

Appendix 1: National Robotarium Project Summary

The material opportunity to deliver the vision of leadership in RAS

Vision

Heriot Watt University's will build leadership in robotics and autonomous systems (RAS) on the strong foundations of our existing capability in RAS research, excellence in teaching and talent development; collaboration with key stakeholders, other universities and industry; and facilitating adoption and deployment in the wider economy.

The vision for the National Robotarium is to create the UK's leading innovation hub for the practical application of robotics and autonomous systems, and through this centre to drive a wave of wealth-creation and inclusive-growth by enabling the increases in productivity, innovation, capability and economic activity that are possible with the practical application of robotics and autonomous systems.



The National Robotarium will provide a unique capability to allow researchers and industry to interact, where 'Living Labs' will provide a partnership structure to test products and systems for industry, bridging from fundamental research to product development, enabling researchers to gain insights into novel research challenge, and providing a pathway for companies, including SMEs, to tackle procurement and supply chain problems.

The National Robotarium is one project within, and an integral part of, the Data Driven Innovation (DDI) theme of the Edinburgh and South East Scotland City Region Deal delivering leading edge research and support for business creation and growth, as well as data skills, new undergraduate and postgraduate programmes, and continuous professional development.

HWU's vision and DDI are consistent with the UK Industrial Strategy, the Scottish Industrial Strategy, and the Science & Innovation Audit for the Edinburgh & South East Scotland City Region, and focus on the wealth-creation and inclusive-growth these seek to create. Further detail of the alignment with UK and Scottish Government Priorities is contained within the full business case as is inclusive Growth.

The Robotarium will deliver a range of benefits focused on five main 'TRADE' strengths:

1. **Talent:** developing STEM and technical skills at Doctorate, Graduate and CPD levels, both in-University and online.

2. **Research:** developing new research at the frontiers of robotics hardware and software, artificial intelligence and autonomy, and their integration in robotics systems targeting a range of sectors important to the Scottish and wider UK economy.
3. **Adoption:** bringing together business, finance and industry to deliver the early “proof of product”, bringing novel ideas to life through adoption and scale-up.
4. **Data:** generation of data sets that can be further exploited by researchers and industry to further develop both the Internet of Things (IoT) and RAS.
5. **Entrepreneurship:** support budding entrepreneurs at all stages via the ‘Entrepreneurial Journey’, creating a pipeline of high growth RAS start-ups.

In particular the wealth creation and inclusive growth will be in the fields of subsea and hazardous environments, healthcare, manufacturing, human computer interaction, asset integrity, and exploiting data driven innovation to enhance productivity in these domains.

The Robotarium will create a return to the UK economy of £12.73 for each £1 of public sector capital funding over the next 15 years.

Opportunity

The opportunity is to capitalise on Robotics and Autonomous Systems (RAS) that are transforming industry and lives worldwide. These RAS technologies transform productivity, create new materials and capabilities, and enable new products and services.

There is also the opportunity to build on:

1. **Edinburgh’s academic capability:** the capability and achievements already delivered through the collaborative initiative on RAS between University of Edinburgh (UoE) and Heriot Watt University (HWU), the Edinburgh Centre for Robotics (ECR), together with the support of the Engineering and Physical Sciences Research Council (EPSRC) and the City of Edinburgh.
2. **UK academic capability:** the UK capability in Universities with major Robotics research: Oxford (researches all aspects of land-based mobile autonomy); Bristol (with a 4,600sqm state-of-the-art centre of excellence for multi-disciplinary robotics research); and Imperial College (with whom we collaborate and who are heavily supported by Dyson in the home automation arena). Through the new EPSRC funded ORCA Hub which will be part of the National Robotarium, HWU is leading collaboration with all major UK universities (with significant industry support)
3. **Private Sector capability:** the innovative UK companies including BAe Systems, Rolls Royce, BP, Subsea7 and Renishaw interested in RAS leadership.
4. **Political appetite:** the appetite and ambition contained in the UK and Scottish industrial strategies, and the desire for inclusive growth.

Current position – strong foundations to build upon

Potential in robotics

Recent figures from the Office of National Statistics show that UK productivity has consistently been lower than most of the rest of the G7 for the past 20+ years. There is general acceptance that increasing the number of robots in use will drive-up productivity.

The UK adoption of robotics lags international competition. There is an opportunity to build awareness and understanding of RAS capability, enable innovation and adaptation, build expertise and capability, and promote RAS application.

A recent National Audit Office report (2017) into Robotics and Autonomous Systems Research identified that there is not a strategic, joined-up approach to investment and there is no evidence of any top-down action to set, coordinate or align priorities. Relative to our international competitors, UK market issues - in designing, building and using Robotics and AI across a range of sectors - include lack of understanding by UK industry of the international situation, consequent lack of industrial investment, under investment by UK Government in underpinning Robotics and AI R&D, and lack of innovation skills education and access for researchers.¹

Countries measured in terms of utilisation of RAS in 2017 (Number of industrial robots per 10,000 persons employed)	
• Republic of Korea	631
• Singapore	488
• Germany	309
• Japan	303
• Sweden	288
• US	189
• UK	71

Overcoming barriers

There appear to be six major barriers to RAS investment and adoption, each of which the Robotarium can actively address:

1. **Asymmetric information:** lack of cross-sector open-innovation and information on adoption of RAS solutions, and resultant uplifts in efficiency and market growth.
2. **Lack of scale:** fragmented innovation infrastructure linked to R&D investment, and lack of clustering of research with innovative companies, start-ups and venture finance.
3. **Risk aversion:** reluctance to invest in and apply new robotics technologies and relevant business processes.
4. **Information:** private sector markets tending to “use up” current sources of research, leading to convergence and irreversibility, and locking society into particular technological options.

¹ <https://www.nao.org.uk/wp-content/uploads/2017/11/Research-and-development-case-study-Robotics-and-autonomous-systems-research.pdf>

5. **Matching technologies and investors:** limited options available to firms, the public sector and wider society.
6. **Cross-fertilisation:** few interdisciplinary and cross industry approaches, limiting the likelihood of such options being selected to address a wider range of sectoral needs.

Wide Support

For these reasons, the private sector supports the need to increase research in robotics and autonomous systems, particularly in healthcare, manufacturing and asset integrity, at HWU. Further details of the support for the Robotarium from the private sector, and potential research and development projects, are included within the case.

Track record of delivery

HWU is uniquely placed to lead the development of HWU education, research and development. The University has:

- a history of research that is of societal and economic benefit. Our performance in REF2014, where we were 1st in Scotland for impact and 9th overall in the UK, confirms that our strategy is delivering impact where it is required.
- pioneered the use of Living Labs to connect background discovery science with integration, adaptation, demonstration and deployment.
- developed strong relationships with industry stakeholders and partners to make significant contributions to economic and industrial development in key sectors like oil and gas.
- commitment to educate graduates who are appropriately skilled in RAS but who also have the capability to apply these skills in multiple application domains ranging from healthcare to manufacturing to asset management.
- achieved UK TEF silver.
- employability scores consistently placing us in the upper quartile of all UK Universities, with 95% of Heriot-Watt students in employment or further study within six months of graduation.

HWU's existing facilities however are overstretched and do not provide the facilities required for developing new activities.

How HWU will achieve the vision

The vision of a leading innovation hub for the practical application of robotics and autonomous systems will be achieved through the creation of a centre to enable robotics and autonomous system innovation and development, and to lead a wave of wealth-creation and inclusive-growth.

This is more than a building; it is a centre of expertise and capability that stimulates minds, facilitates innovation, trains and develops future engineers and innovators, and drives technology and innovation in to the wider economy.

To ensure delivery of the vision it will be necessary to build the capacity and capability to extend research and development in to RAS, and to organize resources, staff, students and researchers to deliver effectively both within the Robotarium and out in to the wider community. There will be strong

focus in the Robotarium's target outcomes and KPIs, ensuring continuous realignment of resources and effort to ensure delivery.

Investing in capacity and capability

To provide the capacity and capability to develop RAS and bridge the technology out to the wider economy, an additional 2600sqm facility will facilitate RAS development, train and develop researchers and students, and engage industry in practical and commercial application.

The facility will meet appropriate building regulations and BREEAM Excellent standards, employ renewable energy systems, and facilitate optimised flexibility for future reconfiguration to meet change needs.

The facility will provide the capacity to deliver the talent, research, adoption, data, entrepreneurship, inclusive growth and investment needed to necessary to economic growth and sustain it for the long term.

1. **Developing Talent:** The facility and the academic leadership it houses will have the capacity to deliver research, development, educational programmes and training. This will be consistent with HWU's standards and core activities relevant to the National Robotarium proposition in the City Region Deal and the Scottish Government's Inclusive Growth policy priorities.

This educational capacity and capability will include new RAS courses at different qualification levels; increased capacity to deliver training; improved access to in-work training through CPD; better scope for informal learning through realising opportunities for co-location; a leading training offer in the City Region through ability to access the latest research and facilities; facilities to attracting talent from outside of the City Region to study and relocate; and increased ability to apply data to "real world" problems.

Specifically, we will design and deliver new courses at different accreditation levels. We will create new DDI-centred full undergraduate and postgraduate courses, including distance learning, and expand existing courses in RAS and related subjects. The RAS Doctoral Training centre will be able to provide continuing professional development to upskill those already in work or whose work will change with the rollout of RAS technologies. We will deliver data skills courses, available to all HWU students, resulting in 1,500 students each year graduating with DDI skills.

2. **Leading research and development:** Research and development will be enabled by improving the range, quality and critical mass of facilities available to leverage more research and investment, enabling the improvement of pathways through which research translates into economic and social outcomes through Living Lab approaches, and creating the conditions for chance interaction and co-production.

We will maintain and develop the City Region's reputation in RAS and the translation of research via Living Labs, and create RAS solutions in key industry sectors. We will increase the research investment in RAS and generate over 75 new Impact case studies illustrating the direct impact of our research on industry in Scotland.

3. **Encouraging adoption and application:** The new facility will stimulate adoption by increasing the awareness and uptake of RAS amongst businesses, the public sector and the general

public. This will be achieved by extending the number and level of partnerships with public and private sector partners; enabling closer collaboration and dissemination of best practice through realising opportunities for co-location; increasing size of industry research contributions; providing access to Living Lab capability to help test and develop products in real world, safe, conditions which can be hard to produce in isolation; extending the reach of RAS into local schools; enabling better public access to the activity being undertaken to build awareness of and trust in the RAS economy; and demonstrating the potential of data to unlock opportunity.

4. **Sharing data:** The benefits of data dissemination will be enabled by providing the facilities needed to securely store and manipulate data; enabling more data partnerships; increasing the breadth of datasets available for correlation and interrogation; improving the accessibility, usability and cost of access to data assets for wider user groups to underpin more research, adoption and entrepreneurship activity; and promoting the data-assets available to attract investment and talent.
5. **Stimulating entrepreneurship:** The development of entrepreneurship within the City Region, Scotland, and the wider UK economy will be enabled by identifying and encouraging the formation, support and space available to spin-outs; promoting better industry awareness of, participation in and investment in spin-out activity; improving access to support services; organising more events that support the creation of an entrepreneurial ecosystem; and widening access to data assets and reducing the cost of access to foster entrepreneurial activity.

Delivering industry-ready research

There will be three key areas of new activity, and in each the focus will be on delivering industry-relevant and industry-ready research in applications critical to the Scottish and UK economies, with key industrial partners who are already identified.

1. **Robotics and Autonomous Systems:** we will develop RAS for hazardous environments including underwater, subsurface and offshore asset integrity capability for the offshore industry that will, for example, create a step-change in current practice of inspection, repair and maintenance. The National Robotarium will house Living Lab spaces for industrial partners, research laboratory spaces, and an instrumented and serviced outdoor space to enable testing and development of innovative autonomous systems.
2. **Manufacturing:** we will establish ULTRA-LAB, a "one-stop-shop" UK Centre of Excellence for ultrafast laser processing, which will enable UK researchers and the industrial community to access the unique capabilities of ultrafast laser-processing for their specific manufacturing applications. Two ultrafast laser automated manufacturing systems will combine with automated beam manipulation systems to enable the development of data-driven industrially relevant and autonomous ultrafast laser manufacturing processes. ULTRA-LAB will provide important support for the high precision manufacturing industry in the UK and Scotland, and form a key complement to and collaborator with NMIS.
3. **Healthcare:** we will establish a realistic domestic environment Living Lab to explore how RAS will support the elderly. The Living Lab will host collaboration with industry health services and charities. The collaboration will deliver cross-disciplinary projects involving new assistive medical aids and increase the usefulness of assistive living environments by producing

exemplar data sets by enabling experimentation with data-driven support mechanisms. The methods developed from the analysis of the Living Lab data will result in costs savings by decreasing the number of staff required and making staff time more efficient.

The capability and capacity provided by the Robotarium and its Living Labs will be the enabler to extend research and development to industrial scale and application in all three areas.

Delivering in the wider economy

These activities will have impact beyond the University and indeed beyond the City region, and our work will be configured to ensure benefits to the wider region in three main areas: inclusive growth, investment, and gross value added.

- **Inclusive growth:** the new facility will enable HWU to unlock benefits from RAS for all parts of our society by improving access to RAS training to those already in work; supporting the roll out of RAS training to schools and further education partners across the City Region via City Deal skills group; contributing to more efficient and effective public service delivery through extended collaboration with public bodies and supporting the development of products that reach the most vulnerable in society. Whilst concerns have been expressed that the exponential growth of autonomous systems will impact on the nature of work and availability of jobs, this project will address this in three ways. First the supply of highly trained graduates into the workforce in the Region, Scotland and the UK more generally, will ensure this Region is at the forefront of the exploiting the growth of new technologies. Second, it is likely that whilst the total number of jobs may reduce, the nature of work and the skills required by those in work will change. The McKinsey Global Institute (Nov 2017) predict that up to one-third of the workforce in richer nations like the UK may need to retrain for other jobs. The National Robotarium CPD programme will up-skill and re-skill the existing workforce for these new jobs that will be required in the economy. Third, the National Robotarium will provide thought leadership, both in research and application by examining the nature of the change required in the workforce. To ensure that, as in the past, technological change leads to real benefits the concept of what constitutes work will have to be rethought. The National Robotarium, will lead examination and preparation for the changing nature of work, making this Region the most advanced in readiness to address the revolution approaching in autonomous systems and data driven innovation.

The scale of the UK talent gap for skills in robotics and autonomous systems is very significant and is expected to continue to be a challenge in the medium to long term, and can be characterised by a combination of:

- New technologies having a significant impact on the nature of work;
- UK businesses already perceive a significant skills gap; and,
- Most businesses do not yet fully understand the implications of advanced technologies

Many reports have characterised the impact of automation. For example, the OECD estimates that 14% of jobs in developed countries were highly automatable, while a further 32% of jobs were likely to experience significant changes to the way they were carried out. In this context the ability to apply such technologies will be of key importance to UK citizens and the wider economy. Irrespective of whether the skills gap grows in the future, the Institute of Mechanical Engineers (IME) found that

growing gap between numbers of roles in science, technology, engineering and mathematics (STEM) is costing UK businesses £1.5 billion annually in recruitment, short-term staffing and training expenses. Indeed, 89 per cent of British STEM businesses had difficulty hiring staff with the necessary skills in the last year, leading to a shortfall of over 173,000 workers. In response, 2018 was declared by the UK government to be the “Year of Engineering”, and estimates that the engineering sector would need to recruit around 186,000 skilled engineers each year until 2024 in order to gain enough candidates to reduce the skills gap.

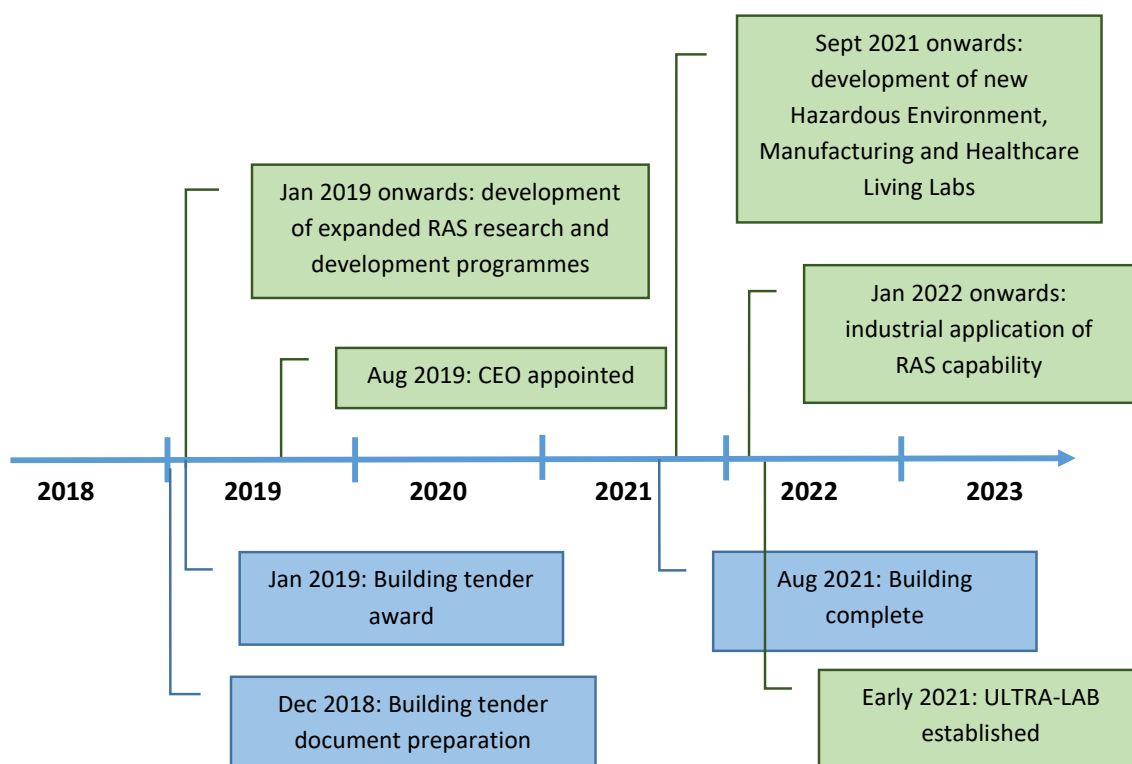
Yet, this massive skills gap is not yet understood, or validated, by UK industry as it does not have the knowledge necessary to manage technology adoption. The 2017 edition of the Deloitte Global Human Capital Trends survey found that business leaders in the UK acknowledge the challenge to commercialise innovation inputs and hence benefit from the associated productivity gains. Only 16 per cent of UK business leaders surveyed considered themselves ready to exploit innovative technologies like robotics, cognitive computing and artificial intelligence. This was lower than both the Global (17%) and West Europe (17%), India (and China. In contrast, business leaders in rapidly emerging economies were most likely to consider themselves ready to implement innovation.

Training an additional 1,500 skilled graduates will contribute to addressing the skills shortage, whilst providing the individual concerned with a skill-set that will continue to be highly prized by industry.

- **Investment:** we will develop a cluster of RAS activity in the City Region that is attractive to investors by providing a sustainable supply of talent; improving access to research; improving access to facilities (especially Living Labs) and data; raising the profile of the City Region as a centre of excellence for RAS; maintaining and extending the reach of the City Region’s international networks; and facilitating the supply of floor space for potential relocations.
- **Gross value added:** we will support our researchers and students to engage with the local economy, and through our new facilities we will invite the local economy and community in to engage with us. Through this approach, embodied in our Living Labs, we will inspire economic activity, seed new innovation and investment, and enable new growth.

The specific investment and activity that enables the realisation of these benefits is the Robotarium facility, which will be constructed, equipped and staffed over a four year period at a total cost of £22.5 million.

- **Construction:** all this capacity and capability is conditional upon building the new facility to house the Robotarium. Construction will commence in 2019 following a 2-stage tendering process in line with Crown Commercial Services guidelines and RIBA Stage 4 employer requirements.
- **Timeline:** the facility will be completed over the period August 2019 – August 2021.



- **Cost:** the facility will cost £22.5 million (in 2018 prices). The impacts on the Income and Expenditure Account, and the Balance Sheet, have been assessed with appropriately-qualified independent verification.

Organising and delivering effectively

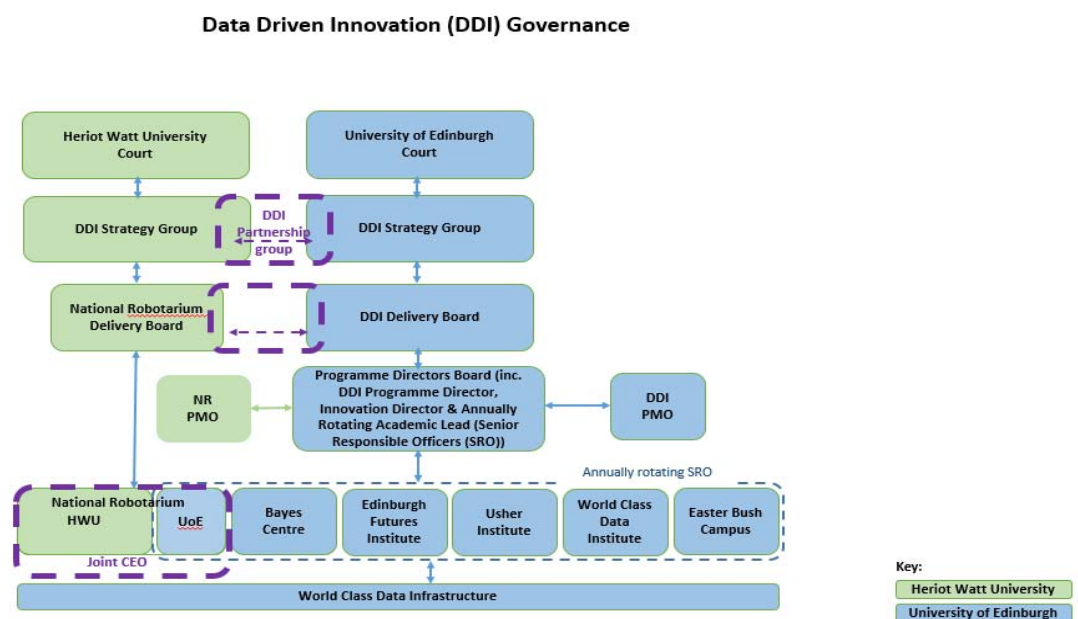
HWU will operate the Robotarium at the highest levels of academic excellence, operational efficiency and delivery professionalism. A strong governance framework will be put in place to ensure the appropriate design, delivery, cost-management and operational management of the Robotarium. An executive management team with the appropriate experience will be appointed to deliver the project. Risk mitigation will be ensured through an appropriate risk mitigation framework. Quality will be assured through appropriate working practices, appraisal techniques and organisational policy. And focus will be maintained on key deliverables and KPIs through the governance framework, management structure and work programmes.

Governance: HWU has a strong governance framework which has proven capability to deliver investment projects and new research and development programmes. This comprises six levels of supervision and control.

1. The **University Court** (“Court”) will provide assurance on the DDI Programme capital and revenue spending, through well-established and proven mechanisms of major project governance.
2. A **DDI Programme Strategy Group** will be responsible for management of DDI programme activities and delivery of agreed outcomes.
3. A **DDI Partnership Group** will ensure, in consultation with senior university officers from the partners, that the overall direction of the DDI is clear and meets its strategic objectives.

4. The **National Robotarium Delivery Board** will be responsible for the operational management of the Robotarium. This board will report to the DDI Programme Delivery Board at each university.
5. A new **Chief Executive Officer (CEO)** will be jointly appointed by both universities deliver the specific outcomes of the National Robotarium.
6. An **Industrial Steering Committee** will advise the Management Board on the strategic development of the National Robotarium and ensure that it functions in partnership with Industry.

Data Driven Innovation (DDI) Governance



Risk Mitigation: the CEO and management team will be accountable for implementing HWU’s established procedures for managing risk through the University’s **Risk and Internal Audit Office**.

Risks are identified in a **Risk Register**, and **Risk Owners** manage the risk and ensure that any mitigation plans are implemented. Risk is a standing agenda item at monthly project team meetings and a section on risk is contained within monthly progress reports, with a risk workshop also held at each stage of the project.

Although we don’t expect to need it, there is a contingency plan for delay, based on the University’s Business Continuity Plan.

Quality: the Robotarium will be operated in line with HWUs consistently high standards for research and education.

Target outcomes and KPIs

Full details of the KPIs and milestones are detailed in the DDI Programme document. Headline key deliverables and impacts for this project include

- Skills engagement with 47,000 individuals (students, school pupils industry personnel);
- Over 60 companies using the living labs to develop their technologies;

- Over 420 companies involved in RAS outreach activities in the form of seminars, engagement events and lectures;
- Over 75 new Case Studies generated illustrating the direct impact of the research in local industry; and,
- 40 teams entering DDI accelerator programme.