Industrial Strategy Challenge Fund: tell UK Gov what to support

1. Application details

Project summary

Challenge summary (40 words maximum)

In one sentence concisely articulate the challenge with no jargon. Say what the challenge is, why it is worth solving and what the positive impact would be if it was addressed.

The Zettabyte Challenge: We generate and consume data at an increasingly alarming rate, with new societal trends and technology game-changers rapidly accelerating demands. We need a radically new approach to data infrastructure to guarantee 'data-freedom' for the next three decades.

Scope: Alignment with grand challenges (20 words maximum)

Identify which of the following 'grand challenges' your challenge relates to:

- clean growth
- ageing society
- future of mobility
- artificial intelligence and the data economy

It underpins delivery of the digital infrastructure required for the AI and Data economy, but has implications for all GCs.

2. Application questions

Question 1: describe your challenge. (500 words maximum)

Provide further information about the challenge, including:

- *a clear, non-technical description of why it is worth solving, why now and why government should be involved*
- *a summary of how it will be possible to judge when the solution has been developed and the challenge addressed?*
- *the real-world impact of the challenge, including who the main beneficiaries would be if it was solved and the impact it would have on the general public*

Addressing the challenge cannot be achieved through 'business as usual'. This expression of interest does not relate to activity already funded by other means. You must show clear business leadership for the challenge.

Data is central to the modern economy. The consumer, service sector and manufacturing are united in their need to accumulate and exchange exponentially growing amounts of data, from the supply chain of manufactured goods to electronic financial services, to delivery of digital services to the consumer. It is predicted [IDC] that in 2025, 10x more information will be created and replicated than was created in 2016, and the amount of critical data that needs to be stored is expected to grow by 39% pa to 2025.

Today, the physical capacity **does not exist** to meet future data storage demand, and the global network capacity to transmit and retrieve the data needs to grow by a factor of 24% pa to service bandwidth requirements.

It is highly likely that every Challenge statement based on innovative solutions in AI and Data economy, Clean Growth, Future of Mobility and Healthy Ageing will require the capture, transport, storage and efficient recovery of data. Yet if we do not have the underlying infrastructure to realise robust, timely and secure data handling, then the roll out and adoption of innovation will be stifled and hence futile.

'Business as usual' means iterative improvement of current data infrastructure which sits stubbornly behind the curve of demand- the consumer and industry has lived with this since we first felt the squeeze on copper based broadband connections. Wireless 5G is off the blocks and emerging- but bottlenecks in the core network, datacentre and last mile to the premises will kill quality of service, and any rise in the cost of data storage will stratify society into 'data-rich' and 'data-poor'.

The Global IT infrastructure accounts for >10% of total global energy consumption, and one of the few areas that is growing due to rate of deployment outpacing the rate of energy innovation. A radical new approach is required to deliver cost effective scalability across the data-network to deliver not only capacity at the right price, but sustainable data transport and storage.

Disruptive innovation is urgently needed to reduce power consumption at source, whilst meeting increasing demand for greater bandwidth and storage. Materials integration offers one of the most exciting routes to deliver the increased chip-scale functionality (combination of photonics, high speed electronics, wireless and magnetics) whilst simplifying packaging requirements, so reducing cost.

Our Challenge statement is two-fold:

- develop the next generation data component technologies that will deliver the bandwidth and storage requirements for 2020+
- position the UK at the forefront of the new industry around integrated components that enable a new paradigm in mass-scalable data handling

Success means hitting relevant global targets eg:

- <$1 per gigabit for optical data transmission
- >2Tb/in^2 areal storage density

in mass-manufacturable solutions that will energise the UK into a global force in data components. We are in a key position to benefit at both the demand side of this challenge with a significant portion of the economy reliant on digital services, and the supply side where have the innovative technology sectors needed to meet the challenge.

Question 2: what is the opportunity for productivity growth? (300 words maximum)

Explain how addressing this challenge would have a positive impact on productivity growth, including:

- *which areas of the economy would see productivity growth*
- *the potential wider social or non-market benefits of solving this challenge, such as improvements in health or environment*

The UK Government published a digital strategy in March 2017 highlighting the importance of the digital economy. The analysis that underpinned this strategy revealed statistics that present an attractive case for focussing on growth in the digital economy to improve the UKs overall productivity.

In 2015, 1.75m people (6% of the working population) were working in the digital sector – 1.1m (61%) within digital businesses and a further 0.65m (39%) as digital specialists within other parts of the economy. The sector contributed £209B in turnover to the UK economy, and the GVA to the economy per worker in the digital industries was almost double the UK average, £92,000 for digital industry workers compared to £54,000 for the UK average across all sectors.

Growth in the number of digital businesses has been far above the norm (30%) and almost double the rate of growth for all UK businesses (17%) over the 2010 – 2015 period.

To paraphrase the headlines on productivity in the strategy, *'Improved connectivity also increases innovation and productivity across the economy, bringing significant economic rewards. Independent research suggests increased broadband speeds alone could add £17 billion to UK output by 2024.'*

As a result the UK government has committed to invest £1 billion to accelerate the development and uptake of next generation digital infrastructure - including full fibre and 5G, along with complementary investments in digital skills, cybersecurity and associated RD+I.

However, there is little attention or detail to the UKs contribution in driving the underlying enabling technology that is required to deliver this next chapter in the digital revolution. For example our own analysis suggests that that the semiconductor materials industry in Wales has a similar GVA multiplier (2.2x average), and it is clear that there is also a strong productivity opportunity via participation in the digital supply chain.

Question 3: what is the market opportunity? (300 words maximum)

Identify the market opportunity associated with this challenge. Briefly summarise relevant evidence of the global value and potential growth of the relevant market or markets.

The total global network equipment market was worth $167B in 2017 (ref ITC 2017). There are specific segments of this market that are particularly relevant to the UK supply chain. For example:

The total optical communications transceiver market is expected to reach $6.87B by 2022 (13.5% CAGR). This is being driven by increasing internet penetration and data traffic arising from smartphone usage and cloud computing. (MarketsAndMarkets, Oct 2016). High speed transceiver solutions for Hyperscale datacentres is particular area of growth that requires highly disruptive solutions to hit the price vs specification target. The UK has both established and emerging players in this area: eg Oclaro (Lumentum), II-VI, Huawei, Kaiam, and Rockley Photonics and many major players in the component supply chain (HiLight Semiconductor, CST, IQE, ICS, Newport Wafer Fab).

Most of the world's digital information is, and will continue to be, stored on hard drives. New innovation in the read-write transducer, with which information is transferred to the hard disk, is critical to increased hard drive data capacity. 25% of the world's transducers are manufactured by Seagate in Londonderry**.** Over the past 10 years 5.5ZB of storage capacity has shipped but 19ZB of storage capacity must ship from 2017 to 2025 to meet demand. Hard drive storage is expected to account for 58% of this, which translates to rapid growth from one to four Billion readheads per annum.

A report comissioned by the KTN in 2016 (The Big UK Data Centre Opportunity) concluded that the UK is the leading european market for Datacentre hardware, buying over ~£20bn annually. *The market is very open to new innovation, built from the UK's globally leading innovation base in optical communications, storage and energy efficient computing, to meet the challenge of rapid large scale deployment and short product lifecycles*.

Question 4: what evidence is there of UK strengths and competitive advantage? (500 words maximum)

Explain how the UK has the research and development capability and business readiness to meet the challenge. Identify:

- *the relevant UK research strengths*
- *the industry supply chain needed to address this challenge at scale, and the relevant UK industrial strengths*
- *how the UK has the capacity to be a world leader in addressing this challenge, and what the likelihood is that UK companies will be able to take advantage of the global opportunities that arise from the development of successful solutions*

This challenge requires strength and depth in advanced materials through to system implementation, with a particular focus on delivering hybrid and monolithic component architectures that enable ultra-high capacity, low energy data storage and transmission. There are several formal centres of research excellence in the UK, including (but not restricted to):

- Future Photonics Manufacturing Hub: Southampton and Sheffield Universities
- Future Compound Semiconductor Manufacturing Hub: Cardiff, UCL, Manchester and Sheffield Universities
- Centre of Doctorial Training in Photonic Integration and Advanced Data Storage: Glasgow and Queens Universities
- The Institute of Photonics, Strathclyde University
- Planned Centre for Integrative Semiconductor Materials: Swansea University

In addition, there several formal technology translation activities with a heavy focus on photonic/RF/magnetic materials integration and applications:

- The Compound Semiconductor Centre – a JV between Cardiff University and IQE Plc
- The Compound Semiconductor Applications Catapult

In terms of industrial supply chain that can take on this challenge, we have several significant global players with high value-add manufacturing operations in the UK that are predominantly export driven:

Seagate Technology is the world leader in hard drive storage. The Londonderry facility manufactures >25% of the world's recording transducers, employing over 1400 people and consists of 40% of Seagate's total transducer development capacity.

IQE is the world leader in the supply of Compound Semicondcutor wafer scale materials, and a primary supplier in the datacomms markets. IQE is ramping up a >£350M investment new production site in Newport which will increase UK headcount to ~400-500 in the next five years, with a target of this investment stimulating 2000 jobs in the wider supply chain for semiconductor based products.

Newport Wafer Fab offers high volume manufacturing of solutions in Silicon, Compound on Silicon and silicon-photonics technologies, with a large scale 200mm wafer foundry with >480 semiconductor specialists in Newport, South Wales.

Kaiam is leading manufacturer of high speed solutions of data transmission in hyper-scale data centre architectures. The company uses silicon micromechanical techniques to solve the challenging step of optical component alignment in its state-of-the-art manufacturing facility in Scotland (employing >450).

Oclaro Inc. is a leader in optical components, modules, and subsystems for optical transport, metro and enterprise networks, and data centers. The UK operation in Caswell has a long history in the development and manufacture of novel integrated component solutions.

Huawei's UK R+D Centre in Ipswich was facilitated by the acquisition of the Centre for Integrated Photonics, which has a >30yr history in component development, originally as BT R+D.

In addition, we have a buoyant SME and emergent start-up landscape, as a source of the disruptive technology that will be drivers of next generation solutions in this area eg: Rockley Photonics (a fabless supplier of silicon photonics chipsets), CST Global (a semiconductor laser chip supplier), Integrated Compound Semiconductors (a suppier of ultra-high speed detector technology), Hilight Semiconductors (a fabless supplier of CMOS ICs for high speed networking applications), Bay Photonics (a supplier of novel component packaging solutions), EFFECT Photonics (highly integrated communications products based on optical System-on-Chip technology), PureLifi (the trailblazer in emerging LiFi technology).

Question 5: what is the demand from industry? (500 words maximum)

Describe the level of industry demand in the UK for ISCF support to solve this challenge. Give:

- *the main UK-based stakeholders with an interest in this challenge, providing a list of supporters as an appendix*
- *how co-ordinated industry and academia are currently, and whether they could effectively come together in multidisciplinary partnerships to provide leadership around this challenge*
- *the evidence, where available of the extent to which industry would be willing and have the resources to co-invest to solve this challenge*

If your challenge is selected it is critical it has a director to run it. Please indicate who would be a suitable leader for your challenge, preferably someone from your proposal team.

There are several strands of activity which have been identified as being absolutely critical to delivering this challenge where there is evidence of emerging self-organisation and encouraging seeds of cross collaboration which can be nurtured and accelerated by ISCF focus and funding:

The £10M EPSRC funded Future Manufacturing Hub in Compound Semiconductors has a strong focus on semiconductor materials integration for component solutions in RF, Optical and Magnetic functionality, with a core of 23 Industrial partners that pledged £11M of support from 2017-2022, (a significant proportion are focussed on tele/ datacommunications).

This is one facet in a >£500M investment from regional, civic, academic and industrial stakeholders committed to seeding a technology cluster in South Wales (CSConnected) which includes the CS Applications Catapult, The CS Centre and The Institute for Compound Semiconductors with core industrial stakeholders in IQE (materials), SPTS (capital equipment), Newport Wafer Fab (wafer/chip fabrication) and Microsemi (chip packaging).

There is a current £30M RPIF application for a new Centre for Integrative Semiconductor Materials (CISM) at Swansea University to widen the scope of the cluster RD+I to look at next (next) generation solutions including polymers, dielectric and organics – with a commitment of ~£45M industrial support from the South Wales Cluster.

A significant effort around next generation hard drive storage focussed on a technology called Heat Assisted Magnetic Recording (HAMR). This requires the integration of laser sources, optics, magnetics and plasmonics to deliver the benefits of HAMR. Seagate initiated a £35M investment in 2014 to deliver volume production of HAMR, focussed on commercialisation of the first generation of the technology, but future generations require dense integration at the wafer level in order to deliver the demand.

This activity underpins the Queens/Glasgow CDT in Photonic Integration and Advanced Data Storage which has 12 industry partners including Seagate, IQE, Oxford Instruments, Oclaro, CST, II-VI and KNT.

There are multiple examples of current CRD activity that demonstrate a track record of successful consortium building and execution eg CSConnected members are currently managing/involved in ~15 current IUK funded CRD projects, based on materials and component innovation driving disruptive applications. Hence we have a robust track record in the core partners of (past and current) investment from seed CRD level to large scale support of longer term strategic initiatives, which is absolutely required to deliver this challenge.

In addition, we already have the core of an early stage (first initiated in 2016), sophisticated RD+I translation ecosystem that is unrivalled in the UK in the area of advanced semiconductor technology, and an emerging focus on connectivity to exploit other national centres of manufacturing excellence. The bid team will be co-ordinated by CSConnected with key staff from the CSC, Cardiff University, Catapult and CISM led by CSC Director Wyn Meredith. Core industrial stakeholders will be Seagate, IQE, NWF, SPTS, Microsemi, Rockley, Kaiam- collectively representing >3000 high value manufacturing jobs.

Challenge sub-themes have been proposed around:

- Storage of the future
- Towards £1 per Gigabit /Beyond Terabit transmission
- Enabling ubiquitous broadband/Backhauling 5G
- Heterogeneous or homogenous - back to fundamentals

You can submit an appendix with relevant supporting information, such as a list of supporters (from industry, academia or elsewhere) and letters of support. Do not provide in-depth economic or market analysis at this stage. This will be co-ordinated by UK Research and Innovation during the assessment phase. Supporting information must be in a PDF format no larger than 1MB.

Question 6: why is ISCF support needed? (300 words maximum)

Explain how ISCF will add value and why existing or planned investments from industry, government or the research base are not sufficient to address this challenge. Explain:

- *how things are done today and what the limits of current practice are from an industry and technical perspective*
- *what is new about the approach you are proposing for tackling the challenge*
- *why now is the right time to invest to address the challenge*
- *how ISCF will address a critical gap in current funding to address this challenge*

There have been many examples of failure to deliver the benefits of component integration due to:

- innovation that delivers high functionality at the cost of manufacturability;
- displacement rather than reduction of cost in the supply chain;
- solutions that cannot justify the risks of displacement on the basis of secondary factors such as reliability, supply chain failure etc.

These factors must be addressed at the source of the innovative process, but such sources (eg Universities, start-ups) are not naturally exposed to the external factors that drive such risks. Many new integration strategies tend to be driven by the novelty of the solution rather than the match to the problem, since integration is inherently flexible and can offer benefits across multiple applications.

ISCF intervention will connect research activities with well-defined problem statements in the context of 'design for mass manufacturing' from the outset, including:

- well-defined industrial problem statements with clear return on investment cases
- development of technology roadmaps in data storage + transport which will benefit from integration
- co-creation to address the roadmaps by majority technology pull, but with a space for high risk technology push into well informed 'research supply chains'

We will create the bandwidth for co-ordination, but more importantly energise the additionality of the collective assets and expertise across the core partners to accelerate the UK lead in the areas highlighted. Time is of the essence given the demand growth articulated in Q1, but we should be aware of the global competition. The EU has recognised the importance of integration by embedding in initiatives such as Pilot Lines and ESCEL. UK participation (and support) is not extensive, and not likely to improve until post BREXIT clarity returns. In the interim we must continue to advance this area by co-creation within our national assets.

Question 7: what level of funding is needed? (50 words maximum)

Provide an estimate of the amount of funding needed over 3 years to address this challenge from:

1. *ISCF.*
2. *Industry.*

ISCF funding comes from UK Research and Innovation and business and the public sector working in partnership.

The Challenge requires an ISCF budget of £97.5M with a minimum industry match funding of approximately £70M, based on average intervention rates. Core partners have indicated a co-investment of £149.9M. We firmly believe there is further leverage to be gained from upward penetration in the supply chain.

Question 8: are you happy for us to share your details with potential collaborators?

If we receive similar suggestions from more than one submission, we could suggest that the organisations involved collaborate. This is so they can provide a stronger, combined submission. Please state whether you agree to us sharing your contact details in this way. Your answer should be either yes or no.

Yes