



Catapult Network

*Fostering Innovation to Drive Economic Growth*

2017

We work with  
**Innovate UK**

**CATAPULT**  
Network



# FOREWORD

Dr Ruth McKernan CBE, Chief Executive of Innovate UK

**The dynamic activity of the UK's network of Catapult technology and innovation centres over the last five years is vividly showcased in this new publication produced by the Catapults as a network.**

The statistics alone are impressive, such as creating over three thousand new collaborations with academia and industry, being active in 24 countries around the world helping UK companies seize the opportunities of global markets and raise the profile of UK R&D capabilities.

The innovation stories set out are illustrative of the impact Catapults are achieving for the UK economy, and the key role they have to play in the government's Industrial Strategy.

From high profile projects like autonomous vehicles, to collaborative cross-Catapult projects such as the Digital and Future Cities Catapults work on the Internet of Things, the Catapults are fulfilling their remit – to bridge the gap between academia and business, and to drive innovation and growth in some of the UK's key industries.

As Chief Executive of Innovate UK I am very privileged to have seen many of these projects at first hand during visits to the Catapults and hear the testimony of businesses across the country describing the difference Catapults have made.

Most recently, I have been delighted by the number of joint projects that Catapults are undertaking and their commitment to supporting the development of skilled staff for our growing businesses.

This is just the start of the Catapults' innovation journey and I look forward to seeing their sustained impact, helping to create jobs and growth for the UK for many years to come.



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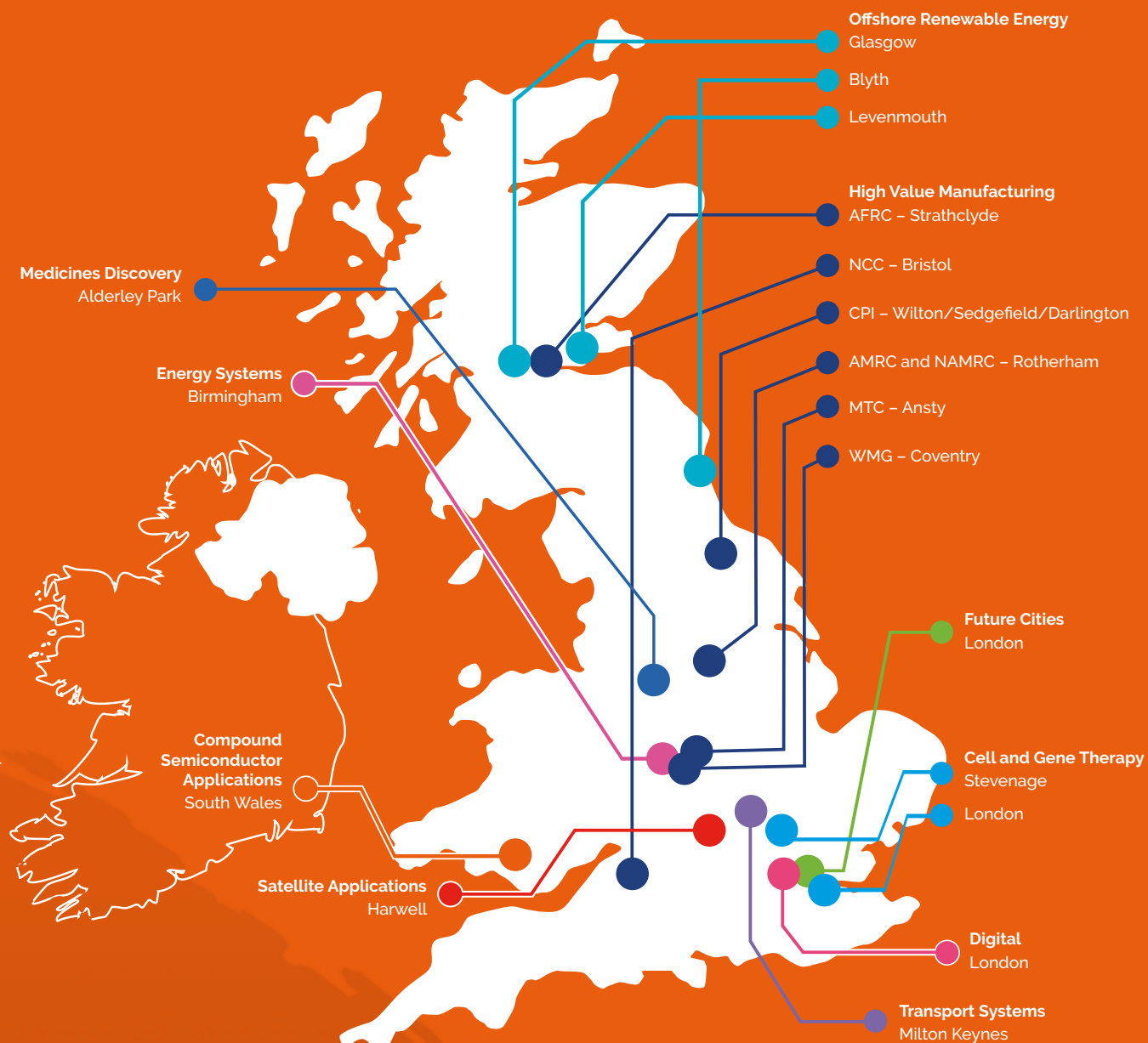
## Regional Centres

### Satellite Applications

- North East
- Scotland
- South West
- South Coast
- East Midlands

### Digital

- North East and Tees Valley
- Yorkshire
- Brighton
- Northern Ireland



# INTRODUCTION

**The Catapults are a nationwide-network of technology centres, created by Innovate UK, designed to harness British innovation and boost productivity.**

They were created in response to a report published in 2010 by entrepreneur and technologist, Dr Herman Hauser, in which he identified a need to,

*"...close the gap between universities and industry through a 'translational infrastructure' to provide a business-focused capacity and capability that bridges research and technology commercialisation."*

The document addressed an issue that had dogged the country for many years: Britain's failure to capitalise fully on the commercial potential of its world-class science and research base. The UK was great at inventing but bad at commercialising.

The country's industrial successes highlighted shortcomings elsewhere. The UK had long been the world's No2 aerospace nation, with particular expertise in jet engines and satellites. Our automotive, creative, engineering and pharmacology companies were (and are) at the forefront of their sectors, globally. Britain clearly had the 'right stuff' but it was unevenly distributed and poorly understood.

The Catapults were tasked with delivering a paradigm shift in how we identify, nurture and deliver market-worthy ideas.

Independent, agile and staffed by teams with broad business experience they were mandated to 'creatively destroy obstacles to success.'

Over the past four years they have done just that, creating over three thousand new collaborations between academia and industry and taking on challenges ranging from the mass production of graphene, the atom-thick 'wonder material', to shaking up the energy industry and putting the UK at the forefront of the Internet of Things.

Catapults operate facilities worth £850m, providing open access to state of the art resource and expert support beyond the means of all but the biggest companies. Some also help apprentices get 'hands on' with the latest technologies, anchoring key skills here. They are active in over 24 countries around the world, developing markets for British ingenuity and attracting inward investment from leading international companies, who increasingly see the UK as a prime research and development base for autonomous vehicles, medicines and smart cities.

Their achievements derive not from the discovery of some Secret Industrial Success Formula, but from the way they combine clarity of vision with ambition and 'real-world' commercial pragmatism.

For a start, the Catapult resource is carefully focused on areas where the UK already has significant strengths, or where the ingredients exist to grow sectors and establish multi-billion pound stakes in high-value emerging markets.

ACTIVE IN  
**24**   
COUNTRIES  
AROUND THE  
WORLD

**cATAPULT**



## INTRODUCTION – CONTINUED

Early on, they worked hard to deliver a wide range of projects in order to forge links and establish their credibility with stakeholders. Catapults are now seen as being trustworthy, expert and neutral, able to convene effective partnerships with academia, government and businesses of all sizes, from start ups to international corporations.

Rather than foist new ideas on an unsuspecting market, they work with industry to build demand for innovation. Because it is understood that their role is to boost entire sectors, not just support selected companies, Catapults have had remarkable success in getting firms to collaborate and share information.

Generating and manipulating data to model problems and create new products is a tactic used across the network and it helps Catapults take a 'whole systems' approach to complex, cross-sectorial issues, such as cutting congestion on the motorways, bringing smart sustainable heating solutions into homes or preparing the country for the mass-uptake of electric vehicles. Modelling real environments in the virtual world also helps

prove solutions before final commitments to invest in building or machinery are made.

Catapults are increasingly collaborating with each other, drawing on the strength of their network and pooling talents to address systemic failure and share best practice across sectors. As a result, Catapults are not only strategically aligned with the Industrial Strategy, published in January 2017, they are the best delivery mechanism for it.

The plan identifies the need to spread opportunity and growth across the country, and its ten priority themes, or pillars, are a checklist for how the Catapults impact the economy: from investing in science, research and innovation to supporting businesses to grow; creating the right local infrastructure and improving procurement. It is a practical list for improving productivity.

The Catapult experience also informed the creation of the Industrial Strategy Challenge Fund, announced in 2016, which will see £1bn invested over four years in six principle technology areas including:

CATAPULTS  
OPERATE  
FACILITIES  
WORTH   
£850M

# CATAPULTS ARE SEEN AS BEING TRUSTWORTHY, EXPERT AND NEUTRAL

healthcare and medicines, manufacturing, robots for a safer world and batteries for cleaner energy.

The Industrial Strategy and Challenge Fund reflect the understanding that sustainable economic growth cannot be delivered by just a handful of sectors, or by 'picking winners, but through the creation of an enduring architecture for success, where every aspect, from how we produce electricity, to how we sell British innovation around the world, is considered and optimised.

This matters now more than ever because a new wave of technology is heading towards us that will sweep away existing norms of how we work, how we make things and even how we live. Artificial intelligence, quantum technologies, synthetic biology, digital manufacturing: these things will test the capacity of every nation to react to the sort of change that used to take generations, but which will now be experienced over the course of just a few years.

Fortunately, Britain has planned for this future and developed the tools necessary to turn 'change' into opportunity.

As the original industrial nation, we know that innovation is restless; rather than be daunted by the technological shifts ahead, the Catapults are already embracing them and experimenting with their application. The skills and facilities the Catapults have invested in are not fixed to one mode or moment but designed to evolve, just as the network overall can reconfigure according to the challenges being faced.

# CATAPULTS HAVE REMARKABLE SUCCESS GETTING FIRMS TO COLLABORATE AND SHARE INFORMATION

The chapters following will detail how the Catapults came into being and how they operate; they will discuss a handful of projects from the 600 plus completed to date, and look at ongoing programmes designed to deliver long term economic and social benefits. The closing section will show how the Catapults are increasingly working together to address the most complex problems faced by the country.

The innovation story starts, however, in space.



## AN INNOVATOR'S STORY

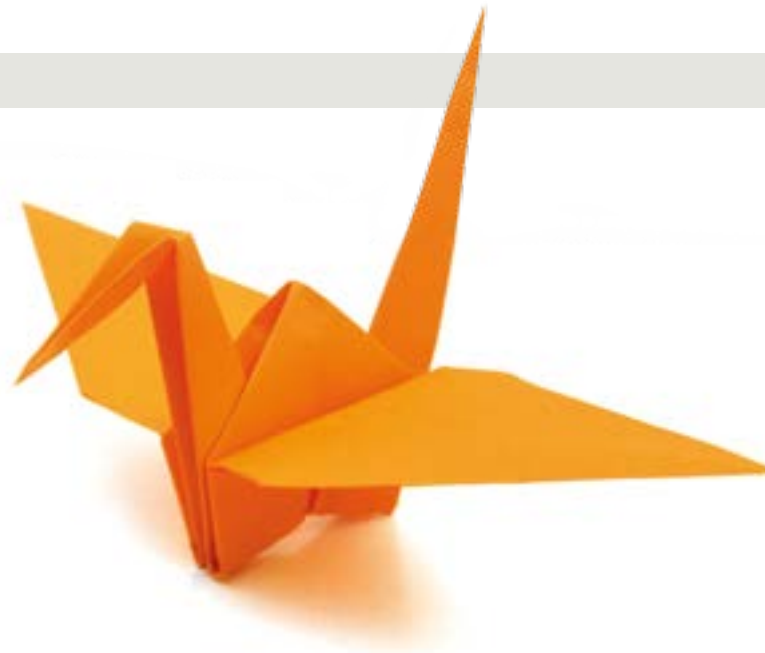
**Mike Lawton is demanding. It is his drive that led him to combine the 2,000-year-old art of origami with cutting-edge materials technology, and pioneer a radical new way of designing and making antennas and booms for spacecraft.**

Having startled the incumbent aerospace giants with the ingenious simplicity of his idea, Mike validated the new concept, in orbit, in a timespan the industry said was impossible: from start-up to space in just 30 months.

*"Demanding is good. It's how you succeed when the odds are against you. I like being told my ambitions are impossible...", he says, smiling.*

Mike is also quick to acknowledge how his impertinent start-up became a respected player in a sector dominated by industrial giants and state funded agencies. "In large part it's thanks to this place."

He's speaking about the Satellite Applications Catapult, a sleek, low-rise building on an Oxfordshire science and innovation campus that is home to a team of over a 100 people. Space engineers and data experts; technology gurus and business builders; blue-sky thinkers and angel investors, they are drawn from around the world and share a simple, if ambitious, goal: to ensure UK innovation is at the heart of a new space age.



A revolution is underway. Between 2005 and 2015, 1,480 satellites were launched. In the corresponding period to 2025, it is predicted that five times that number will go into orbit. This reflects the fact that space services and data enable almost every aspect of the modern world: timing, navigation, communication, entertainment, farming, pollution monitoring, smart cities, tele-medicine, self-driving vehicles... they all rely on information cascading from space and turned into apps and products by a fast growing crowd of creative, data-smart companies.

"As a so-called 'pre-start-up' the Catapult helped me secure my first offer of conditional investment for Oxford Space Systems: we won an Innovate UK competition. This not only provided some initial funding, the Catapult also gave us a home, tested our business

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## AN INNOVATOR'S STORY – CONTINUED

model and helped me improve our pitch so we could secure our first venture capital funding. Their support gave OSS credibility and they introduced us to technology partners and international agencies that, ultimately, put our product into space.

Entrepreneurs are often so in love with their idea they lose sight of the market. That might seem an odd thing to say but quite often people aren't ready for new ideas, especially from up-starts they've never heard of.

You can easily go bust fighting conservatism and inertia. Having the brilliant new idea is only part of the jigsaw. I had many sleepless nights thinking about this, and the responsibility I bore towards the

people here, all betting their careers on this working. I kept asking myself, 'Can we really deliver this? Why would anyone buy from me?' That's the reality of innovation: constant stress!

Testing the idea, presenting it properly, having a business plan that isn't fantasy, building credibility – these things are vital. And very hard to do, which is why I am so glad we found the Catapult. They really know their sector and understand the mindset of entrepreneurs. It was a proper partnership and together we set a record for the space industry.

They know how to make ideas fly. In our case, quite literally." ■

# CATAPULTS REALLY KNOW THEIR SECTOR AND UNDERSTAND THE MINDSET OF ENTREPRENEURS





# WHAT DO CATAPULTS DO?

## Specialist Technology Centres Boosting UK Innovation And Growth

### Catapults...

- ◆ Bridge the gap between research and commercialisation
- ◆ Foster collaboration within and between organisations and sectors
- ◆ Stimulate demand for innovation
- ◆ Get new ideas and technologies to market quicker
- ◆ Break down barriers to success
- ◆ Help SMEs get ideas to market
- ◆ Anchor innovation and jobs in the UK

### A key partner to deliver the UK's Industrial Strategy (alongside Innovate UK)...

- ◆ Investing in science, research and innovation
- ◆ Developing skills
- ◆ Upgrading infrastructure
- ◆ Improving procurement
- ◆ Delivering affordable energy and clean growth
- ◆ Driving growth across the country
- ◆ Supporting business to start and grow
- ◆ Encouraging trade and inward investment
- ◆ Cultivating world leading sectors
- ◆ Creating the right local institutions

**BREAKING  
DOWN  
BARRIERS TO  
SUCCESS**

**cATAPULT**

## WHAT DO CATAPULTS DO? – CONTINUED

### Address big issues...

- ◆ Industrial inertia
- ◆ Supply chain development
- ◆ Systemic failures and complex, cross-sector challenges
- ◆ Barriers to innovation adoption
- ◆ Short-term investment cycles
- ◆ Slow growth in productivity and competitiveness
- ◆ Wider adoption of enabling technologies such as artificial intelligence, biotechnology and robotics

### They are...

- ◆ Unique
- ◆ Expert
- ◆ Trusted
- ◆ Neutral
- ◆ Open access
- ◆ Independent
- ◆ Agile
- ◆ Led by industry professionals
- ◆ Data, technology and innovation/commercialisation experts

### Stimulate demand by...

- ◆ De-risking innovation adaption
- ◆ Testing new ideas and technology in real-world scenarios
- ◆ Pump-priming new markets
- ◆ Building skills
- ◆ Horizontal innovation – sharing ideas across sectors
- ◆ Sharing ideas across sectors
- ◆ Bringing large and small businesses together
- ◆ Making regulation fit for purpose

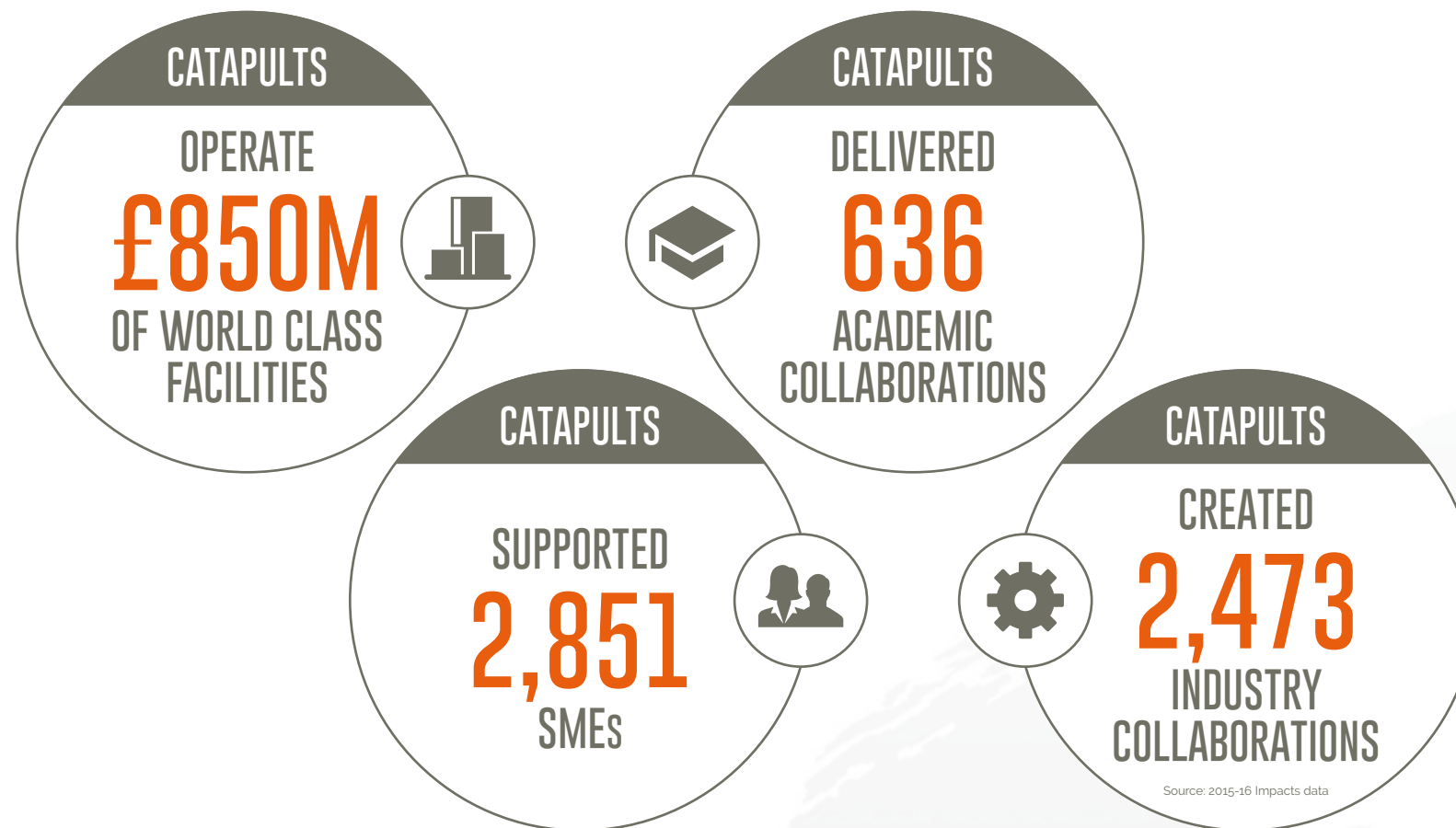
### Work in key sectors and industries of the future...

- ◆ Cell and Gene Therapy
- ◆ Compound Semiconductor Applications
- ◆ Digital
- ◆ Energy Systems
- ◆ Future Cities
- ◆ High Value Manufacturing
- ◆ Medicines Discovery
- ◆ Offshore Renewable Energy
- ◆ Satellite Applications
- ◆ Transport Systems



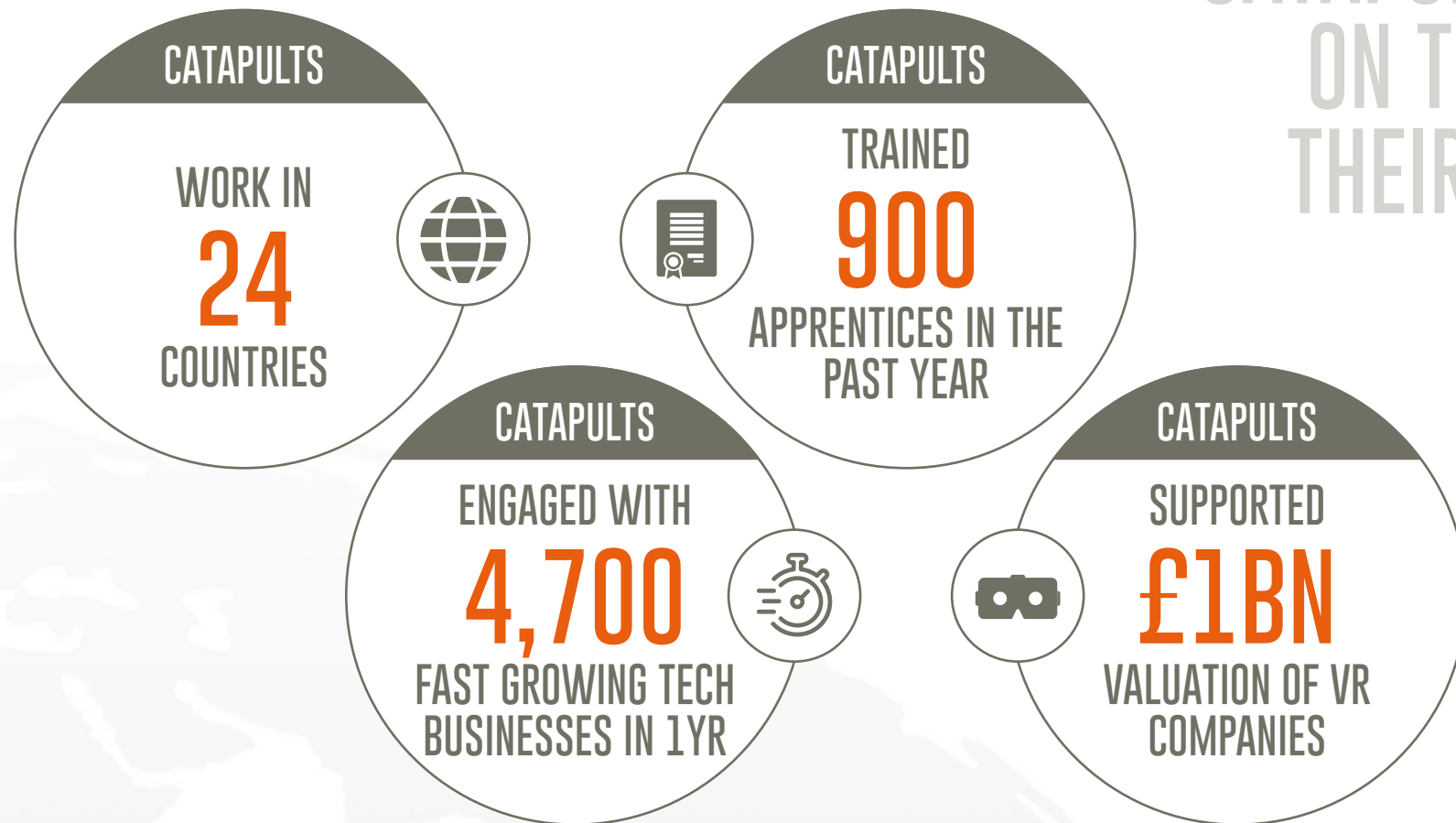
# CATAPULTS DELIVER

Innovating Now To Build A Better Future For Britain



## CATAPULTS DELIVER – CONTINUED

CATAPULTS FOCUS  
ON THE UK BUT  
THEIR REACH IS  
GLOBAL





## THE STORY SO FAR

**The Catapults are a national network of independent technology companies sharing a common goal: to foster innovation and drive economic growth.**

Focused on specific areas of UK expertise, or targeting sectors set to grow, they work in industries as diverse as Cell and Gene Therapy and Offshore Renewable Energy. Some feature large-scale multi-million-pound test facilities; others do their development on laptops. All Catapults bridge the gap between academia and industry, research and commerce, providing a trusted, neutral space where new ideas can thrive and find their way to market.

Traffic jams provide a real-world example of how they work.

### In a Jam

**The average British driver spends 32 hours each year stuck in traffic, at a cost to the economy of £30.8bn. These numbers fail to convey the human price of parents racing on the school run, meetings and connections missed, products delivered late and noxious gas clouds swirling above queues of idling vehicles.**

Britain is the fourth most congested country in the developed world. To the team at the Transport Systems Catapult (TSC) it seemed absurd that an advanced nation should be hostage to such an analogue problem in this digital age.

Smart phones are now location beacons and movement sensors; cars are Wi-Fi hot spots; computers can sift vast troves of data to

identify hidden patterns. If these disparate capabilities could be harnessed, we might create a cure for congestion.

"If you're running the roads you need to use simulations – realistic computer models – to see what effect building works, accidents or new designs might have," says TSC Project Manager Paul Bate. "Highways England has built excellent models but the files are so huge it took days to run a single simulation. That limited their usefulness."

*"We looked at technology we could bring in from other sectors, particularly on-line gaming, where thousands of people can be playing simultaneously, manipulating elements in a detailed virtual world, all reacting in real time. That's when we called Improbable."*

Restless curiosity and a shared love of computer games prompted university friends Herman Narula and Rob Whitehead to start software business, Improbable, in 2012. They created an online platform for gaming, Spatial Ordinance Survey, which could simulate thousands of simultaneous actions in a virtual universe. TSC knew the system's capability having trialled it some time before on a small-scale project. When Paul Bate called this time, it was with an altogether more challenging brief.

TSC, Highways England and Improbable set about reproducing the motorway network in digital form, complete with millions of independently acting vehicles.

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**cATAPULT**



## THE STORY SO FAR – CONTINUED

As the prototype system came together, the team added new sources of information that would make the simulation even more accurate: intelligence from the trunk roads feeding onto motorways; then, live data from a telecoms provider. For the first time the team could see where travellers were coming from before they hit the highways. This was the breakthrough.

"The Transport Systems Catapult was really proactive and hands-on", says Aleksandra Laska, Improbable's New Business Director. "They got lots of smart people together, all with different skill sets, to brainstorm and share ideas. Every two weeks we would have what we called 'sprint reviews' to see if we were on the right track and the whole project moved quickly."

"The speed of development was unprecedented", Bate admits. "But the important thing is: it works as planned and we've done it at scale. We can now get near instant answers to 'what if' questions. It is a wakeup call for a conservative sector and could change the way people run their networks."

With the demonstrator now doing the rounds at seminars and trades shows, Highways England and Improbable are working on plans to develop the technology over the next two years. TSC, meanwhile, is showcasing the opportunity to other parts of the transport industry.

*"Nothing like this exists for the rail network which, in some areas, is still reliant technology from the 1960s. Much of their knowledge is localised with people only able to see what's going on in their area. That means a signal operator in Norwich might send a freight train up the line, oblivious to the fact that it will arrive at Manchester Piccadilly just in time for the evening rush hour."*

"In 2015 we commissioned The Traveller's Needs Study, a huge piece of research involving 10,000 people. It identified that 75% of journeys involved 'pain' – by which we mean hassle and unnecessary stress, largely because of the different ways of travelling – car, bus, train, bike – don't join up.

**75%**  
OF JOURNEYS  
INVOLVE 'PAIN'  
– STRESS, &  
HASSLE. **A**

# ALL CATAPULTS BRIDGE THE GAP BETWEEN ACADEMIA AND INDUSTRY

**CATAPULT**

*“Ultimately, we want to be able to model **any** journey, **anywhere**, combining every form of transport and show it as one joined-up system. Companies can then mine this resource to create products that make it easier for people to get about, like a single ticket that works across all types of transport or timetables that reflect the different phases of a journey. If we can do that, it would be truly transformational, a world-first.”* ■

## Bridging the Gap

**The Highways England project is just one of over 2,400 delivered by the Catapults in their first four years. Whether working in space, cyber space, labs or factories, shared aims and methodologies can be observed.**

First and foremost, Catapults are expert, trusted and neutral. Being independent, and staffed with people with broad business experience, the Centres understand and respond to the needs, wants and challenges of the sectors they work in. Early projects established credibility and proved, to a sometimes sceptical audience, that Catapults are not just ‘another quango’ or extra layer of bureaucracy to be negotiated, but real agents for change, focussed on delivery.

They work on the principle that innovation doesn’t just ‘happen’. For new ideas and technologies to succeed, there has to be demand for them. Hence the Catapults bring universities and industry together to work on problems relevant to the marketplace – a ‘demand-pull’ approach that saves time and money. Over 3,000 academic and industrial collaborations have been generated to date, with support

focused on those ideas strong enough to make the transition from concept to commercialisation.

If sectors such as rail or energy are conservative because of their scale and national infrastructure status, so the world of business can be resistant to change because investors prioritise short-term returns while managers focus on quarterly reports and annual performance bonuses.

Catapults play a vital role here, de-risking innovation. They work with industry on challenges that, when overcome, create new products and unlock new markets. This involves ‘road testing’ new technologies in real-world settings and, in some cases, finding customers for them. Often this means providing equipment and expertise that will be needed by business in the long-term but which no one business will invest in until the return on investment (ROI) is clearer.

The High Value Manufacturing Catapult has seven state-of-the-art research bases around the UK, developing 3D printed parts for jet engines, pioneering lighter, lower cost composites, designing more efficient car batteries and even producing a ‘Factory in a Box’:





## THE STORY SO FAR – CONTINUED

a shipping container sized module, kitted out with the latest in digital manufacturing tools, so smaller engineering firms can rent technical capability that was previously the preserve of their larger, richer competitors.

Across the UK Catapults operate facilities worth £850m, providing open-access for researchers and businesses of all size to state of the art equipment and resources. The latest addition was opened in March 2017, when the newly created Medicines Discovery Catapult (MDC) opened the doors of a £1m laboratory, created in collaboration with the University of Warwick.

With expert staff and world-class technology the lab will provide drug-discovery SMEs, researchers and medical charities with a level of support, and state of the art kit, that was previously unavailable. With its focus on finding treatments for anti-microbial resistance, a growing global threat, the new centre will act, as MDC Chief Chris Molloy puts it, as “a watering hole, around which the community will gather to work together and solve the problems which no one group can solve alone.”

Sometimes, the support provided by Catapults takes less obvious forms. The Offshore Renewable Energy (ORE) Catapult with The Crown Estate set out to persuade companies operating offshore wind turbines to share anonymised data, so it could create the first ever national wind performance database. This would help all players gain a deeper understanding of their own industry. After two years of patient negotiation, 98% signed up and the ‘Systems Performance, Availability and Reliability Trend Analysis’, or SPARTA,

was born. This kind of activity has clear long-term strategic value but is not the sort thing markets typically support.

The Energy Systems (ES) Catapult is leading on the Smart Systems and Heat Programme to create decarbonised, future-proof and economic local heating solutions by connecting consumer needs and behaviour with the development of smart technologies and new business models. The next phase will expand in-home trials so the ES Catapult can build the foundations for a new generation of energy service providers with innovative offerings for British households.

Digital Catapult meanwhile is building an innovation ecosystem around 5G, the next generation mobile communication system.

It is building a 5G testbed in Brighton with a view to develop new applications and services in immersive tech, manufacturing and health that makes use of future 5G networks.

Innovating with data is core part of the Catapult approach. They create fresh insight and find new ways to capture and manipulate information. Cross-sectorial collaboration creates valuable new databases while software products may combine archived records with with real-time satellite feeds. User-friendly tools and interfaces are designed to make data easy to interpret and actionable, for businesses and communities.

Working in conjunction with Belfast City Council, Future Cities Catapult invited small, creative firms from across the UK, expert in





data analytics, to mine city data and find new ways for Belfast to address longstanding issues.

Chief amongst these was the need to maximise revenue from business rates, which accounts for half the Council's annual income. The assumption was that firms were operating in the city without declaring themselves to be businesses. This was due to a variety of reasons; some businesses were classified incorrectly, others registered as residential properties and more generally, the Council's data sources were not up-to-date. Following an open call issued by Belfast City Council, prototype digital tools were produced which used information such as energy consumption to pinpoint potential business rates avoiders. The success of the experiment was evident from the get go. With an investment of £150,000, the Council was able to uncover potential new revenue of £350,000 per year in just the initial pilot phase. With the concept proved, the Council is now conducting further testing before appointing a firm to develop it.

A related project produced a digital 'dashboard' designed to help Belfast engage with its citizens and monitor the performance of civic services, while a third element – the Growth Planner – enables city planners to understand infrastructure needs, now, and for up to fifteen years into the future.

### Small Companies, Big Impacts

**It is not by accident that small and medium sized firms (SMEs) are a key part of the Future Belfast programme. The Catapults are**

**keenly aware of their abilities and importance to the UK economy but also the hurdles they have to clear in order to succeed.**

Product development costs are high, often due to regulation, while opportunities such as the Internet of Things (IoT) favour those companies wealthy enough to get to scale quickly. Investors want returns fast, and tend to favour software firms over those making hardware. Established players have strong incentives to squash (or buy out) nascent competition.

Just as they bridge the gap between academia and industry, Catapults also bring together small, agile and creative firms with the sector leaders. Big and small companies are increasingly co-dependent but often find it difficult to communicate, co-exist or in some cases, even find each other.



## CONNECTING SMALL COMPANIES WITH LARGE SECTOR LEADERS



## THE STORY SO FAR – CONTINUED

Train maker Alstom was frustrated at the slow pace of development in its industry and investigated the use of SMEs to provide an injection of energy and fresh thinking. The trouble was, it didn't know any. Being an industrial giant, its procurement processes were not geared towards SMEs and the start-ups working alongside them.

The solution devised by the Transport Systems Catapult (TSC) was to set up a competition, funded by Alstom, aimed at smaller firms. 62 turned up for the launch with 26 going on to submit detailed proposals. The TSC was part of the judging process with five finalists presenting to the sponsor at an event in London.

The winner, 42 Technology of Cambridge, proposed a new way of fitting train windows that would save Alstom days of manufacturing time per carriage. The four runners-up were also added to the company's supplier roster, providing them with a route to potential work in the future.

If Alstom was surprised at the quality of thinking being done by small businesses, the TSC wasn't. Thanks in large part to the democratisation of computing power, an increasing amount of high-quality innovation is taking place in lofts, hubs, shared work spaces and sheds.

Catapults are able to tap into this resource through its road shows, events, hackathons and energetic young staff. As entrepreneurial start-ups themselves, the Catapults can match the agility of small firms and understand the way they work; they can also share the sort of deep sector learning that takes decades to acquire. From

helping to create credible business plans, to testing new products and locating sources of investment, Catapults help small businesses achieve their potential.

In May 2017, Improbable announced that it had secured \$500m of new investment from a Japanese technology fund. In the language of tech-finance, it is now a 'unicorn': a company worth at least \$1bn. More importantly, its status as a UK company with global potential has been confirmed. Aleksandra Laska acknowledges the important role played by the TSC in helping the firm demonstrate the versatility of its Spatial OS software and develop market opportunities for it:

*"The Transport Systems Catapult has given us great exposure and opened a lot of doors. They worked with us before we even had a product. It has been great to have them as a partner – it's been an amazing journey."*

*"Our approach has always been there. Their culture and way of working was an inspiration to us to continue on that route and not change. With Highways England they gave us the opportunity and exposure to the kind of transport project we hadn't done before. We got to understand their needs and what data they had, which was a huge learning curve."*



## THE STORY SO FAR – CONTINUED

### Boosting Britain

**The success of the Catapults is measured through the impacts they have on sectors. Born out a series of consultations in 2010, they were the carefully considered response to an endlessly discussed and seemingly chronic condition: the UK's inability to turn innovation into economic value.**

Despite being blessed with a world-class science and research base, too often new ideas got trapped in the lab or were failed by business. It became a cliché that only foreign companies could make money from British know-how and a memorable phrase was coined, "the Valley of Death", to describe the place where hopeful products went to die, starved of investment and opportunity.

Ten years into the 21st Century, and with shockwaves from the financial crash still reverberating, Government resolved to deliver a step change. It understood that innovation would be to the next industrial revolution what coal was to the first and that Britain had to raise its game.

High Value Manufacturing, Offshore Renewable Energy, Energy Systems, Cell and Gene Therapy, Transport Systems, Future Cities, Digital and Satellite Applications Catapults made the grade and formed the basis of the new network. Medicines Discovery was added in 2016 and Compound Semiconductor Applications comes on stream later this year.

Where to focus resources was the key question and proposals for embryonic 'innovation centres' were judged according to four main criteria:

- 
- 1 Are the potential global markets accessed through each Centre predicted to be worth billions of pounds a year?
  - 2 Does the UK have world-leading research capability in the area?
  - 3 Does UK business have the ability to exploit the technology and make use of increased investment to capture a significant share of the value chain and embed the activity in the UK?
  - 4 Is the proposed Centre closely aligned with, and essential to achieve, national strategic priorities?

The creation of the Catapults seems especially prescient in light of Brexit and the publication of the Industrial Strategy Green Paper in January 2017.

A new manifesto for boosting the economy, it not only talks about investing in science, research and innovation, it also highlights the need to develop skills; support business growth; cultivate world-leading sectors; improve procurement processes (including levelling



the playing field for SMEs); deliver cleaner, affordable energy; share growth around the country and encourage strong local institutions.

As this supplement will show, the Catapults are already delivering against this plan.

Traffic jams are just one example of the sort of large scale, cross-sectorial, systemic problem facing the UK. Others include the need to 'decarbonise' energy production and redesign the grid to cope with smart homes, intelligent appliances, the demand from electric vehicles and energy storage; we need to cut the cost and time taken to produce new therapies; make our air cleaner and our cities 'smarter' and less wasteful. These challenges are defined by their scale, complexity and by the fact that a 'business as usual' approach won't fix them.

The Industrial Strategy Challenge Fund recognises this. The Catapults played an important role in the genesis of this initiative, announced in 2016, which will see £1bn invested, over four years, in six key technology areas:

- ◆ Healthcare and medicines manufacturing
- ◆ Robots for a safer world
- ◆ Batteries for cleaner energy
- ◆ Satellites and space technology
- ◆ Self-driving vehicles
- ◆ Manufacturing and materials of the future

A series of technological shifts, now underway, underline the vital importance of these interventions. The changes go beyond being merely 'disruptive'; they have the potential to fundamentally re-order industry and society, within a generation.

Machine learning and artificial intelligence; additive manufacturing and digitised production; synthetic biology and blockchains; robots and connected vehicles; personalised medicine and public services on demand; nano-engineering and the Internet of Things: the words may sound familiar but we are only just beginning to fathom their implications.

This is the challenging, fast changing world the Catapults were designed for. Upheaval can be a threat; equally it can be our opportunity. As the world's oldest industrial economy we understand well the consequences of not adapting.

Fortunately, we also know that the future is not a defined destination but work in progress. ■



## A SERIES OF TECHNOLOGICAL SHIFTS ARE UNDERWAY



## WORKS IN PROGRESS

### Carbon Comes Home

**In February 2017, supercar maker McLaren Automotive announced plans to build a new composite chassis factory at the Advanced Manufacturing Research Centre (AMRC), Rotherham, one of the High Value Manufacturing Catapult's seven major facilities. They will jointly develop novel manufacturing technologies and AMRC will both train apprentices and trial processes which will then be transferred to the new factory when it opens in 2020.**

This is significant for a number of reasons.

The £50m investment is expected to produce 200 new jobs and contribute £100m or more to the local economy. It is a notable example of 're-shoring': since McLaren Automotive launched, all its cars have been constructed around the 'Monocell', a moulded carbon fibre chassis produced in Austria then shipped to the UK to be built up. It also illustrates the strategic importance of Catapults in anchoring innovation, skills and wealth in the UK.

Despite its advantages, for many years carbon remained an exotic material reserved for high value products. Time consuming and difficult to work with, it was used in situations where performance and weight saving were more important considerations than cost: aircraft fuselages and satellites, top end tennis racquets and Tour de France bicycles. McLaren pioneered its use in road cars, with the introduction of its iconic F1 model, but at a price tag of \$1m - in the early 1990's.

Over time however, investment in new manufacturing techniques made carbon more of mass-market proposition. In 1993, it took 4,000 hours to lay up a single McLaren F1 chassis by hand; by 2011 its spiritual successor, the Monocell, took just four hours to produce in a semi-automated process.

The global market for carbon fibre is expected to increase 16% per annum between 2012 and 2020 and be worth over \$10bn per year. It is with that long-term value curve in mind that the High Value Manufacturing (HVM) Catapult has invested in facilities and research to ensure that the UK reclaims a leadership position in this sector.

THE GLOBAL  
MARKET FOR  
CARBON FIBRE  
EXPECTED TO  
INCREASE

16%

BETWEEN  
2012 & 2020

# CATAPULTS INVEST IN PEOPLE, TECHNOLOGIES AND FACILITIES

**cATAPULT**



## WORKS IN PROGRESS – CONTINUED

McLaren Automotive CEO Mike Flewitt said, "We evaluated several options ...but the opportunity created by the Advanced Manufacturing Research Centre (AMRC) at the University of Sheffield was compelling. At the AMRC we will have access to some of the world's finest composites and materials research capabilities. With other high-tech organisations, such as Boeing, Airbus, GKN and Rolls-Royce Plc alongside us at the AMRC, we are in very good company." ■

### Environments for Success

**Catapults invest in people, technologies and facilities so the UK is able to maintain its position in sectors where it has established strengths, and punch above its weight in emerging, high value markets. As the Industrial Strategy suggests, these are on-going missions so much of the work of the Catapults takes the form of long term, strategic programmes. The success of the AMRC is one example; the recent history of DNA based medicine in the UK provides another.**

Since recombinant DNA was discovered in the early 1970's enormous research effort has been invested in finding out how the replacement, regeneration or re-engineering of cells, genes and tissues can be used to create new medicines or treatments for conditions ranging from diabetes to cancer.

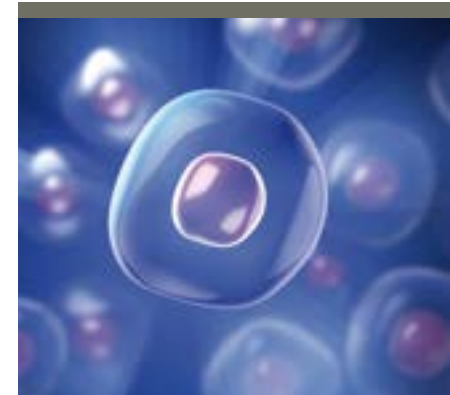
Britain is a leader in cell and gene therapy research but translating that into commercial success required the Cell and Gene

Therapy (CGT) Catapult to work proactively across wide a range of fronts, developing new production and cryopreservation techniques; streamlining the clinical trials process; helping companies comply with regulations; investing in skills and providing new research facilities.

The CGT Catapult recently announced the sales of a subsidiary business, Catapult Therapy TCR which is set up in collaboration with Imperial Innovations which focused on the development of a gene-modified WT1 TCR T cell therapy for acute myeloid leukaemia (AML) and myelodysplastic syndrome (MDS) that are known to overexpress the antigen WT1.

The acquisition of Catapult Therapy TCR Ltd by Cell Medica will enable and accelerate the further development and commercialisation of this innovative treatment in one of the most promising areas of cancer immunotherapy. The optimisation and development of next-generation T cells will be conducted by Cell Medica and CGT Catapult and manufacturing will take place at CGT Catapult's large-scale cell and gene therapy manufacturing centre located at the Stevenage BioScience Catalyst.

This is just one of over 30 new businesses that have been created during the time of the CGT Catapult, which has seen companies in the sector raise over £1.3bn in funding. Inward investment has also grown, with leading international firms from the US, Spain and Japan locating research and development activity here. As a result, Britain now has 7% of a global market predicted to be worth between \$14-\$21 billion by 2025.





Long-term vision is also required when it comes to graphene, the 'wonder material' discovered at Manchester University in 2004. One atom thick, so effectively '2D', it is more conductive than copper and 100 times stronger, by weight, than steel. Despite these tantalising capabilities and predictions that it will revolutionise products ranging from smart phones to desalination plants, the market is still embryonic and current applications few beyond small-scale tests in paints, coatings, lubricants and composites.

Much of what the Catapults do involves creating the right environment for success, or as Chris Molloy, CEO of the Medicines

Discovery Catapult (MDC) puts it, "the creative destruction of barriers".

Sometimes that takes physical form: the Manufacturing Technology Centre (MTC), in Coventry, for example, is a dazzling 21st century cathedral dedicated to cutting edge production technologies. It provided a secure and discrete research base when Rolls-Royce wanted to increase the use of Additive Manufactured components in its jet engines. With MTC having collaborated on the research of materials, processes and design, Rolls-Royce flew the largest aero engine structure ever to contain 3D printed parts last year.

## Innovation Across the Country

**The location of the MTC is reminder that the Catapults, when first conceived, were sited in places with particular skills. They have been highly successful in exploiting this and attracting inward investment into their areas. In addition to McLaren, Boeing is also co-locating with the AMRC, opening its first European manufacturing facility next door. 160 miles to the south, the Satellite Applications Catapult has helped established Harwell as an internationally recognised 'place for space', with 75 satellite or space related companies present, including organisations such as Lockheed Martin, Airbus, Thales Alenia Space and the European Space Agency.**

More recently the Catapults have responded to growing demand

throughout the country and set up new regional offices. The newly formed Compound Semi-Conductors Catapult will be established in South Wales. The Digital Catapult has established a centre in Northern Ireland, while the Satellite Applications Catapult has worked with the UK Space Agency to establish operations in the Midlands, North East, Scotland, South Coast and South West.

In London, Digital Catapult's Immersive Lab gives everyone the opportunity to get hands on with immersive technologies; a resource for businesses of all sizes – as well as academia and researchers – to demonstrate, innovate, and test the latest immersive technology and content. The space is equipped with a range of the latest augmented and virtual reality hardware to encourage commercial innovation the UK's growing immersive community.



### Framing the Future

**Catapults also operate in a less visible but equally important part of the business landscape: the world of regulation.**

Clear and consistent guidelines are essential if businesses are to have the confidence to invest. We also expect new products to be developed safely and to meet rigorous standards, particularly when they are medicines or therapies. The pace of technological development is such that rule makers can never keep up, so the Catapults are active to ensure that regulation doesn't hinder innovation.

In medicine, the cost and complexity of bringing new treatments to market is seen as a major issue at a time when society expects cures for an ever-expanding range of ailments and rates of antibiotic resistance are increasing.

That's why the Cell and Gene Therapy Catapult worked with legislators overseeing advanced therapies to streamline the process, and therefore shorten the time required for new treatments to reach the clinical trials stage. A regime that had been seen as 'complex and uncertain' is now deemed 'highly progressive', helping to make Britain a more attractive base for international companies. As we will see in the next chapter, the newly established MDC will build on this work in the years to come.

Getting the legal framework right is especially important when dealing with emerging sectors, where the needs of markets 20 to

30 years hence are being predicted and the technologies destined for them still in their infancy.

The Transport Systems Catapult is working to ensure that Britain is at the forefront of 'Intelligent Mobility', a shakeup of the travel sector so profound it will rival the advent of trains and commercial jet aircraft.

Although definitions vary, it describes the use of big data, machine learning and technologies such as autonomous vehicles to create cleaner, more efficient, more user-orientated ways of getting around. It envisages different modes of transport being properly integrated; on-demand shuttles taking the place of under-used private cars; and people carrying pods connecting with bus and train stations to provide 'last mile' mobility for commuters, shoppers, the elderly or disabled. Car manufacturer BMW puts the value of Intelligent Mobility services at \$10 trillion per year.

Before its Lutz Pathfinder could be tested on the streets of Milton Keynes, TSC worked with the town's authorities to re-classify areas of pavement so the pod could share space with pedestrians and cyclists. Going through normal planning procedures would have added two years to the project timeline.

TSC provided an exemplar for government and the insurance industry to study and base new rules upon. The UK is now recognised as being one of the best places in the world to test autonomous vehicles and, as a result, Nissan and Volvo are among the international automotive firms that have since brought significant parts of their R&D programmes here. Meanwhile,

**BMW PUTS  
THE VALUE OF  
INTELLIGENT  
MOBILITY  
SERVICES AT  
\$10<sup>TN</sup>  
PER YEAR**



Oxbotica, one of the Pathfinder consortium partners, spun out from Oxford University, is capitalizing on its experience by opening offices in Singapore and Australia.

Toby Hiles, TSC Strategy Director, sums it up: "From small beginnings in Autumn 2013 we helped create the conditions for half a billion pounds to be invested in this area, by government and industry. We have created critical mass. That's our job done so we move on."

The goal of Catapults is not to support a small number of individual companies, or even spin out new businesses, but to grow entire sectors. That means being selective when considering which projects to take on and what firms to invest time in. Having a scalable idea is clearly important but so too is finding a partner with ambition.

Dr Sabrina Malpede has both.

## Winds of Change

**Having taken a degree in aeronautical engineering in her native Italy, Dr Malpede swapped Naples for Glasgow to do a PhD in sail design. Twenty years later Sabrina remains anchored in Scotland.**

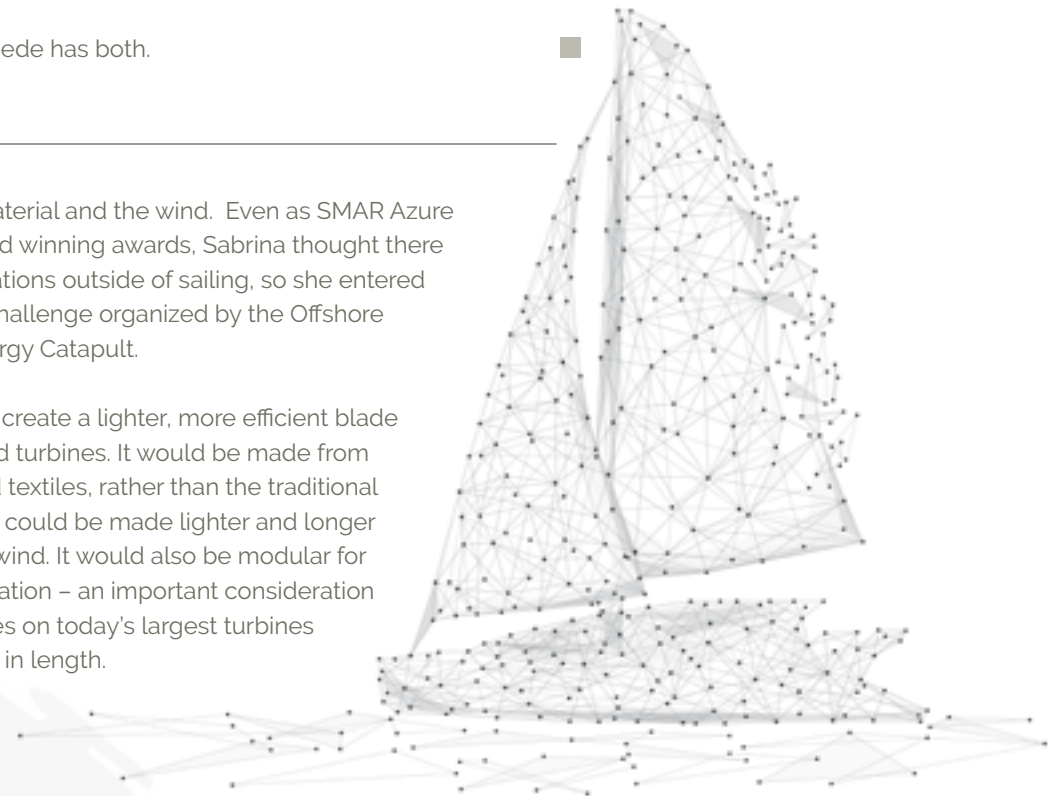
*"I still dream in Italian. Only in English when I'm thinking about work!"*

With expertise in Computer Aided Design (CAD) Structure and Computational Fluid Dynamics, Sabrina founded a company with colleague Dr Alessandro Rosiello, SMAR Azure, to provide design and engineering services to the sailing industry. Its products are now used by 200 organisations in 29 countries.

Their core skill was the ability to create and analyse thin, lightweight and flexible structures whose shape is influenced by their

construction material and the wind. Even as SMAR Azure was growing and winning awards, Sabrina thought there must be applications outside of sailing, so she entered an Innovation Challenge organized by the Offshore Renewable Energy Catapult.

Her idea was to create a lighter, more efficient blade for offshore wind turbines. It would be made from composites and textiles, rather than the traditional glass-fibre, so it could be made lighter and longer to 'catch' more wind. It would also be modular for easier transportation – an important consideration given that blades on today's largest turbines are almost 90m in length.



**CATAPULT**

Simulations showed the design produced 9.7% more energy than existing offerings, so Sabrina and her team were inspired to start a new business, ACT Blade, to develop the product and bring it to market. The goals she set were ambitious, bordering on audacious: to revolutionise the sector and achieve a turnover of £140m within six years.

"As a complete outsider, we are still surprised about the fact that design has not changed much, but it is an opportunity for us.

"Our technology is very disruptive and that could probably make it harder to find early adopters," she acknowledges. "However, the feedback received to date and my current vision of the industry tell us that there is urgent need to reduce the capital cost to produce blades and increase wind farm's efficiency. Our technology is the answer.

*"Developing a new technology comes with high risks. However, if we do things well, how can we lose?"*

The Catapult is backing her vision; having helped ACT Blade secure several rounds of funding it is now developing a new test rig at its world-leading National Renewables Energy Centre at Blyth, Northumberland, to validate and demonstrate a section of the blade prototype.

Start-ups have always looked to exploit opportunities missed by incumbents but with new ideas coming on-stream at an ever-increasing rate, 'disruption' is now part of the daily vernacular of all businesses, regardless of size. It is something Catapults embrace as means of opening up markets to new opportunities and shaking up systemic failures.

SIMULATIONS  
SHOW THE  
DESIGN  
PRODUCED  
**9.7%**  
MORE ENERGY  
THAN EXISTING  
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# CATAPULTS OPEN UP MARKETS TO NEW OPPORTUNITIES AND SHAKE UP SYSTEMIC FAILURES

# A MAJOR CHALLENGE REQUIRES FRESH IDEAS

## Digging for Victory

**“Our research showed that uncoordinated road-works were costing the UK £9.8bn per year, in terms of traffic hold ups, accidents, social costs and so on,” says Future Cities Catapult’s Lavinia Cox. “Its not that people hadn’t tried to make the system better. They had, but it wasn’t working because of siloed thinking and self-interest. It is a major urban challenge which deserved fresh ideas.”**

Major works by Seven Trent Water and Miller Homes in Staffordshire presented Lavinia and her team with an opportunity to pilot a new approach utilising familiar Catapult tactics: increasing collaboration, mapping the problem and sharing data.

The team built an interactive portal to host ‘mid term’ (covering one to five years) data from a wide range of utilities, contractors and developers in the area. Getting disparate parties to communicate and share information took months but resulted in unprecedented levels of coordination between the local authority and the private contractors. The hub not only highlights

opportunities to combine street works, it also measures the operational, social and financial impacts – giving stakeholders added incentive to support the initiative.

The benefits of the Staffordshire Connected Roadworks project were both impressive and tangible: ten proposed works by different contractors were combined into one, requiring just a single road closure. This meant the roads could be kept open for an additional 25 weeks and saved the contractors c. £184,000 in terms of reduced materials and management costs.

*“The key was aligning public and commercial interests so everyone could win. We showed that it works in the real world, with a solution that is scalable and replicable. We’re now looking to roll it out nationally.”*

Using data creatively to look at problems anew and unlock opportunities is at the heart of the Catapult’s thinking. Although they are mandated to be bold and original in their interventions, everything the network does is rooted in market-based evidence. Sometimes following the facts takes them to far away destinations. ■



### Combatting Illegal Fishing

**It is estimated that one in five fish caught has been fished illegally, the product of an illicit global business worth an estimated \$23 billion dollars each year. Large fishing vessels, operating far from land and the eyes of the authorities, plunder tuna and other high value catches wherever they can find them. Off-loading their catch to factory ships, which re-supply them with food and fuel, fishing boats stay at sea for years. The cost is not just financial; crews are often kept on board against their will, economic slaves.**

The challenge of finding the criminals and gathering evidence against them in the middle of an ocean is described by Koebel Sakuma, adviser to Palau's president, "We're a small country with limited resources and we're responsible for patrolling a vast area with one vessel donated by Australia."

The Pew Charitable Trusts, a US based Non-Government Organisation (NGO) approached the Satellite Applications (SatApps) Catapult to see how space might provide a solution.

The SatApps Catapult set up an eight-person team that devised a unique way to spot potentially illegal fishing activity. In normal practice, vessels over 300 tonnes must use an 'Automatic Identification System (AIS) to send a signal with their position. In the event of a catastrophe, this would show its last-known location. Turning its AIS transmitter off normally indicates that a vessel is doing something it doesn't want seen.

Using information from various databases, operators can quickly work out what the suspect vessel is, where it is registered and what its recent history may be. Previous positions are shown as well as the undersea topography over which its sailing. A slow moving ship on a zigzag course around a seamount would suggest fishing activity. Multiple signals in close proximity may indicate a fleet. A manager or fisheries protection officer now has sufficient (logged) information to decide whether to intercept the suspect vessels, or alert port authorities to watch out for them trying to land a potentially illegal catch.

This is possible thanks the unique capabilities of satellites, which are unblinking, indefatigable and able to monitor huge areas at once. The key to the success of the project, however, is the way space data combines with other sources of information to create an easy to use tool that provides, in seconds, actionable intelligence that previously would have taken days or weeks to gather.

The SatApps Catapult team has delivered these services to seven governments to date. It is also making international retailers and wholesalers aware of a potentially lucrative new marketing opportunity: selling fish that have been sourced legally and ethically, with consumers able to trace their journey from sea to store.


Space has an extraordinary ability to boost other sectors but its full potential has been kept earthbound due to lack of finance, a problem common to many parts of the innovation world.



continued inside page

**cATAPULT**



An underwater photograph showing a large school of small, silvery fish swimming in clear blue water. In the background, a vibrant coral reef is visible, covered in various colorful corals and marine life. A fishing net is partially visible in the foreground, suggesting a marine environment. The text is overlaid on the left side of the image.

The SatApps Catapult responded by reaching out to the venture capital community, patiently countering misconceptions about risk, low opportunity and long-timescales. In November 2016 Seraphim Capital launched a dedicated £50m space fund, and this was followed shortly afterwards by two more. Other Catapults have achieved similar success in their arenas. ■





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## People Power

**Boosting UK innovation and creating markets for new ideas is only possible if we have people with the skills to deliver. For example, by 2035, digital engineering and manufacturing advances could generate an additional 300,000 jobs but that would require a step-change in the way we promote industry and nurture talent. There is currently a shortfall of 20,000 engineering graduates each year.**

The Catapults are conscious of the need to build a new cadre of technicians, data architects and business managers and High Value Manufacturing has lead the way, setting up two skills centres.

In the past year, 900 apprentices have gained invaluable 'hands on' experience with the sort of cutting-edge technologies used

in modern manufacturing. Working in partnership with the University of Sheffield and Sheffield Hallam University, the HVM Catapult has also pioneered new 'degree level' apprenticeships which will see students graduate with industry-recognised accreditation. In addition, the HVM Catapult provides specialist short courses, plus more academic programmes to doctorate and MBA level.

Engineering is not the only area where skills are an issue. The growth of the cell and gene therapy sector will require 400-600 skilled staff over the next two years, especially technicians or operators able to run commercial production lines. The CGT Catapult currently operates a 'training through immersion' policy, making its staff more attractive to industry, after two to three years at their headquarters.

THERE IS CURRENTLY A SHORTFALL  
OF 20,000 ENGINEERING GRADUATES  
EACH YEAR



# BUILDING FUTURE SUCCESS

## Brave New Worlds

The first industrial revolution saw the energy potential of coal and steam harnessed to drive machines. The second brought about mass production. We are still in the mist of the third industrial phase, digitisation, but already a fourth is looming. It is characterised by powerful new technologies such as artificial intelligence, quantum and synthetic biology becoming mature, and being used in conjunction with one another to fundamentally alter the way we live, work and make things.

Working at the 'bleeding edge' of innovation, Catapults are already studying these 'disruptors', looking at how they can be applied to real-world problems and exploited to create new markets for British businesses.

The HVM Catapult, for example, works across 27 technology themes, one of which is digital visualisation. It has partnered with construction organisations including BAM and Balfour to demonstrate the use of virtual reality in the planning and management of large building sites. Another project uses augmented reality to provide construction teams with easy to access assembly instructions, process monitoring and remote support.


## Connected Everyday

The Internet of Things (IoT) describes a scenario where sensors are routinely built into billions of devices, or the materials they are made from, so they can communicate and share information over the internet. The everyday stuff of life will become 'smart': kettles, bridges, train tracks, cars, traffic lights, buildings, hospital trolleys and even crops will provide feedback and give us unprecedented insight into how our world is actually working.

Manufacturing and mining already use a form of IoT to keep track of employees and equipment, while smart meters are gradually making their way into homes, providing real-time updates on our energy consumption. The 'digitification' of cars is also well underway, with vehicles increasingly able to sense their surroundings: the latest models collect up to 4 terabytes of information every day – equivalent to nearly 6,000 movies.

Most of these applications are happening in isolation, however, so the IoT is still more of a promise than reality. That is why the Digital and Future Cities Catapults are delivering 'IoTUK', a programme of large scale demonstrators, in health, cities, hardware development and academic research across the country, to advance the UK's leadership in the field.

CityVerve, in Manchester, is a flagship project of the programme. A combination of test-bed and showcase, it encourages businesses, the public sector and wider community to take part in open competitions, events and hackathons, to see how the city's data might



COMPOUND  
SEMICONDUCTORS  
ARE  
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FASTER THAN  
THEIR SILICON  
EQUIVALENTS

**cATAPULT**

be used to create new ideas and services. It describes this information, gathered from sources including healthcare, transport and culture, as 'the vital signs of a living, breathing city'. In addition to the Catapults, 20 organisations are supporting the initiative, ranging from Manchester City Council, the project lead, to technology giant Cisco and festival organisers, FutureEverything.

Alongside the work delivering real-world demonstration of the applications of IoT, the programme supports the development of innovations in hardware, software and service development by UK technology SMEs. Through hardware accelerators and Digital Catapult's deployment of six Low-Power Wide-Area Network (LPWAN) testbeds, seventy-five SMEs were brought closer to the market with their products in 2016/17 with more than £4.25M (GBP) in follow-on funding awarded.

The IoTUK programme is also exploring areas such as security, data interoperability, IoT ready design and investment cases, with partners including the Department of Health (DH) and the Engineering and Physical Sciences Research Council (EPSRC).

Now entering its third year, the PETRAS initiative sees nine leading UK universities working together on over 40 research projects, exploring issues fundamental to the success of IoT: privacy, ethics, trust, reliability, acceptability and security. The learnings will be relevant to all sectors and in the future, and could help ensure that our personal data is stored safely, protect autonomous vehicles from hacking and make critical national infrastructure robust against cyber attacks.

Much of the discussion around IoT focuses on devices but it is essentially a human artefact - a tool for us to understand and improve our environment, powered by the data from our daily interactions. IoTUK therefore is researching what it will mean to live in an IoT world, the benefits and the downsides. This will help policymakers understand the technology even as it becomes all-pervasive.

One area where it is expected to have a major impact is healthcare. Through IoTUK, the Catapults are supporting two large-scale investigations with the National Health Service (NHS). The first will gather data from up to 12,000 patients living with Type-2 Diabetes, to see how they manage their condition on a day-to-day basis. The second will assess how IoT embedded in the home can help dementia sufferers, and their carers, maintain a good quality of life and reduce time spent in hospital.

Less well known but likely to have just as profound an impact, compound semiconductors are a new class of electrically conductive materials which have the potential to revolutionise electronics, just as silicon chips did 50 years ago.

Crystalline structures made from two or more elements, compound semiconductors are more challenging to manufacture than their silicon equivalents but offer processing speeds up to 100 times faster. They are more efficient, can sense light, operate at elevated temperatures and generate microwaves. These properties mean compound semiconductors will extend the range of electric vehicles, make the internet faster and LED lighting more efficient, allow us to generate more power from solar panels and see in a wide spectrum



of colours, opening up new opportunities to monitor health conditions.

Over the past decade, the Engineering and Physical Sciences Research Council has invested c.£750m in the field and the UK now boasts the world's premiere cluster based in South Wales. The new Compound Semiconductor Applications Catapult is locating here and when it opens its doors in Spring 2018, it will help Britain secure a leadership position in a global market predicted to be worth c.\$140 billion by 2023.

The Catapults are independent and specialist in their various sectors. Increasingly, however, they are also working collaboratively, tapping into the growing power of their network in order to deal with inter-dependent systems and to deliver the Industrial Strategy.

### Power of the Network

The Cell and Gene Therapy Catapult is collaborating with HVM Catapult to develop intelligent production systems, to ensure the supply of new therapies – one of the goals of the Industrial Challenge Fund and vital if Britain is to secure 15% of a global market expected to be worth £10bn, by 2035.

The Satellite Applications Catapult has teamed up with its ORE Catapult counterpart to explore how remote sensing from space can help the wind turbine industry. The WindRes project, for example, combines free information from the Sentinel 1 satellite with other data to create an online 'atlas of wind', which will help operators decide where to locate new turbines.

Renewable power generation will play a significant role in helping the country 'de-carbonise' its energy production, reduce CO<sub>2</sub> output and deliver affordable electricity – again, key aims of the Industrial Strategy.

To deliver the vision, the existing system requires re-thinking: we need better methods of making energy, more efficient ways to transport and store it and 'smart grids' so we can model demand and reduce waste.

It is the sort of complex, national-scale challenge that only a joined up network such as the Catapult's can address, and Energy Systems, Offshore Renewable Energy, High Value Manufacturing, Future Cities and Satellite Applications Catapults are already working on the problem, both individually and together.

The mass adoption of electric vehicles is a closely related technology shift, now well underway, which also calls for increased collaboration.

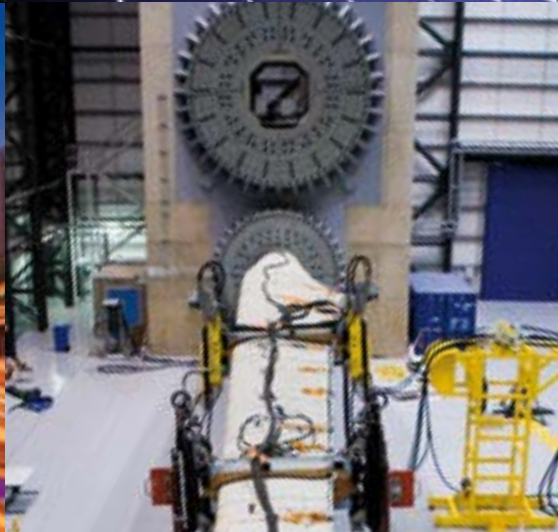
### Spark of Revolution

Battery power was prominent at the beginning of the automobile age, 120 years ago, and the first Land Speed Record was set by an electric car in 1898. Its top speed of 39.24mph was, however, slower than the bicycle speed record of the time and for the next century, internal combustion would dominate and transform personal mobility, changing patterns of work and leisure, the nature of communities and the shape of our cities.

It also contributed to enormous environmental and public health

BY 2030, THE  
CHALLENGE IS  
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**50%**  
OF CARS   
AND  
VANS BEING  
ELECTRIC







problems. Legislation addressing these issues has created the opportunity for electric vehicles to reclaim the streets. By 2030, the challenge is to have 50% of cars and vans being electric or hybrids combining battery power with downsized combustion engines.

For this to happen, a wave of innovation is needed, new supply chains are required and existing infrastructure developed to cope with electric vehicles going mainstream.

For decades, the electricity grid has been configured to meet peak domestic demand occurring around dinnertime. If a significant number of households start charging electric vehicles as well, that peak load will double or triple, with the demand curve extending into the early afternoon. The UK cannot currently generate or transport sufficient energy to meet this need.

The industry recognises this but its size, strategic status and mix of stakeholders creates formidable inertia. When unpredictable energy prices, environmental imperatives and the increasing adoption of technologies such as solar PV (photovoltaic cells), domestic grids and community energy schemes are factored in, the full scale of the energy innovation challenge becomes apparent.

The Energy Systems (ES) Catapult is responding with a major programme called 'Future Power System Architecture'. Convening all parts of the sector, from academics, to operators to government, its aim is to transform the underlying structure of energy production and distribution in the UK.

Working in conjunction with the Institution of Engineering (IET), and with support from the Department for Business, Energy and Industrial Strategy (BEIS), the ES Catapult will take a 'whole system' approach, investigating new technologies and how to connect them to the grid; new business models including local energy markets; and the invisible but all important enablers of regulation, data sharing and cyber security.

"The domestic energy market is too fragmented for existing companies to find a solution by themselves," says the ES Catapult's Chief Executive, Philip New. "There are many barriers too. What we are doing is developing tools and processes – 'experiments' – which ask whether it would be possible to have an entirely different market structure. We are asking what do potential providers need? Could we make it possible? What will enable investment?"

*"Lots of money is spent on invention in this space but very little of it gets to business, in part because of a regulatory system which doesn't reward innovation or risk taking. The sector's first job, remember, is to 'keep lights on' and job two is 'keep prices down'."*

It will not be a quick process and the team talk about 'transition' rather than revolution, but for the first time the UK will have a roadmap to the sort of flexible, intelligent power network we require.

Batteries are a vital part of the system. Renewables produce power intermittently – the wind doesn't always blow – so there is a need to



store energy to ensure supply matches demand. On the consumer side, existing batteries make electric cars expensive and heavy, and their poor efficiency (or more accurately, low energy density) limits range.

The HVM Catapult has been working on the battery problem for sometime and was instrumental in Government pledging £246 million, as part of the Industrial Challenge Fund, to ensure the UK leads the world in their design, development and manufacture.

Its Energy Innovation Centre is the only place in Europe that covers not just battery chemistry but the entire system, from coatings to making cells to "aggressive" testing. It can already produce batteries which are 70-80% more energy dense per litre than those produced by Tesla, the manufacturer which has done more than any other to popularize electric cars.

Although the Challenge Fund relates primarily to automotive batteries, the Catapults will ensure that its innovations cascade into domestic and grid storage. HVM is already working with the Future Cities, Transport Systems and Satellite Applications Catapults to 'manage the push' to greater electrification.

The Catapults combine and configure themselves in different ways according to the problem being addressed. As contacts and experiences are added, the capacity of the whole system increases; the more work it does, the more work it can do in the future. With the network maturing, the Catapults provide the UK with a unique set of tools with which to address the many challenges ahead. ■

CATAPULTS PROVIDE THE UK  
WITH A UNIQUE SET OF TOOLS  
FOR THE CHALLENGES AHEAD

# CONCLUSION

## The UK is an ingenious nation.

We have an international reputation for excellence in academic research and are world-leaders in sectors such as aerospace, automotive, the creative industries and pharmacology. We are also entrepreneurial: Britons are used to setting sail and heading for a far horizon to do business. We need to marshal these strengths because ahead of us lies an increasingly complex and competitive world.

The Catapults were created to meet this challenge.

After five years they are well established and casehardened through the experience of delivering thousands of successful collaborations and projects.

Their networks span from university labs to the boardrooms of international industry, dynamic start-ups to government regulators. They have proven themselves to be expert, trusted, neutral and agile; able to break down barriers and create the right environments for success.

Catapults are different because they are independent and run by teams with broad business experience. They are effective because they work with industry to create demand. Their expertise with technology and data is balanced by their ability to convene and build partnerships; to understand markets and finance; they speak the language of big business and SMEs.

The Catapult's focus is on the UK but their reach is global. They work in 24 countries and have proven highly successful in attracting foreign investment into the UK, helping to anchor innovation and skilled jobs here. This has not gone un-noticed and many countries are now looking at replicating the Catapult model including Australia, Canada, Chile, China, France, Norway and Thailand.

With the Catapult network growing and maturing it is increasingly able to tackle the systemic failures and broken markets that hold the UK back. It means we can also seize opportunities created by the seismic technology shifts now underway, which will upend the established order.

Although they have already achieved notable results, the real value of the Catapults will be seen in the years to come, when long-term strategic plays, such as making the UK the best testing ground for autonomous vehicles, building a better battery or proving the potential of the IoT, bear fruit.

They are the path-beaters to a world we can't properly define but have to prepare for, nonetheless. What we can be sure of is that innovation will be its currency. **That's why the Catapults are innovating now to build that better future for Britain.** ■

CATAPULTS  
WORK IN  
24   
COUNTRIES

cATAPULT





# CATAPULT

Network



Catapults are a network of world-leading centres designed to transform the UK's capability for innovation in specific areas and help drive future economic growth.

[catapult.org.uk](http://catapult.org.uk)