INTELLIGENT MOBILITY SKILLS STRATEGY

GROWING NEW MARKETS IN SMARTER TRANSPORT

October 2016

CATAPULT
Transport Systems

CONTENTS

FOREWORD

The UK has always been a global leader in the field of transportation. It is now time to be the global leader in transport systems. This leadership can only be delivered by people and we must act now to develop the skills and capabilities that will drive growth and help secure a significant share of the global £900 billion market by 2025.

The onset of the Digital Age has already dramatically changed how we live our lives and is poised to transform how we travel in the future. It will herald a new era of 'Intelligent Mobility' that will be characterised by smarter, greener and more efficient movement of people and goods. The UK must now seize the moment to secure a pivotal role and drive global leadership in transport. A significant share of the global £900 billion Intelligent Mobility market awaits those people, companies and nations who have the technical knowledge, entrepreneurial flair and perhaps most importantly, the skills to make this bold transition.

This change will require a great leap in cross sector collaboration, investment and the development of highly capable people who are able to develop new business models and new forms of transport that can truly revolutionise delivery and customer experience.

The Transport Systems Catapult is committed to creating an environment that will help make the UK a world leader in Intelligent Mobility. We must understand the barriers and fundamental enablers required, to prioritise targeted investments, that build sustainable capabilities. We have already developed a strong understanding of traveller's end-to-end journey needs, as well as the technology strategy required to secure the economic potential. However, this is nothing without the capability of the people who will make the difference. Skilled people, who will fuel the engine of growth, create new opportunities and benefits worldwide are essential if we are to realise the substantial benefits.

The launch of this Intelligent Mobility Skills Strategy marks a critical milestone and is a call to action for government, academia and industry. Following months of collaborative research and with significant input from a wide range of stakeholders, we are pleased to be publishing our perspective on an Intelligent Mobility Skills Strategy. We know this document is not the full answer. It will however form the start of a debate – much more has to be done. New markets and new capabilities will always be shrouded by uncertainty, but we aim to foster a shared vision and direction for all organisations interested in developing the skills needed for Intelligent Mobility.

Join us in helping to improve and sustain the quality of peoples' lives and build from the ground up, the skilled people who can drive new economic growth, exports and deliver a new future for transport.

TSC **VISION**

To create an environment that will make the UK a world leader in transport systems innovation.

TSC **MISSION**

Drive UK global leadership in intelligent mobility promoting sustained economic growth and wellbeing through integrated, efficient and sustainable transport systems.

Steve Yianni
Chief Executive Officer

ACKNOWLEDGMENTS

We would like to express our thanks to the following members of our University Partnership Programme for their research and contribution to the Evidence-based Report: A review and evaluation of skills demand, supply and interventions required to support the growth of the UK intelligent mobility market, that underpins this document:

EXECUTIVE SUMMARY
THE BIG IDEA – SEIZING THE INTELLIGENT MOBILITY MARKET TODAY

The global transport market is rapidly changing to a 'smart transport' model, which is estimated to reach £900 billion by 2025 – known as the intelligent mobility market. The UK is strongly placed to win a significant share of this market through a number of unique strengths such as human machine interaction (HMI) and interaction design, localisation and mapping, analytics and simulation or real-time control. These strengths support the UK's ability to position itself as a market leader through our existing autonomous vehicles trials. A crucial element of success lies in the ability to build the intelligent mobility skills of the nation. We either close this gap quickly and acquire market leadership for at least a few years, or risk relegating ourselves to the pack for decades.

TRANSPORT TRENDS – THE RISE OF DIGITAL AND SMART TRANSPORT

This report is a call to action for government, academia and industry to invest in a skills strategy that enables the UK to achieve global industry leadership in the rapidly growing field of intelligent mobility (IM). New technology and changing business models (such as the sharing economy tools), coupled with growing digital capabilities, will herald a new age in transport that offers enormous export, productivity improvement and job opportunities.

Previous investment in skills development and innovation in our leading aerospace or automotive sectors has helped produced world beating industries. Skills investment works. The automotive sector successfully boosted production by 50% since 2010, while innovation helped improve fuel efficiency by 42%. The UK automotive workforce is now one of the most productive in Europe and the UK is home to a number of most recognisable global brands. With digital skills and transportation now converging (Google cars being the simplest example) the digital economy is becoming synonymous with transport and the national economy. Everyone is competing for rare but complementary skills sets, which are in short supply.

The UK is ready for smart transportation. The extensive IM UK Traveller Needs and UK Capability Study[1] sought to understand the fundamental enablers of value and to prioritise targeted investments that can build on innovation that meet the needs of UK travellers across the whole field of seamless transport rather than the tradition single sector modal focus usually adopted. It found the UK traveller to be both frustrated yet progressive and ready for change: 75% of all journeys made in the UK are subject to negative experiences, 57% would not mind sharing their data for services, 32% would share their possessions with others and 39% would use driverless cars today.

UK TRAVELLERS
ARE READY FOR CHANGE

39%

WOULD USE
DRIVERLESS CARS TODAY

57%

WOULD SHARE
POSSESSIONS
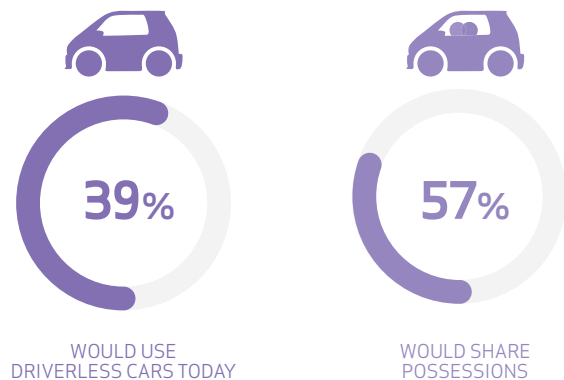
[1] Intelligent Mobility Traveller Needs and UK Capability Study in the UK (2015) Transport Systems Catapult

GROWING UK BUSINESS IN SMART TRANSPORT AND MOBILITY

800,000 JOBS
REPLACED IN THE LAST 15 YEARS

100,000	200,000	300,000	400,000	500,000	600,000	700,000	800,000	900,000	1,000,000
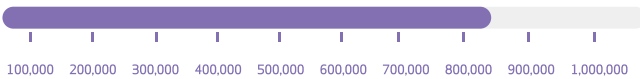
BY TECHNOLOGICAL ADVANCES

Intelligent mobility is the future of transport. The UK is well placed to take advantage of these momentous changes; we must aspire to be at the forefront of the market. The UK has a unique opportunity to build upon the £200 million five-year Intelligent Mobility Programme already funded by government and the private sector. In the BREXIT era, industry can grasp this new market as we control the speed of UK transport legislative change, we control the ability to stimulate the introduction of new technology, we control where to invest to create new jobs, drawing upon our regional strengths and creating opportunity for all.

The digital revolution is fundamentally changing the labour market. Rapid improvements in advanced robotics and artificial intelligence are a growing field enabling the performance of a broader range of non-routine manual tasks. With the improved sensing available in robotics, jobs in transportation and logistics are now likely to become fully automatable. Autonomous transport will be disruptive. It has the potential to have a huge impact on bus and taxi drivers, along with many logistics occupations - whilst also opening enormous opportunities for new, highly skilled job instead.

The trend towards automation is not new. The Organisation for Economic Cooperation and Development (OECD)[2] identified that in the last decade over 8% of 'medium routine' jobs in the EU28 disappeared, while 800,000 jobs were lost in the UK in the last 15 years. **Technology directly or indirectly created another 3.5 million jobs that paid £10,000 more.** US data mirrors this. Of the 4.5 million US job vacancies in 2014, over 500,000 were in information technology (IT) fields like

software development, network administration, and cyber security – many of which did not even exist just a decade ago. The average salary in a job that requires IT skills, whether in manufacturing, advertising, retail or banking, is 50% higher than the average private sector American job. Increasingly, the training required for these roles can be acquired not just through traditional university and community college curricula, but also through non-traditional means, such as coding boot camps and high-quality online courses that can rapidly train individuals for high-wage jobs. Automation is an accelerating trend that is not reversible – we need to equip and upskill our workforce now.

We are at a tipping point. None of our international competitors are being complacent. In October 2015, President Obama released his Strategy for American Innovation[3], which highlighted the advances in computing, sensors and machine learning that have made autonomous vehicles possible. American federal investment is doubling to help bring these technologies to the commercial market. The US government has committed to invest $4 billion over the next 10 years to accelerate the development and implementation of fully autonomous vehicles. In Germany, the national new High-Tech Strategy[4] aims to move Germany forward as a worldwide innovation leader. One of their six priority tasks relative to future prosperity and quality of life is intelligent mobility. They are pursuing research in support of integrated transport policies that optimise the different modes of transport in terms of their efficiency, capability and interactions. To capture a significant share of this market we need to ensure that highly developed IM skills are rapidly grown or we will simply not keep pace.

3.5M NEW JOBS
+ 10K
HIGHER WAGE

[2] Automation and Independent Work in a Digital Economy, OECD, May 2016

[3] A strategy for American Innovation (October 2015) The White House

[4] The new High-Tech Strategy – Innovations for Germany (2014) German Government

SKILLS CRISIS – A SERIOUS CONSTRAINT TO THE UK'S GLOBAL TRADING POSITION

The UK has made significant progress with skills development through apprenticeships and national skills strategies in a range of transport related sectors. Nationally, this includes a commitment to three million apprenticeships by 2020, with over 2.2 million created since 2010. The 2016 Transport Infrastructure Skills Strategy[5] focused on the need to equip industry with the skills to deal with the new technological challenge and to address the anticipated shortage of over 56,750 skilled workers predicted by 2020, purely to deliver transport construction. It has a bold commitment to creating 30,000 apprenticeships, adopting a proactive approach to changing perceptions of working in transport and engineering, increasing workforce diversity and upskilling existing workers. The massive £70 billion infrastructure spending during the life of this Parliament will see companies compete for scarce skills even before companies' global growth ambitions can be met.

Investment in skills by our leading manufacturers has been a key enabler for our world-leading automotive and aerospace sectors. The 2016 Automotive Council Industry[6] report on skills shows that while the sector is growing and transforming there are real challenges with developing the skilled workforce needed to maintain this lead in the immediate and longer term. Short-term sector needs include 2,500 people to fill immediate vacancies, of which 70% of the future oriented skills dominate the top 10 skills needed. As many as 50,000 more people will be needed by 2020. Another 60,000 will be required in

70%

THE TOP TEN SKILLS NEEDED IN AUTOMOTIVE ARE FUTURE ORIENTED SKILLS

the supply chain if the continued focus on UK-sourced content reaches 41%, it will help achieve another £4 billion opportunity. Technological advancements also feature heavily in the future of the automotive industry. More driverless vehicle piloting, sophisticated software and electrical/electronic systems, hybrid and multi-fuel vehicles are being developed to gain better efficiency and environmental performance. All these changes impact on the type of resource required for the industry. These and other sectors will all be competing fiercely for a small set of people with STEM, digital and leadership skills, risking economic growth and jobs across a range of sectors.

If appropriate interventions are not put in place, our assessments identify that £50 billion in GDP per annum could be lost. Much more needs to be done across the entire skills pipeline that feeds UK manufacturing, design, transport construction and innovative industry development.

£50 BILLION
OPPORTUNITY

COULD BE LOST
WITHOUT INTERVENTION

[5] Transport Infrastructure Skills Strategy: building sustainable skills (2016) Department for Transport
[6] Employers' Views of the Jobs and Skills Required for the UK Automotive Industry (2016) Automotive Council

INTEGRATED APPROACH TO EVIDENCE GATHERING

This high level report aims to support decision making and help provide an initial impetus into the direction of investment into a later detailed plan. Robust evidence was delivered through reviewing over 30 reports, interviewing 40 key stakeholders and using an IM skills industry workshop with over 20 industry participants from SMEs and large corporates to help validate, align and commit to the findings and recommendations. Industry specific skills initiatives such as the Department for Transport (DfT) Transport Infrastructure Skills[7] report and the Automotive Council report on skills were also examined to assess overlaps and potential synergies. The Transport System Catapult (TSC) has worked as a key stakeholder with the Centre for Connected and Autonomous Vehicles (CCAV), the joint policy unit between Business, Energy and Industrial Strategy (BEIS) and the Department for Transport (DfT). CCAV was established to address the interaction among vehicles, infrastructure and data to achieve significant economic and social benefits with these technologies (as just one part of the overall IM agenda). This approach has led to a new cross-sectoral IM skills matrix and skills gap assessment , from physical and technical sciences to social and human sciences. It identifies the IM skills demand forecast to 2025 and is fully supported by market, capability and travellers needs analysis.

THE INTELLIGENT MOBILITY SKILLS GAP – KEY FINDINGS

A comprehensive assessment of skills literature[9] identified clear gaps in the provision and development of skills for intelligent mobility if the UK is to deliver either the key technologies or potential economic growth. Most skills strategies cover individual sectors only. This research is a unique model as it spans both the traditional STEM and the human science skills needed to address this market.

Figure 1 - Skills matrix categorisation intelligent mobility skills moving beyond STEM
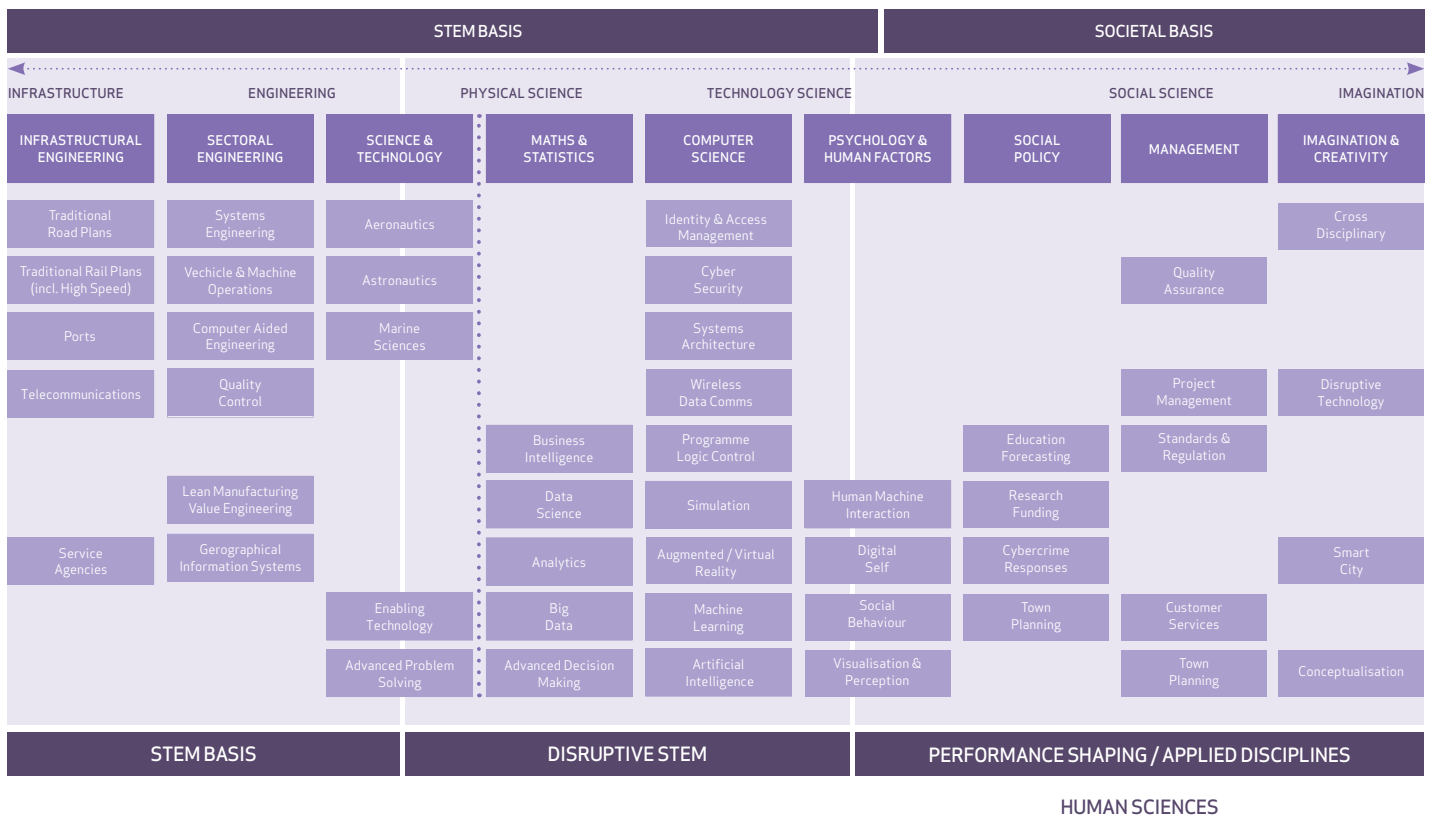
[7] Transport Infrastructure Skills Strategy: building sustainable skills (2016) Department

[8] See Figure 1

[9] Evidence-based Report: A review and evaluation of skills demand, supply and interventions required to support the growth of the UK intelligent mobility market (June 2016) Transport Systems Catapult

The key findings include:

- **The UK faces a potential skills gap of 742,000 people by 2025.** Using the wider skills approach we identified that around 1.159 million individuals will be needed with an estimated supply of 417,000. This highlights a skills gap of 742,000.

- **'Disruptive' high value digital skills are in short supply.** Disruptive skills will reinvent transport systems and create new businesses. Within the overall shortfall 281,000 of these skills occupy the 'disruptive' STEM and human sciences landscape. These have a strong emphasis on high value digital skills that transcend traditional transport sector boundaries.

- **Transport industry experts strongly prefer higher degree apprenticeships.** Consultations, surveys and interviews revealed that industry members strongly preferred higher degree apprenticeships to address future skills gap. They also saw the need for greater and consistent understanding of IM, and the opportunity this market presents in order to help galvanise action.

- **The potential lost opportunity cost to UK GDP is £50 billion per annum.** The assessment has identified that there is a significant opportunity cost to UK GDP with estimates indicating that £50 billion per year could be lost if appropriate interventions are not put in place.

- **An integrated range of interventions is needed to address the skills shortfall. The industry and research participants agreed that no single intervention will address the shortfall** in IM skills. The detailed assessment has concluded that a portfolio of traditional and disruptive interventions is required, from early education to post graduate training, while supporting transfers and skills growth from across other sectors. There is also an increasing level of competition for digital skills, which are portable from sector to sector. Without a national solution oriented to these challenges, a fragmented or neutralised outcome may result, as each sector competes for rare skills to advance their own agenda.

- **Proactive efforts need to be made to attract women to the industry.** There are too few women in the transport industry as a whole. In the cross-cutting digital sector this represents an untapped growth of £2.6 billion per annum. Women still only represent 6% of the engineering workforce and only 15.5% of the science, technology, engineering and mathematics (STEM) workforce.

- **The UK can adopt rapid, novel, low cost international interventions.** New ways of rapidly developing people with digital skills can be adopted. Launched by an entrepreneur's 70-million-euro donation, the French École 42 based in Paris, produces 1,000 job ready 'graduates' a year. Between 800 and 1,000 people enter every year. In 2013, 70,000 applied for the online test, 20,000 completed it and 4,000 were invited for a four-week coding challenge. Each working week of up to 100 hours led to the final selection of 890. This produces highly motivated people, with applicants having ranged from university graduates to those who did not complete school. The only requirement is to be between the age of 18 and 30. With its unique educational approach, where no formal qualifications are required, it is accessible to all and completely free of charge. École 42 is the most daring response yet to the challenge of computer science skill development, as well as a source of innovation for the future.

SEIZING THE MOMENT – RECOMMENDATIONS FOR ACTION

In order to fully capitalise on this rapidly emerging market, four options were examined including the 'do nothing' option. The 'do nothing' option was considered to be highly unlikely to address the skills gap and would risk the UK's global trading position in the long term. The 'do nothing' approach and key historical learnings are explored in section six. The three strategic level options below blend the traditional and disruptive interventions to provide a range of options. These are based on a level of investment over and above the 'do nothing' scenario. In the 'do nothing' option the market would naturally supply 417,000 individuals over the next nine years to 2025, but still fall well short of addressing the overall 742,000 skills gap.

Table 1 - Summary of options

OPTION	SKILLS CREATED	ANNUAL INTERVENTION COST	ROI	ANNUAL UK GDP BENEFIT*	DiFFERENTIATION
1 - Low level investment	57,000	£43m	6.7	£362m	Lower risk investment aiming to gradually develop and qualify people over a nine-year period.
2 - Medium level investment	100,000	£71m	17.1	£1.5 bn	All investment is front-loaded within the next five years to help jumpstart capability and secure market leadership.
3 - High level investment	160,000	£167m	6.0	£1.4 bn	Focuses on the graduate and post-graduate skills, which are costlier to develop over a nine-year period to 2025.

The **preferred option is the medium level option** approach as it can help secure a significant number of newly skilled people and helps fuel strong GDP growth as a cost competitive option.

An integrated set of high-level interventions was developed with stakeholders as illustrated in Table 2. These interventions will be delivered through the creation of an intelligent mobility community hub, which will bring together existing industry, educational and government initiatives to create a coordinated 'virtual hub' that supports overall skills development. To guide these interventions an inter-departmental task force should be established to support and drive the 'one IM industry' skills plan.

Table 2 Summary of interventions

NATIONAL ENABLER	FOCUS AREA	TIMEFRAME TO START	TIMEFRAME TO IMPACT	DESCRIPTION
Intelligent Mobility Hub (new)	Create a focal point to align academia, industry and institutes to maximise impact	Six-eight months	Within five years	Work with the Institute of Apprenticeships and industry to create a shared learner repository providing industry standards, signposting training to support upskilling, skills planning and gap analysis.
Institute of Apprenticeships	FastTrack apprenticeships with particular focus on identified industry needs	Ten-twelve months Twelve-eighteen months	Three -five years Three-seven years	Collaboration with the Institute of Apprenticeships to ensure that all existing STEM apprenticeship frameworks include an element of IM creating 30,000 IM AWARE students. The development of higher degree apprenticeship frameworks with industry and academia to produce IM CAPABLE and work-ready graduates.
Government and industry (new)	Start up a ground breaking computer science school, which includes application to future transport needs	Within twelve months	Within three years	Accelerate learning based upon the model and concept of École 42 adapted for UK IM needs. Use existing technology centres including the Catapult network, the National College for Digital Skills, innovation clusters, skills academies and invest in targeted UK regions to enable access for all. Set and deliver aggressive short-term targets for this programme at least 1,000 qualified people each year, per UK school.
Nationals skills academies and centres of excellence	Build cross-sectoral collaboration	Within six months	Within five years	Formalise engagement through existing relevant national skills academies and centres of excellence and support transitions of ex-service personnel.
Academic institutions	Create new academic qualifications Build awareness and create a pipeline of talent	Within six months Immediate	Under five years	Develop IM modules, courses, conversion MScs and PhD research programmes. Work with existing schools and further education out-reach programmes.
Government and industry	Integration between national investments	Immediate	Under five years	Participate and influence new and existing government initiatives to enhance industry collaboration and accelerate impact e.g. The Strategic Transport Apprenticeship Taskforce (STAT)
Professional institutions	Build professional development and accreditation	Within one -two years	Five-ten years	Develop IM professional accreditation with the national UK Professional Institutions.
Government	Create opportunity for all and close the gender gap	Within six months	Five-ten years	Start a 'Women in Innovation' programme, with dedicated funding including conversion programmes, fund female focused innovation incubators, additional InnovateUK sponsored competitions focused on themes, digital coding camps and use the power of public sector procurement to secure private sector action on gender based skills.
IM hub with key stakeholders	Grow awareness to attract new entrants	Within six months	Five-ten years	Raising awareness of IM through targeted marketing and advertising campaigns across the UK.

Skills are a major contributor to productivity, and as a nation we are not doing well enough or moving fast enough. To fuel the engine of private sector productivity and innovation, a significant and imaginative investment needs to be made to enhance a steady supply of skilled and entrepreneurial people, equipped to help the UK capture tomorrow's market – today.

THE FUTURE OF TRANSPORT:
A NEW ERA OF OPPORTUNITY AND CHALLENGE THAT IMPACTS EVERYONE

Transport in 2030 will look very different than it does today. Intelligent Mobility will have a profound impact on the way we move people and goods around the globe.

Intelligent Mobility market is forecast to reach £900 billion globally by 2025, which corresponds to about 1 percent of the projected global GDP.
Transport Systems Catapult

More change to come in the next 5 -10 years than in the last 50 years.
Mary Marra, CEO General Moters

Sustainability can't be like some sort of a moral sacrifice or political dilemma or a philanthropical cause. It has to be a design challenge.
Bjarke Ingels, Architect

We're asking ourselves how we use innovation to allow Ford to help tackle some of these large societal issues around congestion and transportation. And that is why we're thinking of ourselves as not only a car and truck company, but also as a mobility company.
Mark Fields, CEO Ford

Transport will be hit by a tsunami wave of change on par with the digital revolution in communications. Soon, commuters will be able to purchase mobility plans, as they would a cell phone service, at rates according to their needs.
Sampo Hietanen, CEO MaaS Finland

Together we will build a better future by redefining traditional car ownership.
John Zimmer, Co-founder of Lyft

People may outlaw driving cars because it's too dangerous.
Elon Musk, Entrepreneur

If we can get you a car in five minutes, we can get you anything in five minutes.
Travis Kalanick, CEO Uber

The key word for transportation in the 21st century is choice.
Anthony Foxx, US Secretary of State for Transportation

We still live by the rules of the industry when the phone was created. But we live in the smartphone era and things need to catch up.
Beth Stevens, Sidecar

Electric cars are going to be very important for urban transportation.
Carlos Ghosn, Renault

In the decades to come, filling up a car with petrol will sound as backwards as the horse and cart is today.
Richard Branson, Virgin

I believe public transport has a great future, it has a major role to play in helping Europe and the rest of the world meet the challenge of climate change.
Brian Souter, Founder of Stagecoach

A developed country is not a place where the poor have cars. It's where the rich use public transportation.
Mayor of Bogota, Colombia

ARE YOU READY?

1. INTRODUCTION
SETTING THE UK'S AMBITION IN INTELLIGENT MOBILITY

1. The UK government has demonstrated its commitment to secure a significant share of the rapidly emerging £900 billion intelligent mobility market through a range of recent investments. These have included:

- The establishment of the Transport Systems Catapult (TSC) as one of 11 elite technology and innovation centres to drive and promote IM;

- Creating the Centre for Connected and Autonomous Vehicles (CCAV) in July 2015 as a new joint policy unit between the former Department for Business Innovation and Skills and the Department for Transport. Its remit is to address the interaction among vehicles, infrastructure and data to achieve significant economic and social benefits with these technologies;

- The former Chancellor of the Exchequer provided financial commitment in the 2015 Spring Budget Statement where a £200 million five-year Intelligent Mobility Programme (£100 million from government and £100 million in matched funding from industry) was announced, focusing on enhancing the development of driverless car technology. The 2016 Autumn Budget Statement announced the government's intent to establish the UK as a global centre for excellence in connected and autonomous vehicles; and

- As a signal to industry of the government's intent in May 2016, the Queen's speech cited the on-going commitment of her government to the intelligent mobility agenda.

> " My ministers will ensure the United Kingdom is at the forefront of technology for new forms of transport, including autonomous and electric vehicles
>
> May 2016, Queen's speech

BACKGROUND TO THE SKILLS CHALLENGE

2. In January 2016, the Department for Transport (DfT) published its Transport Infrastructure Skills Strategy[10] report outlining the risk of skills shortages as an acute issue. Examples included:

- Low UK productivity, which as the most determinant of average living standards and growth, has persistently lagged behind other leading advanced nations, and if the UK matched the productivity of the US, it would **raise GDP by 31%;**

- The current supply of skilled people needed to simply deliver transport construction does not meet anticipated demand in the labour market, with a **peak demand shortfall total of 56,750;**

- A **significant lack of diversity** in the workforce, the UK could further increase GDP per capita growth by 0.5% per year, with **potential gains of 10% of GDP by 2030.** This mismatch needs unblocking to optimise the potential for the UK's economic growth;

- With an investment of **£70 billion in transport in this Parliament alone**, a new generation of engineers, designers and construction professionals together with highly skilled people are needed to operate the networks once they're opened.

3. The report laid out an ambitious overall strategy of skills development such as developing 30,000 new apprentices by 2020. The strategy addresses the skills challenges associated within the transport infrastructure sector that are needed to support jobs and enable business growth through a number of ambitious recommendations and targets.

4. The report recognised that the strong role of digital and the emergence of breakthrough new technologies such as autonomous transport, smart motorways and the digital railway require new skills and capabilities needed to operate in a more technically advanced and data rich infrastructure. This particularly applies to IM skills where people need to learn new principles and gain the crucial workplace application experience, to exploit new technologies and support the sector's digital transformation.

5. A cabinet office roundtable event in November 2015 identified the inadequate supply of people with appropriate skills as a key risk to the UK leading the emerging £900 billion global smart transportation market. The cross-sector group, IM-pact UK (Intelligent Mobility Planning and Action Coordination Team) which supports the UK's ambition to capture a significant new share of this market, has been asked via the Centre for Connected and Autonomous Vehicles (CCAV) to build on the work of the DfT's Transport Infrastructure Skills Strategy[11] by identifying the additional skills needed to support the new emerging markets for IM.

6. This document, together with the underpinning Evidence-based Report[12], sets out the case for a government sponsored intervention to develop the UK's intelligent mobility skills base between 2016 and 2025. In this capacity, the report describes the need for an intervention in IM skills development, how the intervention fits with the government's wider strategic objectives, how much it will cost, who will benefit, how it will be delivered and the alternative options considered.

THE INTELLIGENT MOBILITY MARKET

7. As we move into the intelligent mobility era, characterised by greener, smarter and more efficient movement of people and goods, the need for new thinking will increase in order to address the huge market potential.

8. The industries of the 21st century will have technology and data at its core. The relentless parade of new technologies and scientific breakthroughs is unfolding on many fronts, with new technologies and innovations offering transformative benefits. Compared with the Industrial Revolution, McKinsey estimated that this change is happening 10 times faster and at 300 times the scale, or roughly 3,000 times the impact. History tells its own story, of significant change via innovation:

- In 1999, it took Google one month to trawl and build an index of about 50 million pages. In 2012, the same task was accomplished in less than one minute;

- The sales of smartphones and tablets increased six-fold since the launch of the iPhone in 2007, with Cisco forecasting mobile data traffic to increase eight-fold over the next five years;

- There has been a 300% increase in connected machine-to-machine devices between 2008-2013;

- Google has already achieved over 1 million miles of driverless car driving.

Figure 2 - UK relative capability by market area

Importance For Intelligent Mobility

Essential / High / Medium / Low / Restricted

- Traveller Behaviour & Psychology
- Connectivity & Networks
- HMI & Interaction Design
- Localisation & Mapping
- Data Privacy & Security
- Analytics & Simulation
- Sensing Capability
- Data Visualisation
- Information Processing
- Navigation & Path Planning
- Real-time Control
- Material Design
- Manufacturing Techniques
- Energy Storage & Distribution
- Low Emission Propulsion

Limited capability and difficult to catch up

Moderate capability with opportunity to grow

On par with most countries **UK relative capability**

Ahead of most contries

World class

57%

39%

53%

32%

Would share their possessions with others

Always look for ways to optimise their journeys

Would consider using driverless cars today

Would not mind sharing their data for better services

9. By default, society uses technology and data in ways that could never have been imagined 10 years ago. Digitalisation is a key influence on the future of work over the next decades. Ever-increasing computing power, Big Data, the penetration of the Internet, Artificial Intelligence (AI), the Internet of Things and online platforms are among developments radically changing prospects for the type of jobs that will be needed in the future. These developments are also affecting how, where and by whom they will be done. The OECD[13] identified job polarisation across developed countries with an 8% decline in 'medium routine jobs' in the UK, a 4% decline in Japan and a 9% decline in the US. With the increased use of robots for repetitive precision tasks, the demand for higher knowledge-based skills will increase. Lower skilled workers will upskill/reskill into more exciting and interesting fields of work, becoming multi-disciplined and more transferrable between transport sectors. Evidence from 360 job types and Office for National Statistics (ONS) government data provided at the Science and Technology Committee[14] in 2016 showed that technology has destroyed about 800,000 jobs in the UK in the last 15 years – half the secretarial, travel agent, counter clerk and librarian jobs have gone. It also revealed technology has, directly or indirectly, created another 3.5 million jobs in their place, with each one paying on average £10,000 more than the jobs that have gone. Across the country, every nation and region of the UK has had a net benefit from technology development. The trend towards digitalisation is relentless and action is needed urgently to ensure the UK captures the GDP growth, market exports and ability to develop a completely new set of world-leading industry capabilities.

10. The 2015 UK Traveller Needs Study[15] published its findings based on a robust market research base of 10,000 respondents, 100 expert and 50 company interviews. Commissioned to unearth the UK's innovation potential in the intelligent mobility market and to understand UK travellers' needs, it reported on what UK travellers need and value, acknowledging there needs to be an end user willingness to pay for products and services. A key finding was that the UK traveller is progressive and ready for new developments now.

[13] Automation and Independent Work in a Digital Economy (May 2016) OECD

[14] Science and Technology Committee Oral evidence: Robotics and artificial intelligence (July 2016) HC 145

[15] Traveller Needs and UK Capability Study (2015) Transport Systems Catapult

[16] Market Breakdown (2016) Transport Systems Catapult

[17] Technology Strategy 2016 for Intelligent Mobility (2016) Transport Systems Catapult

11. Transport Systems Catapult (TSC) research into the global market for IM identified high growth from 2015 to a total market size of around £900 billion annually by 2025[16]. In its 2016 Technology Strategy[17], TSC identified 18 constituent market segments within the IM market. Each segment is associated with an extrapolated Compound Annual Growth Rate (CAGR) of between 5% and 25% over the coming decade – with the exception of the autonomous vehicles segment, which is predicted to grow at 58% over the same period. This report assesses the UK's capability in these market segments to better understand its competitive advantage and to identify where investment would achieve the greatest impact, selecting market segments that are already large (or where growth rates are forecast to be large) and in which it has significant strengths.

12. Market segments where the UK should focus its efforts include: intermodal smart ticketing; security, resilience, safety and cyber security; Internet of Things asset management; monitoring and management systems; data management and analysis; data collection and communication platforms; and autonomous vehicles. Figure 3 illustrates the relative UK capability strength compared to the rest of the world versus global IM market size by segment in 2025.

Figure 3 - UK capability relative to the rest of the world
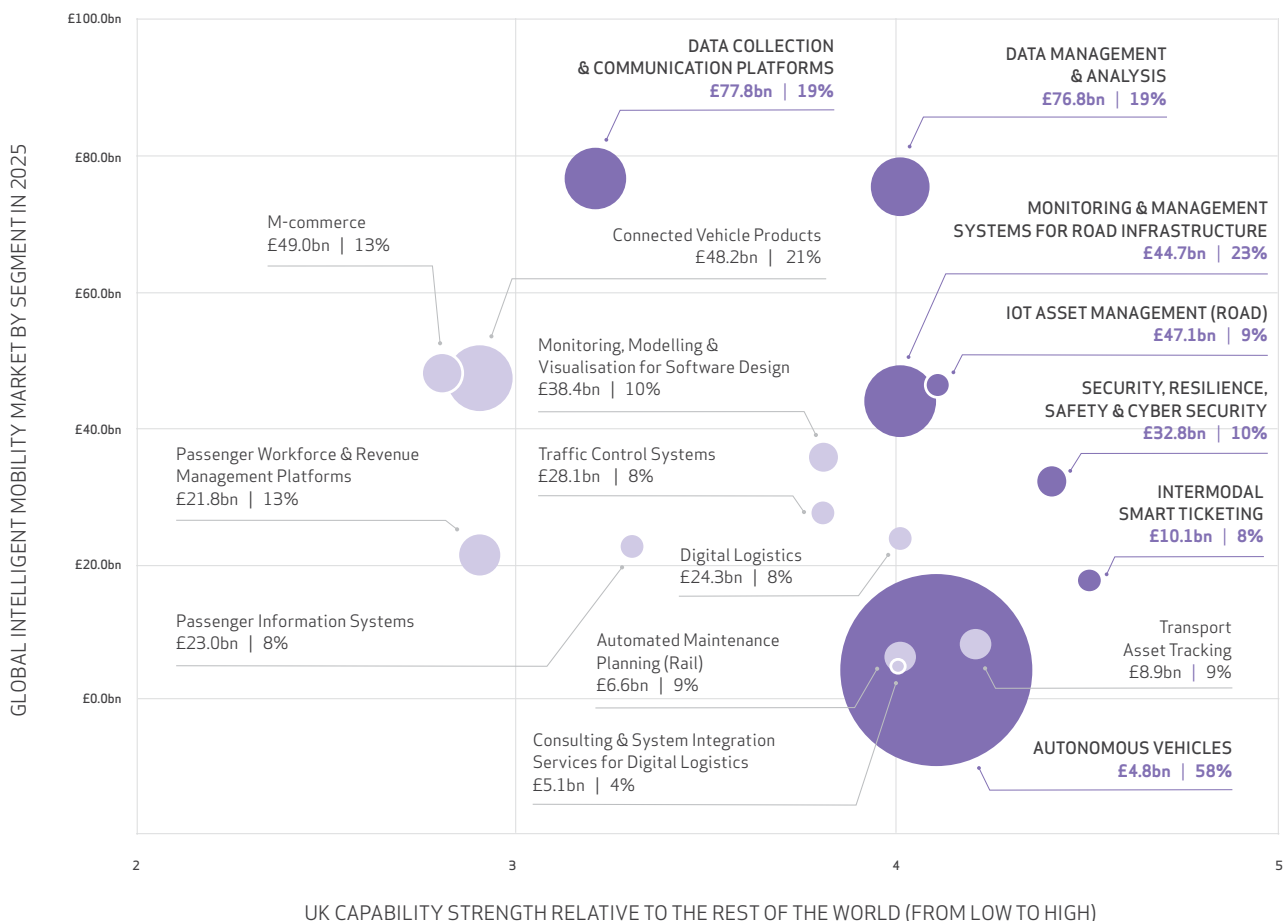
To fully capitalise on this emerging market, it is critical that the UK acts now. We must create a highly skilled, mobile and transferable workforce nationally, with access to a learning environment where each generation entering the workplace acquires the right skills fit for the future supported bya sustainable career pathway.

2. IM SKILLS STRATEGY OVERVIEW
BACKGROUND

13. This document and accompanying Evidence-based Report supports the drive to achieve IM leadership with particular focus on the identification, investigation and demand analysis of skills related to IM in the UK. It is in line with the DfT's Transport Infrastructure Skills Strategy[18] and the BIS Skills for Sustainable Growth Strategy[19]. Our report is based on IM-pact UK's mission, which is to drive the UK's leadership in IM by promoting sustained economic growth and wellbeing through integrated, efficient and sustainable transport systems.

14. If the skills challenge is not addressed in the short-term, the long-term effects of growing skills shortages and gaps will result in the UK losing the opportunity to lead in this vibrant, emerging market. The opportunity cost of such a scenario to the UK economy is substantial, estimated at £50 billion of lost opportunity per annum without appropriate intervention.

APPROACH

15. The Evidence-based Report[20] that underpins this document involved extensive research and consultation. It used secondary data, sourcing and references over 30 reports from the transport, infrastructure and digital tech sectors. Over 40 key stakeholders from industry, government, academia and education have been interviewed on a one-to-one basis. An IM skills industry workshop was held with over 20 additional stakeholders from industry, both SMEs and large corporates. An online survey was also conducted. Industry specific skills initiatives such as the DfT Infrastructure Report[15] and the Automotive Council Report[21] on industry skills were also examined to assess overlaps and potential synergies.

16. Three key areas of research were undertaken to assess the IM skills market which included:

i. Identifying the skills demand;

ii. Quantifying the supply and demand of skills;

iii. Developing a skills gap prediction and proposed intervention scenarios.

17. For the purpose of this report, after a review of the 'do nothing' option, which was discarded, three strategic intervention options have been developed. These options offer potential solutions to the IM skills gap challenges covering a range of interventions that the UK government could reasonably prioritise and invest in to address the skills gap.

18. We have drawn upon reliable evidence bases to identify; the size of the industry, the current impact of skills gaps and shortages to the UK economy and the response to skills gaps and shortages. Subsequently, we have estimated the opportunity cost to UK GDP if no substantive investment is made in addressing skills issues.

[18] Transport Infrastructure Skills Strategy: building sustainable skills (2016) Department for Transport

[19] Skills for Sustainable Growth Strategy Document (2010) Department for Business Innovation and Skills

[20] Evidence-based Report: A review and evaluation of skills demand, supply and interventions required to support the growth of the UK intelligent mobility market (June 2016) Transport Systems Catapult

[21] Employers' Views of the Jobs and Skills Required for the UK Automotive Industry (2016) Automotive Council
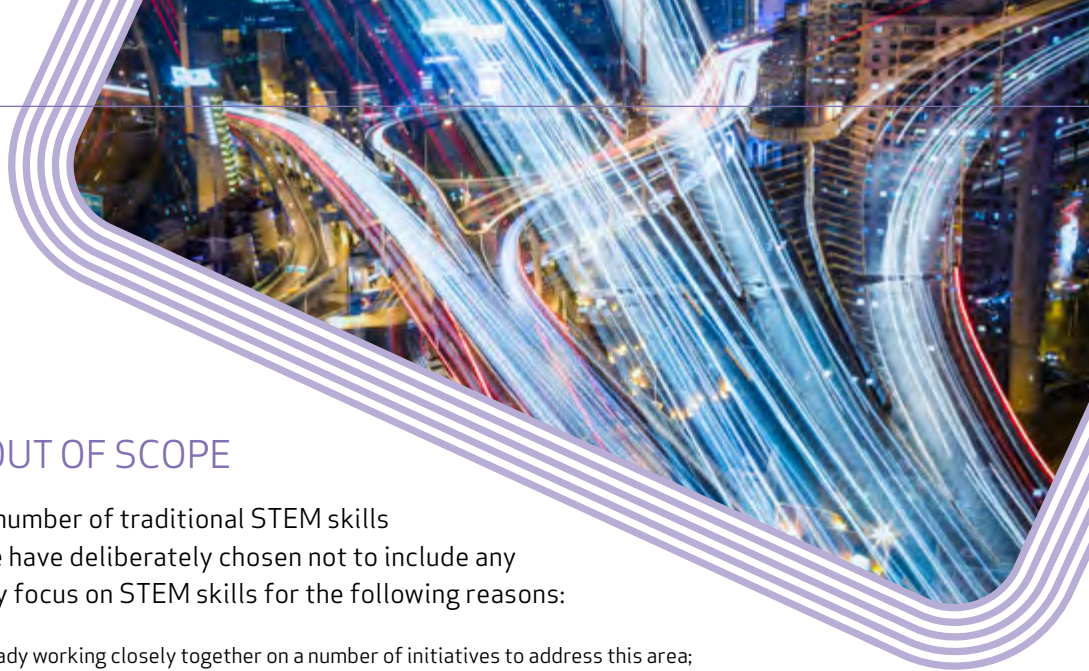
RESEARCH TOPICS OUT OF SCOPE

19. Our research identifies a number of traditional STEM skills that will be relevant to IM. We have deliberately chosen not to include any interventions that specifically focus on STEM skills for the following reasons:

• Industry and government are already working closely together on a number of initiatives to address this area;

• Some of our proposed interventions look to influence the bodies set up to monitor STEM to ensure that these disciplines are IM aware.

20. The proposed interventions focus on those skills that are specific to IM and where higher added value can be achieved across sectors.

SKILLS ISSUES

21. The research undertaken for the Evidence-based Report[22] assesses and highlights several key issues that have been identified in existing published reports for transport and some specific to the IM sector:

• An ageing workforce

• Lack of diversity

• Increased competition for certain skill sets from abroad

• Competition for skilled labour from other sectors

• Inability of skilled workers to move across the transport sectors

22. These themes support the findings from other key skills reports, reinforcing the need to develop robust plans for addressing the skills challenge in a coordinated manner across IM and the more traditional transport sectors to ensure maximum impact.

KEY AREAS OF RESEARCH

Skills demand identification

23. To understand the potential IM skills needed, a clear understanding of IM skills taxonomy is required. These skills were identified by qualitative analyses of existing data and then mapped to source industries. Additionally, a projection of the educational achievement requirements within a five and nine-year horizon to 2025 was made.

24. From the analysis conducted the matrix below was compiled, which illustrates nine skills arenas. This follows a continuum from physical and technical sciences to social and human sciences and a total of 47 skills areas showing a continuum from asset-focussed to knowledge-focussed.

Figure 4 - IM skills matrix

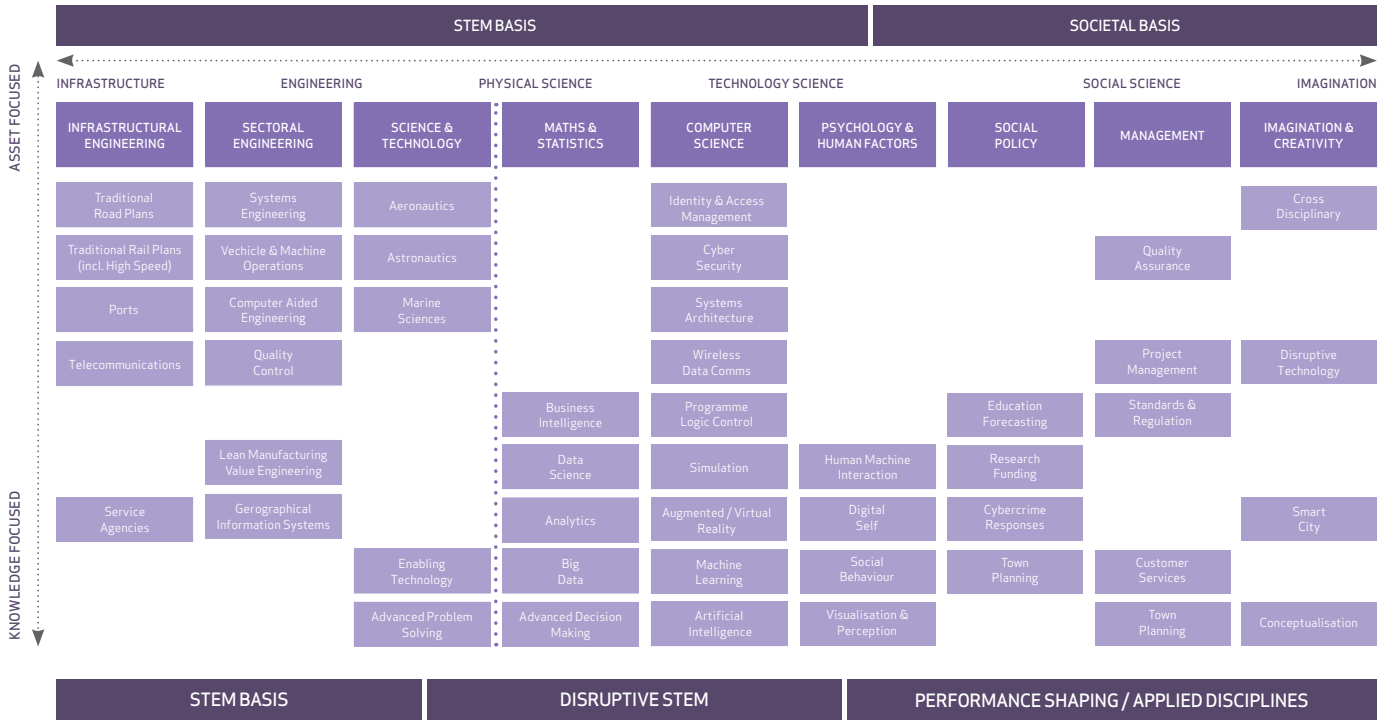| STEM BASIS						SOCIETAL BASIS		
INFRASTRUCTURE	ENGINEERING	PHYSICAL SCIENCE		TECHNOLOGY SCIENCE		SOCIAL SCIENCE		IMAGINATION
INFRASTRUCTURAL ENGINEERING	SECTORAL ENGINEERING	SCIENCE & TECHNOLOGY	MATHS & STATISTICS	COMPUTER SCIENCE	PSYCHOLOGY & HUMAN FACTORS	SOCIAL POLICY	MANAGEMENT	IMAGINATION & CREATIVITY
Traditional Road Plans	Systems Engineering	Aeronautics		Identity & Access Management				Cross Disciplinary
Traditional Rail Plans (incl. High Speed)	Vechicle & Machine Operations	Astronautics		Cyber Security			Quality Assurance	
Ports	Computer Aided Engineering	Marine Sciences		Systems Architecture				
Telecommunications	Quality Control			Wireless Data Comms			Project Management	Disruptive Technology
			Business Intelligence	Programme Logic Control		Education Forecasting	Standards & Regulation	
	Lean Manufacturing Value Engineering		Data Science	Simulation	Human Machine Interaction	Research Funding		
Service Agencies	Geographical Information Systems		Analytics	Augmented / Virtual Reality	Digital Self	Cybercrime Responses		Smart City
		Enabling Technology	Big Data	Machine Learning	Social Behaviour	Town Planning	Customer Services	
		Advanced Problem Solving	Advanced Decision Making	Artificial Intelligence	Visualisation & Perception		Town Planning	Conceptualisation

ASSET FOCUSED → KNOWLEDGE FOCUSED

STEM BASIS	DISRUPTIVE STEM	PERFORMANCE SHAPING / APPLIED DISCIPLINES

Figure 5 - Skills matrix illustrating the categorisation of the IM skills landscape

STEM BASIS						SOCIETAL BASIS		
INFRASTRUCTURE	ENGINEERING	PHYSICAL SCIENCE		TECHNOLOGY SCIENCE		SOCIAL SCIENCE		IMAGINATION
INFRASTRUCTURAL ENGINEERING	SECTORAL ENGINEERING	SCIENCE & TECHNOLOGY	MATHS & STATISTICS	COMPUTER SCIENCE	PSYCHOLOGY & HUMAN FACTORS	SOCIAL POLICY	MANAGEMENT	IMAGINATION & CREATIVITY
Traditional Road Plans	Systems Engineering	Aeronautics		Identity & Access Management				Cross Disciplinary
Traditional Rail Plans (incl. High Speed)	Vechicle & Machine Operations	Astronautics		Cyber Security			Quality Assurance	
Ports	Computer Aided Engineering	Marine Sciences		Systems Architecture				
Telecommunications	Quality Control			Wireless Data Comms			Project Management	Disruptive Technology
			Business Intelligence	Programme Logic Control		Education Forecasting	Standards & Regulation	
	Lean Manufacturing Value Engineering		Data Science	Simulation	Human Machine Interaction	Research Funding		
Service Agencies	Geographical Information Systems		Analytics	Augmented / Virtual Reality	Digital Self	Cybercrime Responses		Smart City
		Enabling Technology	Big Data	Machine Learning	Social Behaviour	Town Planning	Customer Services	
		Advanced Problem Solving	Advanced Decision Making	Artificial Intelligence	Visualisation & Perception		Town Planning	Conceptualisation

ASSET FOCUSED → KNOWLEDGE FOCUSED

STEM BASIS	DISRUPTIVE STEM	PERFORMANCE SHAPING / APPLIED DISCIPLINES

HUMAN SCIENCES

QUANTIFICATION OF SKILLS DEMAND AND SUPPLY

21. In new and emerging markets, it is challenging to forecast demand when products and services are in early development cycles and within a phase of extremely high level of technological development and change. The numbers of people working in existing sectors have been estimated, along with how many of those will need to have some IM related skills by 2025. The number of graduates and retirees coming through the system between now and 2025 is relatively well known. As with a number of other reports our assessment has shown those taking computer science courses are decreasing[23] and of those that graduate, the number actually going in to transport and transport related areas are relatively low. The IM skills gap to 2025 forecast across all arenas is below.

Table 3 - Skills gap prediction to 2025 across all sectors

SKILLS ARENA	IM SKILLS DEMAND 2025	IM SKILLS SUPPLY 2025	IM SKILLS GAP 2025
Infrastructural engineering	465,750	177,000	288,750
Sectoral engineering	165,000	28,000	137,000
Science and technology	60,000	25,000	35,000
Maths and statistics	193,200	50,000	143,200
Computer science	142,800	13,000	129,800
Psychology and human factors	15,000	14,000	1,000
Policy	25,000	25,000	0
Management	87,500	85,000	2,500
Innovation and creativity	5,000	Not known	5,000
Total	1,159,250	417,000	**742,250**

[23] NEXTGEN 2012. New figures reveal crash in Computer Science degrees. Next Gen Skills.
http://www.nextgenskills.com/new-figures-reveal-crash-in-computer-science-degrees/

3. POTENTIAL INTERVENTIONS

26. No one single intervention will address the shortfall in IM skills. We set out three strategic options for an intervention mix that can deliver benefits in the short, medium and long term, based upon the level of investment needed to 2025. The interventions address several key areas: raising awareness, influencing across a range of skills programmes, increasing scope and variety of entry points, ensuring greater cross-sectoral mobility and upskilling, embedding in national standards and centres of excellence and increasing the overall future talent pool.

27. A broad portfolio of traditional and disruptive interventions undertaken in parallel is required to address this gap. In summary, these include:

- Working with schools, parents and existing STEM facilitators to raise public awareness and ensure that IM becomes a credible and exciting career in the eyes of students, parents and schools;

- Collaborating with the Institute of Apprenticeships to ensure that all existing STEM apprenticeship frameworks include an element of IM (i.e. IM Aware);

- Developing higher degree apprenticeship frameworks with industry (i.e. IM Capable);

- Enabling the transferability of graduates from more traditional subjects and upskilling/reskilling of the existing workforce through university provision of conversion MSc courses and new IM-related MScs. The established Doctoral Training Partnerships (DTPs) and Industrial CASE Studentships will provide applied research programmes to tackle some of the real academic challenges that IM brings with it;

- Ensuring that standards and qualifications are aligned with professional body standards such that the IM discipline in all its forms will be recognised and accredited by the appropriate professional institutions;

- Establishing a new and radical approach to the education and creation of job ready 'graduates' based on the concept of École 42 successfully adopted in France.

28. These interventions need to be coordinated and driven – the IM Community Hub concept has been designed with this in mind.

THE IM COMMUNITY HUB

29. The concept of the IM Community Hub is the creation of a skills enabling environment increasing the future IM talent pool, pulling on and together existing industry, educational and government initiatives to create a 'virtual' hub. The hub will create a career pathway for future generations and the existing workforce through a strategic and co-ordinated set of interventions.

30. The IM sector has a distinct advantage over many other sectors in terms of attraction and we must seize the initiative and build upon it, ensuring that this positive mind-set relating to all things IM remains in the minds of children as they reach school leaving age and beyond.

Figure 6 - IM Community hub key elements

31. Working with schools, parents and existing STEM facilitators such as the Smallpeice Trust[24] the hub will provide a 'SEE' themed campaign to raise public awareness of IM, incorporating the Skills Enabling Environment (SEE): Stimulate, Encourage, Enable for STEM Options. IM must become a credible and exciting career in the eyes of students, parents and schools.

32. The assessment identifies a clear need for new skills and upskilling within sectors, but the digitised future will generate homogeneity and transferability of 'digital skills' in ways that will fundamentally upset traditional work patterns. IM solutions must create cross-disciplinary skills.

33. **Raising awareness and embedding IM in apprenticeships**. To address the challenge of cross disciplinary skills, the hub will collaborate with the Institute of Apprenticeships to ensure that all existing STEM apprenticeship frameworks include an element of IM creating immediately 30,000[25] IM aware students. Working with schools, FE establishments and existing national skills academies and industry centres of excellence will ensure that our new apprentices have the broad landscape of understanding and disciplines that IM necessitates.

[24] www.smallpeicetrust.org.uk
[25] Transport Infrastructure Skills Strategy: building sustainable skills (2016) Department for Transport

34. Creating higher degree apprenticeship frameworks. When jointly developed with industry and academia, higher degree apprenticeship frameworks will produce IM capable and work ready graduates across the skills arenas[26] identified with employers. This enables the choice of appropriate apprenticeship training through the Digital Apprenticeship Service, funded by the apprenticeship levy. Research[27] has shown that where a company invests in the training and future careers of their young people, those workers are far more likely to stay with them for longer and are more productive.

Engagement mechanisms for education

Engagement mechanisms for skills interventions will vary dependent on the suppliers involved to achieve the right skills coalition.

Example existing groups include:

- Universities – Universities Transport Study Group, Universities UK, other university groupings

- Industry – professional bodies and institutions

- FE Colleges – Association of Colleges

- School teacher links – relevant subject associations such as geographical associations, teaching unions, resources websites e.g. TES
  Skills interventions from other sectors have used a variety of delivery mechanisms. These involve:

- Creating new institutions (including physical buildings, recruiting staff, designing courses) e.g. HS2 Academy

- Combining existing institutions in new places and organisations e.g. Nuclear Skills Council

- Creating an institution that acts as a clearing house and networking facility

- Creating a virtual institution

As part of the analysis of these educational interventions, we have considered four categories: increasing industry-academia interactions (KTP and KE schemes, CASE PhD studentships), increasing industry exposure for students (school placements, year in industry, pre-university industry placements, undergraduate research opportunities/internships), creating new qualifications (degree apprenticeships, undergraduate and master's degrees) and raising awareness of the IM arena as a careers option (schools interventions, publicity-focused campaigns such as websites and television programmes).

35. Increased flexibility through conversion courses. To enable transferability of graduates from the more traditional subjects and generate homogeneity, universities will provide conversion MSc courses and new IM-related MScs. The established Doctoral Training Partnerships (DTPs) and Industrial CASE Studentships will provide applied research programmes to tackle some of the real academic challenges that IM brings with it.

36. Enabling mobility across sectors. An holistic approach must consider reskilling and upskilling. Ex-military personnel are highly trained and educated officers and engineers are uniquely qualified for careers in IM. Although 600 placements through this route in the traditional transport sector were made in 2015[28], there is huge potential to tap into ex-forces talent.

[26] See Figure 4

[27] Employers' Views of the Jobs and Skills Required for the UK Automotive Industry (2016) Automotive Council

[28] Career Transition Partnership Analysis (2015)

Zipabout – the challenges that an integrator SME faces. As the UK IM market continues its growth as a world class sector, it will need to attract talent from a wide range of industries, in addition to developing talent from within the traditional transportation sector. SME's like Zipabout are ideally placed to attract this talent.

Attracting capable staff from outside of the sector is a big hurdle for some of the incumbent Engineering Consultancies and Systems Integrators in the 'traditional' transportation sector, typically offering technology solutions more at home in the 1980's than in 2016! The image of the industry to 'outsiders' is one of engineers in suits, working on outdated and dreary solutions, and the attraction of more 'glamourous' industries such as online advertising or retail is irresistible to many talented engineers and developers.

Danile Chick
Technical Director, ZipAbout

As an SME working in the sector, it is essential for us to attract longer term contracts and licensing agreements that allow us to develop and grow our business sustainably over the medium to long term. By encouraging the industry to engage more meaningfully with SME's like Zipabout, rather than going with the status-quo, we believe that we can attract the talent necessary to deliver significant growth for the UK in this exciting sector.

37. **Securing a balanced gender workforce.** The huge gender imbalance that is recognised in the engineering, science and technology world[29] should be considered as an exciting opportunity for the IM market. Tech entrepreneur, Baroness Martha Lane Fox continues to promote the uptake of some 800,000 unemployed women or mothers wanting to return to the workforce[30]. In its report on Britain's Digital Future, the House of Lords Select Committee identified that increasing the number of women working in information technology (IT) alone could generate an extra £2.6 billion each year[31]. This report cited the lack of women in technology-driven industries being much wider than just the digital economy, with women representing only 6% of the engineering workforce and only 15.5% of the science, technology, engineering and mathematics (STEM) workforce.

38. **Using fast, novel approaches to develop skills.** It is time to look beyond the more traditional routes if we are going to maximise the talent pool for IM in the UK. We already have a generation of young people of school age who are teaching themselves coding and programming – without teachers. Our research has shown that the majority of skills shortages in IM to 2025 will be in the 'disruptive' skills arena. These skills in computer science related disciplines are critical to feed the IM digital tech economy. Perhaps we should consider a more radical approach.

39. It takes only six months to train a novice with some basic maths to programme in Java. This has been proven by the French entrepreneur Xavier Niel who has set up a new type of computer science school dubbed '42'.

CASE STUDY - ÉCOLE 42

Year after year, France has been losing ground in the digital domain. This decline is attributable, amongst other things, to an educational system that is no longer capable of training the talent that is required by companies in the new technologies field. However, the jobs of tomorrow will increasingly involve digital technology. This is certainly true for intelligent mobility.

In response to this dilemma, four French entrepreneurs came together to create a new type of computer science school dubbed '42'. With its unique educational approach offering access to all, requiring no formal qualifications, and being completely free of charge, École 42 is the most daring response yet to the challenge of computer science skill development, as well as a source of innovation for the future. 42 will create 1,000 job-ready 'graduates' per year.

Every year, 1,000 students are thrown into a single building in the heart of Paris, given top of the range computers and increasingly difficult programming challenges. The students are given little direction on how to solve these challenges so they have to turn to each other (and to the Internet) to figure out the solutions – the concept of 'peer to peer' learning.

École 42 might be one of the most ambitious experiments today in engineering education and one that the UK could learn from.

40. Whatever route the new generation IM capable workforce takes, it will be important to retain them within this sector to capitalise on any investment. Ensuring that standards and qualifications are aligned with professional body standards will be critical. The IM discipline in all its forms will need to recognised and accredited by the appropriate professional institutions.

41. The IM Community Hub will ensure continuity, integration and professional recognition across all the various pathways and entry levels ensuring that the UK maximises the opportunities created by the emerging £900 billion global market in intelligent mobility.

Dr Sam Chapman
Director, Chief Innovation Officer
and Co-Founder, The Floow Limited

The Floow is a one of the UK's fastest growing technology companies with worldwide operations in the IM sector. Our experience in The Floow shows how it can be relatively easy to setup methods for collecting mobility data but what makes the difference is the ability to understand the data that is captured and its interrelation with external data sources. One of the big hurdles that we face in our scale-up is finding suitably skilled staff that can apply interdisciplinary skills to the IM domain. The Floow's data science team currently has all but one individual having highly rated PhD's and the group is led by a recognised fellow of the Institute of Actuaries but we struggle in finding new staff, especially in a period of rapid expansion. Through our interactions with industry and academia, others frequently echo the need for the right mix of skills, the need for industry and academia to communicate better and to ensure that this mix of skills are being delivered to those already working or those primed to work in Intelligent Mobility. A generic set of interdisciplinary IM skills would allow building inherent sustainability into the sector.

INTERVENTION OPTIONS

42. We considered a number of options that are examined in detail. A key starting point must be the 'do nothing' approach, to establish whether government intervention is justified and whether it will add any benefit to the market.

43. Minimal intervention or 'do nothing' option. The minimal intervention or 'do nothing' scenario considers the natural market response to a lack of relevant training and skills development in the IM market. Rather than simply allowing a skills gap to develop unchecked, it assumes that innovators and entrepreneurs in the IM market will 'make the skills happen' to enable their businesses to achieve commercial objectives. Similarly, enterprising training/education providers will see opportunities in niche sectors and will respond to clearly identified market needs. As a result, there will naturally be a number of training and educational courses which meet some of the identified IM skills and the predicted skills gap will therefore, inevitably not be as large as the top-level analysis (1.159 m) might suggest.

Ash Ahmad
Chief Commercial Officer,
WhiteHat

WhiteHat was founded to embrace the challenge in providing businesses with a digital solution to attract the best non-graduate talent between the ages of 16 and 23. We receive applications from over 1,500 young people a week looking to start apprenticeships; these young people come from a diverse range of backgrounds and the majority have strong academic records.

With the apprenticeship levy's introduction in April 2017, there is an opportunity to bring a new generation of bright, ambitious young people a viable alternative to the purely academic route provided by university. This is a hugely valuable proposition for employers who feel that university isn't equipping many young people with the skills they need to succeed.

WhiteHat uses a combination of gamification technology, personality assessments, and video profiling to ensure candidates are matched with opportunities from a specific organisation or role that they have a natural predisposition to excel in. We also use our database to scan for candidates with specific skills, prior qualifications, or who come from certain parts of the country to meet a very strict set of criteria.

WhiteHat advocates for diversity and inclusion and focuses on the importance of these elements to ensure a dynamic and multi-skilled workforce. Our research shows that organisations will invest in young people if they are given the tools to help ensure this investment will pay off and that there is a nearly universal desire to attract people from a wider range of backgrounds.

We are ensuring that businesses have a viable plan to attract diverse young talent without compromising on quality and without it becoming a purely CSR-led proposition.

44. Learning lessons from history. In new areas of traditional industry, such as offsite construction, a lack of incentive has left the development of skills unchecked by lower level government. In this way, the IM market has many parallels. In the construction industry, market growth has been dependent on construction companies adopting innovative enabling technologies. In addition, it has depended on the willingness of financial enablers like funders and insurers to take a risk with untested, less well-known activity. Typically for emerging sectors, the market is driven by unconnected initiatives and made up of small, agile companies with hubs of activity and expertise dotted around the UK. As a result, associated skills tend to be developed by individual sectors on a piecemeal, bespoke and in-house basis. Skills shortages are cited as being the main barrier to the uptake of the technology. As far back as 2006, the Barker 33 cross-industry group commented, "the issue is not about the product… it's about skills, logistics, planning & project management, training, labour, education."[32]

45. Another example is web-based services between 1990 and 2000. Skills for these industries were driven by the private sector, namely early adopter companies who identified opportunity and the early majority who wanted market share. When government did not intervene, a digital strategy and service efficiency was established, leaving the market mature and with enough large companies to offer outsourced skills.

46. Then industry itself developed a new sector, and experts turned to emerging countries such as India where there was a highly qualified labour market available at rates much less than the UK equivalent. The skills that remained in the UK were largely self-taught, fragmented and highly specific because they were devised to solve immediate problems. As a result, much of the core services and skills continue to be imported and detrimental to UK employment.

47. Do nothing approach and IM skills. The current and impending lack of skilled engineers is now widely recognised. However, there are also skills shortages in other IM-associated fields, in particular digital skills and technology. This is likely to have a compound effect on the development of people into and for the IM markets. The recently published report on digital skills mentions a policy ambition for improving the provision of skills[33]. Despite formal education being available, matching skills with the rapidly changing needs in the sector is a major challenge.

48. Within the transport industry, Atkins reported that the workforce in the UK rail sector alone is growing at 4% per annum but there is a prevalent issue of an ageing population: 49% are over the age of 45.

49. As well as the threat of skilled workers moving to well-funded projects in Asia and the Middle East, there is a risk that both the transport and non-transport sectors will compete for similar talent. This puts additional pressure on the availability of appropriate skills with labour costs reported to be rising by 6-8% per annum.

50. In the private sector, entrepreneurs will identify opportunities and build their own talent pool. The UK has a history of developing ideas and new technologies, however the risk-averse nature of financiers means that the intellectual property and ideas generated will often be developed into profitable products and services outside of the UK. Without a skills base to adopt new technologies, this history is more likely to be repeated.

32 The Barker 33 Group (7 March 2006)

33 Tech Nation Transforming UK Industries (March 2016) Tech City

34 The cost of not addressing skills issues in the rail sector (October 2015) Atkins

ESTIMATING THE MINIMAL INTERVENTION SCENARIO

51. The UK Commission for Education and Skills (UKCES) found the following concerns with new construction methods applied in this traditional industry, specifically with the then-provision of education, training and qualifications[35] :

• Fragmented provision;

• Training largely conducted in discipline silos;

• Disconnect between industry and academia;

• Bespoke nature of the industry creates challenges to the provision of qualifications and training;

• Limited understanding of the technologies involved, together with employer resistance to change;

• Apprenticeship provision focussed on traditional technologies.

52. These barriers were preventing the UK industry from taking advantage of a reported 70% growth in the market worth £90 billion worldwide by 2025. 12% of this was related to the new technologies. The UKCES report outlines the need for multi-skilled, knowledgeable personnel who can respond to a variety of situations. The IM market requires the same skill sets if the UK is to be an effective competitor, in particular because of the predicted fast growth in the global development of technologies and applications.

53. Another parallel between the IM market and the strongly growing digital and creative sector is clear. In June 2015, UKCES reported a shortage of people with the right combination of skills in an environment of rapid technological change. It predicted the sector needs 2.1 million extra people to support growth and replacement, and outlines the effect of skills gaps: "18 per cent of digital and creative firms reported that skills gaps have a major impact on performance, compared to 16 per cent in the economy as a whole". It reports that about 67% of UK organisations will provide training, compared with slightly fewer from this sector. Despite this, 40% of digital and creative firms have lost business from a skills gap, especially in the more technical functions like programming and web development. While they report being unable to fill posts, it is unclear if the business has been awarded to other UK providers or the service is imported.

54. Conclusions on the minimal intervention scenario. The minimal intervention approach means that the market will address a very limited element of the skills gap. These interventions will be highly specific to the company/industry involved, sporadic, non-strategic and uncoordinated. Without a clear focus on joined-up, transferrable skills for IM, the benefits of this new opportunity to UK plc will be severely limited and the objective of producing a workforce of skilled, able people who can apply themselves across the range of IM solutions will not be achieved.

HIGH LEVEL PROPOSALS ON OPTIONS

55. In order to address the skills gap, three strategic options blend the traditional and disruptive interventions. These provide a range of returns based upon a level of investment over and above the 'minimal intervention' scenario, where the market would naturally supply 417,000 individuals over the next nine years to 2025:

Table 4 - Summary of options

OPTION	SKILLS CAPABILITY GROWTH	INVESTMENT AND POTENTIAL BENEFITS
Option 1 – Low level investment	57,000	Produces 57,000 skilled individuals over a nine-year period to 2025. This represents a total intervention cost circa £43 million per annum and providing an additional annual average benefit to UK GDP of £362 million with an ROI of 6.7.
Option 2 – Medium level investment	100,000	Medium level investment high impacts, high return option where all investment is front-loaded within the next 5 years delivering an additional 100,000 individuals by 2021. This represents a total intervention cost circa £71 million per annum and providing an additional annual average benefit to UK GDP of £1.5 billion with an ROI of 17.1.
Option 3 – High level investment	160,000	High level investment option that would deliver an additional 160,000 individuals over a nine-year period to 2025. This represents a total intervention cost circa £167 million per annum and providing an additional annual average benefit to UK GDP of £1.4 billion with an ROI of 6.0.

56. A detailed analysis of the three intervention options is provided in section 6.

4. STRATEGIC CASE
BACKGROUND

57. Intelligent mobility is the future of transport. It is about harnessing innovation and emerging technologies to create more integrated, efficient and sustainable transport systems. It marks an exciting meeting point between traditional transport and the new products and services that are emerging as we start to exploit vast amounts of multi-layered data. As such it offers a remarkable opportunity to make much more efficient use of networks and to revolutionise transport, all driven by the needs of the end user.

58. As McKinsey have highlighted[36], the emergence of more and more megacities and new regional pockets of growth will change the places where growth takes place in the economy. Shared transportation and disruptive technology-related solutions will generate new competition, but also new markets. Companies will face the challenges of understanding how the digital revolution will affect their business and of mastering their own digital transformation. Rapidly changing regulatory and geopolitical environments will call for smart approaches to managing external relations in complex stakeholder landscapes. Finally, an increase in the volatility of demand and input factors will require strategic agility and flexibility. This IM economy will require fresh, intelligent skills to ensure that the UK economy is in a position to benefit from new IM markets.

59. The Transport Infrastructure Skills Strategy (2016)[37] outlined the skills context for the future development of careers in transport to 2020. By building on the conclusions of that report, this strategy outlines the importance of IM skills in the context of that skills development strategy. By highlighting the need for more than 55,000 skilled individuals in transport by 2020, the Infrastructure Skills Strategy outlines how through a proactive approach to changing perceptions, broadening the diversity of the workforce and upskilling existing workers to face the new technological challenges is needed.

60. The strategy also identified a clear need for the transport sector as a whole to work collaboratively to ensure that skilled staff are agile in their skills and thus able to move from project to project and, indeed, into and out of allied sectors, such as energy. Data is having a huge impact across the transport sector and the workforce will need to have the capability to manipulate, analyse and model large amounts of data in real time. This is not a historic focus of traditional transport engineering career paths.

61. The ability of the UK economy to secure maximum benefit from the emerging technologies that underpin capabilities in IM are limited by the failure of skills – particularly at an advanced level (level 4 and higher) – to keep pace with the science, engineering and socio-technical innovations that are driving productivity in this area. This lack of skills development has many causes including: failings of traditional educational routes to address multi-disciplinary and fast-evolving skills needs; uncertainty from industry over precise skills needs over the next decade; uncertainty from potential students/future employees in IM due to lack of knowledge about potential careers in this area.

62. These issues prevent an effective response in meeting long-term needs in this emerging sector. The potential for substantial economic growth for the UK economy over the next nine years will be driven by a vast emerging sector of the economy.

62. There is now an opportunity to take decisions that shape the UK's future economy for everyone's long-term benefit. This is because the UK has the first mover advantage in exploiting the commercial potential of IM technologies, processes and associated services. Given the nature of this fast moving sector, it is highly unlikely that this opportunity will exist in five years' time and will instead have been captured by others. The opportunity that exists requires new, more agile thinking and, thus the highly agile skills and capabilities of a workforce in IM for the long-term strategic significance to the UK economy.

[36] Creating Value in Transportation and logistics [online] MGI (2015) http://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/creating-value-in-transportation-and-logistics

[37] Transport Infrastructure Skills Strategy: building sustainable skills (2016) Department for Transport

5. SUMMARY OF IM MARKET ANALYSIS

64. In 2013, the World Bank estimated the size of the global transport market to be between £2.6 and £5.2 trillion. While this massive figure is expected to grow in real terms, the overall proportion of investment in transport is not expected to rise significantly. Faced with huge global challenges, such as ageing populations, increasing urbanisation and dwindling resources, it is clear that the transport industry needs to find ways of working more efficiently. It also needs to work in conjunction with sectors far removed from traditional transport areas. IM provides an intersection between traditional transport and exciting new products and services relating to mobile devices, open data, wireless communication or the Internet of Things. In early 2014, Transport Systems Catapult (TSC) commissioned research that estimated the IM market will grow to just over £900 billion a year by 2025[38]. This work has been refreshed (see IM Market Update 2016)[39] for this report and found to be broadly consistent with the former prediction for the size of the market.

65. The IM market sizing and segmentation relies on the availability, analysis and interpretation of the existing reports, which cover different aspects of markets relevant to IM. Where possible, market information relevant to transport was extracted from these reports alongside any geographic segmentation. However, the reported values are global and do not provide further insights into, for example, the size of the UK market. The summary of the IM market segmentation, size and growth is provided below (source: Technology Strategy 2016 for Intelligent Mobility (2016), Transport Systems Catapult).

Figure 7 – Global intelligent mobility market by segment in 2025

[38] Technology Strategy 2016 for Intelligent Mobility (2016) Transport Systems Catapult
[39] Market Breakdown (2016) Transport Systems Catapult
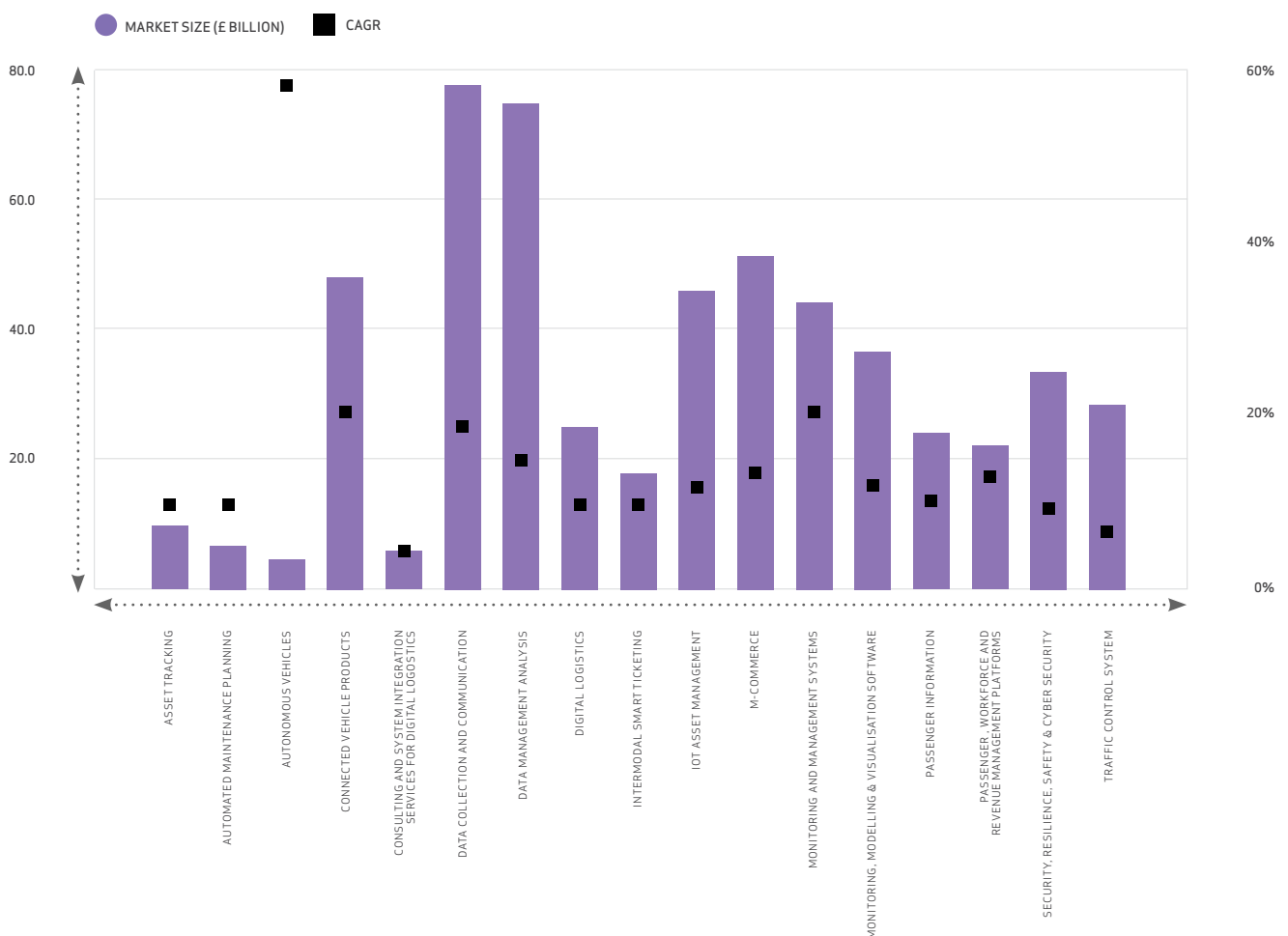
66. The Compound Annual Growth Rate (CAGR) is estimated to be between 5% and 25% over the coming decade for most of the market segments, apart from the autonomous vehicles one which is associated with a CAGR of 58%. This is due to the fact that currently market research forecasts an onset of autonomy in 2025, leading to a small but rapidly growing market at this point.

67. We believe that the current IM market size forecast for 2025 represents a conservative estimate. While the IM market may be larger than £900 billion in 2025, this is not due to new spend. Instead, it is due to a redistribution of spend from traditional transport (e.g. volume car manufacturing, insurance and health) to mobility as a service (e.g. shared ownership, software intensive applications where travellers buy mobility services and move away from direct ownership models). It is also worth noting that market analysts from global research and advisory companies do not currently track the IM market.

68. Intelligent mobility has the potential to become a key driver of the UK economy. It contributed £3 billion in 2016 and, based on initial analysis, we estimate that it could deliver £90 billion directly to the UK economy by 2025[40].

69. By investing in the core skills identified now, the UK can gain global leadership in research and development and innovation (R&D&I) through developing, creating and exploiting the new disruptive IM technologies and services enabling it to take advantage of this fast growing worldwide market.

MARKET LIMITATIONS

70. Historically within the UK transport industry, the various modes of transport (i.e. road, rail, maritime and aviation) have all evolved independently. To date, the focus has been on developing a workforce with traditional STEM skills. Our detailed assessment has shown that there is a clear need for new skills and upskilling within sectors and the digitised future will generate homogeneity and transferability of "digital skills" in ways that will fundamentally upset traditional work patterns. IM solutions must create cross-disciplinary skills.

GOVERNMENT INTERVENTION

71. The government has prioritised science and innovation funding for increased UK productivity and understands that to stay ahead in this global race it requires future planning. Where there is a significant danger that the market is unlikely to produce the desired outcome, intervention from government is also necessary. The government has set out the need for the UK to be able to capitalise on its cutting edge science base and innovative companies if further prosperity and societal wellbeing are to be realised.

72. The case for investment in skills development and the scale of the investment provided should depend on:

• The extent to which market failures are present in IM;

• The extent to which funding could alleviate these failures;

• The size of the societal and economic benefit from skills-driven innovation in IM and the potential market growth of these technologies.

73. By investing appropriately in the delivery of higher-level skills to create the workforce of the future for IM, a smarter workforce will drive smarter transport for the benefit of the UK economy. It can be part of the plan to make an economy that works by ensuring prosperity and skills are spread throughout the country.

74. We will enable delivery of appropriate skills on an accelerated timeframe to create:

- A critical mass of expertise in IM technologies, implementation and services for the UK; accelerating current networks and strengths to transform existing innovation into a world-leading sector of the economy;

- The ability to accelerate the development of practical solutions to challenges at scale that are still in their infancy, enabling the UK to take a global lead through the creation of new services and transformative products;

- Skills development that delivers the very best research and development, and innovation for UK companies.

75. The UK government has demonstrated its clear commitment to IM with announcements in two budget statements:

Firstly, the 2015 Spring Budget Statement announced a £200 million five-year Intelligent Mobility Programme (£100 million from government and £100 million in matched funding from industry). This focuses on enhancing the development of driverless car technology.

Secondly, the 2016 Autumn Budget Statement announced that the UK was to be established as a global centre for excellence in connected and autonomous vehicles.

RATIONALE FOR FUNDING

76. Currently more than 550,000 people are employed in the road and rail sectors, focused primarily on infrastructure, construction, maintenance and operational roles[41]. Maritime employs another 113,000 and aviation 120,000 (excluding manufacturing). All four sectors are expected to see substantial growth over the next five to 10 years and have identified similar skills needs that need addressing including: an ageing workforce; a lack of diversity; trained personnel being attracted to other sectors and/or countries to work; and lack of interest from young people considering career options. For example, High Speed Rail alone faces a shortage of nearly 30,000 skilled individuals to deliver the needs of activity with the biggest shortages in engineering and skilled trade and labour.

77. As the future of the transport industry, intelligent mobility has the potential to drive this growth and skills as a new, exciting and well paid career to design, deliver, operate and maintain the complex transport systems of the future.

78. The government has made a commitment to three million apprenticeship starts by 2020. Long-term investment in skills is a core component of productivity growth, with apprenticeships delivery a high return on investment, particularly at the higher levels.

79. Intelligent mobility could generate an estimated £90 billion worth of value to the UK through the proposed strategic and coordinated interventions. Investing in the skills base takes advantage of a real and current opportunity with the potential to create a lasting legacy for the UK economy.

SKILLS DEVELOPMENT IN THE INTELLIGENT MOBILITY LANDSCAPE

80. There are clear gaps in the provision and development of skills for IM needed to drive the UK economy into a position where it is able to lead the world in the implementation and delivery of key technologies and services to drive UK productivity and economic growth.

81. Investment for skills development should recognise that:

- IM is a multi-disciplined and innovative field, and therefore the effective teaching of future specialists requires a change from the current generally-narrow and disciplined-focus approach given to people today;

- This requires university, college and apprentice courses to be diverse, recognising and bringing in experts/teachers who come from a range of specialist backgrounds, while encouraging problem-based, contextualised learning, and team collaborations;

- The emergence of shared transportation and mobility as a service is fuelling a rapid development of technology-driven solutions for meeting this need, and the incorporation of information technology teaching, as well as design and human-centric disciplines, into IM skills development is fundamental;

- The suggestion that immigration could provide a solution for meeting the potential skills shortfall is challenging, based on potential changing immigration policies in the post-Brexit era. If anything, development of the IM markets is likely to lead to stiffer international competition, particularly from Asia and major US technology corporations.

82. The development of the UK IM sector requires a paradigm shift in how industry skills are taught and developed in the future. Investment in a coordinated strategy, (with opportunities) to encourage, promote and provide multi-disciplined skills training is required if the sector is to develop in the future. The McKinsey Global Institute[42] suggests that the transportation sector in general needs to make bolder, more astute strategic choices than ever before and this applies even more so to the IM markets.

83. All companies in the sector therefore face the challenges of understanding how the digital revolution will affect their businesses. They also have to face mastering their own digital transformation, as well as adapting to increasingly shared, customer-centric approaches to mobility. The UK government therefore needs to be similarly fleet-of-foot if it is to support the developing UK IM industries in meeting these challenges. Government needs to support the development of an increased number of higher education training channels, and provide support for significantly more apprenticeships. This is to enable the potential offered by projected IM market trends to be exploited and ensure that the future IM skills requirements necessary to attain the target market share in 2025 will be met.

[42] Creating Value in Transportation and logistics [online] MGI (2015) http://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/creating-value-in-transportation-and-logistics

5. ECONOMIC CASE
ASSUMPTIONS ABOUT THE SIZE OF THE GLOBAL IM MARKET AND THE UK'S SHARE

84. The economic case for a coordinated central government investment to expand the community of resources with IM-related skills is underpinned by the forecast growth in the global IM market. Table 5 sets out the assumptions used in the economic case about the size of the global IM market and the UK's share. All costs and benefits are presented in UK Pounds Sterling at nominal 2016 prices.

Table 5 - Assumptions about global IM market size and the UK share

THEME	ASSUMPTION	VALUE	SOURCE
1. Global IM Market 2025	Forecast size of the global market for IM products and services, annually by 2025.	£900bn	IM Skills Strategy
2. Global IM Market 2016	Size of the global market for IM products and services, annually in 2016.	£300bn	IM Skills Strategy
3. UK IM Market Share 2016	UK share of the global market for IM products and services, annually in 2016.	1% (£3bn)	IM Skills Strategy
4. UK IM Market Share 2025 (Do nothing scenario)	UK share of the global market for IM products and services, annually by 2025, with no coordinated investment to expand the community of IM skilled resources.	1% (£9bn)	Extrapolated
5. UK IM Market Share 2025 (Ambition)	UK ambition to establish a greater share of the global market for IM products and services, annually by 2025 enabled by the investment in IM skilled resources.	10% (£90bn)	IM Skills Strategy
6. UK IM Skills Strategy Opportunity	UK IM market share ambition (£90bn), less the UK IM market share in the do nothing scenario (£9bn).	£81bn	Extrapolated

85. The IM Skills Strategy estimates that there is an opportunity to generate an additional circa £81 billion per annum in UK GDP through the provision of IM products and services to the global market by 2025 (assumption 6). It is assumed that the opportunity is created by circa 13% average annual growth in the global IM market from circa £300 billion in 2016 (assumption 2) to circa £900 billion in 2025 (assumption 1). The UK's share of the current global market is assumed to be circa 1%, generating an estimated circa £3 billion per year in GDP. With no additional investment to expand the community of IM skilled resources, the UK's current share is assumed to grow in line with the market – remaining at circa 1% or £9 billion by 2025 (assumption 4). The ambition set out in the IM Skills Strategy is for a coordinated central government investment to expand the community of IM skilled resources. It is assumed that fulfilling the ambition will increase the UK's share of the global IM market to circa 10% or £90 billion (assumption 5). Therefore, the opportunity to generate additional GDP enabled by an investment in IM skilled resources is estimated at circa £81 billion (assumption 6).

ASSUMPTIONS ABOUT IM SKILLED RESOURCE SUPPLY AND DEMAND

86. Table 6 sets out the assumptions used in the economic case about the estimated numbers of additional IM skilled resources that are required to increase the UK's market share to 10% by 2025.

Table 6 - IM skills supply and demand assumption

THEME	ASSUMPTION	VALUE	SOURCE
7. IM skills demand	Forecast demand for additional IM skilled resources required to grow the UK's global market share to 10% by 2025.	c.1.159m people	IM Skills Evidence-based Report [43]
8. Existing IM skills supply	Forecast supply of additional IM skilled resources in 2025 generated by existing and planned initiatives.	c.417k people	IIM Skills Evidence-based Report
9. Net IM skills gap (total)	Size of the net gap in the supply of IM skilled resources by 2025 (1.159m – 417k).	c.742k people	Extrapolated
10. Net IM skills gap (in key arenas)	Size of the IM skills gap in key arenas, e.g. computer science, and human factors (specifically excluding infrastructure and sectoral engineering).	c.281k	IM Skills Evidence-based Report
5. UK IM Market Share 2025 (Ambition)	UK ambition to establish a greater share of the global market for IM products and services, annually by 2025 enabled by the investment in IM skilled resources.	10% (£90bn)	IM Skills Strategy
11 Net IM skills gap (in scope)	Size of the IM skills gap in key arenas that the interventions described in the IM Skills Evidence-based Report aim to address.	c.140k	IM Skills Evidence-based Report

87. The interventions outlined in this report are expected to increase the community of resources with IM specific skills in key arenas like computer science, maths and statistics, human factors, policy, management and innovation by 140,000 in 2025 (assumption 11). The increase is assumed to address circa 50% of the net IM skills supply gap for the key arenas (assumption 10). The majority of the total 1.159 million additional demand for IM skilled resources by 2025 (assumption 7) is concentrated on infrastructure, sectoral engineering and science and technology. Interventions already planned by the transport sector are expected to meet approximately 36% of the additional demand by providing 417,000 new IM skilled resources by 2025 (assumption 8).

ASSUMPTIONS ABOUT THE COSTS AND BENEFITS OF CLOSING THE IM SKILLS SUPPLY GAP

88. Table 7 sets out the assumptions used in the economic case about the costs and benefits of expanding the community of IM skilled resources in key arenas.

Table 7 - Assumptions about costs and benefits to close the IM skills supply gap

THEME	ASSUMPTION	VALUE	SOURCE
12. Per capita benefit of an IM skilled resource	The average annual GDP contribution per IM skilled resource enabling the achievement of a 10% market share (£81bn / 1.15m people).	c.£70k per capita (excluding capital, technology and IP)	Extrapolated
13. Per capita opportunity cost	The average annual cost in lost GDP associated with drawing IM skilled resources away from other sectors.	c.£50k per capita	UK GDP per capita employed (World Bank)[44]
14. Migration	Percentage of additional IM skilled resources that would otherwise leave the UK if they did not join the IM sector.	c.20% or 27,000 people	IM Skills Evidence-based Report[45]
15. Cost per resource	Average cost per resource of IM Skills Strategy interventions to expand the community of IM skilled resources.	c.£10,465	IM Skills Evidence-based Report
16. Intervention programme overheads	Total cost overhead of a 9-year programme of interventions to expand the community of IM skilled resources.	c.£40m	IM Skills Evidence-based Report

89. It is assumed that circa 1.159 million IM skilled resources are required to support an increase in the UK's share of the global IM market to 10% in 2025, generating an additional £81 billion per annum in GDP. IM skilled resources must be combined with other inputs (capital, technology, intellectual property etc.) in order to realise the benefits of a greater market share. It is assumed that other inputs are in place and IM skilled resources are the key enablers to realise the benefits. The annual average per capita benefit of circa £70,000 generated by each additional IM skilled resource (assumption 12) is calculated by dividing the 1.159 million total demand for resources by the £81 billion opportunity they are intended to realise.

90. It is assumed that the per capita benefits are offset by an average circa £50,000 per annum opportunity cost associated with drawing the resources away from other sectors of the UK economy (assumption 13). It is assumed that circa 20% of the additional IM skilled resources would otherwise migrate away from the UK if they were not drawn into the IM sector by the Skills Strategy interventions and therefore imposes no opportunity cost on other sectors (assumption 14).

ASSUMPTIONS ABOUT THE TREATMENT OF COSTS AND BENEFITS OVER TIME

91. Table 8 sets out the assumptions used in the economic case about the treatment of costs and benefits over time.

Table 8 - Assumptions about the treatment of costs and benefits over time

THEME	ASSUMPTION	VALUE	SOURCE
17. Interventions timeline	Timeline over which interventions are delivered to generate the required additional IM skilled resources.	9 years (2017 - 2025)	IM Skills Evidence-based Report
18. Time value of money	Discount rate applied to all future costs and benefits to reflect the time value of money.	-3.5% p.a.	Treasury Green Book
19. Cost, risk and uncertainty	Rate applied to all future costs to reflect the risk and uncertainty of the associated forecasts.	+4% p.a.	IM Skills Evidence-based Report
20 Supply risk and uncertainty	Discount rate applied to all future benefits to reflect the risk and uncertainty regarding the supply of resources into the IM sector.	-4% p.a.	IM Skills Evidence-based Report
Demand risk and uncertainty	Discount rate applied to all future benefits to reflect the risk and uncertainty of the demand for resources in the IM sector.	-4% p.a.	IM Skills Evidence-based Report

92. It is assumed that the 3.5% per annum discount rate applied to all future costs to reflect the time value of money (assumption 18) is offset by a 4% per annum increase in costs to reflect risk and uncertainty associated with the forecasts. The 4% per annum discount rate applied to all future benefits to reflect the time value of money (assumption 18) is combined with additional 4% per annum discount rate that reflects the risks around the supply of resources to IM skills interventions and a 4% per annum discount rate that reflects the risks around the demand for IM skilled resources across specific sectors of the IM market.

93. The average cost per resource, blended across all the interventions focused on expanding the community of IM skilled resources, is estimated at circa £10,465 (assumption 15). It is assumed that these costs accrue over a nine-year period from 2017 to 2025. The annual output of additional IM skilled resources to reach a circa 140,000 target is attributed equally over the nine-year period at 15,000 resources per annum. Therefore, the average annual cost of the interventions to expand the community of IM skilled resources is estimated at circa £174 million (£11,600 x 15,000 people per annum). The overheads associated with delivering a nine-year programme of interventions is estimated at circa £40 million increasing the average annual cost estimate to circa £178 million and generating a total economic cost estimate of £1.6 billion.

94. The additional IM skilled resources generated by the interventions are assumed to generate economic benefits in terms of UK GDP for an average of 10 years, at a rate of circa £70,000 per annum less an opportunity cost to other sectors of £50,000 per annum. The first groups of additional IM skilled resources are assumed to start generating benefits from 2017 onwards. An average of circa 15,000 additional IM skilled resources is assumed to enter the market place year on year from 2017 to 2025. The final group of additional resources entering the market in 2025 are assumed to generate benefits out to 2035. Extrapolating the future streams of benefit (net of opportunity cost) from the additional IM skilled resources entering the market each year from 2017 to 2025 and discounting for risk and the time value of money, generates a total estimated economic benefit of £26.9 billion by 2035. The extrapolated economic benefits generated by 2025 are estimated at £10.2 billion. Annual average economic benefits from 2017 to 2035 are estimated at £1.4 billion per annum.

95. The overall return on investment (total benefits − total costs / total costs) in 2035 is estimated at 17 (i.e. a total of £17.0 is generated for every £1 invested in IM skills). The return on investment at 2025 is estimated at 6 (i.e. every £1 invested in IM skills is expected to generate £6 by 2025).

OPTIONS ANALYSIS

96. There are four primary routes for skills interventions for IM:

- Creating brand new skills from those with very low levels of existing skills;

- Converting existing skills and expertise to the IM sector;

- Adding to skills of those already working in the IM sector (workforce development);

- Transferring skills required into the IM sector by those working in other areas.

97. The different elevation levels of skills will have different time scales for the time to impact the IM sector. For example, a higher apprenticeship takes between one and four years to complete, from application stage to the first graduate from a Centre for Doctoral Training will be five years, conversation master's can take one to two years.

96. As part of the options analysis, we have highlighted the importance of interventions across all of these four categories in order to ensure both early impacts in delivering key skills to the immediate demands of the IM market and longer-term delivery of the skills needed to meet the needs of industry in the future. This matrix approach of interventions is core to the overall success of our proposed programme.

99. Within each of these categories, we have analysed from a long list of interventions those with the greatest potential impact. However, making any one of those interventions without the others will have very limited impact on the capability of the IM market to grow taking advantage of these skills interventions.

On that basis, we have focused on a range of scalable options across these four categories with levels of interventions at a low, medium and high level. These interventions are the same with similar skills pathway, shown in a scaled model to be created depending on the levels of investment available from private and public sources.

This approach has been tested and endorsed through continuous engagement with key stakeholders.

OPTION 1 – LOW LEVEL INVESTMENT

100. Low level investment option focusing on delivering an additional 57,000 individuals over a nine-year period to 2025. This has a total intervention cost circa £43 million per annum and providing an additional annual average benefit to UK GDP of £362 million with an ROI of 6.7.

Figure 8 - Low level investment option

Frontloaded costs: 57k people / 9 years		Frontloaded benefits: 57k people / 9 years	
Total costs (2017-2025)	c.£386m	7.4bn	Total net benefits (2017-2035)
Traditional intervention costs (2017-2025)	c.£266m	c.£17.1bn	Gross benefit of interventions (2017-2035)
Ecole 42 costs (2018-2022)	c.£100m	c.£9.8bn	Opportunity cost of resources (2017-2035)
Programme overheads (2017-2021)	c.£20m	c.£388m	Annual average benefits (2017-2035)
Average cost per year	c.£43m	18.1 (6.7)	2035 Return on investment (2025 ROI)

c£31.8bn
(baseline)

c£7.4bn

c£786m

2017   2021   2025   2035
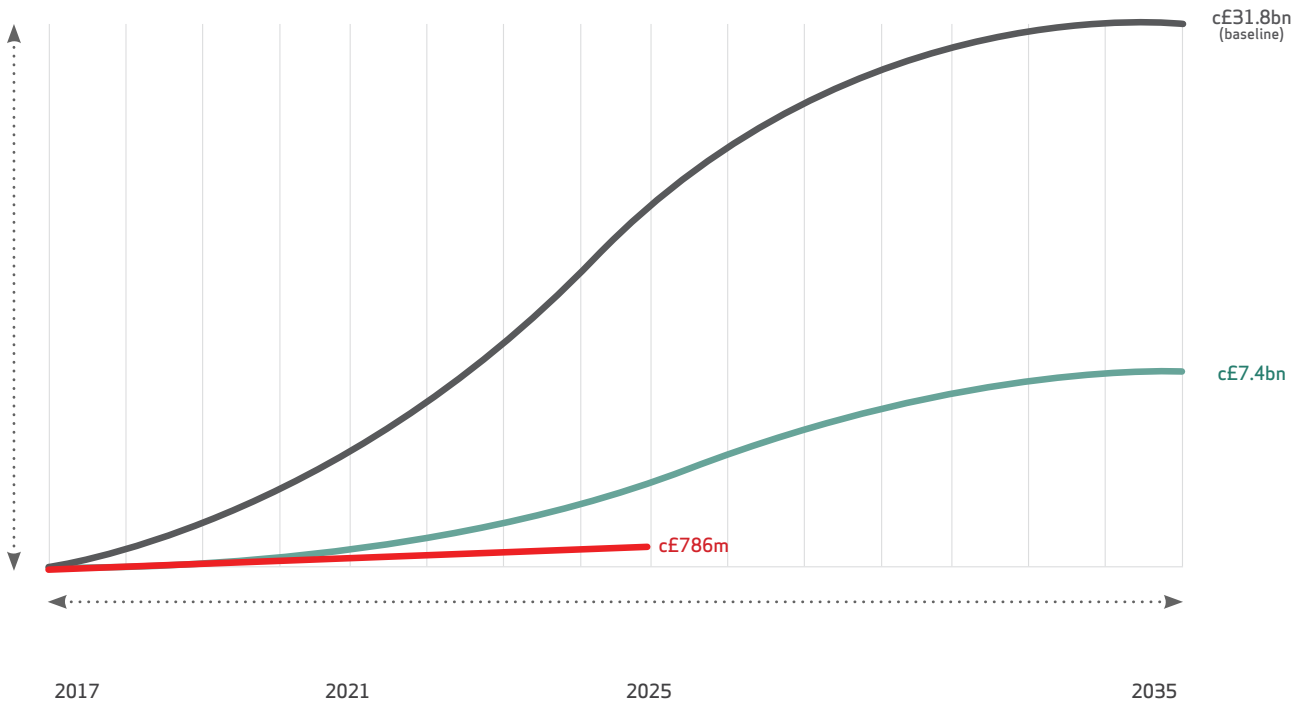
OPTION 2 - MEDIUM LEVEL INVESTMENT W

101. Medium level investment high impact, high return option where all investment is front-loaded within the next five years delivering an additional 100,000 individuals by 2021. This has a total intervention cost circa £71 million per annum and providing an additional annual average benefit to UK GDP of £1.5 billion with an ROI of 17.1.

Figure 9 - Medium level investment option

| **Frontloaded costs: 100k people / 5 years**				**Frontloaded benefits: 100k people / 5 years**
Total costs (2017-2021)	c.£640m		7.4bn	Total net benefits (2017-2031)
Traditional intervention costs (2017-2021)	c.£500m		c.£41.0bn	Gross benefit of interventions (2017-2031)
Ecole 42 costs (2018-2021)	c.£100m		c.£23.4bn	Opportunity cost of resources (2017-2031)
Programme overheads (2017-2021)	c.£40m		c.£1.6bn	Annual average benefits (2017-2031)
Average cost per year	c.£128m		26.5 (17.1)	2035 Return on investment (2025 ROI)
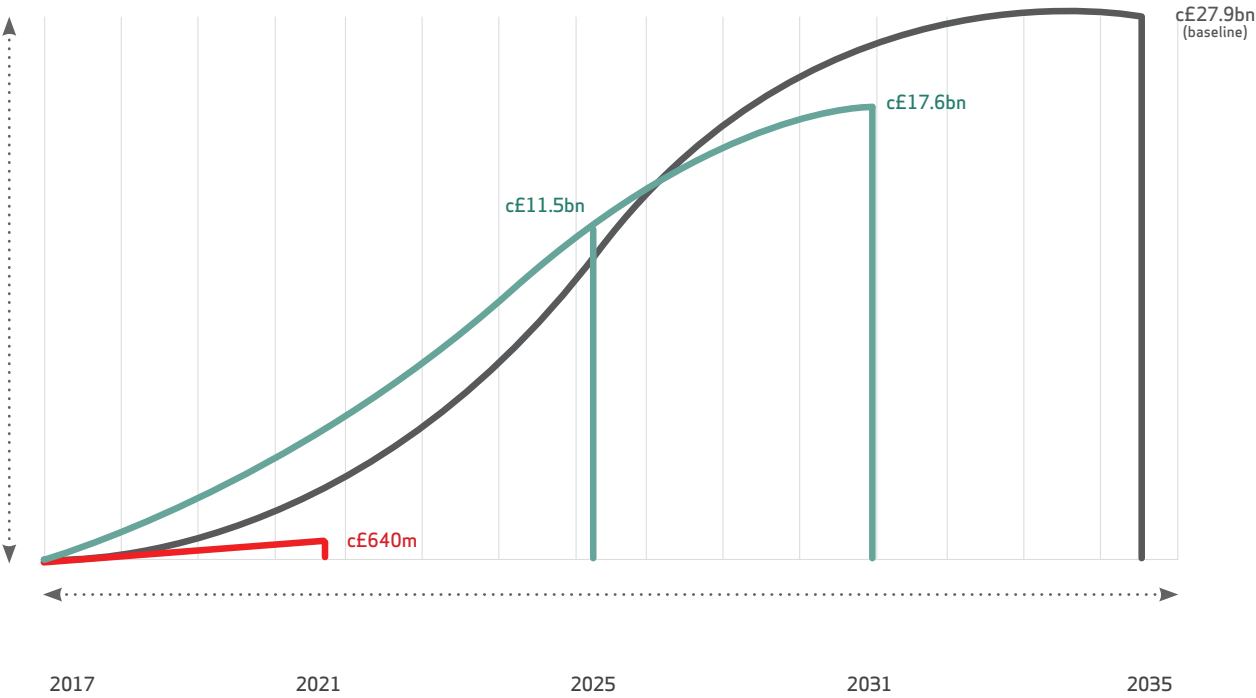
OPTION 3 - HIGH LEVEL INVESTMENT

102. The high level investment option would produce an additional 160,000 individuals over a nine-year period to 2025. This has a total intervention cost circa £167 million per annum and providing an additional annual average benefit to UK GDP of £1.4 billion with an ROI of 6.0.

Figure 10 - High level investment option

Frontloaded costs: 160k people / 6 years		**Frontloaded benefits: 160k people / 9 years**	
Total costs (2017-2025)	c.£1.5bn	7.4bn	Total net benefits (2017-2035)
Traditional intervention costs (2017-2025)	c.£1.4bn	c.£64.9bn	Gross benefit of interventions (2017-2035)
Ecole 42 costs (2018-2025)	c.£100m	c.£37.0bn	Opportunity cost of resources (2017-2035)
Programme overheads (2017-2025)	c.£40m	c.£1.5bn	Annual average benefits (2017-2035)
Average cost per year	c.£172m	17.0 (6.0)	2035 Return on investment (2025 ROI)
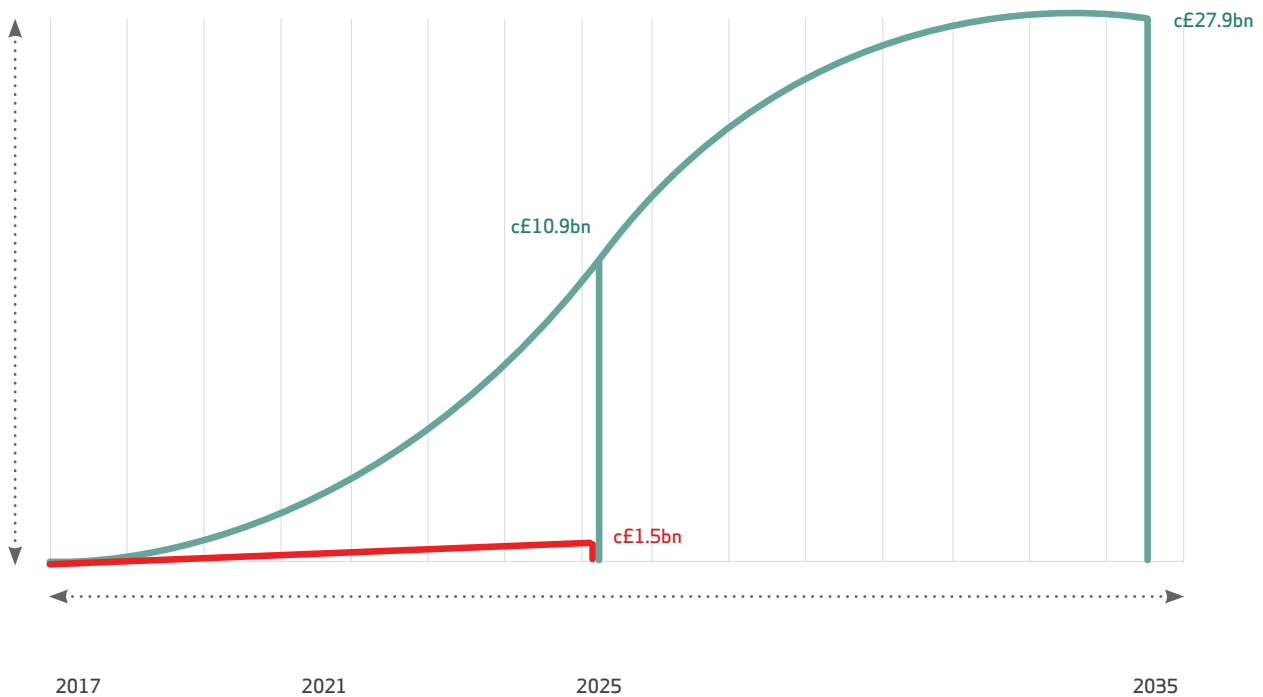
c£27.9bn

c£10.9bn

c£1.5bn

2017   2021   2025   2035

CONCLUSIONS AND NEXT STEPS

103. The strategy presented in this report provides government with the options to address the skills short-fall while building on existing skills policies and interventions:

i.   Intelligent mobility is a fast-growing and lucrative market in its own right with an estimated global market value of £900 billion per year by 2025 and where government has already committed major investment to key IM programmes;

ii.   There is an IM skills demand forecast to 2025 of 1,159,000 individuals with an estimated supply of only 417,000. This highlights a skills gap of 742,000. Of these individuals, 281,000 occupy the 'disruptive' STEM and human sciences landscape, with an emphasis on high value digital skills;

iii. The UK transport industry will need to move away from its traditional silo-based landscape where the focus has historically been on developing a workforce with traditional STEM skills;

iv. To capitalise on this emerging and growing market there is a clear need for new skills and upskilling with an emphasis on high value 'digital skills' that transcend traditional sectoral boundaries;

v.   There is a strong preference among the transport industry for higher degree apprenticeships to address the future skills gap coupled with the need for greater and consistent understanding of IM and the opportunity this market presents;

vi. A coordinated range of interventions is needed, as no single intervention will address the shortfall in IM Skills. The creation of a skills enabling environment will bring together existing industry, educational and government initiatives to create a 'virtual' IM Community Hub. Table 2 summaries our recommended intervention mix;

vii. It is recognised that the IM skills agenda can change rapidly in such a high-tech emerging market and we will continue to liaise with government and industry on the implementation of the findings of this report.

APPENDIX A – IM SKILLS RESEARCH PARTICIPANTS AND CONTRIBUTORS

Table 9 - IM Skills research participants

RESEARCH PARTICIPANTS	ROLE	ORGANISATION
Adam Kirkup	Innovation Executive	Institute of Civil Engineers
Alan Brown MP	Member of Parliament for Kilmarnock and Loundoun	UK Government
Alan Hardy	Chief Financial Officer	Transport Systems Catapult
Alan Nettleton	Technologist	Transport Systems Catapult
Andrew Byrne	Head of Public Policy, Uber UKI	Uber UKI
Anthony Baxendale	Research & Future Transport Technologies Manager	HORIBA MIRA
Babita Kumar	Client Engagement Lead Skills and Learning	Babcock International
Charlie Henderson	Partner	PA Consulting Group
Chris Eccles	Co-Headteacher	Dinnington High School
Chris Jones	Technical Director	Parsons Brinckerhoff
Claire Gillespie	ICT and Digital Technologies Sector Skills Manager	Skills Development Scotland
Dr Amir Soltani	Lecturer – Active Chassis Control Development Environments for Connected and Autonomous Vehicles	Cranfield University
Dr Antonis Michailidis	Technical Coordinator	Jaguar Land Rover
Dr Brooke Storer-Church	Senior HE Policy Advisor, Subjects and Skills	Higher Education Funding Council for England
Dr Clive Hickman	Chief Executive Officer	Manufacturing Technology Centre
Dr Daniel Auger	Lecturer in Advanced Control and Optimisation, Advanced Vehicle Engineering Centre	Cranfield University
Dr Daniel Naish	Principal Engineer Geospatial, Road Design & Capability	Department of Transport and Main Roads, Australia
Dr Dongpu Cao	Lecturer in Automated Driving and Driver Cognition, Centre for Automotive Engineering	Cranfield University
Dr Kevin Stenson	Chief Executive Officer	The Smallpeice Trust
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