:00	23/02/18 17:00	8	£0.00
10		Select suppliers	0 days	23/02/18 17:00	23/02/18 17:00	9	£0.00
11		Tooling	25 days	26/02/18 08:00	30/03/18 17:00	10	£0.00
12		Production	20 days	02/04/18 08:00	27/04/18 17:00	11	£0.00
13		Signoff	5 days	30/04/18 08:00	04/05/18 17:00	12	£0.00
14		**2b EPP fan housing**	**140 days**	**23/10/17 08:00**	**04/05/18 17:00**		**£0.00**
15		**Design and test**	**80 days**	**23/10/17 08:00**	**09/02/18 17:00**		**£5000.00**
16		Design and spec	40 days	23/10/17 08:00	15/12/17 17:00		£0.00
17		Prototype and test	40 days	18/12/17 08:00	09/02/18 17:00	16	£0.00
18		Design on fan / driver 'go / no go'	0 days	09/02/18 17:00	09/02/18 17:00	5	£0.00
19		**Tooling and production**	**80 days**	**15/01/18 08:00**	**04/05/18 17:00**		**£15000.00**
20		Invitation to Tender	20 days	15/01/18 08:00	09/02/18 17:00		£0.00
21		Requote based on design	10 days	12/02/18 08:00	23/02/18 17:00	20	£0.00
22		Select suppliers	0 days	23/02/18 17:00	23/02/18 17:00	21	£0.00
23		Tooling	25 days	26/02/18 08:00	30/03/18 17:00	22	£0.00
24		Production	20 days	02/04/18 08:00	27/04/18 17:00	23	£0.00
25		Signoff	5 days	30/04/18 08:00	04/05/18 17:00	24	£0.00
26		**2c Flow sensor / solenoid**	**100 days**	**18/12/17 08:00**	**04/05/18 17:00**		**£0.00**
27		**Design and test**	**20 days**	**18/12/17 08:00**	**12/01/18 17:00**		**£0.00**
28		Design and spec	10 days	18/12/17 08:00	29/12/17 17:00		£0.00
29		Go / no go	0 days	29/12/17 17:00	29/12/17 17:00	28	£0.00
30		Prototype and test	10 days	01/01/18 08:00	12/01/18 17:00	29	£0.00
31		**Tooling and production**	**80 days**	**15/01/18 08:00**	**04/05/18 17:00**		**£0.00**
32		Invitation to Tender	20 days	15/01/18 08:00	09/02/18 17:00		£0.00
33		Requote based on design	10 days	12/02/18 08:00	23/02/18 17:00	32	£0.00
34		Select suppliers	0 days	23/02/18 17:00	23/02/18 17:00	33	£0.00
35		Tooling	25 days	26/02/18 08:00	30/03/18 17:00	34	£0.00
36		Production	20 days	02/04/18 08:00	27/04/18 17:00	35	£0.00
37		Signoff	5 days	30/04/18 08:00	04/05/18 17:00	36	£0.00
38		**2d External power adapter**	**100 days**	**18/12/17 08:00**	**04/05/18 17:00**		**£0.00**
39		**Design and test**	**20 days**	**18/12/17 08:00**	**12/01/18 17:00**		**£0.00**
40		Design and spec	10 days	18/12/17 08:00	29/12/17 17:00		£0.00
41		Go / no go	0 days	29/12/17 17:00	29/12/17 17:00	40	£0.00
42		Prototype and test	10 days	01/01/18 08:00	12/01/18 17:00	41	£0.00
43		**Tooling and production**	**80 days**	**15/01/18 08:00**	**04/05/18 17:00**		**£0.00**
44		Invitation to Tender	20 days	15/01/18 08:00	09/02/18 17:00		£0.00
45		Requote based on design	10 days	12/02/18 08:00	23/02/18 17:00	44	£0.00
46		Select suppliers	0 days	23/02/18 17:00	23/02/18 17:00	45	£0.00
47		Tooling	25 days	26/02/18 08:00	30/03/18 17:00	46	£0.00
48		Production	20 days	02/04/18 08:00	27/04/18 17:00	47	£0.00
49		Signoff	5 days	30/04/18 08:00	04/05/18 17:00	48	£0.00
50		**2f Electronics and wiring loom (STI)**	**100 days**	**23/10/17 08:00**	**09/03/18 17:00**		**£0.00**
51		Design and test	20 days	23/10/17 08:00	17/11/17 17:00		£20000.00
52		Tooling and production	80 days	20/11/17 08:00	09/03/18 17:00	51	£10000.00
53		**2g Industrial design of box**	**50 days**	**29/01/18 08:00**	**06/04/18 17:00**		**£0.00**
54		Business approval of industrial design of box concept	0 days	29/01/18 08:00	29/01/18 08:00		£0.00
55		Design	10 days	29/01/18 08:00	09/02/18 17:00	54	£20000.00
56		Test	10 days	12/02/18 08:00	23/02/18 17:00	55	£10000.00
57		Tooling and production	30 days	26/02/18 08:00	06/04/18 17:00	56	£45000.00
58		**Full reliability testing and approvals**	**45 days**	**09/04/18 08:00**	**08/06/18 17:00**		**£0.00**
59		Testing	35 days	09/04/18 08:00	25/05/18 17:00	57	£5000.00
60		Approvals	10 days	28/05/18 08:00	08/06/18 17:00	59	£5000.00

7.8 Project Costs

7.8.1 Core Project Module Costs

Upgraded Showerhead	£49,000
Directional Showerhead	£40,000
Shower Handset and Riser Rail Kit	£40,000
Single Box Control Module	£102,000
Integrated Cubicle Shower System	£137,000

7.8.2 Additional Capital Expenditure

VisiSizer Laser Spray Size Analyzer,	£65,000
Software and Supporting Hardware	£51,700

This is required to conduct line items 1-21 of the Upgraded Showerhead Project, allowing us to measure and enhance spray force and patterns.

Laboratory and Laboratory Equipment	£48,200

This is an additional laboratory space within the University of Southampton estate to support the Upgraded Showerhead and Directional Showerhead projects.

7.8.3 Total Funding Required

Core Project Costs	£368,000
Additional Capital Expenditure	£164,900
Total Cost	£532,900
Self Funded (53%)	£282,437
Solent LEP Funding Application – Grant (47%)	£250,463

7.9 Value for Money and Cost Benefit Analysis

Assessing the likelihood of success, whilst avoiding optimism bias has been conducted for each project and is reflected in the summary table below:

Project	**NPV**	**Probability**	**Benefits – Expected Values**
Upgraded Showerhead	£200,000	0.4	£80,000
Directional Showerhead	£550,000	0.4	£220,000
Shower Handset	£2,570,000	0.5	£1,285,000
Single Box Control Module	£1,225,000	0.3	£367,500
Integrated Cubicle Shower System	£2,250,000	0.5	£1,125,000

Table 7.2 – Cost Benefit Analysis

The project costs are forecast to be £532,900, therefore the expected Net Benefit is therefore £2,544,600 NPV in the first year after completion.

7.10 State Aid Compliance

Kelda are satisfied that they fall within General Block Exemption regulations relating to State Aid.

7.11 Monitoring and Evaluation (M&E)

The project lead for this Grant application is Laurence Moorse, CFO. He will have accountability for monitoring and reporting progress against plan and an exception escalation and resolution. Supporting Laurence will be a qualified and experienced full time employee engaged in project management. A specific M&E template will be prepared on commencement of the project and will use the following existing framework as a template for measuring success:

	Definition	**Current Baseline**	**Target**	**Data Source**	**Frequency**	**Responsibility**	**Reporting**
Goal 1	Project milestones completed on time.	95%	100%	Project Libre monitoring	Weekly	Project Manager	Weekly Steering Committee
Goal 2	Project milestones completed to budget	100%	100%	Monthly Cashflow	Monthly	CTO	Monthly Board Meeting
Goal 3	Laboratory testing completed successfully	75%	95%	Laboratory Reports	Weekly	CTO	Weekly Steering Committee
Goal 4	Commence User Acceptance Trials	100%	100%	Installation Log	Monthly	CMO	Monthly Board Meeting

Table 7.3 - Sample Project Monitoring and Evaluation Template

8. Conclusion

We believe this this grant application meets each of the objectives of the Solent LEP guidelines. This project is a supply chain technology partnership of three entities, two commercial, one academic, and is industry led by Kelda Technology, a clean tech innovator.

The principle benefit of securing funding is in increasing exports from the Solent LEP region. The global opportunity for sales of innovative water saving technology has been presented in the form of latent demand and the worldwide opportunity for distribution. The expected Net Benefit in year one is nearly £2million NPV, of which exports from the region are expected to form 50% of the total.

The secondary benefit is in safeguarding jobs and creating new jobs within the region, alongside expansion of facilities within the University of Southampton estate.

The final benefit is in commercialising new technology on a global scale. The foundations for success have been laid in the development of the core shower product, but market entry to volume sectors depends upon a programme of research, development and design as laid out in this submission.

The path to success is clearly defined, through established sales channels, with a realistic and quantified sales pipeline in place and a value for money well in excess of 4:1.

8.1 Annex Documents

University of Southampton Trial Report

University of Southampton Spray Force Report

24Haymarket Funding Evidence

Letter of support from Cuesta Ltd, representing Prof J Shrimpton of the University of Southampton

Letter of support from Rodd

Letter of support from Trimline

Letter of support from SO3D

RODD/

Dear Sir/Madam,

Kelda Technology have approached Rodd to help them develop their revolutionary shower system. Kelda have outlined an exciting product roadmap for their technology which will allow them to be more competitive and enter new markets.

We believe that there is great opportunity in both the consumer and business to business marketplace for this innovative and efficient technology. Rodd work with clients across multiple market sectors, we design consumer experiences and category defining products for global consumer brands and start-ups alike. With over two decades of development experience our services span user research, consumer innovation and design direction - we believe that with our support Kelda can accelerate and focus their development activities in order to maximise the consumer facing potential of their technology. Rodd Design is based locally in Lyndhurst within close proximity of Kelda Technology and the University of Southampton.

We are very happy to support Kelda Technology with their the application for Solent LEP Innovation funding and look forward to a successful partnership that will have enormous impact for the local economy.

Ben Davies
Managing Director

rodd.uk.com

SO3D technologies
ADDITIVE MANUFACTURING & DESIGN

Dear Sir/Madam,

Kelda Technology have approached SO3D to help them develop their revolutionary shower system. Kelda have outlined an exciting product roadmap for their technology which will allow them to be more competitive and enter new markets.

We believe that there is great opportunity in the marketplace for this innovative and efficient technology. Using SO3D latest additive manufacturing technology's we can help them achieve their goals in a fast and cost-effective affiliation. SO3D is based locally in Botley within close proximity of Kelda Technology and the University of Southampton.

We are very happy to support Kelda Technology with their application for Solent LEP Innovation funding and look forward to a successful partnership that will have enormous impact for the local economy."

Best Regards

Will Howden

MD and Founder of SO3D Technologies

ESTD 1965

TRIMLINE

Creating World Class Interiors

30th October 2017

Dear Sir/Madam

Kelda Technology have approached Trimline to help them develop their revolutionary shower system. Kelda have outlined an exciting product roadmap for their technology which will allow them to be competitive in the Cruise Line.

We believe that there is great opportunity in the marketplace for this innovative and water efficient technology and Trimline are the right company to help them achieve this. Trimline is based locally in Southampton within proximity of Kelda Technology and the University of Southampton. Trimline and Kelda are in commercial discussions to partner marketing and rolling out their exciting technology to the Cruise line industry globally which will have direct benefits to both companies.

We are very happy to support Kelda Technology with the application for Solent LEP Innovation funding and look forward to a successful partnership that will have enormous impact for the local economy.

Yours faithfully

Mike Oliver
Trimline Ltd

Trimline House
Paget Street, Southampton
Hampshire SO14 5GN, UK

T +44 (0)23 8033 4242
E enquiries@trimline.co.uk
W www.trimline.co.uk

MAJOR REFURBISHMENTS
IN-SERVICE SUPPORT
DESIGN

Cuesta Ltd.

7 Belle Vue Road,
Salisbury,
Wiltshire.
SP1 3YD

07576278802
john.shrimpton@gmail.com

Friday, 27 October 2017

Dear Sir/Madam,

Kelda Technology have approached Cuesta Ltd to help them develop their revolutionary shower system. Kelda have outlined an exciting product roadmap for their technology which will allow them to be more competitive and enter new markets.

We believe that there is great opportunity in the marketplace for this innovative and efficient technology. Cuesta Ltd have the fundamental background in multiphase flows and atomizer design to help them achieve this. Rodd Design is based locally in Southampton within close proximity of Kelda Technology and the University of Southampton.

We are very happy to support Kelda Technology with their the application for Solent LEP Innovation funding and look forward to a successful partnership that will have enormous impact for the local economy.

Best Wishes,

John Shrimpton

Director

UNIVERSITY OF Southampton
Research Institute for Industry

Name: Dr Mohamed Torbati

Position: Senior Consulting Engineer

Title of Work:	**Comparative drop diameter measurements**
Work for:	**Kelda Showers**
Client:	**Chris Jackson**
RI*f*I Number:	**00997/C**
RI*f*I Consultant:	**Dr Mohamed Torbati**
Work by:	**Dr John Shrimpton & Dr Quentin Francois**
Date:	**7 February 2014**

Research Institute *for* Industry
Faculty of Engineering and the Environment, University of Southampton, Highfield Campus, Southampton, SO17 1BJ, United Kingdom
Tel: +44 (0)23 80597052 Fax: +44 (0)23 80597051 Email: rifi@soton.ac.uk www.rifi.soton.ac.uk

3. Spray Momentum perception

3.1 Background

This is a commercial study for Kelda Showers of the perception of "spray momentum" due to a novel type of shower head regarding to a classic shower head. The idea is to change the flow rate of one shower head until it "feels" like the comparator. The study has been performed on 25 students aged 18 to 24, male and female.

3.2 Introduction

The shower rig and the new shower head (Photo 7) have been designed by the client, the classic shower head was also provided by the client. These are the same objects than for the Measurements Tests.

Photo 7

The goal of this study is to record the water flow spreading out of the classic shower head giving the same "spray momentum" perception than a fixed flow of 5 L/min displayed by Kelda new showerhead and to gather a few comments about this one. A video of the experiment being processed has been sent to Kelda showers.

3.3 Method

The equipment is introduced to the students and the test is described. Students are asked to put their hand under the spray from the Kelda head (Water flow: 5L/min). Then the commercial shower head will be switched on and they will be shown and will feel the flow range from low to high. Then, from a middle range flow, the flow rate of the commercial unit will be increased or decreased so the flow rate of the commercial unit feels the same as the Kelda unit, according to student feeling. Once the student acknowledges a "same spray momentum" perception, the water flow rate is recorded by the person in charge, using a 1L graduated pitcher and a chronometer.

Typical ambient room temperature conditions will be present during the test. The water will be heated around 38°C and the temperature is checked before each test. Students are asked to use one hand to feel the water flows, both sides, eyes closed if needed.

3.4 Results

All raw data are available in an attached .xslx file for further analysis.

Table 7: Result of the experimental trial on the new shower head involving 20 participants

Gender	Flow (L/min)	Comments
Male	13,8	Less water, higher pressure
Male	12,1	Difference in stream wideness
Male	8,3	Less water
Male	12,4	NA
Male	14,3	Better sensation
Male	11	More comfortable
Male	12,5	NA
Male	13,7	Nice feeling
Male	14,7	Stronger pressure but less water
Male	10,3	Less water, more pressure
Male	9,7	Spray-like
Female	11,6	NA
Female	12,5	Impressed
Male	12,6	Air feeling
Male	10,7	NA
Male	11,6	NA
Female	12,4	Good feeling
Female	9,0	Nicer, softer
Female	11,2	Softer, finer, more comfortable
Male	12,2	Liked the finer spray
15 males, 5 Females		
Average	11,83	
Standard Deviation	1,684011501	

3.5 Conclusion

The classic shower head use two times more water than the newly designed shower head for the same perception. Comments are mostly positive and if the decrease of water flow is sometimes felt, the pressure is appreciated.

4.0 References

[1] N. R. Labiris and M. B. Dolovich, "Pulmonary drug delivery. Part I: Physiological factors affecting therapeutic effectiveness of aerosolized medications," *British Journal of Clinical Pharmacology*, vol. 56, pp. 588-599, Dec 2003.

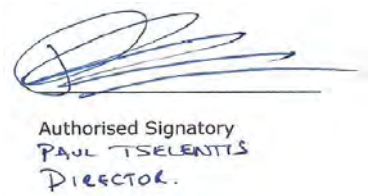
FAO: Laurence Moorse
Kelda Showers Limited,
2 Venture Road,
Chilworth,
SO16 7NP

30 October 2017

To whom it may concern:

This letter is to confirm that in June 2017, 24 Haymarket Nominees Limited invested a total of £1,527,054.75 in Kelda Showers Limited. It is our understanding that Kelda Showers Limited are planning to spend at least £300,000 of this investment on Product Development Projects.

Yours faithfully,



24Haymarket Nominees Limited

Trial Report **June 2016**

Assessment of the Data Collection and Further Analysis of the Usabilty Trial of the Technology of Kelda Showers Ltd at two Pure Gym sites in Southampton.

Professor John S Shrimpton BEng, PhD, DSc, CEng, FIMechE
Faculty of Engineering and the Environment
University of Southampton

About the Author

Professor John S Shrimpton is Professor within Engineering and the Environment at the University of Southampton. John specialises in the measurement and modelling of multiphase fluid mechanics, and maintains a suite of research codes and a laboratory, which specialises in optical diagnostics.

He is a chartered engineer and active internationally, being an adjunct Professor at the University of Chicago, a member of the IMechE, the Aerosol Society, the ILASS-Europe and the ICLASS technical committee. He has undertaken a wide range of industrial consultancy and collaborative research work for clients such as Oxford Lasers, GSK, BMW, Exxon, Johnson Matthey and Northrop Grumman.

Purpose of the report

For the past forty years, shower technology has remained largely unchanged and a core shower design sells in large volumes for well-established manufacturers in a globally mature market. Innovation beyond simply cosmetic improvements to showers is viewed as both costly and risky.

In contrast to this development stagnation, Kelda Technology has utilised engineering technology from the aerospace and high performance automotive sectors to deliver a step change in shower performance. In laboratory environments, long term testing of the Kelda Technology shower has demonstrated the benefits shown opposite.

The aim of this report and the user surveys is to provide verification of the measurements conducted at Pure Gym in Bitterne of new shower technology and to analyse the measurements and user survey data for trends. A user survey was also undertaken at Pure Gym in Southampton Central. Both surveys had over 100 participants.

Specific objectives of this report are:

1. Verify the measurement methods are reasonable
2. Quantify the measurement accuracy of the equipment
3. Demonstrate that Kelda Technology showers save at least 50% of the water used by the non Kelda showers.
4. Demonstrate that the user experience is at least neutral when Kelda Technology is saving this level of water

Analysis of objectives

Here I provide evidence to back up the assessments of the objectives.

Two measurements were made at Bitterne Pure Gym; the water flow rate of the shower and the temperature of the water.

1.1.1 Water Flow Measurement

Variations in the supplied water flow are to be expected, since it is understood the Bitterne facility runs 14 shower heads and associated washbasins and WCs, with the hot water being delivering by three combi boilers operating in parallel. It was recommended that a set of measurements be undertaken when the facility is highly and lightly used to examine any impact, though it is expected that the water saving comparing Kelda Technology and non-Kelda Technology showers would not be significantly affected.

Measurements of water flow rate were taken at 30 minute intervals randomly from one of the six non-Kelda Technology showers by rolling a dice, and immediately after that a measurement was made of the Kelda Technology shower water flow, using the same equipment and method.

1.1.2 Temperature Measurement

The temperature is measured by an RS 615-8206 digital thermometer with a rated accuracy of +/-0.2%. The thermocouple was placed in the bucket of water being weighed and the temperature was recorded. The water cools as soon as it emerges from the shower but once in the bucket the rate of cooling drops significantly since the surface area to volume ratio of the water drops significantly.

This is confirmed by watching the temperature reading which holds constant during the temperature data acquisition. Thus the temperature measurement is a good measure of the temperature of the water hitting someone having a shower under either of the units under test.

1.2 Quantify the Measurement Accuracy of the Equipment

This section relates to the accuracy of the water and temperature data recorded during the trials. It should be noted this defines the random error (the error in making the measurement), and can be reduced by averaging. By definition, the average measurement has no random error, as long as one makes enough measurements.

1.2.1 Water Flow Measurement

A measurement of a known volume of water was made at the start of the entire test and another at the end of the entire test. These differ by less than 0.5%, confirming there is no bias in the measurements recorded during the test. A series of 10 repeat tests were undertaken to measure the inherent variability of the water measurement.

The minimum and maximum measurements are 7.970kg and 8.733 kg. The average (A) and the standard deviation (SD) are 8.197 kg and 0.219 kg. Assuming the measurement error is random then the error is 'normal'. This means the standard deviation gives a 'confidence interval'. It says: if you do an experiment N times (and N is a large number), then 66% of the measurements are within one SD (ie A +/-SD), 95% of the measurements within 2 SD (ie A +/-2SD) and >99% of the measurements within (ie A +/-3SD). It is reasonable to say that the inherent measurement error of the water flow is +/-2SD, or +/-0.44.

So for the reference case noted here, we would write that the water measurement is 8.2 +/-0.4 kg (95% of the time). If we work out the error as a percentage this is 5%. In other words the volume of water recorded varies by 5% or less, 95% of the time. This is reasonable. The measurement is 60 seconds in duration and the error arises from placing the bucket in, and taking out of, the shower spray plume. The putting in and taking out probably has a random error of a second or two, and 5% of 60 is three (seconds), which would be the worst error within the 95% confidence limit.

1.2.2 Temperature Measurement

The minimum and maximum measurements are 39.80 and 40.50 centigrade. The average and standard deviation are 40.06 and 0.23. Therefore, applying the same principle as above, we would write the temperature as 40.1 +/- 0.5 degrees Centigrade. An inherent measurement error of 1% (more specifically, the temperature measurement will be in error by 1% or less 95% of the time).

1.3 To demonstrate that Kelda Technology showers save at least 50% of the water used by the non-Kelda Technology showers

The most accurate way to calculate the water saving is to divide the water flow from a Kelda Technology shower by the water flow of a non-Kelda Technology shower when these two data points are taken together in time. This eliminates the effect of temporal variations in the supply pressure, combi water flow rate and so on. Dividing one data point with an inherent 5% error with another with an error of 5% gives an error of that quotient of 10%.

As this error is random, we average over many samples to find the correct value, since the average is (for a large number of samples) free from this error. Therefore, we averaged each day's data, and then averaged these over the test period to get single values of flow rates and water saved.

Average water used per test over the entire test cycle is 4.1kg for the Kelda Technology shower over 8.3kg for the non-Kelda shower, a 50.3% saving in water use. Looking at the water saving percentage on a per day basis, there were a few days where the saving is less than 50%. One was Saturday 14th May, a day where we would expect the facility to be heavily used and here the water saved is only 47%. However, a closer look at the data shows this is because of a reduced flow rate of the non-Kelda Technology showers on that day.

1.4 To demonstrate that the user experience is at least neutral when Kelda Technology is saving this level of water

Two surveys of shower users have been conducted at Pure Gym, Bitterne and at Pure Gym, Southampton Central and the key question in the surveys was 'is the Kelda shower better, about the same, or worse, than a traditional gym shower?'

Adding together the respondents who say better and about the same, over the entire test at Bitterne (men) and Southampton Central (women), 73% of men and 91% of women say that the Kelda Technology shower is better or about the same in terms of performance as a non-Kelda Technology shower.

It is also noted that of the women who did NOT say the showers were 'about the same', more women (50.49%) said the Kelda Technology shower was better than the traditional gym shower (compared to 8.74%) who said the traditional gym shower was better).

Summary conclusions of objectives

1 The methods outlined in section 1.1 are appropriate and reasonable for the objective.

2 Section 1.2 shows that the water flow measurement has an inherent error of 5% or less and the water temperature measurement of 1% of less.

3 It is confirmed that over the duration of the trial that the Kelda Technology shower system saved 50.3% of the water used by the traditional gym showers.

4 It is confirmed that at the Pure Gym trials at Southampton Central and Bitterne, 91% of female users and 73% of male users say that the Kelda Technology shower is better, or about the same, as the traditional gym shower.

The benchmark for this test programme was the Rada VR105 shower head, used in conjunction with a Rada T1 300 push button valve and a 9 litres per minute flow restrictor.

Trials conducted at:
Pure Gym, Bitterne
Pure Gym, Southampton Central

Professor John S Shrimpton BEng, PhD, DSc, CEng, FIMechE Faculty of Engineering and the Environment University of Southampton

June 2016

50.3%
water saving

73%
of men say a Kelda shower is as good or better than a standard shower

91%
of women say a Kelda shower is as good or better than a standard shower