



The Royal Academy
of Engineering

ICT for the UK's Future: the implications of the changing nature of Information and Communications Technology





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Table of Contents

Foreword

1. Executive Summary

- 1.1 Background
- 1.2 Conclusions and recommendations

2. Introduction

3. IT and communications infrastructure

- 3.1 Universal broadband

4. Skills and education for IT

- 4.1 IT in the classroom
- 4.2 Core IT skills for business competitiveness
- 4.3 IT competence, leadership and decision making

5. Research, development and innovation in IT

- 5.1 Innovation in infrastructure
- 5.2 Industry-Academia interaction and IP
- 5.3 The UK as an IT leader

6. Concluding remarks

7. References

8. Glossary and abbreviations

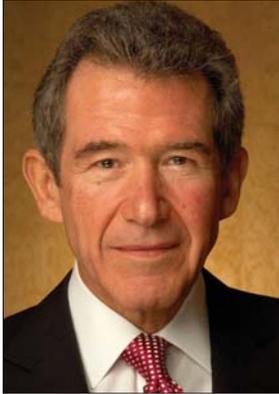
Appendix 1: Study group

Appendix 2: Contributors

Appendix 3: Methodology

Appendix 4: Digital natives survey summary

Appendix 5: Business research on ICT capabilities: loD survey summary



Foreword

The recent global slowdown, and in particular its impact on the financial services sector, has reminded everyone of the benefits of a more diversified economy. The United Kingdom has the opportunity to continue to diversify by growing more high technology industries which exploit to the full the growing 'information economy'. This requires investing in the UK's ICT infrastructure, filling the gaps which exist at all levels of society in our IT capability, and ensuring that we lead in certain important technological areas such as mobile communications, safety critical systems and the encryption required to ensure IT security.

The Academy undertook this study in order to show how we could grasp this opportunity. Our study complements and builds on work already being done by government. In some instances we suggest some different approaches.

Lord Browne of Madingley FREng FRS
President
The Royal Academy of Engineering

1. Executive Summary

1.1 Background

For companies and countries alike, a recession represents a period of great challenge. Whilst the impact of recession on businesses, organisations and society as a whole is profound, the most alert should emerge in a stronger competitive position, poised to exploit the subsequent upturn. A key determinant for success in the recovery after the recession will be the degree of exploitation of the immense potential of Information and Communications Technology (IT and ICT¹) to transform both public and private enterprise.

IT is itself undergoing profound changes that – unless fully acknowledged, analysed and addressed – will present significant risks to the future competitiveness of the UK. The pace at which business technology has evolved over the past 30 years has been breathtaking. Since the early origins of mainframe computers and simple desktop PCs we have seen the evolution of corporate networks, the emergence of new business applications and IT architectures, the explosive growth of the internet and communications technologies and now the seamless integration of wireless and mobile into the enterprise. The exponential growth in capability per unit cost still has a long way to run.

Accordingly, The Royal Academy of Engineering has undertaken a study to:

- consider the importance of the IT base for the UK economy
- examine the present and projected state of UK IT-related business activity in a global context
- identify potential opportunities for improvement
- make policy and other recommendations.

Now is the time for the UK to take bold actions in key areas including: enhancing the UK's IT infrastructure; recognising and addressing critical gaps in IT capability at all levels of society; and exploiting UK leadership in key technology areas. In terms of infrastructure, 100% broadband availability is required. In the area of IT capability our workforce skills must be extended to promote full computer literacy in our schools, enterprise and public sector. Action is also required to ensure better awareness in boardrooms of the potential and the pitfalls of business change facilitated by new IT systems. In the area of research, development and innovation, it is essential to ensure UK universities and businesses effectively partner in order to realise the value of ICT research.

1.2 Findings and recommendations

The following summary provides a high level view of the findings in each section of the report, the recommendations that follow from them and the expected outcomes of implementing those recommendations.

1. While historically the fields of Information Technology and Communications Technology have been separate, they are rapidly merging and the distinction between the component technologies has little meaning. This convergence reaches its fulfilment in areas such as 'Cloud Computing'. The terms IT and ICT used in this report are increasingly interchangeable.

Infrastructure

Finding 1

Ubiquitous broadband access is a prerequisite for a modern knowledge-based economy. It is essential that the UK, as a global trading nation, remains at the forefront of global broadband connectivity (page 14).

Recommendation 1

Government should facilitate genuinely affordable, reliable and fully pervasive broadband coverage for the entire UK by 2012, reducing the cost by exploiting competitive and innovative approaches (Page 14).

Expected outcomes

Universal broadband coverage will:

- support economic vibrancy
- support social inclusion and resilience in crises, such as extreme weather and pandemics
- provide a communications infrastructure which is itself resilient.

Skills

Finding 2

Every school leaver should be an effective user of IT. The current programme focusing on primary and secondary school use of IT is welcome but required resources must be delivered alongside teachers with relevant academic qualifications and adequate time to keep abreast of new developments. IT education has been confused with computer literacy and so has been ignored in the drive for STEM skills and capability (Page 17).

Recommendation 2

The current ICT programme in schools should be expanded in two key areas: the programme should be broadened to include the exploitation of new interaction modes and interfaces; and concepts such as computational thinking should be given broader exposure. (Page 17)

Expected outcomes

Expansion of the current ICT programme in school will:

- lead to improved social inclusion
- better and more widespread use of IT across all academic disciplines (such as the use of ICT in enabling the decoding of the human genome)
- awareness of IT throughout the population
- inspiration of the next generation of IT innovators for the UK economy.

Finding 3

The UK has lost or is in danger of losing core IT skills underpinning business competitiveness. Development and maintenance of such skills are essential to the creation of a strong cadre of technicians to keep the 'virtual pipes' working for the UK economy (Page 21).

Expected outcomes

Greater exploitation of cloud computing and collaborative web based capabilities will:

- lead to increased participation in transformational computing platform technologies
- wider partnerships for UK industry which will then be well-placed for optimal business exploitation of these capabilities.

Finding 6

The culture around Intellectual Property (IP) and its exploitation in IT must change to support effective collaboration between universities, SMEs and large international companies. The way IP is protected is often a barrier to innovation – stemming from the patenting of basic constructs in software being used as a weapon by big companies against other big companies. As a consequence, this creates a large barrier for an SME without a large patent portfolio. Further, university technology transfer offices are often overprotective and may hamper collaboration. (See page 31)

Recommendation 6

Technology transfer organisations such as those associated with universities and research organisations should adopt novel business models which enable value to be created more effectively from ICT research. (Page 31)

Expected outcome

A collaborative and more open approach to IP is likely to allow higher value to be realised from ICT research.

Finding 7

There is a substantial opportunity, and some indications of UK leadership, in ICT-related areas such as sensors, robust and reliable software, security and social/economic applications. (Page 33)

Recommendation 7

The Technology Strategy Board should focus on a coherent range of related applications and technologies and concentrate increased investment in a small number of key projects. The selections should accelerate those areas where the UK can win a lead in world markets, such as highly dependable software and socio-technical sensor-based applications. Partnerships should be facilitated which enable the bringing of new concepts, products and services to market (Page 33).

Expected outcomes

Better focused support from the TSB could lead to:

- economic growth through differentiated leadership for UK technology transfer
- strengthened UK leadership in core technology areas.

One good example of this model is the BBC with its work with new media companies.

2. Introduction



Information Technology is at the base of the UK's future competitiveness

Information technology is a broad discipline with a very substantial impact on UK and UK based businesses. IT encompasses electronic engineering, computing, communications, control systems and software. The discipline of computing, in terms of both 'know-what' and 'know-how', supports all of engineering and core science and has as broad an impact [1] as mathematics. This breadth of impact is explicitly recognised in the 'Driving Innovation' strategy of the Technology Strategy Board [39].

Computing is integral to all sectors of the economy including defence and aerospace, games and entertainment, retail, healthcare, construction, manufacturing, finance and pharmaceuticals. The UK's future competitiveness depends on establishing, and sustaining leadership in all aspects of IT with particular emphasis on know-hows. At the same time the world of computing and IT is changing profoundly and unless these changes are acknowledged, analysed and addressed, they present significant risks to the future competitiveness of this country. The importance of IT to the economy was recognised in the *Digital Britain* report by the UK Government [60]. This report supports many of the aims and objectives of *Digital Britain*, although the Academy sets out certain alternative strategies for implementation (see Chapter 3).

IT, the economy and the workforce

UK IT industry produces an annual gross value-added (GVA) of £30.6 billion, 3% of the total UK economy [46].

Continued adoption and exploitation of ICT has the capacity to generate an additional £35 billion of GVA to the UK economy in the next 5-7 years [47].

1.2 million people are employed in the IT workforce: 597,000 in the IT industry itself and 650,000 IT professionals work in other industries [48].

22 million UK employees use IT in their daily work.

Around the world the IT industry is under extreme transformational pressure. This is due to changes occurring on many fronts: globalisation; commoditisation; market driven short-termism; increasing systems complexity; and open innovation. At the same time, the IT discipline continues to reinvent itself at a rapid pace through the introduction of new technologies, new applications and new modes of human interaction. These changes create opportunities as well as challenges for the industry and for the UK as a whole. This study set out to understand some of these pressures and to determine the extent to which the UK was well positioned to take advantage of opportunities.

IT has been a driving force and enabler for globalisation in many industries, and the industry is itself an active participant in the off-shoring of a substantial percentage of its professional roles. For example, in the US the IT professions

that are geographically mobile contribute over 10% of the total potential offshorable occupations in the entire country [2]. While such off-shoring may result in the loss of some local jobs, there are often significant advantages that enable growth.

Public companies are under intense scrutiny and persistent pressure to deliver quarter-to-quarter growth. This drives an ever increasing focus on short-term results with some concerns that craftsmanship is being squeezed out of many industries [4]. The same is happening in IT, with potentially significant consequences for professional career development, product and service quality and for the long term vitality of the industry in general. These pressures may have particular significance for IT in the UK because of the relative lack of substantial indigenous centres of IT industry leadership. With rare exceptions such as in ARM and Autonomy, much of the IT industry leadership in the UK is held in local subsidiaries of multinational, typically US-headquartered, companies.

The UK needs to be positioned for sustained success, both in terms of the IT industry itself and those other areas of the economy whose competitiveness relies on effective ICT exploitation. This report details a range of recommendations focusing on infrastructure, skills, research and development, and innovation.

2.1 IT and communications infrastructure

It is now widely accepted that achieving 100% broadband coverage, with a commitment both to service quality and regular enhancement of the available bit rates, is an essential element of future business success. Reaching out to small and medium enterprises (SMEs), wherever they are located, is essential both to provide cost-effective connectivity and to explaining clearly the business benefits achievable.

Wider benefits include sustaining rural communities and contributing to the broader 'green' agenda. Achieving 100% home broadband coverage is also vital, both in terms of driving new markets and minimising societal disparities. This report identifies new, more cost-effective options available through the use of advanced wireless communications technology to provide both 'fixed' and 'mobile' broadband access.

2.2 Skills and education for IT

The professional skills required for leadership are also experiencing significant change. Over the past 20 to 30 years there has been a steady move away from deep technical skills in operating systems, programming languages, and system fundamentals. Now the skills focus is more on applications and integration. Computer science is becoming more closely integrated into many other disciplines, for example, in the application of computing skills needed to ensure leadership in national defence through systems and intelligence, in

solving complex problems in biology, in delivering competitive advantage to the finance sector and in studying complex social systems. This study sought to understand if skills gaps were emerging as a consequence of these new developments.

Some of these gaps are already recognised and there are actions underway to address them – for example, improving the primary school IT curriculum. Others are recognised but it is not yet clear what the appropriate actions should be – for example, the substantial reduction in enrolments in computer science in Western universities which is a persistent concern. While some hold to a view that ‘IT doesn’t matter anymore’ [6], the view expressed in this report is that IT and IT skills still matter a great deal, but that IT is changing and this creates new skills and challenges at all levels of education and life experience. A key issue here is the identification, development and evolution of the necessary competitive skills in IT in the UK. The 2006 Leitch Review of Skills [8] is certainly relevant in this context, but it only scratches the surface of this issue with respect to IT and its profound consequences for the UK’s future.

The UK has been a leader in this area and has made extraordinary scientific and business contributions in the past. The challenge is to ensure the future competitiveness of UK industry and the UK economy. This study set out to identify actions required to ensure the UK maintains a global leadership role.

2.3 Research and development and innovation in IT

There are significant opportunities for the UK to benefit from research & development in IT and significant benefit to UK businesses that apply IT capabilities and infrastructure. SMEs in particular can benefit from partnering with universities and adopting novel IT solutions into their business models and practices. Investment in, and willingness to take up IT innovations will be a crucial step to recovery from the current recession.

Unfortunately, there are barriers to technology take-up, including distrust of outsourcing; security concerns; weak linkages between SMEs, universities and larger corporations; and IP issues. Steps need to be taken to reduce these barriers, allowing fuller exploitation of IT innovation and supporting more global business engagement. The study explores these further and makes recommendations for the mitigation of these barriers to UK competitiveness.

The study also examines investment choices relating to IT research. The UK is in a leadership position in some areas of IT and focused effort is required to maintain that leadership.

3. IT and communications infrastructure

"...in other, mainly business and financial, service industries the strongest relationship with productivity over the first half of the 2000s comes from the proportion of workers with access to high speed internet."

"...in manufacturing firms intensity of e-procurement shows the strongest relationship to productivity advantage" and "in distribution service firms the largest impact on productivity is related to the intensity of use of e-commerce for selling."

ONS and Eurostat

Access to high-speed internet connections is now accepted as being essential for economic growth and competitiveness, yet the UK lags behind other countries in the universal provision of high-speed broadband to homes and businesses. It is essential to establish an IT infrastructure with upgradeable 100% broadband access if the UK is to compete effectively in the knowledge economy, to maintain social cohesion and to enable citizens to participate in learning and social networking communities.

This chapter sets out the case for universal broadband and the best technical solutions for delivering this cheaply, easily and with a path for future upgrade.

3.1 Universal broadband

Broadband access has been frequently identified as a key driver for IT competitiveness and, by proxy, for innovation within the UK economy as a whole. It has been heralded as a new fundamental utility alongside electricity, gas and water; and is essential for promoting regional development, enabling businesses to grow and develop irrespective of their location [9][10]. Studies of the UK and other European countries, such as France, Nordic countries and the Netherlands, have shown positive correlation between IT use and labour productivity. This productivity stems from enabling increased links to suppliers in manufacturing industries and increased links with customers in service industries [11], although these benefits depend on a critical mass of networks and IT usage [12]. National parity of infrastructure, such as broadband, has been highlighted as an important factor in helping companies to realise productivity benefits. Indeed, the research commissioned for the study amongst UK businesses, detailed in Appendix 5, highlights support by government for investment in affordable broadband infrastructure as a key expectation from business.

Average download speed in the UK was 4.1Mbps in April 2009². South Koreans have between 50 and 100Mbps. Sweden can access 100Mbps at low cost. This situation limits the UK's competitiveness [17]. Finland has shown that mobile access to the internet can result in productivity gains, such as those realised from flexible working [12]. The IT industry will be responsible for designing the standards and addressing security and privacy issues raised by greater and easier IT access over the next decade. The threats that arise from not meeting these challenges could be grave as businesses rely more and more on IT systems and infrastructures [10].

"Cloud computing is the future – but you need connectivity to make it work"

Peter Waller, Head of Broadband and ICT, South East of England Development Agency

It is important that the opportunities facilitated by affordable broadband access are made available throughout the UK, resolving broadband 'NotSpots' and providing an upgrade path for bit rates to at least 10Mbps/sec over the next three years. This will benefit small and medium enterprises (SMEs) in rural areas and is a vital element in addressing 'digital divide' issues. Major new developments, such as 'cloud computing', depend on fast and efficient broadband access. Lack of ubiquitous access would otherwise heighten the disparity between urban and rural economies.

2. Ofcom UK Broadband Speeds July 2009

"Telco architecture will be a hybrid of optical fibre and radio with exceptionally high capacity."

**Dr. David Cleevely, FEng,
Founding Director at Centre for
Science and Policy, University of
Cambridge**

"Governments need to step in where markets have failed. There is no doubt that Intel will keep producing chips and Microsoft software, or their successors will, but Governments need to intervene in those areas where there is regulation, such as the Transmission Layer. Particularly critical is their role in providing deregulation and investment incentives [need to make investment] to improve broadband by taking us out of copper and into fibre (or create an environment where others will find it commercially attractive to invest)".

**Rees Ward, CB, former Chief
Executive of the Defence
Communications Services Agency
(DCSA)**

"Web presence is fast becoming a pre-requisite for staying in business" and "As far as the younger generation is concerned, a business is invisible if it does not have a web presence."

**The Institution of Engineering and
Technology**

The *Digital Britain* report from the Departments for Culture, Media and Sport and & Business, Innovation and Skills [60] gives a Government commitment: *"To ensure all can access and benefit from the network of today, we confirm our intention to deliver the Universal Service Broadband Commitment at 2Mbps by 2012. This can be delivered through upgrades to the existing copper and wireless networks."*

In this the UK Government is following the lead of the Irish Department of Communications Energy and Natural Resources (DCENR) which announced on 22 January 2009 a €233m public investment plan to provide 100% broadband coverage in Ireland by September 2010 [34]. The assertion in the *Digital Britain* report that: "the UK's commitment leads Europe" is, therefore, not strictly correct.

This Irish initiative harnesses the disruptive power of the latest cellular mobile technology as well as containing contractual commitments to increase regularly the available bit rates throughout the five-year lifetime of the scheme. It is noteworthy that the Irish competition, which involved both fixed and mobile providers, was won by the mobile provider Hutchison 3G Ireland with innovative provision of fixed broadband connection using mobile technology and self installed mobile repeaters to boost signal strength (and thus achievable bit rate) within homes and businesses. It came as a surprise to many that a solution based largely on mobile technology proved the most effective in rigorous evaluation rather than a more traditional fixed and mobile approach. This suggests that the approach adopted in the UK to implement 100% coverage should allow for innovative solutions as well as the more traditional ones.

Genuinely pervasive broadband is the vital precursor to transforming the Internet from a network primarily for interconnecting people and servers (a network of people) into a network for interconnecting machines (a network of things). This will open up many new applications and markets, which the UK would be well positioned to exploit.

In the detailed interviews carried out for this study, many interviewees stressed the importance of pervasive broadband access that was regularly upgraded to achieve progressively higher upload and download speeds. Interviewees also stressed the importance of applications that depend critically on affordable broadband access.

A number of interviewees stressed the need to target much higher data rates: Dr David Cleevely suggested an aspirational target of 1Gbit/sec to every home. The reality in the medium term is a need for a mix of schemes with Fibre to the Home (FTTH) for new build, Fibre to the Cabinet (FTTC) enabling 50Mbit/sec VDSL services in urban and suburban areas and innovative wireless-based solutions in the harder to reach rural locations. Reasonable business cases can be developed for the FTTH and FTTC solutions but ubiquitous rural coverage at high data rates is unlikely to be achieved through market solutions alone.

Finding 1

Ubiquitous broadband access is a prerequisite for a modern knowledge-based economy. It is essential that the UK, as a global trading nation, remains at the forefront of global broadband connectivity.

3.1.1 Recommendations, implementation and outcomes

Recommendation 1

Government should facilitate genuinely affordable, reliable and available 100% broadband coverage for the UK by 2012, reducing the cost by exploiting competitive and innovative approaches.

Following the Irish model, the Government should implement its commitment by holding a publicly funded European procurement on a five-year programme for the completion of 100% fixed broadband coverage in the UK with an initial minimum downstream bit rate of, in our opinion, 4Mbits/sec (rather than the 2Mbits/sec suggested so far) and minimum upstream bit rate of 1Mbit/sec. This should be technology neutral other than for a requirement for low latency. As part of the competition evaluation, extra benefit should be given to bidders who give contractual commitments for upgrade paths to at least 10Mbits/sec downstream over the five-year life of the programme and to progressively lower latency and contention ratios. Bidders should be required to set tariffs comparable to those set nationally, (for example, no rural premium charge). The winning bid would be that which committed to the required performance and quality targets at the minimum level of public subsidy. The target would be for that subsidy to be for five years only with the business case self-sustaining from that point.

Recent actions on regulatory reliefs by Ofcom give confidence that normal market forces will resolve pervasive broadband access, at least to the 50 Mbit/sec level, within the major cities and towns of the UK. However, intervention will be required to minimise the urban-rural disparity in broadband access. Pervasive fibre to the home has been projected to need a currently unrealistic level of investment of more than £25bn.

A separate competition for the provision of rural broadband could be limited to a defined set of postcodes that represent geographies presently not covered by broadband, or only currently covered at data rates below the defined minimum. Recent advances in mobile radio technology (3G-HSPA now being deployed and by 2010 3G-LTE/ WiMax) offer the prospect of genuine competition between fixed and mobile providers for this rural fixed broadband market. The bidding rules should allow the successful bidder to offer a limited amount of coverage by satellite (say 5% of the geographic areas defined as subject to the scheme) outside the prescribed 'low latency' restriction. This identification of defined areas not currently adequately covered, should minimise market distortion and facilitate European Commission 'State Aids' clearance. The bidders should also be required to include in their bids funded proposals for 'demand stimulation', especially campaigns targeting SMEs and explaining the advantages of broadband enabled e-commerce. Previous

initiatives (for example in the 100% broadband coverage of Northern Ireland) have focused too much on supply-side provision and too little on facilitating and nurturing demand. Provision should therefore be made within bids for a realistic level of funding for appropriate demand stimulation campaigns. It is estimated that, for example, the total investment required for a mobile broadband solution would be less than £5bn.

Ofcom should be required to make available spectrum (potentially up to 2 x 20MHz), as part of the release of 'Digital Dividend' former UHF television spectrum, to support a mobile broadband solution, should this win the rural procurement competition. Such additional spectrum would enable the vast majority of coverage to be achieved from existing sites, thus minimising both planning delay concerns, as well as reducing the level of overall capital investment required. Given the need for public support and a competitive procurement process, the release of spectrum should be handled in a manner best suited to rapid and competitive provision of broadband services. As such, an auction of spectrum may not be appropriate.

For rural access, a five year plan with defined targets and milestones is required, including metrics relating to contractual payments to the winning bidder conditional on achieving the interim roll out and bit rate upgrade targets; independent end-to-end measurements of performance and quality of service (as experienced by customers) ensuring adequate customer support, investment in next generation interconnection and provisioning as well as local access; and robust security and availability plans, tested to demonstrate contracted levels of integrity and resilience.

The rural recommendation would require a formal public procurement exercise in line with EU legislation. The key milestones in the procurement and commissioning process, which could potentially be completed in eight years, would be:

- agree policy and launch procurement exercise
- winning bidder contracted
- 100% coverage complete at initial contracted bit rate
- first bit rate upgrade completed
- second bit rate upgrade completed
- contract ends – network commercially viable

These recommendations formed the basis of a response [44] in March 2009 by The Royal Academy of Engineering to the *Digital Britain* consultation carried out by the Department of Culture, Media and Sport and the then Department of Business, Enterprise and Regulatory Reform. It is disappointing that these recommendations do not seem to have been reflected in the final Digital Britain proposals which, in particular, do not take full advantage of the possibilities afforded by mobile broadband.

4. Skills and education for IT

“Literacy, numeracy, ICT and personal development should form the new core of the primary curriculum.”

Sir James Rose, former Director for Inspection, Ofsted. Quote from: Review of Primary Education Curriculum, 2009

The findings of this report point to a complex, significant and growing IT skills gap. The gap is broad (it covers all sectors – education, enterprise and government); wide (it encompasses people at all stages of their personal and professional development); and deep (the types of skills required are hard-earned).

There are many activities already underway in this area which we strongly endorse and support, including the DCSF STEM programme and the recent recommendations from Sir Jim Rose’s Review of the Primary Education Curriculum [57]. This chapter sets out further recommendations for improving IT skills and awareness at all levels of education and through continuing professional development.

4.1 IT in the classroom

Addressing the school curriculum has been highlighted in previous studies as a route to improving IT skills. Proposed initiatives have included creating a performance benchmark at A-level for STEM subjects, with success in these subjects having an increased weighting in school performance tables. An underlying problem is that only 15% of school IT teachers have a degree in the subject and nearly 70% have no post-A-level qualification in IT [26]. This shortage of specialist teachers has been highlighted as needing urgent attention.

The low levels of student interest suggest that the current IT curriculum lacks appeal to pupils. Computing should be made exciting by highlighting the end result of computer science in terms of its applications, rather than focusing on the nuts and bolts of computing. As in any subject, students need to be engaged with high-quality teaching which connects computing with the latest technologies [29]. At present, however, teachers don’t have time to learn new skills or keep up with the latest technologies used, for example, in gaming, film special effects software and internet applications.

IT and Computing are taught in schools as part of Key Stages 3 and 4 of the National Curriculum. Ofsted [63] found there was insufficient challenge in the teaching of these subjects and that they were being taught in isolation from daily life. This was backed up by many of those interviewed who also found that the GCSE focus was on exploiting the use of computers, little attention being paid to programming. There is an underlying confusion between IT as a fundamental life-skill and ‘enabler’ in the teaching of all subjects, and computing as a scientific discipline, with the present balance skewed towards teaching ‘software use’ [24]. Students should be encouraged to explore what goes on behind the IT applications they use, from social networking and messaging tools, to computer graphics and computer games.

“ICT isn’t like other subjects which don’t keep changing. Teachers really need time to keep abreast of new developments.”

Julia Vale, GCSE IT Teacher

Whereas there is evidence that some STEM subjects may be enjoying a renaissance in schools, IT and Computing are not. Pupil numbers taking GCSE

“The primal broth of innovation in UK universities is fine, but there is a decline in undergraduates in computer science. How can we get teenagers to understand what underlies, for example, Facebook or computer games? The BBC Micro led an earlier generation to get their hands dirty. We need a new approach to education for this generation.”

**Professor Andrew Hopper CBE
FREng FRS, Head of the University
of Cambridge Computer
Laboratory**

“Programming should be as fundamental as reading, writing, and arithmetic. You should do it as early as possible. It encourages problem solving and will lead people to have more interest in it.”

**Professor Jon Crowcroft FREng,
Marconi Professor of
Communications Systems,
University of Cambridge Computer
Laboratory**

“I would like school kids to know that with a computer you can simulate things, build simple applications on the web, do basic scripting so they can think about components and join things together. I want them to have strong feelings about the technical limitations of computing. I want them to understand something about complexity and how to recognise it – for example, linear is great; exponential is bad news.”

**Dr. Andrew Herbert FREng,
Managing Director, Microsoft
Research**

in IT in 2008 fell by 14,000 or 20%. This will have a knock-on effect on numbers taking the new Diploma in ICT which started in 2008.

Finding 2

Every school leaver should be an effective user of ICT. The current programme focusing on primary and secondary school use of ICT is welcome but required resources must be delivered alongside teachers with relevant academic qualifications and adequate time to keep abreast of new developments. ICT education has been confused with computer literacy and so has been ignored in the drive for STEM skills and capability.

4.1.1 Recommendations, implementation and outcomes

Recommendation 2

The current ICT programme in schools should be expanded in two key areas: the programme should be broadened to include the exploitation of new interaction modes and interfaces; and broader exposure to concepts such as computational thinking is required.

It is essential that a significant proportion of the 14-19 age group understands computing concepts – programming, design, problem solving, usability, communications and hardware. It is of particular importance to reform the teaching curriculum in schools to differentiate between the learning of genuine IT and the use of IT. Understanding the basis of the subject is fundamental – understanding of applications can build on this and can be delivered either through higher qualifications or training in employment. This fundamental understanding is currently largely absent from curricula. For example current Key Stage 3 and Key Stage 2 curriculum content fails to develop thought processes and habits conducive to working with computing and Information Technology.

Professor Jeannette Wing of Carnegie Mellon University argues for broad adoption of computational thinking, as in logical, serial thinking, with the ability to construct and analyse abstract models, seeing it as a ‘fourth R’ to the traditional 3Rs of education [50]. The skills associated with computational thinking are useful for everyone; they include systems design, understanding human behaviour, applying abstraction and decomposition techniques and heuristic problem solving. Wing suggests “we should expose pre-college students to computational methods and models”, and “this kind of thinking will be part of the skillset of not only other scientists but of everyone else”. Adopting this view across the UK’s education system is strongly endorsed.

Awareness of computing should be introduced and presented in a manner calculated to gain general appreciation and retain the interest of those showing aptitude. If sufficient suitable staff cannot be funded, on-demand Learning Grid material should be provided and promoted. This can be augmented by after-school club activity analogous to that provided by the Young Engineers, EES, Imagineering and C4G schemes. A high profile initiative similar to the four STEM pilots should also be considered.

“...Lack of coding experience may lead to difficulties in areas such as website PHP, validating security, high level functionality and middleware/management interfaces...”

Nick Coleman, Founding Chief Executive, Institute of Information Security Professionals

“...One of my concerns about these trends is that we are hollowing out the community that understands systems and new technologies; downstream there is a hazard in that. In our industrial base, if we haven't got people working on future technologies and systems then we are putting ourselves at risk of only doing our applications on aging technology...”

Dr. Andrew Herbert FEng, Managing Director, Microsoft Research

“With the trend in outsourcing to other countries, base skills are being lost. It is hard for a workforce to gain experience on higher value technologies if they have not been exposed to some of the base enabling technologies. Thus, providing finances permit, the UK will be in a stronger position to develop talent if the technologies are based locally, i.e. in the UK.”

The Institution of Engineering and Technology

It is recommended that DCSF continues to implement the STEM programme detailed in its report of October 2006 and that the review being undertaken of the ICT and computing syllabi is accelerated as a matter of the highest importance and that this should be completed by Sept 2010.

4.2 Core IT skills for business competitiveness

The Leitch Review of Skills in 2006 highlighted a national need to refresh skills continually across sectors and subjects: “A highly-skilled workforce drives innovation, leadership and management, enabling businesses to compete in the global economy.”[8]. In the 21st century, skills need to be ‘economically valuable’ and there is a need to move from supply-driven skills provision to demand-led. In IT the demands are particularly acute.

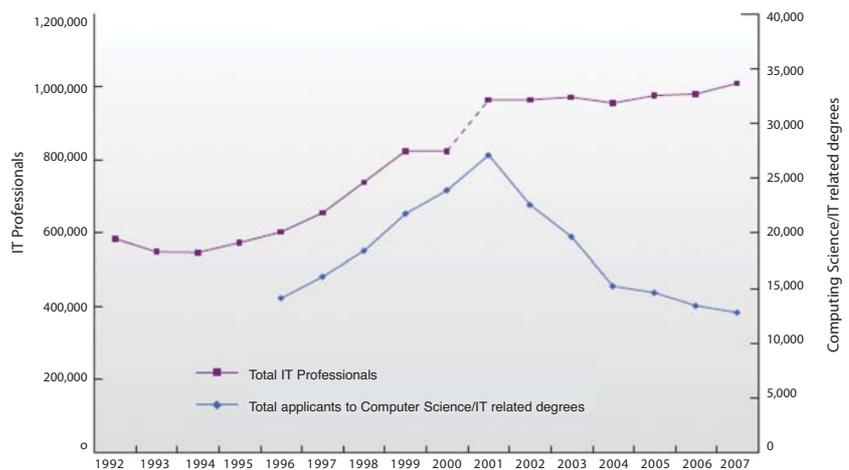


Figure 1: IT professionals in the UK workforce / UK applicants to Computer Science / IT related degrees. From Women in IT Scorecard, 2008 [49]

Declining numbers in computing:

19% of IT professionals are women, 23% of the overall IT workforce

The number of applicants to Computer Science/IT related courses in HE has declined from 31,000 in 2001 to 15,000 in 2007, of whom currently only 15% are women [40].

The reduction in graduate numbers as a result of the ‘dot com’ bust in 2000 is still being felt [23]. The subsequent resurgence of the technology sector and the high profile of companies like Google is redressing this balance [30]. However, it is predicted that shortages of IT specialists will result in between 20,000 and 25,000 jobs being moved offshore over the next few years [20].

Declining numbers of computing graduates [19] in the UK mirrors experiences in countries such as the US and Australia [5], with the result of fewer new entrants into IT jobs having the necessary deep-based technical skills. The IT industry invests an average of £3,300 per person per year on commercially provided training, of which only a small fraction is technical training [20]. The Leitch review recommended that the Sector Skills Councils should consider

collective employer action to address these specific needs but that the bulk of payment for these high level skills needs to be met by individuals and employers.

Previous studies have shown that the IT skills gap goes beyond those in technical positions [16]. The total UK IT workforce is 1.2 million but there are an additional 4 million business managers who need broad, deep and continually adapting IT skills. It is anticipated, for example, that virtually everyone in the NHS will need IT skills to do their jobs in the near future [23]. In 2004 20 million of the 27 million UK workforce needed to be equipped with skills to use IT as part of their daily job, yet 40% of today's IT users have no formal IT training. Individuals without reasonable skills in the use of IT risk being excluded both professionally and socially [10].

Research commissioned for this study amongst UK businesses highlights the difficulty organisations experience in accessing combinations of skills such as those required to genuinely understand business needs and translate these into IT and business change requirements (see Appendix 5).

The Government has a role to play in stimulating private sector investment in education and training [8]. Falling numbers of applicants for computing degrees suggests that the high-level skills shortfall is a problem that will continue to grow. 150,000 new entrants are needed in the IT sector each year of which the majority will need to be new graduates [24]. As the population ages and new talent becomes less available, employers and employees will need to reskill or upskill existing talent. This is particularly acute in IT where change occurs more rapidly than in most other sectors [24]. If these challenges are not met then there is a risk that more high-skilled jobs will be sent offshore or not come to the UK in the first place. Currently it is estimated that 13% of high-skilled jobs are being lost overseas for this reason [11].

The IT skills gap has been well documented for a number of years [37]. Several effects have been both widening and deepening this gap. The decline in student interest in IT continues while the demand for IT positions continues to grow.^{3,4}

“For last 10 years you could get good development skill sets offshore; now you're seeing that in infrastructure. There is now more skills growth offshore toward engineering skills than software development. You are beginning to see really good skills coming online in offshore locations.”

Senior Banking ICT Executive

Further, the gap is deepening because the nature of these positions in demand is moving more toward 'high level skills' such as software professionals, IT managers and IT strategy and planning roles [20]. The gap is becoming harder to fill because fewer individuals are completing formal education with the required degree qualifications. The challenge is further exacerbated by growing levels in the off-shoring of IT positions [42]. While off shoring of skills is attractive if the required skills are not available in-country, the consequence is that in country skills are eroded further and either lower-skilled individuals must fill the gap, skilled people must be brought into the UK or the work must go elsewhere.

3. UCAS results for 2008 entry (reported February 2009) show an increase in ICT subjects of about 6% compared with an overall enrolment rise across all subjects of 10%.

4. While this outlook is a year old, and there has been significant economic transformation in the interim, the gap is significant.

Many contributors to the study have highlighted and cautioned on the consequences of this hollowing out of core IT skills in the UK. One commercial software research leader pointed out that globalisation is driving demand for new skills in global management while technical, routine skills will travel easily offshore. The danger is that technical skill is replaced with management skill in the belief that core technology skills will not be necessary for UK domiciled positions.

In corroboration of Dr Herbert's views in the above box, another telecommunications CEO noted a "...potentially damaging 'hollowing out' of the UK skills base as a secondary consequence of outsourcing. It may be challenging to retain the high level competencies (for example at ARM in processor design) without having had experience at the lower levels".

The response to this widening and deepening gap has not been adequate. It is not possible to bring in overseas expertise – ICT skills are not included on the Home Office's Migration Advisory Committee 'shortages occupations' list [38]. Firms will find themselves unable to hire staff because of a gap in locally educated skills, and unable to import technical skills. Work will thus go elsewhere. According to Gartner [43], CIOs must be prepared to source their IT from offshore global locations or suffer competitive disadvantage, as emerging markets ramp up their technology investments. Gartner Vice-President Partha lyengar also predicts that the industry will witness a 'borderless state' by 2015, with organisations sourcing their software, hardware, telecoms, IT services and people from all over the world.

One venture capitalist noted "We see offshoring in all our companies...". This particular trend will not continue indefinitely; salaries will converge and the cost motivation for off-shoring may be gone by 2020. In the interim, the skills gap widens. Further, while it has previously been the case that lower level technical roles have been moved offshore, there is now growth in the off-shoring of more senior, more strategic positions.

If the borderless state vision is realised then industry will locate its IT technology investments wherever the skills are strongest. Geographies with insufficient skills will not be able to compete for this work. IT investments of a national interest (for example, high security systems) may be at particular risk.

A potential analogy can be seen in nuclear power. The UK is facing a challenge today in the area of nuclear power skills. Years ago, universities discontinued many courses in nuclear engineering, leaving a wide gap between a soon-to retire workforce and those needed to be ready for a nuclear renaissance by 2020. There are now efforts to address this issue in the nuclear sector.

Similar risks exist in the ICT gap but the risks are much wider because: "Information and Communication Technology (ICT) underpins all industry sectors, enabling businesses to operate globally, consumers to access a wide range of information sources, products and services and governments to

A diminishing systems and technology focus in university curricula adds another dimension to the deepening skills gap:

"I talk mostly to the research intensive universities, and what I see there is a strong drift away from systems and technology and into applications. I think that's driven by the fact that Government pressure on academics to work with and be supportive of industry. The nature of UK industry is more on the user side and ICT is embedded in companies that do something else – for example, energy, banking, telecoms. So, the focus goes to the application layer. In parallel with that I see in universities with a more vocational orientation a strong pressure to produce project managers rather than technicians, and business orientation rather than just technology."

Dr. Andrew Herbert FEng,
Managing Director, Microsoft
Research

"There is no really technical GCSE or A-level. Even the Diploma doesn't code. There should be a choice for people who are interested."

Julia Vale, GCSE IT Teacher

support and protect their citizens. ICT encompasses electronic systems and services that gather, store, recover, maintain, manage, transmit, process, interpret, present and protect (in house and in transit) information" (The Technology Strategy Board [39]).

The loss of deep technical skills is impacting some areas of UK leadership such as the games industry. A lack of focus on accreditation is resulting in programmes unfit for purpose, and this is leading to a critical shortage of skilled graduates. The UK is losing its leadership position in this industry as jobs are moving overseas [40]. Similar losses are occurring in other areas such as telecommunications where the need for deep skills in embedded, low-level systems and real-time processing is pushing companies to China because there is a lack of skills available in the UK.

Finding 3

The UK has lost, or is in danger of losing core ICT skills affecting competitiveness.

4.2.1 Recommendations, implementation and outcome

Recommendation 3

Many more 14-19 year olds should be motivated pursue careers in ICT and allied trades. This can only be achieved with the development of appropriate qualifications in the implementation, upgrading, installation and support of complex IT systems.

To bridge the gap in core skills needed for competitiveness, it is essential to encourage students in schools and further education to develop these crucial skills. The proposed introduction of a GCSE in Computing, the revision of the ICT curriculum at A-level and the introduction of the Diploma have already been raised as important steps in the right direction. The negative public perception of technology careers continues to be a barrier. Making parents, children, and teachers aware of the quality and variety of interesting jobs the industry has to offer would be helpful in promoting a positive image of careers in technology [9]. Industry and academia need to reconnect with schools to provide career advice to address this [25].

One immediate solution to the present shortfall of computing skills is to promote postgraduate computing courses; in the long term, the issue needs to be addressed by the reform of the ICT GCSE, informed by best practice in other countries and involving input from all stakeholders, including students, teachers and business. The result should be an iterative ICT curriculum which is flexible and adaptive, and can evolve continually in line with changes in ICT and its application. Basic electronics and programming skills should be introduced as part of the core curriculum from primary school up. Taking lessons from 'Teach First' and the recent initiative to encourage early retirees to become maths teachers, more links should be created between industry and schools, enabling individuals to take secondments and sabbaticals in schools and return to industry or retrain at early retirement and go into teaching.

4.3 IT competence, leadership and decision making

As highlighted previously, there is an increasing demand for professionals, including CEOs, and other users with high-level IT skills [7]. Ensuring that those in senior positions have the necessary IT skills and understanding is a core requirement for the UK's future competitiveness.

The public sector as a whole spends approximately £14bn per year on Information Technology and directly employs about 50,000 qualified IT professionals. This presents an opportunity to support mechanisms for user innovation and to act as an early adopter of advanced ICT [17]. A 2006 National Audit Office report criticised public sector approaches to innovation for being overly top-down and dominated by senior management. This presents a huge potential risk when these individuals are not fully cognisant of ICT disciplines [22]. Government needs to ensure that those in the public sector have a better understanding of the internet – especially with respect to information governance and security, as witnessed by high profile data losses by the public sector. It is also important that those in the justice system truly understand cybercrime [27]. Management schools have been identified as needing to play a role in solving these issues, both through Masters level and senior executive education [28].

The role of IT in raising productivity has already been mentioned. However, the UK's productivity gap, compared to other nations, is compounded by deficits in innovation, skills and management practices. Investment in IT needs to be matched by support of organisational change and improved management practices [21]. Countries which make better use of IT investment by matching it with other changes in the business, as seen in the US, see better returns on productivity.

In business generally, there tends to be a separation between the people who run the business, the technology used to run the business, and the market for the products and services produced by the business. Many companies, not just core IT companies, would recognise the statement that all administration, HR, finance, and sales and marketing, supply chain, production functions etc are critically dependent on IT. Today, IT is absolutely critical to competitiveness. Most businesses, it could be argued, could not function without IT tools such as teleconferencing, live meeting technology, email, instant messaging, phone and email integration and mobile phone and desk phone integration. However, many of those we interviewed for our study pointed to a lack of IT understanding in the business community.

There appears to be an age related digital divide. People in their 50s today, who are in leadership roles are not themselves born of the 'IT generation' and may have had neither the time to develop IT skills, nor a full awareness of what the technology can deliver, whether for their organisations, their clients or their supply chains. CIOs are not typically on company boards, nor in many cases at the next level down and so IT knowledge does not always feed into business decisions. Companies derive great benefit from having people on their main board who understand the potential capabilities of IT to transform business processes and who can develop a dynamic relationship with users to demonstrate the importance of key information systems.

“The danger is the successes of these large and complicated systems is that less-well informed leaders (for example, politicians and business leaders) then demand even more complicated systems - many of which are simply impossible at this stage to realise.”

Professor Keith Mander, Deputy Vice-Chancellor, University of Kent

Sometimes IT disasters have been a result of problems with technology (for example, the SLAMMER and conficker worms [62], or the collapse of the website for the 1901 census data [61]). On other occasions, they have been the result of an over ambitious business change programme, not enough contingency planning, incomplete time for testing and rollout, lack of end user education and other such factors relating to skills. Private sector projects fail for the same reasons as public sector ones.

Some companies seize the opportunities possible through the innovative use of IT. Merrill Lynch, for example, has programmers sitting behind their traders developing programs for use literally the next day. Other industries could benefit from much greater interaction between the IT and business teams.

The government has made significant progress in professionalising IT and appointing CIOs in every Department of State. The government has more complex ICT challenges on average than the private sector, owing to scale and a requirement for universal coverage. However, outside the IT community, the government also still lacks sufficient senior skilled and knowledgeable staff, and still makes flawed calls for proposals. The political agenda is such that some decisions may be driven by political requirements rather than robust business cases. Government officials need to be continually aware of the advances in IT and the role it plays in all aspects of life, not least the economic well-being of the country.

Finding 4

Too often in senior positions in government, industry, schools and institutions, the UK lacks adequate IT competence to support related project decision making and delivery. This lack of depth of understanding extends through middle management and needs addressing now, rather than waiting for the next generation to reach management positions.

4.3.1 Recommendations, implementation and impact

Recommendation 4

For more effective decision making and implementation in an IT-enabled world, special action is required for both businesses and policymakers. This includes strengthening strategic and managerial capabilities through access to appropriate IT-related expertise. This is about understanding interactions and consequences more than the development of specific IT skills and should include topics such as ethics, privacy, security, resilience and accessibility.

The Institute of Directors (IoD), the British Computer Society (BCS) and the Institution of Engineering and Technology (IET) should develop a programme and qualification for public sector board members to provide them with the required IT skills and knowledge. For government leader development, the National School of Government should link with the IoD to take elements of the business qualification and re-use it in government, also linking in leadership centres focussing on local government and healthcare.

In the same way as it is widely regarded to be 'useful' to have a finance qualification if you are on the board of, or leading a company (over 50% of CEOs in the FTSE 100 have a financial background⁵), it should be regarded as 'useful' to have a technical IT qualification or some experience of successfully procuring, or delivering a major or strategically critical IT programme.

5. Robert Half, 23 March 2009, www.roberthalf.co.uk. Note: Financial experience / background signifies those with a qualification in accountancy (for example a Chartered Accountant), those who have held a previous FD, CFO or similar financial role (for example financial controller) or those who have worked within the banking industry

5. Research, development and innovation in IT

“Though some areas do better, such as retail, marketing and insurance, they still lag behind the US and some parts of Asia. There is marked reluctance to go beyond cost-reduction to creation of opportunity as overseas enterprises do – it’s an ingrained cultural issue, reflecting businesses being run by accountants.”

Internet CEO

There are significant opportunities for the UK to benefit from research and development in IT and innovative use of IT. SMEs in particular can benefit from partnering with universities and adopting novel IT solutions into their business practices. Investment in, and a willingness to take up IT innovations will be crucial in establishing and maintaining economic growth. The UK is in a leading position in some areas of IT, and effort is needed to maintain that leadership.

5.1 Innovation in infrastructure

Evidence suggests that there is still a window for infrastructure investment [15] to give the UK an edge over its rivals. These investments “offer far more value when shared than when used in isolation” and Government should take a lead in ensuring this advantage for the UK. History has shown that “the power of an infrastructure technology to transform industries diminishes as the build-out nears completion” and this window of opportunity will be open only briefly [6]. The marketplace for provision of these infrastructure services needs to be open and competitive to encourage companies to make the long-term investments required [9]. Those firms which have access to high-speed internet have shown an increased ability to innovate by bringing in ideas from outside the firm to develop new products, services and processes [12]. Technology and infrastructure developments, however, need to be linked with developing human capital to maximise returns for individuals and the UK [16]. The need for high-speed, reliable and pervasive broadband access has already been addressed in Finding 1.

Finding 5 addresses those capabilities that can add real business value, for both user and supplier, through the exploitation of broadband infrastructure. Research by the Institute of Directors over the period 2004-07 [58], highlights that UK SMEs want to grow their businesses and that they see ICT investment as key to achieving that goal. At the same time, as illustrated below, SMEs are growing increasingly concerned about a wide range of IT issues from data security and business continuity, to keeping up with new technology and training. Many SMEs find that the contribution from IT is increasingly business critical, yet it is becoming ever more difficult to support that IT professionally from within their own limited resources

“The UK is ahead of Europe in exploiting high technology but behind the USA.”

**Dr. Hermann Hauser CBE FEng,
Director, Amadeus Capital Partners.**

The new web-based technologies such as cloud computing and Software as a Service (SaaS), directly address this challenge. They can level the playing field for SMEs with respect to their larger competitors. In particular they can provide cost effective access to expensive sector applications which are becoming steadily more important within supply chains. As broadband access extends, it is becoming possible for an SME to have its applications professionally hosted off-site, accessing them through ultra thin clients. Fast broadband access means that low latency and thus good response times can be maintained. With the right contracts and service level agreements in place, virus protection, firewalls, intruder detection, data back-up, resilience and so on can be outsourced to those for whom it is a core competence. SME staff can then focus on their own business.

“UK ICT capabilities need to be at a competitive global price point, with flexibility/speed/agility at the core. One fix on the horizon will be the growth of Cloud Computing, e.g. Software as a Service.”

Nick Coleman, Founding Chief Executive, Institute of Information Security Professionals

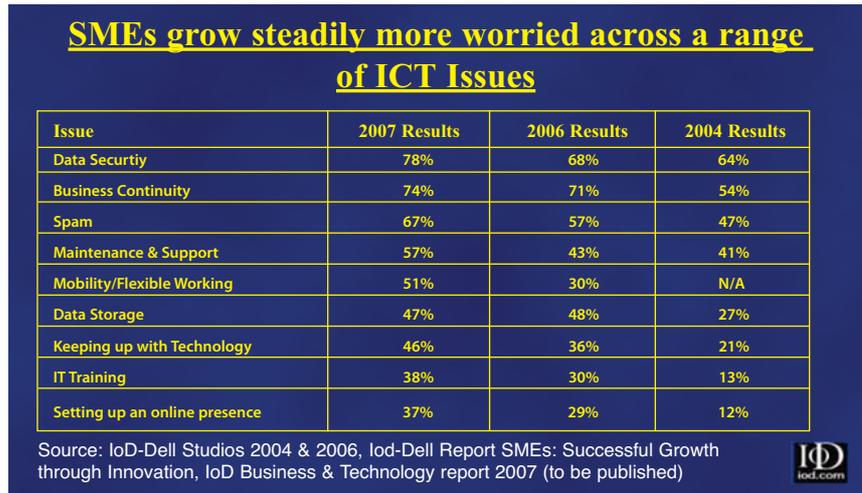


Figure 2 Perceptions of SMEs from IoD survey

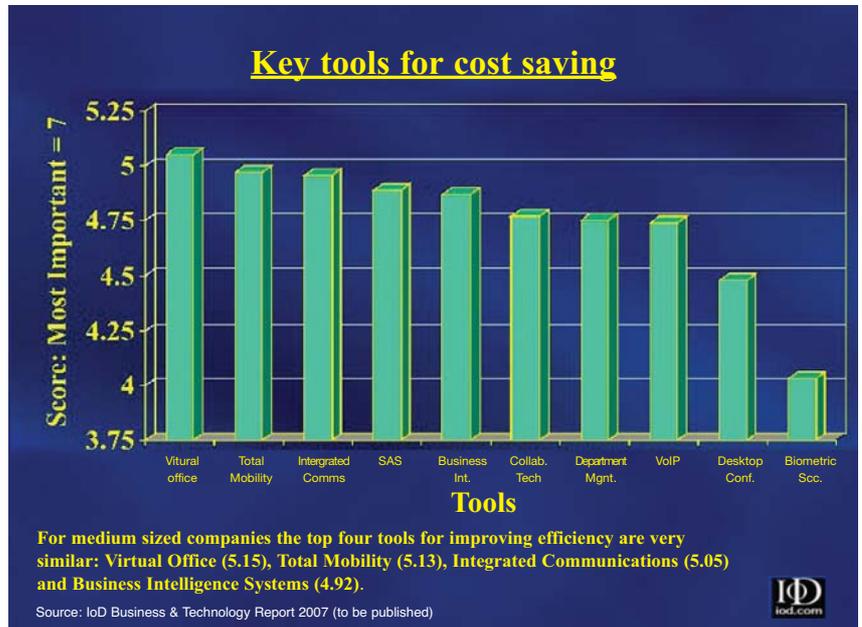


Figure 3 Key tools for cost saving, from IoD survey.

The recent IoD research suggests that attitudes amongst SMEs are changing quickly to reflect the new possibilities. As the charts above illustrate, SaaS is now regarded by SMEs as a key tool both for cost saving and for improving efficiency. Indeed even those tools rated more highly, such as ‘Virtual Office’ and ‘Total Mobility’ depend implicitly on hosted applications (because they enable global access to the user’s desktop applications and data from any thin-client). Large server farms properly dimensioned and loaded, supporting the associated network of ultra thin clients, are likely to be more power efficient than millions of individual PCs running at very low utilisation for much of the time. Large mass storage systems, even with multiple layers of redundancy and backup are likely to be far more efficient than millions of hard drives often spinning whilst scarcely used. However, cloud computing and SaaS introduce additional security issues, including the dependability of the software that is used to provide and access the remote services, the possibility that the

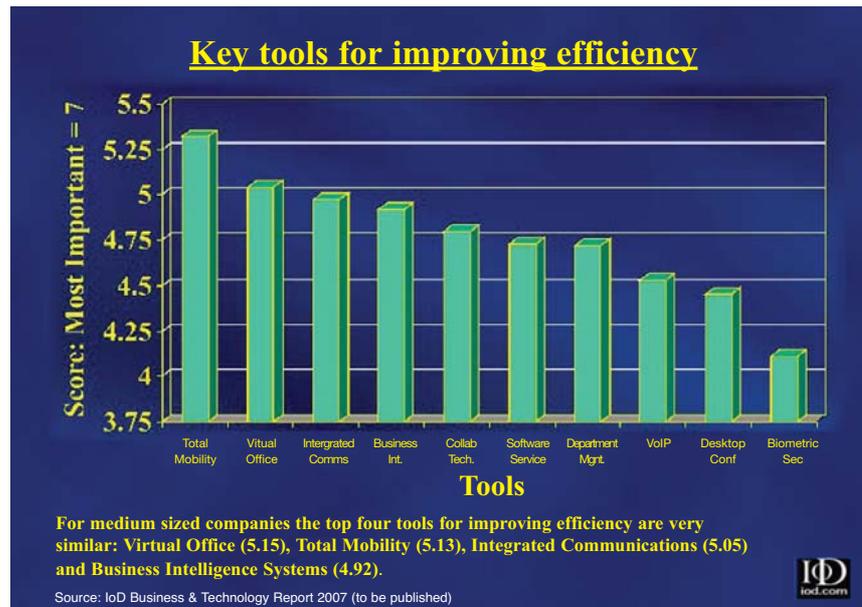


Figure 4 Key tools for improving efficiency, from IoD survey.

“The ‘cloud’ will become real. People at work will have a multiplicity of devices that they need to keep in touch and update (e.g. they will only want one version of their calendar and will want to download it from one location).”

Ian Watmore, former Permanent Secretary, UK Department for Innovation, Universities and Skills (DIUS)

confidentiality of data may be compromised by being held remotely, and the risk that the service may become unavailable for an extended period as a result of technical failure, hostile action, or legal challenge.

SMEs have been shown to suffer the most from their limited possibilities to exploit IT [16]. These companies are missing opportunities to serve their customers through digital marketplaces and become more sophisticated in their exploitation of IT in different business processes. Mid-sized firms in particular have been highlighted as being less comfortable about outsourcing services and often do not have the necessary in-house expertise to fully exploit the potential of IT for their businesses. It has been suggested that government could address these and other problems by establishing a centre of excellence to share good practice and CIO development [11].

The successful exploitation of IT needs the participation of SMEs to achieve the required leverage for productivity gains: local IT advisers should be supported and developed [23]; government could increase placement of R&D funds and other procurement with SMEs; and the R&D tax credits system should be expanded to include the patent process and other IP protection costs [9][25]. These actions have been proposed by previous studies to create the right environment for innovators and entrepreneurs to thrive and for their businesses to grow [25].

Finding 5

The technical evolution of IT (such as cloud computing and Web 2.0 collaborative capabilities) indicates that competitive leadership requires substantial infrastructure investment in technologies such as broadband and server farms. That investment will be stimulated in part by business demand. While many SMEs recognise the value in participating, there are barriers such as distrust of outsourcing; unease with respect to security; unfamiliarity with government procurement practices; weak linkages between SMEs and universities; and software IP issues.

5.1.1 Recommendations, implementation and outcome

Recommendation 5

Government should encourage widespread exploitation of cloud computing and collaborative web-based capabilities by UK businesses. It should reduce barriers to entry through appropriate regulatory and self-regulatory structures. It should also encourage the creation of an indigenous UK supply industry for hardware, software and service provision, differentiated by commitment to high levels of resilience and security.

First, it is important to raise awareness and education levels within SMEs of the value and approaches to exploitation of web-enabled globalisation to their businesses. The Department for Business, Innovation and Skills (BIS) should promote a substantial awareness campaign on the potential business advantages to SMEs from the use of web-based technologies. This initiative should be aligned with the proposal on IT infrastructure in Recommendation 1.

Research by the IoD illustrates that many SMEs are now so concerned about the challenges of operating their own IT systems (such as data security, business continuity, rapid obsolescence, limited access to skills, etc.) that despite having reservations about outsourcing and concerns over 'lack of control', they are now prepared to examine a range of third party hosted solutions. An awareness campaign should build on this major shift in perception. It should also stress the opportunities for converting capital costs in IT investments into operational costs as well as the opportunities to use ICT systems that coordinate sector supply chains on a per seat per hour basis. It should further stress the importance of integrity and resilience in supply and the potential advantages of UK-based suppliers. The campaign should be delivered at a local level through business organisations such as the Institute of Directors (IoD), Federation of Small Businesses (FSB) and local Chambers of Commerce.

There is a substantial risk to the very existence of SMEs if, having entrusted their key data and applications to remotely hosted solutions, these do not turn out to be reliable. It will only require a very few high profile business failures, driven by errors of the hosting provider in addressing security and business continuity issues, to destroy the reputation of this nascent industry.

To address this and to remove barriers to wide spread exploitation BIS should encourage the creation of a self-regulatory structure for those UK-based organisations providing hosted and web-based services. BIS should work with industry bodies such as Intellect to develop a 'kite mark' structure indicating strict adherence to a code of good practice in terms of availability, resilience and data security.

Other barriers to ICT exploitation

During the course of this study, the Working Group heard of a number of other barriers to the full exploitation of ICT in the evidence gathered, but were unable, in the time available, to fully develop them. Some recommendations were suggested to the Working Group during interviews and correspondence that the Working Group carried out. Among these were the following, which stand out as deserving further development:

- Direct some of the resources (people, investment, research, infrastructure, business support services etc) that have been focused on the financial services sector to create an environment which supports and encourages innovation companies to locate to the UK.
- Encourage relocation through corporate tax breaks (there is an urgent need to balance the 'sector portfolio' in the UK to reduce dependence on any one sector). Make it very attractive for large corporations as well as start up companies to choose the UK first for their innovation investment.
- Many interviewees expressed concerns about public procurement and the consequences for small firm engagement. The current policy strongly favours large companies – in particular, by driving very large contracts and introducing stringent tests of financial stability. The need to open up public procurement opportunities to SMEs was a common theme from many entrepreneurs, CEOs, venture capitalists and academics.

"The US rules that force 20% of procurement money to go to SMEs are excellent. The UK should copy."

**Dr. Hermann Hauser CBE FEng,
Director, Amadeus Capital Partners.**

5.2 Industry-Academia interaction and intellectual property

Successful, collaborative innovation requires effective management and protection of intellectual property. The global trend is for IT research & development to be concentrated in areas where the IP regime most suits development and investment. This results in significantly lower R&D investment in jurisdictions where intellectual property rights protection is weaker. If the correct balance between protection and openness can be provided, there could be a very big competitive opportunity for the UK. Unfortunately, the UK has not yet created an environment where people are encouraged to innovate rather than litigate.

"Innovation should be an international team sport (and it needs well defined and understood rules)."

**Professor Andrew Hopper CBE
FEng FRS, Head of the University
of Cambridge Computer
Laboratory.**

The linear model of innovation, where it is assumed that basic research ideas lead to applied research and then onto commercial applications, serves IT badly and hinders innovation out of universities. Software patents are a complex and problematic issue and the pathways to their commercialisation are too slow and cumbersome. There is also a view that software patents are largely irrelevant and can create problems. As time to market is key, strategic alignment is required between technological capabilities, IP and appropriability mechanisms and market opportunity. Some firms, such as Google, are successful because they are able to gain a first mover advantage and establish key relationships and then use these relationships to establish a global footprint. Others, such as Microsoft, have become successful by adopting fast-follower strategies embedding their technologies with standards that are established and become dominant.

University technology transfer offices (TTOs) have an important role to play in identifying, translating and enabling adoption of research externally, but they need to fully understand their contribution to the IP value chain. The approach to technology transfer from UK universities has generally been based on the development of physical products using models of IP protection and commercialisation often derived from the manufacturing sector. This usually involves the creation of patents, licence arrangements and the formation of spin-out companies in order to take ideas to market. This has served its purpose for commercializing some outputs from IT research but these models do not effectively support newer forms of value creation through, for example, the development of new business models or the creation of services.

The focus on patenting and university spin-outs, emanating from the US experience and the desire to emulate the success of particular clusters such as Silicon Valley, has had consequences for technology transfer in the UK. Even in areas where ideas can be suitably protected in patents, the record in terms of value creation and productivity growth from research, has been, at best, patchy [51]. Evidence from the US illustrates a number of issues. The Bayh-Dole Act of 1980, which gave US universities control of inventions and intellectual property arising from research funded by the Federal Government, helped to transform the role of universities in the innovation system. In particular, it led to the entry of less experienced universities into patenting and this has been an important factor in changing the IP portfolios of US universities [52]. The growing importance of biomedical research and pursuit of associated patents and value from IP has tended to reinforce this approach.

Evidence shows that the number of patents granted to UK universities doubled between 2000-1 and 2005-6 with a tripling of income from licensing intellectual property [53]. This is to be welcomed. But strengthening university IP regimes has not been of universal benefit in improving the ways in which ideas generated from university research are transformed into valuable products and services. As David Mowery points out [52], it has led to a system in the US, in which one channel is being favoured at the expense of others, creating a regime for protecting IP in the form of patents often at the expense of other forms of cooperation between universities and industry.

This has had two consequences which may reduce the potential benefits of exploiting the outcomes of many novel areas of IT research and could hurt innovation by reducing the spill-over effects from university-industry collaboration.

First, even in more traditional styles of research and commercialization, this patent-licence-spin-out model has been shown to have limitations in creating the value university TTOs had expected. Evidence from the US shows that few universities have realised significant financial benefits and, for most, revenues from licences have been modest. For example, Mowery's research shows that the University of California system (one of the leading US academic technology licensors) received net revenues of just US\$16m in 2003 from its technology transfer activities. In the same year, its sponsored research income from industry amounted to US\$235m out of its US\$3bn budget [52].

Second, there is evidence that barriers to interaction between industry and universities may have increased in the UK and that IP regimes may be becoming too bureaucratic, deterring firms from participating with universities in the normal course of research collaboration [53]. This issue has been raised by leading industry technologists. For example, Rik Parker, Rolls Royce's Director of Research and Technology, has criticised the UK higher education sector's overemphasis on IP rights, suggesting that these often frustrate industry partners because of time wasted in resolving IP issues in universities that cannot afford to protect them properly [54].

Finding 6

The culture around Intellectual Property (IP) and its exploitation in IT must change to support effective collaboration between universities, SMEs and large international companies. The way IP is protected is often a barrier to innovation – stemming from the patenting of basic constructs in software being used as a weapon by big companies against other big companies. As a consequence, this creates a large barrier for an SME without a large patent portfolio. Further, university technology transfer offices are often overprotective and may hamper collaboration.

5.2.1 Recommendations, implementation and outcomes

Recommendation 6

Technology transfer organisations such as those associated with universities and research organisations should adopt novel business models which enable value to be created more effectively from IT research.

Innovation processes themselves are undergoing a major transformation - characterised by multiple contributors joining and reforming into dynamic collaborative groups and across increasingly global networks, supported and enabled by innovative technology [55] [56]. Firms are seeking new types of alliances with research providers and success often involves collaboration in networks involving SMEs, large firms and research providers. Growth in the cluster of small new media technology companies associated with the BBC illustrates this. In the IT sector, open-source has resulted in new approaches to co-creating ideas and generating markets and these may require different treatment in terms of technology and service development.

Technology transfer organisations – in particular those associated with UK universities – should recognise these changes and adapt accordingly. As noted in Finding 6, the patent-licensing-spin-out model is not necessarily appropriate or effective with IT research. New business models are needed. Two examples illustrate the opportunities of creating value from new business models in the IT sector.

- Skype adopted a model to reduce average revenue per user (ARPU) in the creation of new internet communication services. This confounded the traditional model of telecommunication providers which typically attempted to increase ARPU and minimise services. To reach a new market,

Skype had to create a system of inter-relationships between content providers and end-users. Instead of focusing on product or individual service competition, Skype developed a competitive position by controlling the ICT system associated with internet communications. The ability to develop systems architecture and interoperability created the value that then allowed revenue streams to flow.

- In the case of MySQL – a database software programme sold to Sun Microsystems for \$1bn in 2008 – the inventor, Marten Mickos, used an open-source approach to give away software in order to seed the market. He deliberately enabled others to develop the software in an open-source environment, only charging a licence fee for use if the developer/user refused to publish changes to the software. This resulted in rapid market growth with more than 10m users, some of whom contributed to creating a valuable and stable software platform with many applications.

5.3 The UK as an IT leader

While targeting areas of concern, previous studies have highlighted the significant advantage that the UK derives from its computing industry. For example, the video games industry conceives and develops products in the UK which are played “everywhere from Beijing to Birmingham, Alabama” [24]. This study has highlighted a number of further sectors in which the UK has shown leadership and which could be examined as a source for future UK competitiveness.

The current generation of software systems has largely been feature-driven, as Moore’s Law drove computing into new application areas and as the connection and combination of systems created new ways of using computing (for example mashups and social networking). There has been a parallel growth in internet worms and computer viruses. Around the millennium, it became apparent that dependability and robustness were becoming a major issue, leading to the formation of the Trusted Computing Group and other dependability initiatives.

Lord Broers, Past President of The Royal Academy of Engineering, agreed that there was much expertise in UK universities in security and encryption but added that “more money is needed to unlock it.” Lord Broers sees the market opportunity: “Security of IT systems is both a threat if it goes wrong and a business opportunity to produce robust, reliable software – something the UK is not currently very good at”.

In parallel, the falling cost of circuits with embedded processing power has created new markets for sensor networks and radio frequency ID chips for personnel tracking, logistics, passports and many other applications. The idea of pervasive computing has started to become a reality and a new range of applications has emerged using novel sensors and new styles of interaction such as the Wii™ games platform and the iPhone™.

Such pervasive systems are expected to play a major role in amongst other things, intelligent transport networks, environmental monitoring, defence, security and medical applications. The success of these applications will

“I see tremendous progress in theoretical computer science and that is beginning to deliver software with a provable mathematical guarantee. The software is more dependable, reliable and robust. The market will pay more for software that works. For example, in Microsoft, we now have a set of tools that we can put third party device drivers through and do formal verification on them. This device driver code is sometimes several hundred thousands of lines long.

This has been a 30-odd year journey in which the EU and the UK have provided great strength. ... There are business opportunities in this area.”

**Dr Andrew Herbert FEng,
Managing Director, Microsoft
Research**

depend crucially on advances in sensors, the development of software that can be trusted to have well defined properties, high dependability with no security vulnerabilities and on proper accommodation and exploitation of sociology, psychology and economics as they apply to the way that humans interact with these systems.

The UK has particular strengths in all these areas, as Professor Andrew Herbert of Microsoft Research and others stated in their evidence. A recently completed six-year research programme by DIRC, the Interdisciplinary Research Collaboration in Dependability (see www.dirc.org.uk) was described as “setting the international research agenda” in socio-technical computing, with further leadership in other key technologies.

Finding 7

There is a substantial opportunity, and some indications of UK leadership, in ICT-related areas such as sensors, robust and reliable software, security and social/economic applications.

5.3.1 Recommendations, implementation and outcomes

Recommendation 7

The Technology Strategy Board should focus on a coherent range of related applications and technologies and concentrate increased investment in small number of key projects. The selections should accelerate those areas where the UK can win a lead in world markets, such as highly dependable software and socio-technical sensor-based applications. Partnerships should be facilitated which enable the bringing of new concepts, products and services to market.

“We are leaders in many technical areas, such as chip design, hardware design, optoelectronics, embedded sensors, web technology etc, even though in many cases we are not good at commercially exploiting this expertise. However, there are some excellent examples, like Autonomy, ARM and RM where we have excelled – proving we can do it if we want to.”

**Professor Nigel Shadbolt FEng,
University of Southampton**

The UK has often been accused of being good at developing IT but not at exploiting it. Highly trained computer scientists are available in India, Sri Lanka and China and their expertise is easily tapped into by firms which offshore their operations [5]. The top three nations in terms of IT spending in 2005 were the US, Japan and UK. However, two of the fastest growing software industries are in India and China (\$423.4bn and \$26.5bn in sales respectively in 2004/05). The EU software industry is also strong, with recognised strengths in communications, web services and cognitive systems [17].

The UK's share of European venture capital investment has been in decline in recent years as focused initiatives in countries such as Germany and Israel have been driving their growth. Compared to countries such as France and Canada, which have introduced targeted incentives for video games development, the UK has become a less attractive place for establishing such firms [9]. The UK is behind Australia, the US, Sweden and Germany in terms of e-business take-up. Successful management of offshore relationships will require IT professionals to have a new set of skills and firms will need to find new ways to ensure that remote workers feel integrated with their business and retain their loyalty [10]. It has been recommended that the UK should scale up its collaboration with Asia's innovation hotspots if it wishes to exploit its science and technology industry within the global market [24].

“... a massive growth in sensing and “sense and react” applications. The rate of change will not slow down; that’s good – that’s our opportunity. The next wave needs co-operation but not capital intensive plant like chip fabrication plants.”

**Professor Andrew Hopper CBE
FREng FRS, Head of the University
of Cambridge Computer
Laboratory**

“The ubiquitous computer will dominate – with most people interacting with literally hundreds of computing devices. Sensor-webs will be pervasive, underpinned by extensive data webs. New opportunities will be found in every direction.”

**Professor Nigel Shadbolt FREng,
University of Southampton**

Current TSB strategy is supposedly tightly focused but it is difficult to find many technologies or applications that are clearly out of scope for support. The TSB’s resources are small by international comparison and, unless they are more focused, there is unlikely to be any significant impact on the UK economy. Since the 1970s, the Government has been reluctant to pick specific technology focus areas. These concerns have never inhibited strategic action by the UK’s international competitors such as the US and Japan; indeed, it is the essence of any strategy that it involves placing large bets and excluding far more than is included.

Highly dependable software and socio-technical sensor-based applications are areas where the UK already has research leadership and a developing industrial base and where there are large and sustainable markets. Other areas where there is emerging evidence of significant likely benefits include social networking technologies, multi-media broadcast technologies, and simulation and visualisation technologies.

But it is not just a matter of targeting investment at promising technology areas. In line with Recommendation 6, these investments must be targeted at, and must encourage the development of, new business and partnership models for the exploitation of IT research. This is an applied field where markets emerge, grow and change very quickly. Research needs to be in tune with the market potential, implying that much of the research and development on applications should be carried out in collaboration with innovative lead users – for example in health, environment, energy, transport and media systems.

6. Concluding remarks

Some of the findings of this report have been previously identified elsewhere, but not yet acted on. The evidence collected in this report underlines how vital it is for the UK economy that strong action should follow now. The report has identified roles for government, the IT industry, small and large businesses and the education sector, all of which can make a contribution to supporting the UK economy through innovative use of IT. There are areas where the UK lags behind other countries in its use of IT, and areas where it has a lead. Action on the recommendations in this report is essential to ensure that the UK retains its leading position and catches up with those countries which it currently follows.

The key actions identified in this report are that there must be an innovative approach to engineering IT infrastructure if this is to be done in an affordable and flexible way, leaving the path to upgrade open; that there has to be a re-thinking of IT education to prepare young people for the IT roles that exist now and will exist in the future; and that SMEs, large corporations and government must take seriously the need for IT expertise in order to capitalise on the opportunities it presents. The recommendations focus these actions into specific areas, but there is a general need for an open and innovative approach to exploiting IT.

In concluding the study report, we wish to acknowledge the strong level of interest in the subject expressed by the wide range of individuals (see Appendix 2) and institutions consulted, including the British Computer Society, the Institution of Engineering and Technology and the Institute of Directors. We wish also to draw the reader's attention to the report recently produced by the Royal Society, *Hidden Wealth – the contribution of science to service sector innovation* [59].

There is great enthusiasm for grasping the opportunities that IT presents. The windows of opportunity that exist may, however, be small and action is essential now.

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8. Glossary and abbreviations

cloud computing	An approach to the provision of computing resources over the internet without requiring the end-consumer to make a large capital investment. Instead, consumers access these resources as a service. The service may be offered for a fee, or in some cases may be provided at no charge. The types of services available are varied and include computation, storage, backup/recovery, file transfer, specific software applications such as accounting and billing packages and others.
contention, contention ratio	Describes the degree to which a broadband service is being shared by other users in a region (e.g. a street/district). Many home broadband services are delivered in this shared manner, with 20-50 other users on the same connection. If all users are active at the same time then the amount of capacity available to each is diminished by the activities of others sharing that connection. A contention ratio of 50:1 means that 50 users share the same connection.
FFTC	Fibre To the Cabinet - Describes a communications infrastructure in which optical fibres are used to deliver service to a cabinet on the street (sometimes called Fibre To The Curb). The remaining distance (typically 300 metres or so) to homes in that area is serviced with more traditional metal cabling, e.g. copper.
FTTH	Fibre To The Home - Describes a communications infrastructure in which optical fibres are used to deliver service right into the home environment.
latency (and low latency)	Latency refers to the amount of time it takes for an operation to complete. In communications networks latency is a measure of the delay for data to travel from one point on the network to another.
NotSpots	Used to characterise a region in the UK (or anywhere in the world) where broadband service is poor, or non-existent.
Software as a Service (Saas)	One particular type of service offered in the Cloud Computing model in which applications are made available to end-users over the internet.
tradeable, tradeable profession	A tradeable profession is one can be relocated from one geographical location to another without disrupting the core service being delivered. The expression is often used in discussions about offshoring.
ultra-thin clients	The term 'client' refers to a device (or the software on a device) that enables users to interact with services that are typically provided by a remote server. A traditional client (e.g. a PC) may have a suite of local computing capabilities - e.g. business analysis software, graphics programmes - and these are used to interact with the users. In contrast a thin client relies on both the computational power of the server system for most of its data processing, and

on the capacity of the network to deliver fully prepared output to the user. An ultra-thin client is another point on that spectrum in which even more is expected of the server and network capability.

VDSL

Very high bitrate Digital Subscriber Line - Technology to enable fast data communication over traditional copper wiring for short distances (e.g. 300 metres). Coupled with FTTC for end-to-end high-bandwidth broadband delivery.

virtual pipes

It is common in ICT to refer to the technology providing the interconnection of systems that deliver information to consumers as 'plumbing'. It is in this sense that the term virtual pipes is intended.

Web 2.0

Refers to internet applications that offer more interaction styles for the user than traditional web-sites. Web 2.0 technologies typically support more collaborative and engaged interaction for users ... two examples include social networking sites (e.g., Facebook) and Wikis - a type of website that supports end user modification of content.

Appendix 1

Study Group

Membership of the study group who produced this report:

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The study group gratefully acknowledges the assistance of the following individuals who provided help with the conduct of several of the interviews:

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Appendix 2

Contributors

The Academy is very grateful to the many people named below who contributed their time and insight to the study. The Academy is also grateful to a significant number of people who contributed through anonymous surveys:

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Dr David Cleevely FEng	

Appendix 3

Methodology

The study was conducted using a methodology similar to previous Academy studies, including The Universe of Engineering [1] and the Challenges of Complex IT Projects [45].

The study consisted of five phases:

1. Identification of core issues and questions the study should address.
2. Evidence gathering to address the issues raised in the core questions.
3. Report writing.
4. Peer review and approval by the Academy's Engineering Policy Committee.
5. Publication and dissemination.

A series of interviews with leaders from across and beyond the UK was conducted to inform. These leaders were drawn from Government, ICT industry users and suppliers, relevant professional societies and universities. Interviews with senior people from disciplines relating to business leadership, economic policy, and general innovation were also conducted.

Evidence collected from interviews and desk sources was augmented through an invitation to submit evidence aimed - in particular but not exclusively- at leaders in ICT and related disciplines. An invitation for evidence was issued through The Royal Academy of Engineering to its Fellowship. In addition, a questionnaire was created for distribution to selected members of the Institute of Directors (please see the summary of results from this questionnaire in Appendix 5 in this report). A similar questionnaire was also developed and distributed to postgraduate students in business and ICT at several universities in the UK (please see the Digital Natives survey in Appendix 4 in this report).

The study questions

The study group developed a set of questions that were presented to a broad constituency of ICT creators, users and exploiters within the UK. These questions can be found here.

The study focused on the following high level question:

What actions are required for the UK to maximise its capability to realise benefits from ICT by 2020 and beyond?

This question was further refined into the following more specific questions.

1. How well does your enterprise today harness the benefits of ICT to strengthen its global competitive position?
 - 1.2. What is the present strength of UK ICT capabilities?
 - 1.3. How successful is your enterprise in exploiting ICT for competitive advantage?
 - 1.4. Can you identify specific examples from your enterprise, or your industry, in which there exists clear evidence that ICT use has led to benefits?
2. Given the changes taking place in the ICT landscape, what are the expected future (by 2020) benefits of having the UK as a location for your enterprise?
 - 2.2. How will the technical landscape of ICT capabilities change in the next five to 10 years?

- 2.3. How might governments affect the landscape of ICT capabilities and UK competitiveness (such as through protectionist measures, investment)?
 - 2.4. How might the globalisation of capital markets impact ICT investment in your enterprise (such as impact on leadership, skills and capabilities)?
-
3. What should governments, industry, the professional societies, schools, and universities do to ensure future competitiveness of the UK economy?
 - 3.2. What strategy should be adopted with respect to ICT to enhance UK competitiveness?
 - 3.3. What investment should be made to implement the strategy?
 - 3.4. What is your vision for leadership in ICT and its application?
 - 3.5. What types of ICT skills will be necessary to ensure competitiveness for the UK economy?

Appendix 4

Digital Natives survey summary

UK Future Use of IT (UK FIT)

Between 31 October and 25 November 2008, 36 full responses and 30 partial responses were recorded from a survey of 'digital natives': MBA and PhD students in business, engineering and computing at Imperial College London, University of Oxford and Aston University.

This data set is too small to draw overall conclusions. However, the results provide an interesting comparison for the same questions which were posed to company directors through the IoD survey conducted as part of this study (see Appendix 5).

Over half of the responses came from Imperial, just under a third from Oxford and the remainder from Aston.

The questions and responses were as follows:

What skill set are you currently lacking and which do you think are necessary?

The students felt that deep understanding of the needs of the business and of users were of most importance. Some participants also felt that they already possessed these skills. The skills that users felt they lacked most which the business needed were: communication; the need to innovate/reduce costs at board level and deep hardware and software competence.

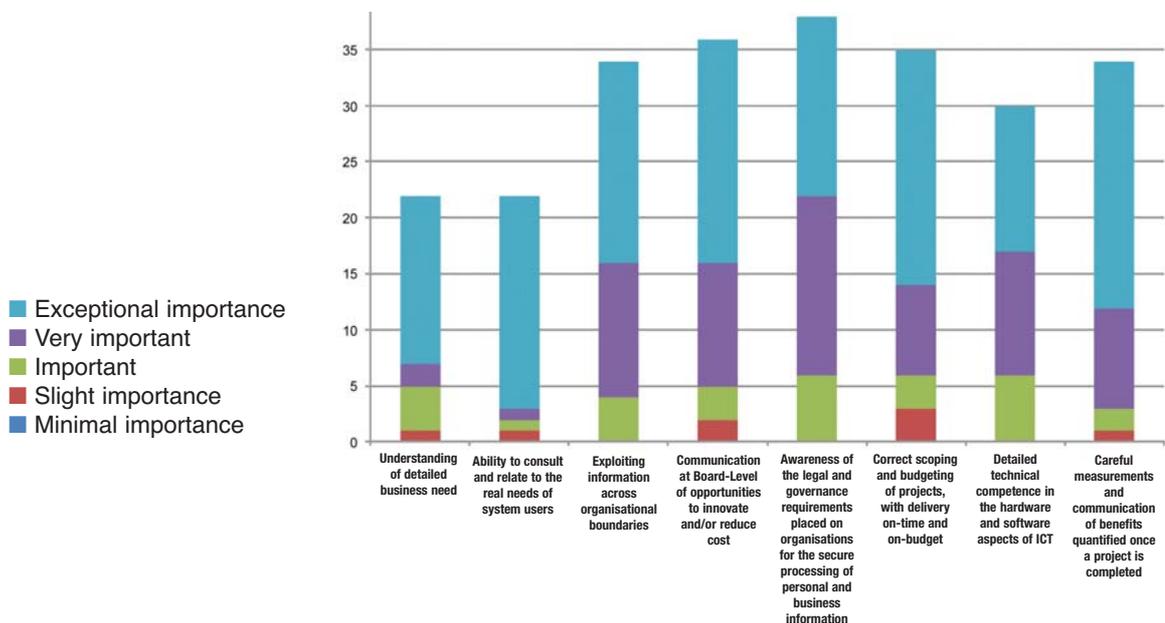


Figure 1 Importance of expertise in the successful exploitation of ICT

How important do you believe is access to the following areas of expertise are in the successful exploitation of ICT?

This question highlighted that the vast majority of responses found all the prompted areas of expertise either very important or exceptionally important.

Comparison of the UK's ICT capabilities with other countries

In ICT capabilities such as broadband communications, knowledge management, enterprise resource planning and business systems, the responses indicated that the country over which the UK had the greatest lead was Japan (most responses stronger or much stronger in the UK). The country which was felt to be most ahead of the UK (most responses weaker or much weaker in the UK) was China. France and Germany were felt to be broadly similar to the UK.

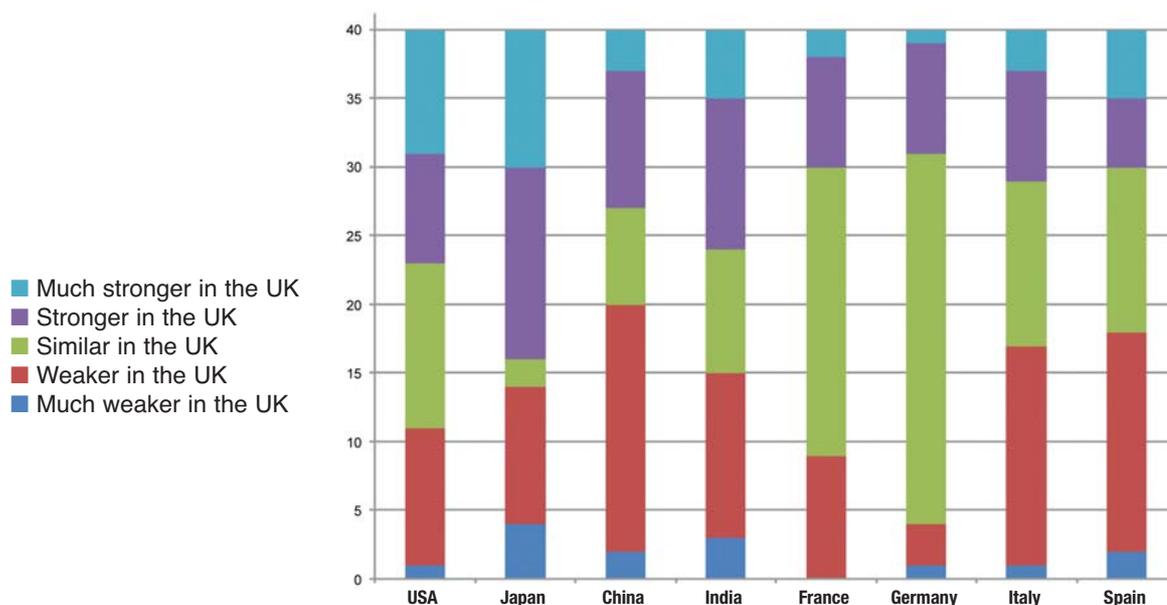


Figure 2 Comparison of the UK's ICT capabilities with other countries

Changes in the next five to 10 years

Over the next five to 10 years, responses indicated that increase of mobile, always connected systems and new methods of interface were the two biggest changes that would occur in the IT landscape.

Advantages of a UK location in terms of access to ICT capabilities

The UK's key advantages were highlighted as:

- Access to individuals who combine business and IT skills.
- Strength of competitive communications infrastructure.
- Access to business change skills.

What single action do you believe that it is most important that the UK Government should take to improve UK organisations capabilities to successfully exploit IT?

The word cloud indicates a wide variety of different actions for Government:

- Tax incentives.
- Create easier to use infrastructure.
- Implement policies for better regulation.
- Training schemes.



Appendix 5

Business research on ICT capabilities

The Institute of Directors (IoD) kindly agreed to incorporate a series of research questions for this report into one of its regular 'Business Opinion Surveys' of members. The research described below was carried out by GfK-NoP in October 2008 on a sample of 1000 IoD members by extended telephone interview. The sample was balanced by organisation size, sector and UK region to be representative of the IoD's 54,000 members as a whole. IoD's membership reflects predominately SMEs, with only 21% of the membership in organisations employing more than 200 people.

Do you think that ICT capabilities in the UK are weaker, stronger or similar to these countries?

On the question of UK ICT capabilities compared to other competitor countries, Japan, USA and Germany, (in that order), were regarded by IoD members as being stronger. France, India, China, Spain and Italy, (in order of weakening capability), were judged to be worse than the UK. More detail is available in the chart below. A score of '3' would indicate parity with the UK.

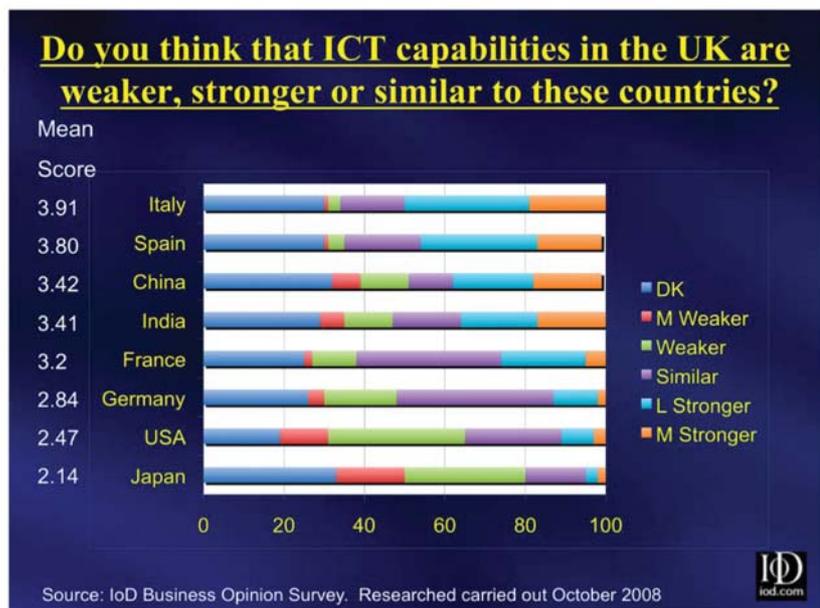


Figure 1 Perceptions of the UK's ICT capabilities compared with other countries.

How would you rate the impact of ICT on...?

IoD members were also asked to assess the impact of ICT on three key business fundamentals: cost reduction, innovation and competitive advantage. ICT impact was felt to be mildly positive for all three, with competitive advantage (score 4.42) and innovation (score 4.38) outperforming cost reduction (score 4.06). A score of '4' would give neutral impact. The surprise in this result is that ICT's impact is seen as relatively small. This suggests further scope, perhaps

through greater investment in people and process, to extract more value from investment in ICT, as illustrated by the research from the Office of National Statistics (ONS) [12]. The detail is given in the chart below.

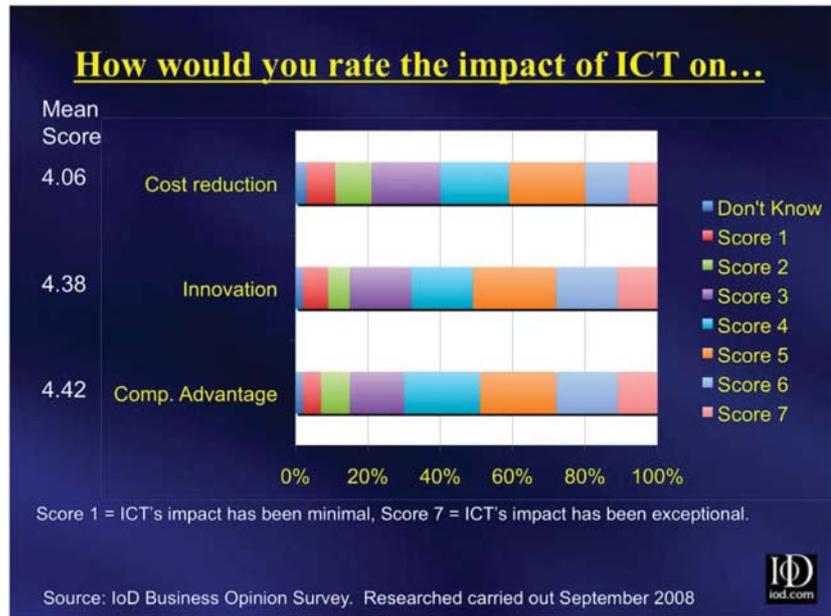


Figure 2 Perceptions of the impact of ICT.

Is ICT's impact on the following weakening, not changing or strengthening?

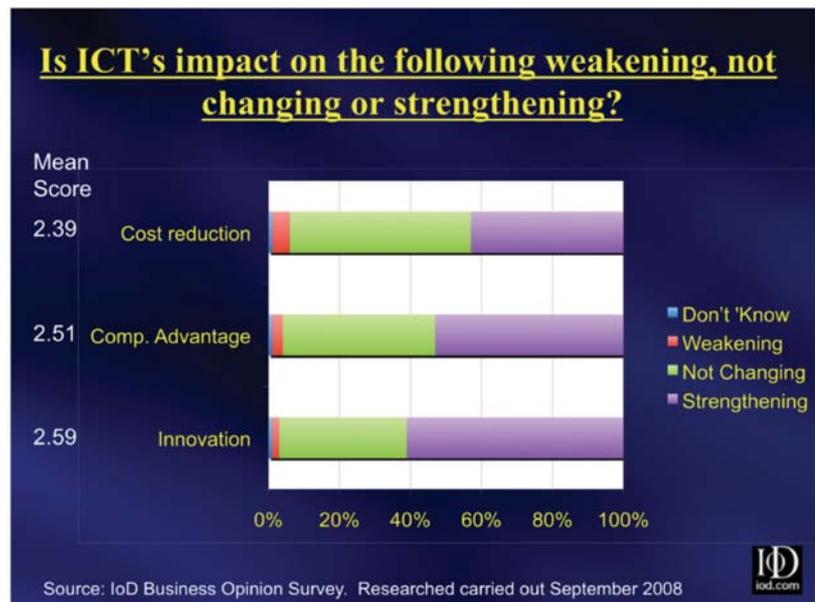


Figure 3 Perceptions of the impact of ICT.

IoD members were much more positive about 'the direction of travel'. As illustrated in figure 3 (where a score of '1' indicates weakening, '2' parity and '3' strengthening all three areas were regarded as having a significantly strengthening impact over time with innovation leading on a score of 2.59.

Example	Percentage respondents	Highest scoring sector
Improved customer service	9%	Business and professional services
Cost savings	9%	Financial services
Better marketing	8%	Financial services
Time saving	8%	Distribution and hotels
Remote access & home working	8%	Business and professional services
E-mailing/Messaging/Video comms.	7%	Business and professional services
Product development	7%	Manufacturing
Better communications	7%	Government, education and health

Table 1 Areas of business where ICT has been of quantifiable benefit.

IoD members were also asked to give specific examples where the innovative use of ICT had led to quantifiable benefits for their organisations. The table below illustrates the leading responses.

How much impact do you think the following would have on the successful implementation of an ICT change programme?

IoD members were asked to rate a number of key factors in terms of their impact on the success of ICT change programmes and ease of access to these skills. The most important factors identified were “setting a correct scope and budget” – score 5.33 and “fully understanding the detailed business need” – score 5.14. All the factors illustrated in the chart below were judged significant having scored above the median of ‘4’.

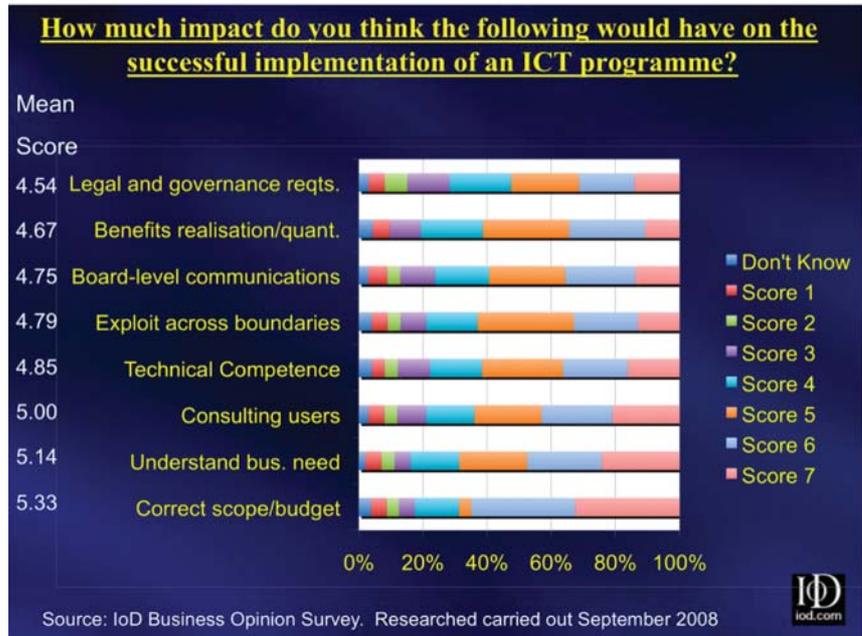


Figure 4 Perceptions of what has highest impact on successful ICT implementation.

Aspect	Mean impact	Hardest skill to find? (% resps.)
Correct scoping/budgeting	5.33	16%
Understanding business need	5.14	22%
Consulting users	5.0	16%
Technical competence	4.85	4%
Exploiting info. across business	4.79	10%
Board-level communications	4.75	8%
Benefits realisation/quantifications	4.67	8%
Legal and governance reqts.	4.54	5%

Table 2 Relative difficulties of finding skills in IT staff.

As will be evident from the preceding table, the services/skills that respondents found hardest to access were those that required a combination of both technical and business competence such as scoping and budgeting or understanding business and user needs. This illustrates powerfully the need to develop more 'hybrid' professionals with a combination of technical, business and inter-personal skills.

Potential helpful actions by the ICT industry?

The survey respondents were asked to identify: "the one thing the ICT industry could do to help improve UK businesses' successful use of ICT"? The results are illustrated in the table below.

Example	Percentage respondents	Highest scoring sector
Talking to users/benefits focus	16%	Business and professional services
Simplifying the language	9%	Government, education and health
Improve capability awareness	9%	Financial services
Become more user friendly	7%	Other
Reduce/communicate costs	5%	Manufacturing
Consolidate existing systems	4%	Financial services
Better training	4%	Manufacturing
Deliver to budget	2%	Business and professional services

Table 3 What should the ICT industry do to help improve UK businesses' successful use of ICT.

The results again highlight the real irritation amongst user organisations that the ICT industry still "does not speak their language"

Potential helpful actions by Government?

The respondents clearly identified four key areas in which Government action would help:

- Offering stronger tax incentives for ICT investment and/or reducing Corporation Tax (13% of respondents).
- Increasing the availability of grants and business support schemes (12% of respondents).
- Increase support for ICT education and training (11% of respondents).
- Invest more in infrastructure and especially affordable broadband access (9% of respondents).

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