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A STRATEGY FOR THE HENRY ROYCE INSTITUTE

1.0 INTRODUCTION

This is a strategy for the Henry Royce Institute, the UK National Centre for research and innovation of advanced materials. The document sets out the main principles that will guide the ongoing development and maturing of the Royce, the high level strategic objectives we will pursue and the operating model we will adopt. It emphasises the importance of understanding and nurturing key relationships throughout our stakeholder map and of getting the culture of the institute right, as this will set the direction for a successful and sustainable future.

The Henry Royce Institute was founded after an £250m investment from the Government that will allow the UK to grow its world-leading research and innovation base in advanced-materials science, which is fundamental to all industrial sectors and the national economy. It operates as a hub and spoke model, with the hub at The University of Manchester, and spokes at the founding partners, comprising the universities of Sheffield, Leeds, Liverpool, Cambridge, Oxford and Imperial College London, as well as UKAEA and NNL.

At the heart of the Royce philosophy is a commitment to the highest quality science, driving fundamental research into advanced materials and material systems. The science is supported by foundations of world class people, facilities, equipment and training, as well as a desire to meet challenges with an excellence in solving problems.

This document is not intended to be an operational plan, but to provide a strategic framework from which all other plans can be guided. It is the context for everything that we do.

2.0 VISION

Our Vision is to be 'An international flagship for the accelerated discovery and development of new materials systems for economic and societal benefit'.

Our research has the potential to have a significant impact on the world around us. The Royce will be a focal point, nationally and internationally, for people to come and learn about materials science and develop it into a major economic force. We believe that collaboration between world-leading researchers and world-leading companies will see real solutions, driven by research providing societal and economic benefit to the UK economy.

To advance this vision, we are creating an Institute which will act as a catalyst for advanced materials research, not just within the partners, but across the whole UK materials community, delivering science, facilitating relationships, engaging with business and influencing policy.

3.0 MISSION

Our Mission is to support and grow world-recognised excellence in UK materials research, accelerating commercial exploitation of materials research and delivering significant positive economic and societal impact for the UK.

We will execute this Mission through:

- Supporting excellence in materials research and growing an excellent research base
- Catalysing exploitation
- Enabling access to the latest facilities and capability
- Strengthening the UK materials supply chain
- Developing a more coherent and integrated materials community
- Encouraging collaboration

We have four overarching principles that support our mission. The first is to establish a unique integrated UK capability for the full value chain, namely the design from 'atom to the component', fabrication, test, and analysis and characterisation of advanced materials. The second is to provide an environment that allows the iterative design of advanced materials cost-effectively and at speed, providing a critical component to delivering on the government's economic strategy. The third is to aid the reduction in time-scales to translate discoveries to applications, provide strategic leadership together with training and career development in areas of particular need. The final principle is to focus on the early TRLs linking up with industry, catapults and other activities to take these ideas further forward into the marketplace. However this does not preclude us from helping industry with higher TRL issues and challenges on a more tactical basis.

4.0 STRATEGIC THEMES

Following a robust and thorough Strategy formation process, we have created a strategy based around eight strategic themes which will be critical to the successful and sustainable future for the Henry Royce Institute. Each theme has a strategic statement, a set of key principles, a description of the delivery mechanisms of the theme and a description of the anticipated outcome if fully matured. The eight themes are as follows:

- Science
- Funding
- Business Engagement
- Operations
- Innovation
- Skills and Outreach
- Identity, People & Culture
- International

5.0 SCIENCE STRATEGY

To be ‘an international flagship for the accelerated discovery and development of new materials systems for economic and societal benefit’, the portfolio science we do must be world class and impactful. We must help UK academics and industry to obtain new insights through access to expertise and cutting edge facilities, whilst addressing issues of sustainability and national resilience to global factors. We must advise on policy and help to tackle critical questions of societal or economic benefit.

5.1 KEY PRINCIPLES

5.1.1 Materials and Material Systems

Today, value is derived from the invention of completely new materials (e.g. graphene) and, importantly, from the development of multi-functional materials systems and devices (e.g. graphene spin valve). This requires a more joined up innovation framework beyond the remit of materials commodity suppliers or even individual research teams. The Royce enables joined up science delivery chains to allow fast design, make, characterise, test and iterate.

5.1.2 Targeted, but Opportunistic

While the facilities of the Royce can contribute to a wide range of science and technology developments, the science program is targeted on 9 core areas across the energy, structural, ICT and health areas. Each is led by a champion and coordinated through a stakeholder network of industrialists and academics enabling the focus to evolve and reflect changing national priorities. New topics will be developed in response to future needs either at the existing Partners or by enlarging the partnership.

5.1.3 Inventing the future whilst able to tackle the problems of today

The long term strategic research focus is primarily on technology readiness levels 1-4. It is also important that expertise and facilities can be drawn on to tackle higher TRL issues for companies of all sizes (immediate issues, technology threats, scale up issues, validation measurements etc.), to drive industrial funding.

5.1.4 Being interconnected

The Royce is open to academics and industry from across the UK but will focus on developing relationships and projects with other key players including Universities, other institutes, RGOs, Catapults and Manufacturing Research Hubs. In addition, external partners can affiliate their complementary facilities with the Royce, to establish a cost efficient materials research lab for the UK. In addition we will work with other bodies to support standards and validation.

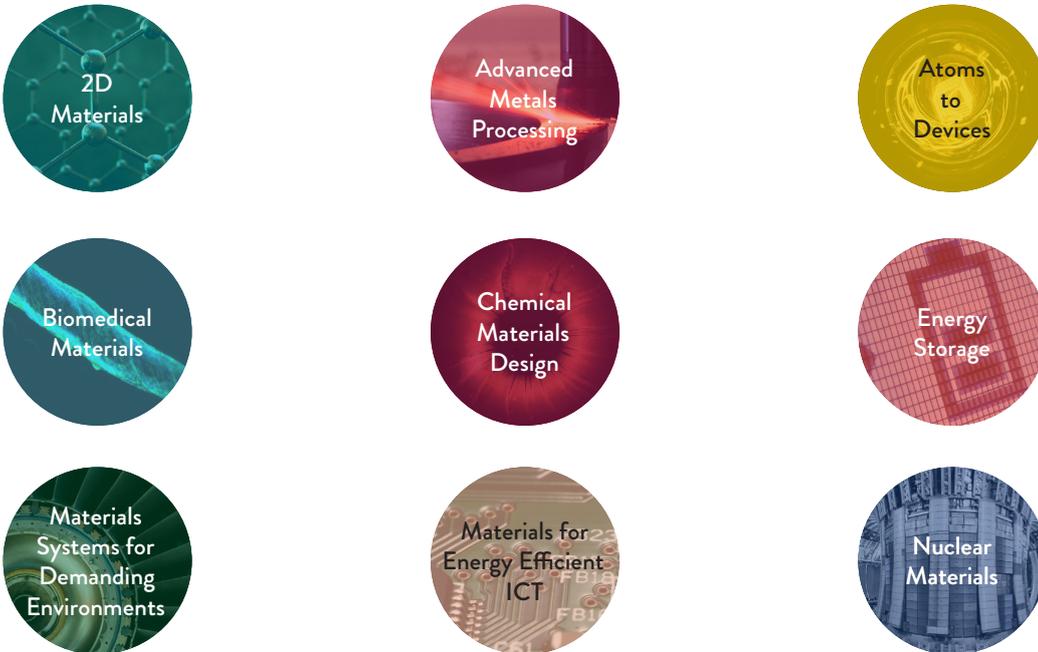
5.1.5 Materials intelligence

Royce will aim to become an independent source of advice and fore-sighting, advising government, and contributing to national priorities setting across sectors. It will create roadmaps and formulate the “big ideas” that draw the materials community together. It will also look to provide information to guide decisions regarding sustainability, use of natural resources and national security of supply.

5.2 DELIVERY

5.2.1 Core Area Themes

The nine core areas of Science, each led by a Core Area Champion are as follows:



Each Core Area theme will deliver world class science both by the hosts and by visiting researchers. A fuller description of each theme is available in Appendix I. They will form or contribute to networks for strategic landscaping of current capabilities, future opportunities, big ideas, challenges and needs and form an interconnected research supply chain of expert capabilities and facilities. They will host National Research Facilities and link with others elsewhere as well as participating in national challenge fund projects

5.2.2 Theme Evolution

It is important that as the Royce matures, we evolve the science capabilities offered by the Institute. This may be within the existing themes through natural growth and new capital investments, through the affiliation of complementary centres of excellence. It may also mean the creation of new Core Area Themes from the existing Partners, or through the addition of further Partners to extend the scientific footprint. We will also review the strategic alignment of existing themes at a sensible point in time to ensure continued relevance.

5.2.3 Core Science Team

It is intended to create a small central scientific team to help create national roadmaps for existing and new areas of materials research capability and to deliver policy advice. This will require a fore sighting capability across a range of sectors which will allow the Royce to influence UK researcher and funding agencies around new grand challenges, industry strategy challenges, strength in places and other initiatives.

5.3 STRATEGIC OUTCOME

- A clear and purposeful series of scientific themes
- A comprehensive set of theme landscapes giving scientific direction
- Interconnectivity between themes driven by the major societal/economic/industrial challenges
- An interconnected and responsive science base for materials research
- Royce seen as a principal independent advisor and shaper of policy
- A horizon scanning capability to identify new opportunities in science
- A clear process for growth into new areas of advanced material science
- An expanded network of partners

6.0 BUSINESS ENGAGEMENT STRATEGY

As an Institute focused on translating materials research into commercial applications and benefit, the Royce should proactively engage with all levels of industry to drive low TRL research outcomes that are relevant and meeting industrial challenges, provide industry access to academia and facilities, and provide a framework for translation of research to products, thus enhancing the UK industrial footprint. This should occur with a simple and market-driven suite of offerings that provide a clear value proposition for industry and one long-term revenue stream for the Royce.

6.1 KEY PRINCIPLES

- 6.1.1 As the Royce, we will have the capability to interact with the full range of businesses from multinationals to start-ups.
- 6.1.2 These companies will tend to be characterised by competitive advantage gained through materials science, either as a specialist materials developer, or as an application owner.
- 6.1.3 The interaction with these companies can range from low TRL research to high TRL problem resolution.
- 6.1.4 We will strive to enable these companies to access Royce expertise and facilities through a range of tailored models, including free/low cost access for SMEs.
- 6.1.5 We will act as a 'single front door' for companies to access advanced materials research through a transparent process that respects existing relationships and maximises the opportunity for all Partners and the wider network.
- 6.1.6 We will act as a 'virtual research facility' for emerging businesses
- 6.1.7 We will act as a vertical integrator, facilitating connection between SMEs, mid-size and large companies.

6.2 DELIVERY

6.2.1 Targeted

We will deliver a matrix of industry segmentation by sector and size to enable targeted engagement. The axis of the matrix will be Size (i.e. FTSE100 vs SME) and Sector (i.e. Aero vs Auto vs Biomedical). We will also understand and target dependent on their value chain position, focusing on both the specialist materials developers as well as application owners.

6.2.2 Engagement Forum

We will provide a series of engagement vehicles to initiate contact with companies depending on the matrix. Some of these will be “Science Push”, utilising Royce forums to share research/knowledge, often with multiple companies in attendance. They could be “Industry Pull”, often with single companies attending a sandpit to triage challenges and de-risk innovation.

We will run Sector-specific forums/events, often partnering with other organisations (i.e. Catapult events). It is also intended to drive Engagement through industrial funders (e.g. business growth hub/KTPs), government contacts (e.g. DIT) and run Funder events. All of this will be supported through appropriate communication channels

6.2.3 Engagement Mechanisms

We will develop a range of offerings that can be tailored appropriately for the size and scale of business, whether they be Pre/Post competitive (i.e. confidentiality vs public domain), strategic partnerships/industrial membership, specific collaborative research projects, service provision or even consultancy (e.g. technology road-mapping). Through a central business engagement team with partner representatives, we will coordinate activity/opportunities as well as developing a series of mechanisms to efficiently support these engagements. These will include, but not limited to, a template of commercial terms and IP/collaboration agreements, a visible lead capture and development process and an Engagement ‘toolkit’.

6.2.4 Industrial Secondments

We will develop a series of Industrial Secondment opportunities for researchers from companies to join the Royce for a period of time to aid in specific research projects as well as upskilling the UK supply chain.

6.3 STRATEGIC OUTCOME

- Engagement with a range of industries and business sizes (‘healthy funnel’)
- Clear processes and mechanisms for industry engagement across all sizes of company
- Key challenges solved including translation of research to products
- A competitive commercial model that allows Royce sustainability
- Research outcomes created that are relevant to industry
- A clear and market-driven offering

7.0 FUNDING STRATEGY

To deliver the world-leading ambitions set out in the science strategy, the Royce must establish a funding base comprising a portfolio of long-term, continuous and secure income from a diverse range of sources.

7.1 KEY PRINCIPLES

7.1.1 Budget

An assessment of the overall budget required for the Royce to operate in the period beyond the initial set-up investment, indicates the following:

- The leadership team and centrally-coordinated activities (£3.4m to £4.1m per year)
- Pilot pump priming research projects (~£300k-400k per year)
- Training-related staff and skills development activities (£450k to £540k per year)
- The operation and delivery of existing and upcoming facilities (£23m to £32m PA)
- The ongoing upgrade, refresh and extension of facilities (~£10m over 6 year period)
- New equipment related to expansion into additional themes (~£15m-£20m over 6 year period)

7.1.2 Funding sources

The required budget will be covered from a diverse range of sources to give a mixed funding model broadly comprising four areas. Firstly, we will seek core government funding. Second, Research Council grant income will be received, both from strategic initiatives for large-scale projects (i.e. circa £5m/annum) and through access charges on standard grants. Thirdly, we will engage with industry to provide a source of funds through external, industrial investment and commercial contract work. Finally we will seek income and leveraged funding associated with new Partners and Affiliates

7.1.3 Core Funding

For the Royce to deliver on a number of its strategic objectives, it is critical that Royce has a sustainable core funding element. These objectives cover, but are not limited to:

- supporting both the UK academic and industrial communities through the development of advice and strategy
- building strong advanced materials networks
- raising the expertise of PhD students
- providing a “single front door” for academia and industry to access an interconnected framework of world-class facilities
- nucleating new avenues of science and invention
- supporting SMEs

Strategically we are seeking core funding to cover:

- The leadership team and its centrally-run activities, training and “pump priming” research at 100% equating to £4.7m in Year 6, rising to £5.5m in Year 10
- Provision of free at the point of use, or reduced rate access to facilities for specific subsets of the user population, namely, PhD students, researchers conducting short pump-priming or exploratory projects in support of grant applications or to gain an understanding of the capabilities available, and SMEs. This is targeted to be 30% of the operational budget equating to £7.1m in Year 6 rising to £10m in Year 10

The remaining operational budget will be covered by Research Grant income and Industrial Engagement income

For the Royce to be able to refresh facilities and expand into new areas in response to government and industry needs (both at existing and new Partner institutions), annual capital investment will be required with the aim that a proportion is core-funded by individual capital grant applications .

7.2 DELIVERY

- 7.2.1 We will build key relationships with UKRI and government agencies to influence policy development in the materials science space. We will ensure policy-makers have access to our expertise and will provide advice for government reviews and reports on future investments.
- 7.2.2 We will target strategic funding initiatives such as PPs, ISCF, SPF and GCRF, and will be positioned to influence the future direction of such calls. We will be ready to respond to, and capitalise on, calls at short notice.
- 7.2.3 We will align our capabilities to addressing UK priorities, in particular the challenges faced by industry to secure their investment in our research and facilities. We will conduct horizon scanning to ensure we are on the front foot and ready to respond appropriately to industrial funding opportunities arising from new challenges.
- 7.2.4 We will support our Core Areas Champions and UK leaders in the Royce themes in securing programme-type grants, both within and across Royce themes to enable them to deliver the science strategy. We will support Partners in seeking alternative funding sources for new equipment through grants and institutional matched funding packages.
- 7.2.5 We will bring additional investment into the Royce through expanding our partnership and allowing new Partners or Affiliates to join through up-front contributions and/or incorporation of their existing facilities.
- 7.2.6 We will ensure a substantial income stream through high utilisation levels of our facilities by commercial customers and large industrial partners. We will make our facilities attractive and easy to access at short notice.

7.3 STRATEGIC OUTCOME

- A sustainable, low-risk and long-term funding model which balances income from a diverse range of sources.
- An element of core funding which is maximised to enable a degree of free, or reduced, at the point of access facility utilisation.
- Influence of government policy around investment in the grand challenges of materials science, and to be the preferred partner for high-value, strategic, time-limited project funding.
- An income stream to our facilities from a range of non-HEI users paying commercial rates.
- Central funding to support academic secondments, fellowships and Royce PhD cohorts.

8.0 OPERATIONAL STRATEGY

Our operational strategy will establish seamless, resilient and transparent structures and processes so that working with or within the Royce is simple and outcome-driven. By ensuring our facilities and expertise are easy to access for all, we will facilitate world-class science and enable the delivery of our mission through the strategic pillars.

8.1 KEY PRINCIPLES

8.1.1 Organisation

A clearly defined organisational structure for the Royce with distinct roles and areas of responsibility will be key to the effective functioning of the institute.

- A hub and spoke model will operate, with the hub's central team supporting and facilitating the delivery of world-class science and its translation through the spokes of the Partner institutions.
- Detailed role profiles and associated responsibility matrices will ensure transparency, accountability, and will engender a sense of ownership in delivery.

8.1.2 Governance Structure

In order to deliver on our commitments to funders and ensure value for money for the investment, a robust governance structure across all levels of the organisation, from local teams at Partners up to the Governing Board, will ensure activities are in line with strategic priorities.

- Decision-making will be devolved within the organisation to those with the relevant expertise.
- Regular meetings across groupings – whether business support units or scientific core area communities – will be established to ensure the free flow of information throughout the organisation.

8.1.3 Reporting

Reporting and quality assurance will be aligned with wider, national requirements in the sector to ensure efficiency in data collation and reporting on KPIs. There will be rolling reviews of activities and outputs, with full reviews published every 2 years.

8.1.4 Membership

The Royce's founding Partners will promote growth through their external collaborations, over time leading to the incorporation of new members. We will explore novel forms of partnering with other HEIs, the broader scientific community and businesses of all sizes to provide a range of membership models for prospective Partners and Affiliates. Each model will have clearly defined expectations and commitments for both the Royce and the member.

8.1.5 Personnel

The Royce will create a career structure which will both maintain continuity and enable staff to circulate and progress.

- Recruitment will focus on diverse talent with the potential to embrace new ways of working and who will be unconstrained by traditional sector approaches
- A particular emphasis will be placed on the recruitment and development of the specialist technical staff whose expertise will be key to the operation of our facilities and delivery of our science portfolio

8.1.6 Finances

Financial management systems which align with those of Partners will be established to facilitate the efficient management and distribution of funding.

- Simple reporting processes will seek to minimise the burden on Partners whilst maximising the value of the information sought.
- Equipment will be set up and registered as research facilities with charge-out rates determined using the transparent approach to costing (TRAC). These will be made readily available to other HEIs for inclusion on grant applications.

8.1.7 Infrastructure

Detailed implementation plans for the Royce Hub and estate across the Partners will ensure efficient occupation and use of space, with equipment locations determined according to suitability of space, facility groupings and proximity to expertise. The Royce Hub has been structured to encourage interactions and this ethos will be central to office and shared space design. Our estate will also be adaptable to respond to changing priorities.

8.1.8 Equipment and Facilities

Paramount to the discovery and development of new materials systems is our portfolio of state-of-the-art equipment and facilities. To ensure these will be easily accessible to our users and remain at the forefront of advanced materials techniques we will:

- Make straightforward, comprehensive and consistent information on equipment widely available through a variety of channels.
- Put in place simple and intuitive access models which facilitate a range of activities – from simple contract work on a single piece of kit through to complex projects conducted on facilities located across a number of Partners.
- Determine SLAs for initial enquiry through to access to expert and finally agreement of contract.
- Implement user evaluations to inform continuous improvement of our processes.

- Put in place and promote a shared health & safety culture across all Partners in line with industry standards.
- Consult relevant stakeholders in the specification and procurement of equipment to ensure it meets the needs of users and represents value for money.
- Maintain internal asset registers to prevent duplication.
- Share best practice and expertise across Partners and, where appropriate, maintenance/service contracts.
- Include refresh and renewal of equipment in future funding models.

8.2 DELIVERY

A portfolio of plans and process documents (the Royce Operating System) covering the key principles outlined below will form the backbone of our operations and will ensure consistency of approach across the Partners. These resources will be available to Partners through an internal portal and, where appropriate, also externally through our website.

8.3 STRATEGIC OUTCOME

- A clear and concise model of Royce operation with simple processes and KPIs
- An intuitive and efficient access model for equipment use
- Increasing equipment use and resulting scientific outputs
- Involvement of non-partner universities and incorporation of additional Partners
- A Royce Hub Building that works for all Partners

9.0 INNOVATION STRATEGY

As an Institute representing the highest level of research in the field of materials science, the Royce should facilitate and accelerate innovation from a number of different perspectives:

- Catalysing ideas and problems into research and commercial opportunity.
- Internal professional networking to resolve research/executional challenges.
- Innovation to solve industry/societal problems that require a materials solution.
- Identifying the real world potential and formulating routes to accelerating commercialisation

9.1 KEY PRINCIPLES

Innovation can sometimes be a somewhat chaotic process, with inputs from multiple sources. To provide some structure we will need to utilise four core principles:

9.1.1 Provide Direction

Innovation is rarely a “Eureka moment” where someone just invents something. It needs to be guided by challenges that are relevant to the science strategy. We need to have a method for allowing challenges to be set from the “inside out” – i.e. the challenges raised by the research itself, and the “outside in” – i.e. challenges raised by industry or government etc. to which materials science and research can provide a solution.

9.1.2 Catalyse Innovation

Innovation in a large collaborative set-up like ours requires people to be pushed from the easy path they took before, to be open minded, work differently and expose their ideas to criticism. Here positive leadership styles and our culture will be key across the Partners. In addition, we must find ways to expose people to new ideas external to their area of expertise/institution. We will need to have both a physical and a virtual way of doing this.

9.1.3 Provide Environments for Collaboration

In our environment, we will seek to provide financial and cultural incentives to collaborate. We must ensure our model, our culture, and our buildings reflect this need. The virtual side must find a way to connect cross-discipline, cross-institution and cross-industry.

9.1.4 Manage the Outputs

In theory, with collaboration will come an explosion in ideas and we must plan for the inevitable chaos. We should create routes for the best ideas to flourish including giving them exposure to critical audiences. In addition we need to understand how to give new ideas a period of incubation to ensure they get enough initial familiarity and understanding so they can survive the first treacherous steps to realisation. We should achieve this by feeding ideas back to the experts who are supporting the challenges, to ensure integrity and quality of ideas before implementing.

9.2 DELIVERY

9.2.1 Portal

We will deliver an Innovation/Network Portal that provides a forum and a process for questions to be posed, challenges to be set and potential solutions to be offered within a number of different communities:

- Internal to one university
- Internal across the partner network of universities
- External to the wider university community
- External to industry

9.2.2 Process

We will deliver a process that allows these ideas to be critically examined, filtered and acted upon

9.2.3 Workshops

We will facilitate a series of Accelerator reviews with appropriate SME/VC/PE audiences to allow opportunities for commercialisation of ideas to flourish

9.2.4 Advisory Panels

In order to ensure we have the right balance between technology push and challenge pull for innovation in the science we propose a small number of Advisory Panels across major industry themes to give guidance on market trends, product and application trends as a catalyst for new research ideas

9.3 STRATEGIC OUTCOME

- A clear process for fast and effective innovation in the materials science space
- A clear number of spin-outs and start-ups and corporate innovations delivered as a result of the Royce
- A reputation as an effective vehicle to move ideas to commercialisation
- A supportive and creative community with interdisciplinary knowledge/skills exchange

10.0 IDENTITY, PEOPLE & CULTURE STRATEGY

As a national Institute representing materials science and innovation across the UK, the Royce should:

- Facilitate an open, inclusive and collaborative network, incorporating industry, academia and other stakeholders in the advanced materials community.
- Create a culture that respects the diversity of the Royce network, engenders trust, and supports the success of its individual institutions in creating economic and social value through research.
- Add value by connecting people and ideas, and providing a world-class environment for innovation.
- Present the Royce and its role in a clear and visible way for Partners, their staff, and external audiences, who should all be able to easily access and contribute to the Royce.

10.1 KEY PRINCIPLES

- 10.1.1 Our culture will be representative of a world-class Institute; professional, responsible, impactful and trusted. It will also reflect the constant aspiration to high quality, embodied in the work of the Institute’s namesake Sir Henry Royce.
- 10.1.2 The Royce should be a national exemplar for inclusion and diversity, particularly in STEM, and this will be a founding principle of all Royce activity as recognised by relevant national award schemes.
- 10.1.3 The Royce Hub’s role will focus primarily on facilitation of the Royce network, and not a top-down organisation.
- 10.1.4 The role of the Royce and its value to the UK will be presented clearly to all stakeholders, using SMART communications to grow awareness across our community.

10.1.5 The Royce will support the highest standards of health and safety in advanced materials research, and for those accessing Royce equipment and facilities.

10.2 DELIVERY

10.2.1 We will create a clear set of values that will be informed by all Partners and the wider community, and communicate these to the public as the founding principles of all Royce activity

10.1.2 Personal responsibilities for growing and championing the Royce Identity, People and Culture strategy will be defined

10.1.3 A relevant set of KPIs will be defined to measure progress against the Royce Identity, People and Culture strategy

10.1.4 We will create a set of stakeholder maps to understand which organisations and individuals should be involved and consulted in the running of the Royce. These will evolve over time.

10.1.5 A set of mechanisms will be developed to regularly and proactively collect feedback from Royce Partners and wider network, in order that the Royce be shaped by its community. This may include working groups, events, online and offline feedback processes

10.2.6 A SMART communications plan will be developed to grow awareness of the Royce and support delivery of its wider strategy

10.3 STRATEGIC OUTCOME

- A clear definition of the Royce
- A clear definition of the roles and behaviours of leadership, hub, partners and non-partners
- Recognition as an exemplar for inclusion and diversity by relevant national award schemes
- Increased awareness of Royce and its values amongst all stakeholders
- A world-class organisation which supports its people to deliver all other strategic outcomes

11.0 SKILLS AND OUTREACH STRATEGY

Our skills and outreach strategy will ensure there is a full capability pipeline of highly trained individuals entering and working in the field of advanced material science. We will help to upskill and train a number of diverse communities within PhD, early career researchers, academics and industry alike. We will help to inspire the younger generation in the excitement and prospects of a career in STEM subjects. We will support and build upon the UK's world class position in advanced materials research through the development of an extended, durable and evolving network of advanced materials practitioners and leaders for the future, both in academia and in industry – an “engaged learning community”.

11.1 KEY PRINCIPLES

- 11.1.1 We will support a culture of learning and skills development in materials science across academia and industry
- 11.1.2 We will be a facilitative partner with a critical but constructive ear for ideas and initiatives coming from the learning community, recognising best practice and being a conduit for sharing and encouraging it.
- 11.1.3 For doctoral students, we will provide access to Royce facilities, workshops, training and other events which will be on an equal basis for doctoral students whether registered at Royce partner institutions or not. We will undertake only activities which add value to their existing training programmes, bringing together doctoral students from across the CDT network, or individuals from the broader doctoral landscape, where appropriate. We will provide a fertile space for ideas generation and exchange, providing a bigger landscape for advanced materials students to inhabit and develop in.
- 11.1.4 Equality Diversity & Inclusion will underpin our approach in terms of addressing the skills pipeline from school to doctoral level and beyond and in providing access to our programmes.
- 11.1.5 Outreach will be in all directions, to the next generation, to members of the academic and industrial community and to government and funders alike

11.2 DELIVERY

- 11.2.1 A variety of accessible mechanisms and platforms will be established for maximum engagement and benefit to the various constituencies represented in our engaged learning community.
- 11.2.2 We will collaborate with other institutes, professional bodies and HEIs (i.e. Innovate, KTNs, Royal Academy of Engineering) to support and define relevant programmes with the greatest potential impact and the least risk of duplication.
- 11.2.3 We will seek to engage the support of industry in defining programmes which address their skills requirements, so that new recruits at doctoral level are able to transition more quickly into the roles expected of them.
- 11.2.4 We will provide support for career development opportunities from apprenticeship level through to academic fellowships by supporting and delivering training and, where appropriate, providing funding for individual positions.
- 11.2.5 We will seek further funding to support our programmes.
- 11.2.6 We will participate in and arrange a number of outreach forums

11.3 STRATEGIC OUTCOME

- An engaged learning community
- Series of skills programmes tailored to range of groups e.g. early career researcher, industry, etc.
- Student numbers rising
- Number of universities using Royce to train its students rising
- Knowledge transfer: upskilling of students and staff for industry and vice versa
- Next generation of materials scientists e.g. uptake of UG courses
- Enable outreach from the youngest age to training across all levels of research

12.0 INTERNATIONAL STRATEGY

The Royce will be recognised within the international materials community as a world leading organisation in terms of equipment, academics, network and capabilities. There will be a clear model for interfacing with international funding, academic and industrial organisations.

12.1 KEY PRINCIPLES

- 12.1.1 The Royce will seek to engage with international academics involved in world class research
- 12.1.2 The Royce will seek funding from a range of international; sources, relevant to the defined science strategy
- 12.1.3 The Royce will engage with international companies with a particular focus on the those interactions with the potential to bring footprint into the UK
- 12.1.4 The Royce will be aware of, and be responsive to emerging global trends in materials science
- 12.1.5 The Royce will facilitate international collaboration in order to meet the UK Industrial Strategy challenges

12.2 DELIVERY

- 12.2.1 The communication plan will have an international element to increase the profile of the Royce through targeted social media, publications, conferences etc.
- 12.2.2 We will collaborate with government (EPSRC, BEIS, DIT) to identify and enhance opportunities for inward investment and export
- 12.2.3 We will deliver a framework of agreements to enable international collaboration
- 12.2.4 We will liaise with international funding agencies around the world to increase the funding stream into the Royce partnership

12.2.5 We will engage with businesses from around the world

12.2.6 We will seek opportunities for two way exchange of world class academics with the Royce

12.3 STRATEGIC OUTCOME

- A Henry Royce Institute that has an international reputation and is recognised globally
- An established international funding stream
- A business engagement model that encourages interaction with companies around the world
- A group of internationally renowned academics involved with the Royce
- The Royce will be an attractor for international talent and expertise

13.0 EXECUTION AND CONCLUSION

This Strategy will be translated into a set of Operational and Strategic Plans through a Business Plan Deployment Process, but these are not covered in this document.

With planned and thorough execution, the Henry Royce Institute will enjoy a successful and sustainable future as the UK National Centre for research and innovation of advanced materials, recognised as an international flagship for the accelerated discovery and development of new materials systems for economic and societal benefit.

END

APPENDIX 1 - SCIENCE THEMES

2D MATERIALS

Two-dimensional materials are one-atom thick materials capable of being combined in nano-stacks to deliver unique functionality. By far the best known is graphene, but there is a large and growing family of 2D materials that promise to revolutionise the materials world. 2D materials were pioneered in the UK, following the isolation of graphene at The University of Manchester in 2004, and, since then, they have become the subjects of a massive international research effort, due to their potential to influence a number of areas such as membranes for filtration and coatings, energy storage and functional composites. 2D material research at Royce will focus on developing the key underpinning science needed for future product development. The University of Manchester will establish a suite of functionalisation of 2D materials with in-situ characterisation/testing capability which, combined with existing infrastructure at Manchester, will provide UK academic groups and companies with a single access point for the development, production and analysis of 2D materials. These materials will be exploited in inks for printable electronics, enhanced composites, coatings and membranes, and in electrodes in fuel cells, lithium-ion batteries and super capacitors. In the long term, this facility, in collaboration with the National Physical Laboratory, will lead the way in formulating standards for 2D materials, providing a crucial point of reference for the 2D materials supply chain in the UK.

ADVANCED METALS PROCESSING

This theme will deliver a step change in the discovery and making of new material systems. Our researchers are creating alloys with higher performance, better manufacturability, greater flexibility and lower cost. Metals production consumes about 5% of global energy use and is responsible for an annual emission of more than two gigatons of CO₂, so our systems will also have lower environmental impact – reduced CO₂, reduced reliance on strategic elements, designed for whole life cycle. Advanced Metals Processing will feature agile and lean manufacturing, which is flexible and tailored to customer requirements. Our academics will have the ability to make alloys at a scale that is relevant to research and to upscaling for industry needs. Application areas include: Light weight system solutions for transport industry; New steels for nuclear industry; Net shape aerospace components; Additive repair of high value components; Materials tailored for orthopaedic applications; Primary metal suppliers for automotive manufacturers; Primary metal suppliers for aerospace component manufacturers, gas turbine suppliers.

ATOMS TO DEVICES

Atoms to Devices is concerned primarily with the deposition of functional films either by vacuum (top down) or solution processes (bottom up) through patterning in all three dimensions. It also includes the manufacture of powders for thick film deposition. Potential application areas cover almost all industrial sectors and particularly ICT, Healthcare and Energy. These applications could transform the following markets: £360bn photonics/imaging/communication; £270Bn semiconductor; £164Bn Cybersecurity; £50Bn energy storage. Royce academic partners, and the wider UK academic and industry community, has a vibrant, world-leading network in materials science and engineering, with excellence across the disciplinary areas required to create a vertically integrated Atoms to Devices programme. This interconnectivity is rarely seen in a single institution, and the Royce collaboration provides a unique and timely means of achieving this.

BIOMEDICAL MATERIALS

Novel medical approaches to improve human health and well-being are essential for maintaining the UK's internationally leading position in medical technology. A new generation of "smart" biomaterials is required. The Biomedical Materials is a key theme within Royce and the intention is to accelerate the discovery, manufacture and translation of biomaterials through a platform of state-of-the-art equipment. The two identified grand challenges of advanced biomaterials research are restoring biological function with minimal invasiveness (e.g. regenerative medicine, novel prosthetics and implants) and developing new therapies that reduce patient risk, improve efficacy, and lower cost (e.g. nanomedicine theranostics and personalised medicine).

CHEMICAL MATERIALS DESIGN

Combining high-performance computing and materials science, collaborating between academia and industry, will be a game changer for the discovery of new materials and their analysis. The Royce research will have a significant impact on a wide range of industrial sectors, from nanofabrication to nuclear engineering. In the future, it will involve engineers and scientists working together to tailor novel materials to create sustainable structures for the power and transport industries. Royce facilities, which are located in the new Materials Innovation Factory at Liverpool, will feature open access labs which can be used by both academics and industry.

ENERGY STORAGE

Better energy storage materials are required for the electrification of transport and for decarbonisation of the grid. The Royce research area focuses on batteries, supercapacitors and thermoelectrics to solve the material challenges involved in the all-solid-state battery. This would transform the safety of Li-ion batteries, enable the use of lithium metal electrodes delivering a step-change in energy density, leading to safe electric vehicles with a more than 300 mile driving range and faster charging. The global market in lithium batteries is growing exponentially, reaching £50bn in 2020. The UK will require the equivalent of two gigafactories for electric vehicles alone by 2025.

MATERIAL SYSTEMS FOR DEMANDING ENVIRONMENTS

For industrial applications demanding environments are present everywhere and corrosion is all around us; whether that is in energy production, the marine sector or the aerospace and automotive sector. Corrosion can also be important in the medical sector as implants need to function in very extreme and unusual conditions. It is important to have safe materials for biomedical components, as well as for these heavy engineering components for example plant, infrastructure and transport. We will design, make, characterise and test new material systems for demanding environments, supporting energy, transport and other sectors. This theme has a large research capability on nuclear fuel cladding and high-pressure, high-temperature research, including a large autoclave testing facility.

MATERIALS FOR ENERGY EFFICIENT ICT

Today's excellent technologies operate at a level way below the scientific limits to performance. Imagine a mobile phone which had: a processor and memory which drained 1/10th of the power; a safe battery with three times the energy density and 10 times more charge; a transparent solar coating so that the battery could be recharged by the sun; a display with a quarter of the thickness, drawing 1/3 of the power and was unbreakable and half the weight than it does today. Your phone would need charging once a month and replacing once a decade. Royce can turn the possibilities above into reality. Energy Efficient ICT focuses on: Energy Generation: new materials that are able to power autonomous devices by harnessing energy from the environment. Energy Storage: significant improvements in the energy density, longevity, cost and compatibility of

the various energy storage technologies required to power the next generation of ICT devices. Energy Use: radical approaches to reduce power consumption in processing and memory, towards the theoretical limits that are many orders of magnitude below current silicon-based technology, and making devices more lightweight.

NUCLEAR MATERIALS

To deliver science and innovation in advanced materials for nuclear applications driving impact and economic benefit for the UK. Nuclear activity can be split into two areas: Nuclear fuels and waste streams in the nuclear fuel cycle; Structural materials for fission and fusion energy. We could see: Fuel production and performance including accident tolerant fuel; Energy & materials co-production; Waste conditioning & disposal; Self-healing coatings; Novel nuclear structural materials; Mechanical properties and irradiation effects in engineered alloys. The Nuclear research area will establish Royce capability for scientists and industry to prepare, test and analyse radioactive materials for fission and fusion applications. It will enable substantial programmes of work on authentic irradiated nuclear materials and support The Industrial Strategy. Our researchers will deliver innovation in materials, materials performance data and understanding to reduce costs and increase productivity in current and future nuclear programmes. We will exploit advanced materials with confidence and the data necessary to underpin safety.